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HEARINGS

BEFORE THE

COMMITTEE ON SCIENCE AND ASTRONAUTICS

U.S. HOUSE OF REPRESENTATIVES

EIGHTY-EIGHTH CONGRESS

FIRST SESSION

ON

H.R. 5466

(Superseded by H.R. 7500)

MARCH 4 AND 5, 1963

[No. 3]

Part 1

Printed for the use of the Committee on Science and Astronautics

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1964 NASA AUTHORIZATION

MONDAY, MARCH 4, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
Washington D.C.

The committee met at 10 a.m., pursuant to call, in room 214–B, New House Office Building, Hon. George P. Miller (chairman), presiding.

The CHAIRMAN. In the interest of time and without objection, the committee will be in order.

Today we have Mr. Webb and Dr. Dryden before us. They have asked that they be allowed to make their statements before we do any questioning. I have agreed to this.

I may say that this is the beginning of the NASA authorization hearings and tomorrow I think your subcommittee will start, Mr. Teague?

Mr. TEAGUE. Day after tomorrow.

The CHAIRMAN. The day after tomorrow, Mr. Teague starts, and Mr. Karth, your subcommittee about the same, and Mr. Hechler, when are you going to start?

Mr. HECHLER. I will have to consult my staff.

The CHAIRMAN. All right, so that detailed questions can be reserved for the subcommittee hearings; that is, those matters bearing on the fiscal year 1964 budget will be in subcommittee hearings, but we are here today to get a report of what has taken place and what we may expect in the future.

We are very happy to have you here, Mr. Webb and Dr. Dryden. We have a great common interest and it is always a pleasure to see you. You may proceed, sir.

STATEMENT OF HON. JAMES E. WEBB, ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. WEBB. Mr. Chairman, we certainly appreciate the opportunity to be here again today.

As you know last Monday it was my privilege to outline for you the basic policies and issues with which the present posture of the National Aeronautics and Space Administration is concerned.

Today it is my purpose to present to you an outline of the authorization of funds for the program for 1964 so that these may be related. I judge that this is in accordance with the total picture you and the committee would like to have before the subcommittee hearings start.

I would like to say that we did discuss the accomplishments of the past year in some detail last week. Today Dr. Dryden is here and with your permission will discuss the accomplishments of the inter-

national program of NASA and will speak about future trends in the space program.

As you know, Dr. Dryden leaves for Rome in a few days to meet with representatives of the U.S.S.R. for further discussions and negotiations regarding cooperative programs. Dr. Seamans will be here tomorrow to present the overall NASA program, after which the responsible officials will be prepared to present the details of the various program areas in your subcommittee hearings.

The total NASA request for fiscal year 1964 is $5,712 million and is comprised of $4,912 million for research, development, and operation and $800 million for construction of facilities.

Turning first to the programs carried under the section on research, development, and operation, there are five major program areas.

In the area of space sciences, NASA is requesting $836.7 million. The Office of Space Sciences conducts programs to investigate the characteristics of the Earth, the near and far regions of space, the Sun and its influence on Earth, the Moon, and our neighboring planets. These programs are conducted using sounding rockets, earth orbiting satellites, lunar probes, planetary and interplanetary probes. At present the United States clearly leads the world in hard-won knowledge in the important areas of geophysics, solar physics, and interplanetary science. We are continuing an aggressive program in this area to assure that the United States retains its leadership.

Basic to NASA's space sciences program is the fact that scholars and researchers, scientists and engineers in qualified educational institutions widely spread throughout the Nation, are the principal reliance for the production, extension, and communication of new scientific and technical knowledge.

In carrying out these responsibilities, the universities, and the teachers in them, relate the training of additional people to the process of research. Consequently, they are in a position to rapidly expand the areas of fundamental knowledge on which our advances in engineering must be based and are sources of the additional scientific and technical personnel required by the United States in meeting the objectives of its aeronautical and space programs. In addition to the direct research support of the space program and training of new personnel, universities are also uniquely qualified to bring to bear the thinking of economists, businessmen, scientists, and engineers, sometimes organized in multidisciplinary groups, on the potentials for solving problems of economic growth through the utilization of the results of the research we do to accomplish our principal missions in space.

Thus, there is a close relation between our efforts in the space sciences and our efforts in the area of applications.

The budget estimate for our applications program is $140.7 million. In this area NASA is developing the spacecraft and technology needed to establish operational meteorological and communications satellite systems. In addition, the Office of Applications has the responsibility for working out ways and means to catalog and make available to industry and other leaders innovations and processes arising from our space development efforts which can form a basis for

economic growth or the solution of other problems faced by our society.

Useful work in space, including useful scientific work, depends on advanced technology.

The request for the advanced research and technology program is $597.2 million.

The Office of Advanced Research and Technology is charged with providing a continuing and advancing broad technological and research base for this country's future aeronautical and space activities. In this program, research is conducted in the many fields related to aircraft, propulsion, launch vehicles, spacecraft, electronics, systems integration and management, tracking, and data acquisition, reentry, methods of simulation and training, and related human factors.

The technological advancements made as a result of this kind of research effort in the past have formed the basis for all our present aircraft and space systems, and a continuance of this kind of effort is the only sure way for this Nation to maintain its position of leadership in aeronautics and space activities in the years ahead.

The result of useful work in space, at present, is information, and this must be returned to earth to be of use.

The request for NASA's tracking and data acquisition program is $379.2 million. Every space flight mission in our present program, whether rocket development, scientific satellite, space probe, or manned spacecraft is undertaken to gather information in a form that can advance our base of knowledge and thus add an increment to our technological capability.

The critical means to get such information back to the managers of the missions and then to the scientists in our laboratories and universities, is the worldwide network of tracking and data acquisition stations. It should also be noted that vast amounts of information received each day must be placed in a form that can be used by the scientist and engineer. It is the automatic data system utilized by NASA's Office of Tracking and Data Acquisition which accomplishes this task. Since the sun never sets on our work in this area, it provides a continuing image all around the world of the way our efforts in space can be of value to all nations, and is thus doubly important because many of these tracking stations are manned by the nationals of other countries. In some cases the operation of foreign stations is completely paid for by other nations. This system of stations located around the world is a tremendous national and free world asset and makes a tremendous contribution to our Nation's space program.

With respect to the manned space flight program the request in this budget is for $3,758,200,000. It is under this program that the Mercury project will be completed with the scheduled 1-day earth orbit mission. We are proceeding at a fast pace with the Gemini project which will prove out much of our Apollo equipment, provide experience and training for our flight crews, and provide answers to important technological problems associated with rendezvous and long-duration flight.

This Gemini project is planned to lead logically onto the Apollo project in a continuing integrated schedule designed to give us the technical capability, the scientific advances, and the trained flight and ground crews, which will culminate, insofar as this budget is concerned, with landing men on the moon, exploring its characteristics, and returning them safely to earth. All of these programs have specific objectives and form a total program that has a broad objective of establishing, for the United States, preeminence in manned space flight. This budget does not include programs to utilize this capability beyond the Apollo program.

As this committee knows, gravity is one of the strongest forces in the physical world. To overcome gravity and launch men into space, we use a gigantic controlled release of energy in the form of fuel burned in rocket engines. The great value of the rocket engines NASA has developed is that they consume almost incomprehensibly large quantities of fuel and thus produce vast amounts of energy in a very short time.

The advanced Saturn's five engines burn 900 tons of fuel per minute and produce 7½ million pounds of thrust. This is a really big machine and requires big buildings for its assembly, big test stands for static firings, and big launching facilities.

The huge facilities required to handle these big space machines are an essential foundation for our Nation's space power. They can be used for military or civilian purposes as required. Since they are capital investments that will be useful over long periods, the budgetary requirements are heavier in the earlier years of our programs.

The construction of facilities section of our request for 1964 totals $800 million.

In the committee's hearings today and tomorrow and the hearings to follow before your subcommittees, responsible officials of NASA will make a complete presentation of these complex programs.

In the four volumes of the justification books which have been submitted to you, a full breakdown of each and every part of the program has been made with an explanation of what, where, how, and when work will be done and what it will cost.

It is important to note that the budget requested for the total program of NASA for fiscal year 1964 includes less than $50 million for new programs. All the rest is to maintain the projects now underway on schedule and to pay the contractors for the work they have obligated themselves to do to meet these schedules.

President Kennedy, during a tour of some of our major space facilities last September summed up our space objectives in these words:

> Those who came before us made certain that this country rode the first waves of the industrial revolutions, the first waves of modern inventions, and the first wave of nuclear power.
>
> Our leadership in science and in industry, our hope for peace and security, our obligations to ourselves as well as to others, all require us to make this effort, to solve these mysteries, to solve them for the good of all men, and to become the world's leading spacefaring nation * * * only if the United States occupies a position of preeminence can we help decide whether this new ocean of space will be a sea of peace, or a new terrifying theater of war.

My own view is that if we do not have a position of preeminence in space at the bargaining table of the nations, or in the minds of the world's leaders, the decisions that bring peace or war are not apt to be of our making.

You will note the President did not say that our national goal is that of landing the first man on the moon, or, for that matter, of being "first" with respect to any single achievement in space. We have done many things first, and we will do many other things first—including, we hope, sending the first explorers to the moon—but this is not the objective which the President stated.

Rather, he forcefully declared our determination to attain "a position of preeminence" in space and to "become the world's leading spacefaring nation." That is the policy on which this budget is submitted to you.

This distinction needs to be understood. The mastery of space, and its utilization for the benefit of mankind, will not be determined by any single achievement. Superiority in the space environment with its great advantages and benefits will be won and very likely can be held by that nation which first fashions into a usable system all of the scientific knowledge, all of the technology, all of the experience, all of the space launch and terminal facilities, and all of the aids to space navigation required for safety and regular services.

These are the capabilities and resources which the United States must have, and this budget is designed to make rapid progress toward acquiring them.

Moving from our present position to achieve mastery of space requires that we add substantially to our scientific knowledge and to our utilization of technology. The NASA program is progressing on both of these fronts. In a complex effort such as this, conducted in a new medium about which much is yet unknown, the scientist and the engineer inevitably must work closely together and grow increasingly dependent upon one another. We are encouraging this intimate partnership in every way we can in all our NASA centers, in industry, and in the Nation's universities.

In the exploration of space, the scientist must depend upon the engineer to design the equipment which will enable him to investigate conditions and forces which exist there. But at the same time, the engineer must look to the scientist for precise knowledge which will enable him to design equipment which will be more efficient and reliable in this harsh environment.

The NASA program, therefore, is designed to expand both science and technology. We are moving forward on a broad front. We have avoided becoming trapped in a narrow program—one limited, for example, to developing only the technology needed to reach the moon with state-of-the-art hardware. To do so might well be to find, some years hence, that we had won the battle and lost the war as far as ultimate and enduring superiority in space is concerned.

Mr. Chairman, in this program we are developing and building the largest, most powerful machines ever built by man. It has been said that man will never build a machine stronger than the spirit of man.

It takes courage to build these giant machines such as the Saturn, which can boost 220,000 pounds into earth orbit or send 90,000 pounds outward to the moon. It takes courage for men like Bill Pickering to develop a Mariner and send it out to Venus.

It takes courage for Von Braun and Debus to be prepared to test and launch these machines and it takes courage to put together the kind of worldwide tracking and data acquisition network which brings back to us tremendous amounts of knowledge and to put these into the largest computer complex in the United States at the Goddard Space Flight Center, which many of your members have already seen. Let me say it not only takes the courage of the men in NASA, in the executive branch of the Government, including the courage of the President, to submit this kind of a budget to this committee, but it takes courage on the part of Congress, the elected representatives of the people here to look to the future of the Nation in these matters. May I say that those of us in the executive branch appreciate the courage with which this committee has faced up to these problems.

Thank you, Mr. Chairman, for the opportunity to make this statement. The authority and funds requested have been determined by the President to be required to meet our space requirements in the light of all other governmental requirements. In this budget we believe we have an excellent program balance, goals that can be met, a capability to shift emphasis as required by new developments, a capability to identify and take advantage of new opportunities as they arise, an effective marriage of the applicable resources of industry, universities, scientists, engineers, and governmental entities, and the means to do NASA's part to meet the emerging needs for coordinated effort within governmental activities and operations.

We have established effective, prudent, and business-like methods of going forward to do what is needed. We appreciate the support this committee and the Congress has given this program. We respectfully urge your favorable consideration of this budget.

That is the end of my statement, Mr. Chairman, and Dr. Dryden is available to discuss the matter I mentioned.

The CHAIRMAN. Thank you very much, Mr. Webb.

Now, under the previous announcement we will proceed with you, Dr. Dryden.

For the benefit of those new members, I may say that Dr. Dryden is perhaps the man who brought to space the longest practical knowledge and most technical knowledge in the field.

He is head of the former National Advisory Committee on Aeronautics. He has made great contributions to the field of aeronautics and he is also making great contributions to NASA. He has been the man who has negotiated with the Russians and is apparently making progress in the field of communications satellites.

Doctor, we are glad to have you here. You may proceed.

STATEMENT OF DR. HUGH L. DRYDEN, DEPUTY ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Dr. DRYDEN. Thank you, Mr. Chairman and members of the committee. It is a privilege to appear here today to discuss the accomplishments of NASA's international program and some future trends of the Nation's space program.

With regard to NASA's programs of international cooperation, conducted pursuant to national policies embodied in the National Aeronautics and Space Act of 1958, the first substantial fruits of these programs were realized in 1962 and further significant programs were laid down for future years. During 1962—

the first two international satellites, Ariel and Alouette, were successfully placed in orbit,

launchings of sounding rockets bearing scientific payloads were carried out in cooperation with eight countries.

thirty-seven countries engaged in special projects in support of our weather and communications satellite programs,

foreign participation continued to grow in the operation of our global tracking and data acquisition network overseas, and,

a new NASA international fellowship program was successfully established in our own universities.

This very considerable activity has been brought into being without the export of dollars or the exchange of funds of any kind. Instead, cooperation in the literal sense has formed the basis for a series of joint enterprises of importance to our own scientific and practical objectives in space. Without going into a great deal of detail, I should like to provide a closer look at the extent and character of these international activities by means of a series of charts.

The first chart (fig. 1, page 8) relating to the satellite program, lists joint satellite projects in being.

• NASA INTERNATIONAL PROGRAMS •
SATELLITES

COUNTRY	SATELLITE	OBJECTIVE	U.S.PARTICIPATION	FOREIGN PARTICIPATION	LAUNCH
CANADA	ALOUETTE S-27	SOUND IONOSPHERE FROM ABOVE	THOR-AGENA B LAUNCH DATA ACQUISITION	EXPERIMENTS SPACECRAFT DATA REDUCTION & ANALYSIS	PMR 9/62
UNITED KINGDOM	ARIEL S-51	STUDY IONOSPHERE AND SOLAR RELATIONSHIPS	SPACECRAFT DELTA VEHICLE LAUNCH DATA ACQUISITION & REDUCTION	EXPERIMENTS DATA ANALYSIS	AMR 4/62
	UK-2 S-52	MEASURE OZONE GALACTIC NOISE & MICROMETEORITE FLUX	SPACECRAFT SCOUT LAUNCH DATA ACQUISITION	EXPERIMENTS DATA REDUCTION & ANALYSIS	WALLOPS LATE 1963
	UK-3 S-53	EXTEND S-51 & S-52 EXPERIMENTS	SCOUT LAUNCH DATA ACQUISITION	SPACECRAFT EXPERIMENTS DATA REDUCTION & ANALYSIS	WALLOPS 1966-7
ITALY	SAN MARCO	STUDY UPPER ATMOSPHERE & IONOSPHERE	SCOUT (2) TRAINING LAUNCH (PROTOTYPE) DATA ACQUISITION	SPACECRAFT (2) EXPERIMENTS LAUNCH DATA REDUCTION & ANALYSIS	WALLOPS (PROTOTYPE) INDIAN OCEAN LATE 1964 OR 1965

NASA/AI 12/31/62

FIGURE 1

Both Alouette and Ariel, the Canadian and British satellites, are still in orbit and continue to provide extremely valuable data, giving us our first information on the ionosphere from above and the first information combining certain aspects of solar radiation and the ionospheric environment. Besides making these solid contributions to our knowledge of near space, these programs are already stimulating further joint contributions. Informal discussions are under way with Canadian scientists with respect to an important follow-on joint program to monitor the ionosphere by satellite.

As the chart indicates, the degree of participation by NASA and the foreign cooperating agency varies from case to case, sometimes smaller than our own, sometimes—as in the case of the Italian San Marco program—probably considerably larger than ours.

The next two tables (sounding rockets launched from Wallops Island and sounding rockets launched from foreign ranges) list international cooperative sounding rocket programs already carried out or scheduled for this calendar year.

The first table (fig. 2, page 10) covers launchings conducted from Wallops Island while the second covers launchings from ranges established by the cooperating countries abroad. Data was successfully obtained in all but one of the eight cooperative launching programs carried out last year from our own or foreign launching sites.

• NASA INTERNATIONAL PROGRAMS •
SOUNDING ROCKETS LAUNCHED FROM WALLOPS ISLAND

COUNTRY	ROCKET	OBJECTIVE	U.S. PARTICIPATION	FOREIGN PARTICIPATION	LAUNCH
AUSTRALIA	AEROBEE	MEASURE VLF RADIO NOISE	ROCKET LAUNCH AIRBORNE TELEMETRY	EXPERIMENT VLF GROUND EQUIPMENT DATA ANALYSIS	12/62
CANADA	BLACK BRANTS (6)	STUDY VEHICLE & INSTRUMENTATION PERFORMANCE	LAUNCH	ROCKETS INSTRUMENTATION DATA ANALYSIS	6/62 12/62
FRANCE	NIKE-CAJUNS	TEST SPECIALIZED OPTICAL EQUIPMENT	ROCKETS LAUNCH EXPERIMENTS	OBSERVATION EQUIPMENT DATA ANALYSIS	1960-61
	AEROBEE (2)	STUDY IONOSPHERE IRREGULARITIES	ROCKETS LAUNCH	EXPERIMENTS DATA ANALYSIS	EARLY 1963
ITALY	SHOTPUT (1)	FLIGHT TEST SAN MARCO INSTRUMENTATION	ROCKET LAUNCH	EXPERIMENTS DATA ANALYSIS	1963
JAPAN	NIKE-CAJUNS (3)	COMPARE RESONANCE & LANGMUIR PROBES	ROCKETS LAUNCH LANGMUIR PROBES DATA ANALYSIS	RESONANCE PROBES DATA ANALYSIS	4/62 5/62
NORWAY-DENMARK	NIKE-APACHE (1) & NIKE-CAJUNS (3)	STUDY D & E REGION OF IONOSPHERE	ROCKETS LAUNCH EXPERIMENTS DATA ANALYSIS	EXPERIMENTS DATA ANALYSIS	12/61 6/62 EARLY 1963

NASA/AI 12/31/62

FIGURE 2

• NASA INTERNATIONAL PROGRAMS •

SOUNDING ROCKETS LAUNCHED FROM FOREIGN RANGES

COUNTRY	ROCKET	OBJECTIVE	U.S. PARTICIPATION	FOREIGN PARTICIPATION	LAUNCH
AUSTRALIA	SKYLARKS (4)	MEASURE STELLAR & NEBULAR ULTRAVIOLET RADIATION	EXPERIMENTS DATA ANALYSIS	ROCKETS LAUNCH	WOOMERA 9/61, 11/61
CANADA	VARIOUS US (C.30/YEAR)	STUDY AURORAL ZONE PHENOMENA	ROCKETS DATA ANALYSIS	LAUNCH	FORT CHURCHILL
INDIA	NIKE-CAJUNS (4)	STUDY UPPER ATMOSPHERE WINDS	ROCKETS LAUNCHER LAUNCH TRAINING	LAUNCH EXPERIMENTS CAMERAS DATA ANALYSIS	THUMBA, 1963
	NIKE-APACHES (9)	INVESTIGATE EQUATORIAL ELECTROJET	ROCKETS MAGNETOMETER EXPERIMENTS DOPPLER EQUIPMENT TELEMETRY TRAINING DATA ANALYSIS	LAUNCH SUPPLEMENTARY EXPERIMENTS GROUND OBSERVATIONS	THUMBA, 1963
ITALY	NIKE-CAJUNS & NIKE-ASPS (8)	STUDY UPPER-ATMOSPHERE WINDS	EXPERIMENTS	ROCKETS LAUNCH DATA ANALYSIS	SARDINIA 1/61, 4/61, 9/61, 12/62
	SHOTFUT (1)	FLIGHT TEST SAN MARCO INSTRUMENTATION	ROCKET	LAUNCH EXPERIMENTS DATA ANALYSIS	INDIAN OCEAN 1963
NEW ZEALAND	ARCAS (3)	MEASURE MESOSPHERIC WIND DRIFT & TURBULENCE	ROCKETS LAUNCHER	LAUNCH EXPERIMENTS DATA ANALYSIS	BIRDLING'S FLAT 1963
NORWAY-DENMARK	NIKE-CAJUNS (7)	STUDY D & E REGION OF IONOSPHERE	TELEMETRY TRAILER EXPERIMENTS LAUNCH & TELEMETRY TRAINING DATA ANALYSIS	ROCKETS LAUNCH EXPERIMENTS DATA ANALYSIS	ANDOYA 8/62, 12/62, 1963
PAKISTAN	NIKE-CAJUNS (2)	STUDY UPPER ATMOSPHERE WINDS	ROCKETS LAUNCHER TRAINING	LAUNCH EXPERIMENTS DATA ANALYSIS	SONMIANI BEACH 6/62
SWEDEN	ARCAS (1)	MEASURE WINDS DURING OCCURRENCE OF NOCTILUCENT CLOUDS	ROCKETS EXPERIMENTS LAUNCHER GROUND TELEMETRY	LAUNCH SUPPLEMENTARY EXPERIMENTS RECOVERY DATA ANALYSIS	JOKKMOKK 8/61
	NIKE-CAJUNS (4)	DIRECT SAMPLING OF NOCTILUCENT CLOUDS	TRAINING DATA ANALYSIS		KRONOGARD 8/62

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FIGURE 3

The second sounding rocket table (fig. 3, page 11), listing the launchings carried out abroad, illustrates the advantages to be gained through access to geographic locations of critical scientific importance, like the Australian range in the Southern Hemisphere, Norway in the auroral zone, and India on the geomagnetic equator. The joint experiments with Sweden have permitted direct sampling of a rare phenomena of the northern skies, faint patches of night-glowing clouds. The matter recovered may well give us our first real insight into the nature of this phenomenon.

Altogether, more than half of our sounding rocket work in 1963 will probably involve international participation and cooperation in one form or another. The Japanese program, for instance, combines two different methods of studying the lower ionosphere in one sounding rocket payload. By comparison of the data obtained from both methods, the confidence level in the results from each can be more clearly established. This not only adds to the general body of scientific knowledge but also permits ionospheric experimenters to choose the technique best suited to their own capability and experience.

The fourth chart (fig. 4, ground-based projects, page 13) indicates the very broad participation of other countries in various ground-based activities contributing directly to the success of orbiting experiments. The very successful program of foreign weather observations coordinated with TIROS passes will be amplified during the year through use abroad of the APT system. This system will permit direct readout of local cloud photographs by countries purchasing or constructing the modest ground facilities developed by NASA for the system.

NASA INTERNATIONAL PROGRAMS
GROUND BASED PROJECTS

PROJECTS	COUNTRIES
WEATHER OBSERVATIONS COORDINATED WITH TIROS PASSES	35 ARGENTINA, AUSTRALIA, AUSTRIA, BELGIUM, BRAZIL, BURMA, CHAD, CHINA, REP. OF, COLOMBIA, COSTA RICA, CZECHOSLOVAKIA, EL SALVADOR, FRANCE, HONG KONG, HUNGARY, ICELAND, INDIA, IRAQ, IRELAND, JAMAICA, JAPAN, KENYA, MAURITIUS, NETHERLANDS, NEW ZEALAND, POLAND, PORTUGAL, RHODESIA/NYASALAND,FED., SOUTH AFRICA, SUDAN, SWITZERLAND, THAILAND, UNITED ARAB REPUBLIC, UNITED KINGDOM, WEST NEW GUINEA
PARTICIPATION OF GROUND TERMINALS IN COMSAT TESTING	6 BRAZIL, FRANCE, GERMANY, FED. REP. OF, ITALY, JAPAN, UNITED KINGDOM
IONOSPHERE BEACON	20 ARGENTINA, AUSTRALIA, AUSTRIA, BRAZIL, FRANCE, GERMANY,FED. REP. OF, GREECE, INDIA, ITALY, JAPAN, KENYA, NEW ZEALAND, NIGERIA, NORWAY, PERU, SINGAPORE, SPAIN, SWEDEN, SWITZERLAND, UNITED KINGDOM
IONOSPHERE SOUNDING	14 ARGENTINA, BELGIUM, BOLIVIA, CHILE, COLOMBI.., DENMARK, FRANCE, GERMANY, FED. REP. OF, JAMAICA, NETHERLANDS, PERU, SPAIN, SWEDEN, UNITED KINGDOM

NASA/AI 12/31/62

FIGURE 4

96-504 O—63—pt. 1——2

I might explain that. The satellite will continually broadcast what it sees and a country with a rather simple receiving station can obtain six or eight pictures of the clouds over their own country. The cost of this receiving equipment, as I recall it, is something on the order of $24,000 or $30,000.

Several additional countries will shortly join those listed as having played an indispensable part in the intercontinental television and other demonstrations carried out with Telstar and Relay.

The remaining programs indicated on this chart provide for local observation of satellite signals. Such coordinated observation is required for the success of these ionospheric investigations. All are carried out on a contributed basis.

The next chart (fig. 5, personnel at overseas tracking stations, page 15) shows quite graphically the participation of foreign personnel in the work of NASA's global network of tracking and data acquisition stations. In over half the cases, local technical personnel are directly involved in the station operations, and in a number of instances their salaries are paid by the host country. Training of qualified personnel abroad progresses steadily.

NASA INTERNATIONAL PROGRAMS
PERSONNEL AT OVERSEAS TRACKING STATIONS

SCIENTIFIC SATELLITE NET	NASA	U.S. CONTRACTOR	FOREIGN NATIONALS
ANTOFAGASTA, CHILE	1	14	29
JOHANNESBURG, SOUTH AFRICA	0	0	34
LIMA, PERU	1	7	33
QUITO, ECUADOR	1	19	26
ST. JOHN'S, CANADA	0	0	16
SANTIAGO, CHILE	1	19	22
WINKFIELD, ENGLAND	0	0	14
WOOMERA, AUSTRALIA	0	0	20
MANNED FLIGHT NET			
GRAND CANARY ISLAND	1	22	15
KANO, NIGERIA	1	23	23
ZANZIBAR	1	19	28
GUAYMAS, MEXICO	1	23	17
BERMUDA	2	31	51
WOOMERA, AUSTRALIA	1	0	24
MUCHEA, AUSTRALIA			20
DEEP SPACE NET			
WOOMERA, AUSTRALIA	0	1	16
JOHANNESBURG, SOUTH AFRICA	4	0	28
TOTALS	15	178	416

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FIGURE 5

As the next chart shows (fig. 6, personnel exchanges, page 17), an increasing number of foreign graduate students, scientists, and technicians are working here in our universities and NASA centers under programs which, except for senior scientists, require that subsistence and travel be defrayed by the sponsoring foreign country. Thus, a two-way channel is maintained for the flow of ideas between outstanding personnel here and abroad, in the framework of our own, or joint space projects.

The record of foreign visits to NASA installations bears testimony to the rapid growth of interest in space activities abroad. In this connection, I might note that NASA, with the concurrence of the Department of State, has established contact with the two new regional organizations provisionally established in Europe during the past year, the European Space Research Organization (ESRO), and the European Launcher Development Organization (ELDO), and that our readiness to consider cooperative arrangements of mutual interest has been conveyed to them.

The cumulative impact of the various international programs briefly noted here is indicated in the last chart (fig. 7, NASA international activities summary, page 18). Over 60 countries are involved in one way or another, most of them in flight-support projects. Most significant, they embrace the east, west, north, and south, friendly countries as well as neutrals, developed and undeveloped. The Soviet Union appears on this list for the first time as we make ready to commence meetings in Rome where joint working groups will attempt to implement the bilateral agreement reached in Geneva last June.

While these first agreed experiments call for coordinated rather than integrated projects with the U.S.S.R., success in carrying them into effect would unquestionably be useful.

You may wish to ask questions about this later. I simply emphasize two things at this point. This is not a meeting to talk about new avenues of cooperation, but to implement the ones that were agreed upon last year, and the people who are meeting are primarily working level people to talk about the details of the coordinated launchings of weather satellites, the satellites for studying the earth's magnetic field and to make some experiments on the next ECHO balloon which is to be launched.

I should like to say a word with regard to the costs of these international cooperative activities. A basic criterion for our entry into such joint efforts is that the projects be integral with, or complementary to, NASA's on-going scientific or applied programs.

Costs are not, therefore, allocated to international programs as such; the foreign participation actually represents a net contribution to NASA programs and, often, a reduction in their cost.

If one were to estimate very roughly the costs to the countries involved of their participation in elements of the on-going NASA program, a figure in the neighborhood of $30 million for the period 1961-63 results. This figure represents the estimated cost of British and Canadian satellites, the construction by foreign governments of communications satellite experimental stations, the establishment and use of new sounding rocket ranges abroad, the cost of participating in sounding rocket programs, and the support of foreign personnel involved in the operation of our overseas stations and in training pro-

• NASA INTERNATIONAL PROGRAMS •
PERSONNEL EXCHANGES

		1961	1962	1963 (EST.)
RESIDENT RESEARCH ASSOCIATES				
POSTDOCTORAL AND SENIOR POSTDOCTORAL GRANTS TENABLE AT NASA CENTERS	FOREIGN NATIONALS	14	26	30
	COUNTRIES	10	13	15
INTERNATIONAL FELLOWSHIPS				
GRADUATE FELLOWSHIPS AT U.S. UNIVERSITIES ON SHARED-COST BASIS FOR THEORETICAL AND EXPERIMENTAL TRAINING IN SPACE SCIENCES	FOREIGN NATIONALS	1	18	35
	COUNTRIES	1	8	12
	UNIVERSITIES	6	20	23
TECHNICAL TRAINING				
AVAILABLE AT NASA CENTERS IN SUPPORT OF AGREED COOPERATIVE PROGRAMS	FOREIGN NATIONALS	9	30	45
	COUNTRIES	5	7	9
VISITS				
ALL NASA CENTERS OPEN TO VISITS BY FOREIGN OFFICIALS, SCIENTISTS, INDUSTRY, AND PRESS	FOREIGN NATIONALS	1000	3000	4000
	COUNTRIES	42	54	56

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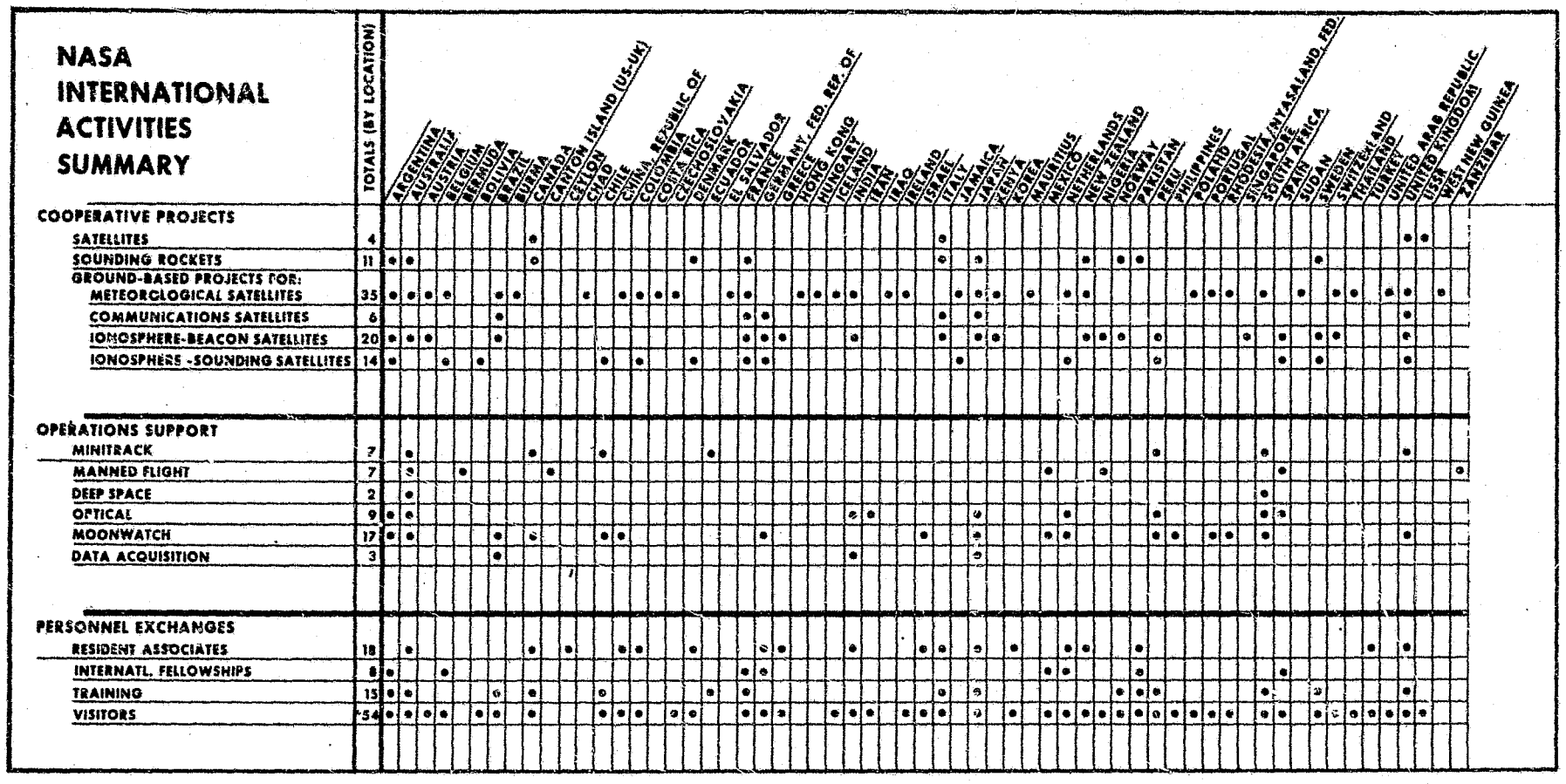
FIGURE 6



* THE FOLLOWING COUNTRIES ALSO PARTICIPATED IN THE VISITOR PROGRAM, AND ARE INCLUDED IN THE ABOVE TOTAL: BRITISH GUIANA, CAMEROON, DAHOMEY, FINLAND, INDONESIA, LEBANON, SOMALIA, SOUTH VIET-NAM, TRINIDAD, AND VENEZUELA. IN ADDITION, THE EUROPEAN PREPARATORY COMMISSION FOR SPACE RESEARCH (ESRO) PARTICIPATED IN THE VISITOR PROGRAM AND IN THE FELLOWSHIP PROGRAM.

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JANUARY 1963

FIGURE 7

grams. This cooperative program has been a sound and useful aspect of the Nation's space program.

I should like now to discuss some future trends of the Nation's space program.

Major NASA programs of the future will, as in the past, be determined within the total context of national need and of the availability of resources. I wish to emphasize this point. To indicate a possibility, or to undertake a study of a new direction, is just that and no more. The Nation's interest in space, and the level of support, will in the long run be determined by the large policy decisions of the American Government.

We do have the responsibility of looking ahead—of being ready to indicate next steps, or alternate next steps, to the President and to you, the Congress, and of making our own recommendations as to a course of action. To satisfy this responsibility we make many studies, both of our own and by industry groups under contract. Perhaps only a few of the studies will be along lines which eventually lead to hardware development.

In the manned space flight area, the obvious candidates for additional or follow-on projects are more extended exploration of the moon by the establishment of a station on the moon permitting prolonged occupancy, a manned laboratory orbiting the earth as a satellite, and manned reconnaissance of the planets.

Each of these involves a companion project in the launch vehicle field, a lunar logistic vehicle, a resupply vehicle to the orbiting laboratory which might be Gemini or Apollo or a new vehicle, and the Nova which might be either a liquid or solid rocket or perhaps Saturn V plus a nuclear stage.

It seems to us that an orbiting laboratory is a necessary preliminary to manned planetary expeditions, since both man and equipment must be tested for months in the space environment, information obtained as to whether artificial gravity is necessary in the manned spacecraft for planetary travel, and experimental demonstration made of assured reliability for the period of the journey. In the case of manned flight to the moon the Apollo vehicle is itself the space laboratory in which men and equipment can be demonstrated for the necessary period by orbital flights about the earth, and in which limited scientific and technical investigations not directly related to the manned lunar mission can be conducted.

We believe therefore that manned planetary exploration comes in a later time period after a suitable manned orbiting laboratory is available.

Now we have a problem of what all of these words mean specifically.

The concepts of orbit in laboratories range from the Mercury, Gemini, and Apollo capsules as one-, two-, and three-man orbiting laboratories to very large space stations, rotating to provide artificial gravity. Obviously the capsules presently in the program do not have sufficient space available for experimentation, and have only a limited lifetime in orbit.

Something larger, of longer duration in orbit, and with resupply capability is required. Many exploratory design studies have been made of the technological feasibility of assembling a large space laboratory in space from multiple launches with one or another of the available launch vehicles.

We believe, however, that technical feasibility alone does not justify a project of this magnitude and cost. We are attempting to grasp the problem from the other end, that is, to ask what one can and would do in a space laboratory in specific fields of science and technology with a view to establishing a realistic and useful concept. We hope that such studies will provide the information necessary to justify and support a decision to be made in time for the fiscal year 1965 budget. Obviously, such a large program must be designed to fulfill national needs.

As previously stated, the orbiting laboratory will require a resupply vehicle, but it is possible that this need can be met by the Gemini or Apollo capsule. Depending on the time scale, the resupply vehicle might be derived from the X–20 or Dyna-Soar technology, if it turns out that extensive maneuvering is required during reentry.

This brings us to the lunar station and its companion lunar logistic vehicle. Here also the concepts of a lunar station vary from a temporary shelter to extend the residence time of the Apollo astronauts on the moon for a few days to a large more or less permanent base, and in some of our internal studies we are introducing the idea of rescue missions which might involve some simplified supply of capsules or missiles.

Likewise, the concept of a lunar logistics vehicle varies from the rather simple substitution of a freight carrying spacecraft for the lunar excursion module on the Apollo launch vehicle—which carries men in the command module who return to earth without landing—to a large unmanned spacecraft carried to the moon by the Saturn V launch vehicle or by some new launch vehicle of still greater capacity.

Obviously a commitment to the more ambitious concept of a lunar logistic vehicle is in fact a commitment to proceed with a large lunar station and extended exploration of the moon. While technologically this project could probably move very rapidly, we again need to study whether there is some justification in addition to the purely scientific exploration of the moon. We will be aided in assessing the situation by the early measurements and observations from Ranger and Surveyor. Studies of the various concepts have been underway for some time.

Those of us who carry the responsibility for recommendation or action will, of necessity, by the fall of this year make a decision to begin preliminary steps toward hardware development on one or more of these projects.

Looking to the future we foresee a certain merging of parts of the space science program with the manned space flight program, as we study the types of scientific programs that might be carried out by men in Gemini and Apollo. In similar fashion we are studying the types of scientific experiments which might require the use of Saturn for the unmanned exploration of the planets.

Such a launch vehicle would be required for orbital and landing missions to Mars and Venus. However, it seems likely that such flights, if approved, would come at the end of the decade.

In planning for the future it has been our custom to set for ourselves certain mission objectives or target milestones for the years immediately ahead. For calendar year 1962 these objectives were the orbital flight of an astronaut, the launching of an orbiting solar

observatory, the impact landing of instruments on the moon in Project Ranger, the launching of a Topside ionospheric sounding satellite, the launching of a Venus probe, and the launching of a real time active communication satellite leading to civil application. All but one of these targets were accomplished.

The three-orbit flights of Glenn and Carpenter and the six-orbit flight of Schirra are well known to you as are Telstar, Mariner, Alouette, and OSO. Our Ranger flights were unsuccessful in 1962 but we look forward to success in 1963.

One of the most important targets in 1963 is the launching of a two-stage Saturn I, realizing and demonstrating the weight-carrying ability of 20,000 pounds which we set out to obtain at the very beginning of NASA, as the members who were on the committee at that time will recall. If we meet this target, which we hope to, we will then have a capacity beyond what the Russians have already demonstrated, namely, about 14,000 pounds in orbit. Of course, they may do something between now and then which seesaws and we then have in the background Saturn V which will put 220,000 pounds—110 tons—in earth orbit. Other important targets for 1963 are the launching of the Nimbus meteorological satellite, and the orbiting geophysical observatory.

In 1964 the targets are the qualification of the 200,000 pound thrust J–2 hydrogen-oxygen rocket engine for flight, the qualification of the 1½-million-pound thrust F–1 rocket engine for flight, the soft landing of instruments on the moon in project Surveyor, the reconnaissance of Mars by an unmanned vehicle, the launching of the Apollo capsule in earth orbit, the demonstration of rendezvous between a two-manned satellite and an unmanned satellite in project Gemini.

In 1965 we hope to launch the first orbiting astronomical observatory and to make the first launch of the Saturn V first stage which employs five F–1 engines for a total thrust of 7½ million pounds. In the last half of the decade we expect to flight-test the Snap system and the nuclear thermal engine, Nerva, in the Rift spacecraft stage, and prior to 1970 we expect to accomplish the Apollo mission for landing men on the moon and returning them safely to earth.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you very much, Dr. Dryden.

Have you any questions, Mr. Yeager?

Mr. YEAGER. Just two, if I may, Mr. Chairman.

Dr. Dryden, in your statement, beginning at the bottom of page 11, you discuss the commitment to proceed with a lunar logistics vehicle. However, you also mention rescue missions. Is it possible you will need it for this purpose?

Dr. DRYDEN. The pieces of paper I have seen talk about landing a second empty lunar excursion module on the moon, so that you would send out an Apollo with perhaps a one-man crew, I don't know for sure, we are thinking about it at this time.

Furthermore, the capsule could be used to supply life, support equipment to give you opportunity for more missions. I would have to say that this study is not completed, this study of rescue, so I can't give you any definite answer to your question.

Mr. YEAGER. As you view it at the present time, this might be differentiated from a lunar logistics vehicle?

Dr. DRYDEN. Yes.

Mr. YEAGER. One other question. If you make a decision in the fall of 1962—perhaps this should be addressed to Mr. Webb—a lunar logistics vehicle, or lunar logistics base, or orbiting station, is this likely to require supplemental authorization before 1965.

Mr. WEBB. Did you say 1962? I assume you meant 1963?

I think probably not.

As I see it, there is a tremendous amount of work to be done under the budget which has been submitted. We are in the process of shaking down into a hard-boiled capably managed operation a total organization that has doubled every year for the past 5 years, that under this budget will almost double again, not quite, and under which a very large portion—about 90 percent of the work is done by nongovernmental entities under contract to this agency.

At the same time that we are in this shakedown process, we are building a strong capability to get anything done that we need to do; at the same time that we are doing this, we are making very careful tests of the space flight systems involved in these contracts and in our present plans. We are further making continuing studies of what additional payloads can be used with the NASA launch vehicle program.

You see, we have created here a stable of vehicles running up to Saturn V which have great capability. We are proceeding with the Rover nuclear rocket which, when added to the advance Saturn, could give you very large increase in capability beyond Saturn V. So I would say that the projects that you mention, if a decision were to be made in connection with the 1965 budget most likely would not involve a supplemental for 1964 but would be put to Congress through the Authorization Act as a policy decision.

I would have to add this caution: I believe this committee is thoroughly aware that we have seen no evidence as yet that as large a rocket as Saturn V is in preparation by the Soviet Union. Should it become clear that a rocket of this capability is being prepared and is beginning to be tested and developed by them, I think we would have to take a very careful look at a great many of these things and perhaps speed them up beyond the schedule that I have in mind, and which I have described to you.

Would you want to add something to that, Dr. Dryden?

Dr. DRYDEN. Only that during the current year we have some money for studies and we are studying these with a view toward crystallizing them into specific recommendations. Now we have not set a deadline except that we would like to have some very general conclusions at the time that we submit a budget.

Mr. YEAGER. Thank you, sir. That is all.

The CHAIRMAN. Mr. Teague?

Mr. TEAGUE. No questions at this time, Mr. Chairman.

The CHAIRMAN. Mr. Fulton.

Mr. FULTON of Pennsylvania. I am glad to have you both here. I think the National Aeronautics and Space Administration is making good progress.

Serving as one of the congressional advisers to our U.S. Mission to the United Nations, I would like to congratulate Dr. Dryden on his work at Geneva, and on the good progress that has been made there.

Of course, the first question that arises in anybody's mind who is a taxpayer in the United States is, is this money necessary? Do we need it all? Is NASA spending too fast so that it is not getting efficient results?

Are we being careful with the U.S. taxpayer's money, that would be my main question.

I do want to finish with a suggestion to Dr. Dryden in my position as an adviser of the U.S. Mission to the United Nations. I had suggested last year that to show the world that we in the United States are open in our scientific research and development, we take the various members of the nations' delegations of the United Nations and show them Cape Canaveral. That suggestion was adopted very successfully and I would recommend that it be an annual event, that the United States schedule the trip again so that we do show the difference between Tyuri Tam of the Soviet Union and Cape Canaveral of our own.

I want to leave specifically that one question on the necessity of the money for the NASA 1964 fiscal year and how we are spending the funds.

Mr. WEBB. I would be happy, Mr. Fulton, to make a short statement on that. It could require a very long statement.

Indeed, the whole process in justifying this budget will in one way be an answer to this question.

Mr. FULTON of Pennsylvania. With the chairman's permission, make a short one and summarize in the record.

Mr. WEBB. All right.

I think the first thing you have to bear in mind is that we are doing things never heretofore done. Man has never made a machine capable of carrying 90,000 pounds to the moon. We are developing these large installations on the ground for the assembly, test, and launching of these vehicles, and it is very, very important that the matching of these facilities with the vehicles that are coming forward under the program be done early and that they be aimed at insuring reliability. As I said here a week ago, I believe economy will be achieved through achieving the greatest possible success on each flight rather than through cutting corners with respect to the number of tests of these vehicles.

The large cost in development of an airplane engine or of a rocket engine is in the testing of the equipment and making absolutely sure that that engine will in fact perform precisely as it was intended to perform or, if not, determining exactly what the limit of its performance is.

This program involves a careful balance between the actual flight program and the testing of the equipment and the capabilities which relate to the testing and it does involve several fairly novel—you might say innovative—types of arrangement for insuring success which I believe will produce economy.

I don't think there is any economy in letting the Russians get ahead of us in the space program. What is needed is a most careful and continuing examination of what is possible and what is not possible at the present time in advanced electronics, in the very sophisticated use of energy for many purposes, in the use of new materials, fabrics, metals, lubricants which can save weight and provide the necessary

strength and capability. Also important is the marriage of these with the life sciences in which we are now actively engaged. This is because we utilize men not only in the flight vehicles, but in these vast systems for doing research, for technological development, and for the operation of such worldwide systems as we have in our tracking and data acquisition programs and then the drawing together of a system that permits you to conduct these flights, to keep up with a number of vehicles.

The chairman and some of the others, I believe you, Mr. Fulton, were at the Goddard Space Flight Center when we had the celebration of tracking; I believe you referred to it at an earlier time.

Now, we are using 140 miles of magnetic tape every day at Goddard Space Flight Center alone to bring in, analyze and send out to the scientists and to other technical people the data we are acquiring from the substantial number of space vehicles already in flight.

To accomplish this—and this is the statement that I would like to make about efficiency and necessity—we have established through the Bellcomm Corp. a continuous review of the state of the art in each of these areas of technology. We have established a continuing review of the assumptions and concepts under which our systems have been prepared and are being presented to you under this budget.

We have a continuous matching, using the best operations research methods of these concepts and assumptions with the state of the art in these different technologies. Then we have a third matching operation, which involves a continuous review of the mission profiles and the hardware which is required to accomplish them so that the mission profiles and these specific boosters and spacecraft and communications systems are constantly being matched with assumptions and concepts to see if they really do meet them and then with the state of the art in these various areas.

Now, further than that, we have the second system superimposed, which is under development by the General Electric Co. which will develop the most innovative means we have ever had to make unambiguous measurements through instruments of the exact performance of each of the components of these systems, from the engine straight on through. There will be a constant storage in computers of this data on each component leading right on through the static test of the big boosters and the integration of the spacecraft and then the launch at Cape Canaveral.

So here is a major new kind of effort to achieve reliability and to determine how many tests you must make to get that reliability. This, in a way, is the most crucial item in how much it costs you to make a specific flight at some date in the future.

I think we are being very innovative. I would make one last comment, Mr. Chairman. We will announce today, as I forecast a week ago, that we are placing the management of our entire procurement operation under Mr. W. L. Lingle who is now Assistant Administrator for Management Development and who will assume this additional responsibility.

We are lifting it to the level of the general manager so that Mr. Lingle in that capacity will report directly to Dr. Seamans as general manager.

Now, we expect to find better ways to spend money efficiently, but we do not expect to drop tests out of the system to improve reliability until we have a better way to insure that reliability.

Dr. DRYDEN. Mr. Chairman, I would like to be at least counted on this question as to whether we need the money and its expenditure is justified. I suppose being older I say let's look at the record.

When this big expansion started, I think we asked for $200 million. I don't remember the exact amount, but I believe we made it very clear at that time that unless the Nation were prepared to go ahead with the build-up that we then forecast to a total I believe we estimated at $20 to $40 billion a year for the lunar landing alone, there was no use spending the $200 million.

There is no use having chunks of concrete and steel sitting around at Canaveral stopped in the middle of their construction or parts of the Saturn S–5 laying around.

Mr. FULTON of Pennsylvania. I don't believe you meant $20 billion a year.

Dr. DRYDEN. No, $20 to $40 billion total. I don't differ very much from my colleague. He says if you cut the budget a nickel we can't make the time scale.

All I say is that any substantial cut in this budget will jeopardize the time scale of doing this job that we are committed to within this decade. I just want to be counted on this question so that there is no misunderstanding.

The CHAIRMAN. What you are telling us, Doctor, is that we made this commitment when we passed the NASA Act, adopted it, started this program.

Mr. WEBB. And the items, Mr. Chairman, in this program, are really less, as Mr. Fulton has indicated, than we justified to you last year because the Nova is not in it. The tests on the Rover have been of a nature that require us to do further work before we proceed with the Rift. So in a sense what we are saying is that we have put the work under contract to American industry. We have established a system by which we are making every effort to insure success with the flight missions that will be flown with the hardware that American industry is delivering. Now, the money is required to pay contractors under contracts already let.

The CHAIRMAN. Mr. Karth?

Mr. KARTH. No questions.

The CHAIRMAN. Mr. Chenoweth?

Mr. CHENOWETH. I want to congratulate you on the job you are doing. I congratulate you and Dr. Dryden. We are ahead of the Russians and want to stay ahead of them and you deserve great credit for that. We are dealing today with finances and your budget and that presents a serious problem.

We are not dealing with your accomplishments or achievements or what Dr. Dryden is going to do in Rome. We are dealing with the coldblooded fact that you want more money than some feel you should have or will spend wisely—I won't say have been spending wisely up to now.

Mr. Webb, do you really feel now if we cut any substantial sum out of this budget that this jeopardizes our whole space program?

I wasn't sure last week when you made a statement about cutting it a nickel.

Mr. WEBB. In the press conference I was asked about this being a hard-boiled budget. The President has reduced it to the lowest level at which that we could conscientiously tell him we would keep the scheduled dates on the program.

He required the space science program to meet the same criteria as oceanography and all of the other science programs.

After stating that the President had cut it to the lowest level he could, I was asked by the reporters, do you mean if this budget is even cut a nickel that you are going to slip those target dates and I said "Yes." All of these matters are relative. I would say this to you and I said this to the President: I think the country and certainly we would be more comfortable in meeting these target dates if the budget were higher than it is. Indeed, we did show that the most reasonable budget from the standpoint of accomplishing this work was more than $6 billion, so the President has presented you with a difficult problem here in the Congress.

The normal process of saying we can cut something is not in this budget.

Mr. CHENOWETH. The President, I believe, has said that his No. 1 objective this year is to cut taxes, not referring to the space program; but the No. 1 objective is to cut taxes. A great many people feel in this country, and I think there is quite some feeling in Congress, that we should cut taxes and we want to help the President, but there is also the feeling that there should be some corresponding reduction in Federal expenditures, and there are those who feel that perhaps this program is one where some reductions could be made without doing any great harm or irreparable damage to the space program or the security of this Nation.

How do you feel about that?

Mr. WEBB. Mr. Chenoweth, I think that one reason you were able to say that you had some respect for the operation that we had conducted is that we have never gone out in this agency with an emotional appeal to the public based on putting space ahead of other things.

I have stated in every appearance before this committee that the requests made by the President in his budget for space were in line with the other things in his budget.

I think part of my responsibility as Administrator is to see that this takes place in the budget-making process.

Now, I have done this, as I stated a week ago, even in extended conferences with the President. I have traveled with him when he visited the space installations.

Now, the objectives here have been very clearly stated. The schedule has been laid out for you and I do not believe that it would be wise to reduce it. The whole process of examination of both the military budgets, the space budgets, and others has been, I believe, more carefully done this year than it has been done in these areas in a long, long time.

We have passed the point of starting things on a hope that technological breakthroughs would make them possible before additional information is required.

Everything that we are proposing here is "doable" with the one exception that we do not know how long men can live and work in the space environment under zero gravity conditions.

We know we can solve that problem even if we have to insert artificial gravity, but not within the time limits set here. So I would say that in the determination not to be second best in the minds of the leaders of new emerging nations around the world, in the leaders of the important nations in Western Europe and countries like Japan, in the development of a capability for doing whatever we have to do in these areas of space and to insure that a military breakthrough is not utilized against us, this budget is firm and solid and ought not to be cut.

Mr. CHENOWETH. You are a good salesman, Mr. Webb.

Mr. WEBB. Thank you.

Mr. CHENOWETH. You have a good product to sell. It is a question of whether we can afford to buy all you are trying to sell.

Dr. DRYDEN. Mr. Chenoweth, let me give you a consideration. A billion dollars is a lot of money. If you started counting it in dollar bills at the time of Christ, you would only be through a few hundred million by now.

There is another way of looking at it. We have 200 million people more or less in this country—I chose 200 million to make the arithmetic easy—the job of going to the moon is a $20 billion job and if you do this arithmetic you find it will cost $100 for each inhabitant of this country distributed over a period of years.

You can say $20 a year for 5 years or $10 a year for 10 years. The Mercury project costs about $600 million. It actually costs $3 per inhabitant of this country. Any budget is a weighing of values and the way in which you look at it I think sometimes makes a difference in the result.

On the one hand you look at the large sums and we forget this is a large country. We look at the values obtained.

Did we get $3 value to each inhabitant of this country for the whole Mercury program, not just the Glenn flight, but the whole program, not yet finished?

Well, you can answer this and the average man can perhaps attempt to answer that question.

Now, I am not advocating spending and throwing money away. I am not saying this for that reason at all, but to look at it from the other way in proportion to the size of the country rather than each of us looking at it as an individual, to us a billion dollars is an unthinkable amount of money, but I think if we look at it in terms of the whole Nation, it looks a little bit different.

Mr. CHENOWETH. Well, I told you, Doctor, I think you have done a good job. Let me ask you this:

You used a billion dollars as an example. Suppose you took a billion off this budget or suppose we added a billion on; these are just arbitrary figures. You can't figure this to an exact science where one dollar is going to throw everything out.

What would be the impact? Suppose we took a billion dollars off it.

Dr. DRYDEN. I think if we took a billion dollars off of the budget, most of us who know the difficulty of these problems would not really want to say that we believe we can make this landing by 1970.

Mr. CHENOWETH. How much would it delay it?

Dr. DRYDEN. This computation can be made but the magnitude of the uncertainty—which is what you are fishing for, is a little hard to determine. I would say it would be within the next couple of years after that.

Mr. WEBB. It depends on how much you would appropriate next year and the year following that because this budget has been projected as requiring a level of effort for several years between $5½ and $8 billion and then tapering off unless you add additional things.

I have indicated to you that there is only $50 million in this budget for new projects.

Mr. CHENOWETH. But you say you are doubling your program, doubling what you had last year?

Mr. WEBB. That is right.

Dr. DRYDEN. But we are saying that this is close to the maximum annual rate and it comes early in the job because you have to build the facilities, the long lead time items, and you have to finance the big boosters long before you make a flight.

Mr. CHENOWETH. Suppose a cut of half a billion was made, let's just cut it in two; what would that do?

Mr. WEBB. Well, I have stated that the criteria of the President was that the dates that we have set which we believe will give us a reasonable opportunity to make the lunar landing within this decade could not be maintained at anything less than the level recommended by the President.

Now, as to how much slippage you would have, with respect to the $100 million, $200 million, whether you would get a breakthrough, whether you would want to hope for a breakthrough that would permit you to make it up, or whether you would run into difficulties with us up here with a supplemental—I would rather rest at this point, if you would permit me to, with the fact that we expect to justify everything in this budget to you over the next period of weeks, during these hearings. Then maybe you will want to come back at a time when we have had a little more examination.

I, myself, would feel more comfortable if $300 million or $400 million were added to this budget in terms of the future of this Nation, the efficiency of the production, what can be accomplished, the work you can get done per dollar, than I would be to see it $300 million less than that and I think we are very, very close to the margin below which it would not be good policy to cut it.

Mr. CHENOWETH. But you would not say, Mr. Webb, if we did cut it a substantial amount, that it is going to destroy your whole program and render useless everything you have done? It might delay the man on the moon a few months, but what other effect would it have?

Mr. WEBB. Well, Mr. Chenoweth, I think the point that I have tried to make in my statement is that we are making here on a widespread basis with participation in industry and universities and governmental entities, an effective marriage between scientists and engineers.

Now, Mariner confirms the fact that there is a constant spewing out of particles from the sun of several different kinds.

They are traveling at 250 to 500 miles a second in this space medium. They are not concentrated, but they are highly accelerated.

Now, this kind of information that the scientist is able to measure and define is going to be utilized by engineers in many, many ways. Further, we are going out now to study the universe through the messages coming to the earth from what is happening out in the universe.

We have to get up above the earth's atmosphere to do this. We have the orbiting observatory to look around the earth. This kind of information is necessary, and every year without it you are losing something. In the present kind of world we live in, if other people learn this information and how to apply it in areas of technology before we have it, it is, I think, unfortunate for this Nation.

I would just like to make one other point if I may. At the end of the war one of the most difficult undertakings we had as a nation was to bring the wartime Government into a structure that Congress could deal with. During the war we were out to win the war and we passed by many of the normal constraints and processes of government by which decisions are made, so we established the Corporation Control Act and brought all of the great wartime agencies, with a few minor exceptions, under that.

Now, ever since then—and it was my privilege to serve for 3 years as Director of the Budget when this policy was adopted, and I was an Administrator in the Agency to administer it—we have followed and are following a policy that gets before the Congress the presentation of all of the facts because we believe the correct decision can only be made after you gentlemen judge these facts.

As a general statement, I think if you start these hearings on the basis that we have given you a program that you will want to approve when you have examined the facts the country will be better off than if you assume that there is some automatic and simple way to reduce it by a few hundred million dollars.

Dr. DRYDEN. May I make one other mathematical observation? You speak of $400 million; that is more than two-thirds of the supplement by the Federal Government on this program; the rest of it is in industry.

Any substantial cut has to come out of industry.

Mr. CHENOWETH. I don't want to take further time, Mr. Chairman. I want to thank you, Mr. Webb, and Dr. Dryden, for your able presentation this morning.

You must remember, however, that we too have serious responsibilities. I think that the Congress and the people are looking to us to look over this budget carefully; that is why I was wondering what the impact would be.

You are always most affable and genial, Mr. Webb, and you make friends wherever you go.

Mr. WEBB. I hope, Mr. Chenoweth, that you will examine this budget with a microscope; I believe it will stand up under that kind of examination.

The CHAIRMAN. I want to assure you, Mr. Webb, and Dr. Dryden, that we will. I think you have seen the rather hard-boiled subcommittee chairmen work in this committee with their counterparts on the outside and we are going to examine it under a microscope.

Before I do anything else, I had meant to welcome Mr. Teague back to the committee. I have just given him his orders that he is to get out of here and stay home for the next couple of days because I don't want him to have a relapse, so why don't you go?

Mr. TEAGUE. Goodby.

The CHAIRMAN. Mr. Hechler.

Mr. HECHLER. No questions.

The CHAIRMAN. Mr. Van Pelt.

Mr. VAN PELT. No questions.

The CHAIRMAN. Mr. Casey.

Mr. CASEY. No questions.

The CHAIRMAN. Mr. Mosher.

Mr. MOSHER. Two questions.

I assume at some point we will have specific information concerning the nature and significance of the differences between the three budgets that you have mentioned, Mr. Webb.

You said that there was $5.2 billion, $5.8 billion, $6.2 billion that you presented to the President. I would think that this committee would want specific information as to the nature of the differences there, what these entailed.

Will we have that?

Mr. WEBB. Mr. Mosher, I doubt it. You see, when you go through all of the process of determining a budget, you use a lot of working papers. Now, the President was very anxious to reduce this budget to the lowest level that it could be.

We did a vast amount of work to help inform him. A choice was made, and under the 1921 act, as you know, the President is required to submit his best judgment and we are required to come here and defend the President's budget.

Now, that process does not normally include a complete examination of all the working papers and factors that entered into the President's determination, but does require us to fully and completely give you all of the information which you need about the specific budget and the items in this, so that you can judge whether this really is the correct level at which to operate these programs?

Mr. MOSHER. We won't, then, have any specific information between the $5.2 billion and the $5.7 billion?

Mr. WEBB. No, sir; you can develop what you need by your questions but I do not believe that it would be in accordance certainly with normal practice to present that kind of information.

Mr. MOSHER. From what you have already said, the significance of the difference was considerable in the amount of time as far as manned flight is true; I judge that is correct. Is that a fair statement?

One other question, Mr. Chairman.

Did I understand you to say, Mr. Webb, that if we have to insert artificial gravity into the manned flight system that in itself will make the 1970 goal an impossibility; did you say that a few minutes ago?

Mr. WEBB. I don't think I said that directly, but I implied it and I think certainly it would be debatable.

Now, Dr. Dryden is a better judge of that than I am. I would say if we had to start over to develop spacecraft different from the Apollo, we would have a delay.

Dr. DRYDEN. This is probably true. You recall we will determine this fact in the Gemini, and in fact shortly after that in the Apollo capsule itself.

Now, there are a few people among the doctors and others who are not convinced that you can't find some medical method of dealing with some of the problems. I just don't know but as an engineer rather than a life science man I would say the way the engineer would go at it would be to consider artificial gravity.

Now, there may be some other solution found through other avenues.

Mr. MOSHER. I judge you think there is a strong possibility that it will not be necessary?

Dr. DRYDEN. That is right.

Mr. WEBB. That is right.

The CHAIRMAN. Mr. Casey.

Mr. CASEY. No thank you, Mr. Chairman—one statement, Mr. Chairman, with reference to Judge Chenoweth's remarks about reducing the budget. If we had no goal as to time, we could loaf along at our leisure, isn't that right, Mr. Webb?

Mr. WEBB. I am sorry. I thought you were addressing the chairman. Excuse me.

Mr. CASEY. If we had no goal as to time, we could loaf along at our leisure, could we not?

Mr. WEBB. You would pay a penalty, Mr. Casey, even for that, because here is a program that is cranked up, that is ongoing, that has momentum, many outstanding men from industry have given up their jobs and come to work here, the contracts have been let.

Now, if you start squeezing that process down, you lose momentum and I think it would cost you more. I think we will get more for our dollars if we can make this program stick and carry it out.

Mr. CASEY. In view of the buildup we have made to this point.

Mr. WEBB. That is right, and also the careful planning that we have done to do it on this schedule and the large number of procurement actions we have already gone through, and the specifications that are now being perfected by those contractors. A good deal of that would have to be done over again because the state of the art will change with time.

Mr. CASEY. That is all.

The CHAIRMAN. Mr. Roudebush.

Mr. ROUDEBUSH. Mr. Webb, would you say it was a fair statement that we are not necessarily spending these millions and billions of dollars in space because we want to but because we have to?

Mr. WEBB. Yes, sir.

Mr. ROUDEBUSH. Secondly, I would like to ask you, have you given any thought to the next fiscal year—the one that will follow this one—have you any idea since this program is geared over let us say a 10-year period, reaching for the moon by 1970, what it will cost us next year? Have you any guess?

Mr. WEBB. Yes; I think this again resolves itself to the question of when you put something in the program that you might call a new project, something on the postlunar scale.

Now, we can level this program out at about $6 billion. We might well find we could do it in the general area between $5½ and $6 billion for the next 2 or 3 years provided we do not add additional proj-

ects and provided we do not slip schedule dates. If you get to the slippages of dates, you come down, but the whole program probably suffers in much greater proportion than the funds you save in any one year.

Mr. ROUDEBUSH. In other words, if we continue our projects according to plan and we have no catastrophe of any type, we can figure on spending $5½ and $6 billion the following year?

Mr. WEBB. Unless the Russians start doing something which makes you want to speed up, for instance.

Mr. ROUDEBUSH. I see. That would cost money?

Mr. WEBB. Yes; that would cost money.

Mr. ROUDEBUSH. Well, getting back to Dr. Dryden's mathematics, I would like to point out that we are spending about 5 cents out of every dollar that the American Government will spend during the next fiscal year, but we are spending about 10 cents out of every dollar for payment of interest on our national debt and when you have to borrow the money to go into the space business you increase your cost factor by 100 percent about every 20 or 25 years.

Mr. WEBB. Let me point out one thing. This committee took a strong lead in the decision that we must obtain all of these benefits. As one kind of illustration now, we are finding that the horizon scanner used on the Mercury project is coming into commercial use and is going to make vast changes in a number of industries that produce thin sheets of metal or plastic out of rolling mills. What happens is, you can get a feedback from this device into the machine which controls it and permits it to come out with an absolutely accurate material instead of having to roll it out a long way and then measure it after it cools off, particularly the heat-treated metals and fabrics.

Mr. ROUDEBUSH. One other quick question.

Mr. WEBB. The point I want to make is that this kind of thing is going to substantially change the process of industries in the United States and give us a tremendous number of advantages on earth because it is spread out so widely throughout the country, throughout industry, throughout the universities.

Mr. ROUDEBUSH. You would call these knife and fork benefits from our space program, isn't that what it amounts to, or bread and butter benefits would probably be a better term.

Mr. WEBB. And in large amounts in my opinion.

Mr. ROUDEBUSH. Another quick question.

Do you think the people of the United States are safer as a nation and individually due to our space efforts?

Mr. WEBB. Without a doubt.

Mr. ROUDEBUSH. Thank you very much. That is all I have, Mr. Chairman.

The CHAIRMAN. Mr. Randall.

Mr. RANDALL. Most of the questions, of course, will be asked in the subcommittees. I, for one, have reason to believe and have faith that this budget will be combed very carefully and I know that last year we found some money that could be saved and I am sure we can again this year.

I read in the papers that while all the tension is on the manned space flight program, that if this budget is cut, that there may be a

tendency to reprograming again and dropping some of the other items in the budget for the benefit of the manned space flight program.

Now, you mentioned the big problem of zero gravity and artificial gravity. Isn't there still some other problems that remain to be solved such as that we don't know all of the answers yet as to the effect on our astronauts by forces other than gravity, isn't it necessary that we go ahead with this space science program to get those answers first before we are sure of the manned space flight success?

Mr. WEBB. Absolutely. I think that is an extremely important point and I think you know, Mr. Randall, that I have resisted those pressures to go in for a narrower program. I made that part of the policy in my statement.

Mr. RANDALL. Your last statement, to go to the moon and return a man safely, that is the part we are talking about, isn't it?

Mr. WEBB. And to learn everything that can be learned in the process so that we can utilize it for many purposes.

Mr. RANDALL. Thank you.

The CHAIRMAN. Mr. Pelly.

Mr. PELLY. Thank you, Mr. Chairman.

Mr. Webb, you said in your statement that the agency was now in the process of shaking down or hardening its program and personnel and mentioned specifically that you were announcing a new procurement official.

It seems to me—and I would like your comment—it is about time that the agency started shaking down to the point where you weren't given a blank check so much as you have had in the past for the transfer of funds.

I have hoped that in the subcommittees there would develop a procedure which is more in line with the military and some other agencies in the assignment of responsibility and authority to spend money for specific items and not to have the tremendous authority you do at present to use the money any way that you want.

Mr. WEBB. Well, first, Mr. Pelly, let me say that the real test of whether the present system is good or not depends on how it has worked.

Now, we have an absolute rule that we inform Congress immediately after we do a reprograming and therefore you have the opportunity immediately to bring these things under question before the work is underway.

The second point is that we have come before you in the posture hearings and have gone before the Senate committee and made a full explanation of every action we have taken on this program.

Mr. PELLY. I wasn't criticizing you, you understand.

Mr. WEBB. However, the test is not whether or not you think people have too much flexibility; the question is what they do with it.

I think that if you examine this program you will find that we have a far stronger program today than we could possibly have had had we not had this reprograming authority and utilized it effectively.

Now, second, let me point out to you that although $200 million, slightly under $200 million, sounds like a very large amount of money, you also are charging me with spending $3,700 million this year and the $200 million related to the $3.7 billion, to make the whole $3.7 billion more effective, is not a large amount of flexibility.

Mr. PELLY. Well, I think that in the early stages of a program that certainly there was full justification for ample flexibility and I think you have certainly merited the confidence that was placed in you, but we know how similar sums are handled by the Air Force for research and they don't have that authority. It therefore has seemed to me that when you have hardening up this whole procedure and are now getting a new organization for procurement that perhaps the time has gone by when you need the flexibility you now have even though Congress has a chance to act after notice or before you proceed on some of these changes.

As an individual member, I get a notice like other members of this committee and Heaven only knows, I hardly know enough about what your projects are in order to act or ask the chairman. I don't know who is looking into that, maybe our staff is. I think that it has worked well, but I think the time has come for you to justify this authority that you have on the basis that the time has come now when perhaps you could operate within the regular budgetary procedures.

Mr. WEBB. Well, Mr. Chairman, I would like to say to Mr. Pelly that I do not think the time has come to curtail these flexible arrangements.

Secondly, I think the committee will find that the United States is far better off as a result of the action that we have taken and I may say to you that this is not an easy thing for an administrator to do, but we have taken the steps and we have done them responsibly and we have done them under a procedure that has many safeguards in it.

It is not as free as you might have indicated when you say you can do anything you want with the money. We handle a reprograming action as carefully as we do a procurement and there are a specific set of procedures governing this which brings out best minds to bear on the problem and with a formal signoff, with the factors involved in the decision written into the final signoff at any office level.

Mr. PELLY. But even on your procurement you don't have the same restrictions that other agencies do because you don't know what you are getting into and we think we have recognized that.

Mr. WEBB. But every contract of over $5 million comes to the top three officials of this agency, and I don't know of any other that does it that way. Dr. Dryden, Dr. Seamans, and I sit on a committee and hear the evidence on every proposal before a final decision is made.

Dr. DRYDEN. We do operate under the Armed Services Procurement Act. Our regulations are essentially identical to theirs. We sit on a board that listens to changes.

Mr. PELLY. We had in the subcommittee a member of the staff who described your procedure and certainly impressed me with his language, but I still have a feeling that bids can't be called on many of these projects because there is no experience to go to and that certainly makes it a great responsibility.

Mr. WEBB. Yes, Mr. Pelly, but the question is whether we have developed a competent first-class industrial team here and if you look at the industrial partners we have in this enterprise, it is one that could inspire confidence on the part of anyone.

Mr. PELLY. Well, I would hope that this flexibility would not go on indefinitely because I don't think that it is the way that the spending of the taxpayers' money should be normally handled.

Would you agree with that?

Mr. WEBB. I think in a research and development agency of this kind, one that is working out in very advanced areas, in electronics, aeronautics, and others, I think when you come to problems of the supersonic transport, for instance, to take a field we already know a good bit about, aeronautics, you are simply going to have to have flexibility if you are going to get the job done.

I would make a flat statement—without trying to compare this operation with any other, and I have seen a good many of them in the Government—I think right now under the system that we have this committee can feel that this agency is getting as much or more for each dollar spent as any comparable activity anywhere in the U.S. Government.

Mr. PELLY. Well, in size the Air Force—their provision for research is comparable and they don't have the authority you have——

Mr. WEBB. It is much larger.

Mr. PELLY. $1,400,000 or——

Mr. FULTON of Pennsylvania. $1.66 billion.

Mr. WEBB. You are thinking only of space. They have a much larger amount in total.

Mr. PELLY. Thinking in terms of those two, the Air Force does not have the authority to transfer which you have, as I understand it, and——

Mr. WEBB. But neither do they have the kind of system which we have for moving ahead with research and technology.

For instance, we differ from the AEC and all of these other agencies in that we manage these contracts with industry from a technical center, like the Lewis Laboratory, for instance, or Dr. von Braun at Huntsville; they are not managed from a contract office. So we are required to move rapidly here.

Now, a good deal of what the Air Force or operating agency is doing, is taking science or technology and putting it into an operational system which is going to be used widely over the world, where articles will be manufactured in large numbers such as ballistic missiles.

Now, our operation is quite different from that, but it is keyed to strong technical leadership by people within the employ of the Government, utilizing these other resources to furnish a good deal of the muscle to get the job done.

Now, in this kind of thing if you are going to take advantage of your technical competence, you have got to have some flexibility.

Mr. PELLY. It is pretty obvious in its wisdom this committee thought you needed that authority in the past and I just raised the issue as to how long that should continue, and I am sure that this is one of the things that the subcommittees are going to want to consider.

The CHAIRMAN. I think a subcommittee can look into that very well.

I want to try to hurry along.

Mr. Ryan.

Mr. RYAN. Mr. Webb, it is my recollection that——

The CHAIRMAN. Mr. Ryan, I want to point out that we have 21 minutes and we have six people. Maybe I have been too lenient in the past.

Mr. RYAN. May I ask two or three questions?

It is my recollection that last year, and perhaps before last year, the President stated a national goal of putting a man on the moon in the sixties.

Mr. WEBB. This decade, he said.

Mr. RYAN. This was certainly stated before Congress at the time I think that——

Mr. WEBB. May of 1961.

Mr. RYAN. At the time of John Glenn's flight.

Mr. WEBB. May of 1961.

Mr. RYAN. And that has been the stated goal of your agency.

Now, am I to assume that you submitted to the President last December any budget proposal which did not have that target date implicit in it?

Mr. WEBB. Yes, the lower one did not have that target date implicit in it.

Mr. RYAN. It did not. What would have been the target date under the lower estimate?

Mr. WEBB. Well, again it depends on a good many factors, like the space science program and others, but it certainly would have slipped beyond this decade.

Mr. RYAN. The other question is this: Last year——

Mr. WEBB. I may say I did not do that voluntarily. I did it because it was necessary in the budget process to consider alternatives beyond this date.

Mr. RYAN. Last year as I recall Congress created a communications satellite corporation and certainly was led to believe that we were turning over space competence, space communications competence, research and development, to private enterprise.

How do you justify now asking for an appropriation for the United States through NASA to continue research and development in communications satellites when we now have this corporation which is supposed to run this operation?

Mr. WEBB. It was never contemplated under the law, Mr. Ryan, as I can recall the debates, that research and development toward a communications satellite system and toward multiple launches, for instance, and the use of rocketry, and the use of all of the advanced work we are doing with probes like Mariner, that all of this would be abandoned. I think the thing that perhaps you were thinking about was that the common carriers do have a competence in putting together a common carrier system.

Now, if I recall the law correctly, it states that NASA will do some of the research for the corporation when requested by the corporation, that NASA will do the launching. We certainly must increase our competence to do launchings at a far more efficient level, and more cheaply than we have done.

One of the main things that has to be determined now is the commercial life of communications satellites. Our program is actively aimed in this direction. Interestingly, Relay, it looks now, is going to give us more valuable information with respect to commercial life than Telstar gave us, so the United States is not going to have an effective position in communications satellites by abandoning the kind

of research and technology that NASA is developing. I don't think any commercial corporation could undertake these risks any more than they could undertake the risks of the aeronautical research that we do.

Mr. RYAN. Well, I don't want to pursue that further.

The last question: What is the status of the proposed contract to the astronauts? I believe there has been a story about a $3 or $5 million contract being offered to the astronauts.

Mr. WEBB. We have established, after considerable study, a policy within NASA with respect to this matter which has been published. It includes a number of items which I can look in my book and find for you.

Now, under that policy the astronauts are free to contract to sell their personal stories. They are required to appear at press conferences and are charged with the active responsibility of giving in these press conferences and other direct contacts all of the information that comes from their space flight, but they are free and their families are free to sell their personal stories. There are contracts being proposed to their representatives, and these contracts are being submitted to us, because it is necessary for the Administrator to approve those contracts.

We have not approved one as yet, but we have under active consideration one or more that have been proposed.

Mr. RYAN. Thank you.

The CHAIRMAN. Mr. Rumsfeld.

Mr. RUMSFELD. Yes, Mr. Chairman.

Mr. Webb, to go back to this reprograming for a moment, I can certainly see the need for flexibility when NASA was smaller and newer, but after 5 years and with a $5.7 billion request I would think—and I can't recall any Federal agency that has ever voluntarily yielded back authority or responsibility to the Congress—but I must confess that I disagree respectfully with your suggestion that the test should be whether or not we are getting our dollars' worth.

It seems to me that while possibly under—and I would certainly agree under you and Dr. Dryden the agency is doing an outstanding job, but conceivably under some future administrator this wouldn't be the case.

It seems to me that the test should be in view of the fact that the Air Force seems to be functioning in similar areas, the test should be whether or not this additional congressional authority is in fact needed, and if it is, fine. If it isn't, why isn't the Air Force coming to the Congress and saying, "We must have this if we are going to function economically and efficiently?"

Mr. WEBB. Well, I don't want to lay down a test for the Air Force. It is an operating organization that must defend the United States at a moment's notice. It has many operational requirements that an agency engaged in research and development does not have.

I happen to believe, Mr. Rumsfeld, that this Nation is engaged in a great contest with the Russians as to which form of government can effectively do the things that will build power. The system we have got is building power, and I would caution against tampering with

it unless there is some benefit, some substantial benefit to be gained.

Dr. DRYDEN. I would like to furnish for the record a statement of what flexibility the Air Force has. I know they do reprograming.

(The material requested here is referred to as "appendix A" inserted at the end of today's hearing.)

The CHAIRMAN. Yes. I think the assumption has been made here that they do not, but DOD does reprogram and the DOD gets its money in blocks with less restriction on it. They are going to develop a new TFX plane. They are going to get a big block of money to do this and within that block they do what they want.

Dr. DRYDEN. Yes, it depends——

The CHAIRMAN. Great hearings have been held on this, but I don't want to take Mr. Rumsfeld's time.

Mr. RUMSFELD. I would think that would be helpful.

One final question. Back to this $5.2 and $5.7 billion budget. Am I to understand that NASA is not going to furnish this committee the delay which you presented to the President when you presented the alternative budgets?

Mr. WEBB. No; we are not going to present to you exactly what we presented to the President unless all of the rules change, but we will answer every question you want to ask to the best of our ability.

Mr. RUMSFELD. Then what is the delay in months which you estimated between those two budgets?

Mr. WEBB. We did not make that kind of estimate in connection with the $5.2 billion budget.

Mr. RUMSFELD. Thank you.

Mr. WEBB. But we also did not specify the exact speedup that would occur at the $6.6 billion which we also submitted to the President.

Mr. RUMSFELD. Thank you.

Mr. WEBB. But we did weigh with him the implication of those decisions.

The CHAIRMAN. Mr. Patten.

Mr. PATTEN. No questions.

The CHAIRMAN. Mr. Wydler.

Mr. WYDLER. Do we have any idea how much the Russians are spending in space development?

Mr. WEBB. We have some ideas, yes, but we cannot be very precise about it.

Dr. DRYDEN. I wouldn't know how to answer it in rubles, it is so tangled up with their military budget.

Mr. WYDLER. Is there some way we could weigh it according to a scale?

Mr. WEBB. We have some idea of the kind of activities they are engaged in but generally speaking we do not know too much about the advanced things until they fly.

Mr. WYDLER. Well, how would it compare with our program? We hear these general statements at all times that we are engaged in a race. I wonder how much effort our opponent is making in this race.

Dr. DRYDEN. We do not know. We do not know the organization,

the men responsible, that is all classified over there. You don't even know who runs the program.

Mr. HECHLER. Would the gentleman yield?

Mr. WYDLER. Surely.

Mr. HECHLER. Could you do it in percent of G.N.P.?

Mr. WEBB. I don't think you can. I think what you can say is that some time ago when I was before this committee and when people were taking me to task for not having Huntsville and McDonnell Aircraft on double and triple time and so forth because the Russians had flown one 14,000-pound craft, and had had three flights of a 10,000-pound craft. Now this has been some time ago, and these are important technological capabilities, so you have got to say that they are able to mobilize and focus ability of a very high order. When they made this multiple launch, which I believe Mr. Fulton or somebody asked me about here last Monday, showing a very precise capability to launch, so as to bring spacecraft close together in space, this is another very great capability, and it takes resources to do it. That is the best way you can judge what they are putting into it.

The CHAIRMAN. I would say that a press conference was held shortly after that which Mr. Webb and Dr. Dryden and I think Dr. Seamans attended, and where they met the press.

I think that is available and they can furnish it to you in NASA. It is rather thick and it goes into most of the detail so far as we know of the Russian effort in that regard.

Mr. WEBB. Yes; I would be glad to send you that.

Mr. WYDLER. Could you give me any idea if we were to put our program to 1971 to get the man on the moon, how much the budget would have to be this year?

Mr. WEBB. 1971?

Mr. WYDLER. In other words, if we projected it a year further.

Mr. WEBB. No, I don't think I want to do that.

Mr. WYDLER. Nobody has ever done that?

Mr. WEBB. Well, you see you want to try to make a detailed computer run type of analysis on a program involving $5,700 million in estimating things where the tolerance probably is greater than a year.

If we get certain very major breakthroughs that would provide opportunities for us, we might be able to save a year anyway.

On the other hand, if we run into some very grave difficulties we could lose a year or two trying to solve them. Nobody has ever built a booster that has the equivalent power of a line of diesel locomotives between New York and Chicago. One booster that we are building has that.

Mr. WYDLER. I know, but your present program is based on 1970, isn't it?

Mr. WEBB. It is based on doing it within this decade and our target dates have a leeway short of 1970.

Mr. WYDLER. One last question. If you were to take out one item from the budget, what item would you take out?

Mr. FULTON of Pennsylvania. Which arm do you want?

Mr. WEBB. Well, is every member of the committee going to ask me that? I just don't think you can consider this budget that way.

Now, there are certainly some items in this budget that can be postponed or delayed. If you delay them, however, you pay a penalty for every one, and I don't think that I want to try to weigh between a centrifuge that goes into the training of astronauts at Houston which permits a complete simulation of a long mission and what it would take to send those men from Houston up to Johnsville to have their centrifuge work and thereby not have this continuous training simulation exactly as it will occur in flight.

This is the kind of question that would have to be asked in order to answer you.

The CHAIRMAN. Why don't you send them to Grumman? They have a centrifuge there.

Mr. WEBB. The trouble, Mr. Chairman, is then you destroy the very thing you are after, which is a complete simulation to determine the degradation of performance of men under stress.

The CHAIRMAN. Yes; I was saying that for Mr. Wydler's benefit because we were up there the other day for a dedication.

Mr. WYDLER. Thank you.

The CHAIRMAN. Mr. Fulton.

Mr. FULTON of Tennessee. No questions.

The CHAIRMAN. Dr. Weaver.

Dr. WEAVER. With our emphasis on a lunar landing, do you feel we are sacrificing any elements of our overall space program?

Mr. WEBB. No; I would answer on a positive level, that we are developing science and technology at a very, very rapid rate which will be useful for our military security, useful for operational systems, and will have many other collateral benefits.

Dr. WEAVER. If we were to place our emphasis completely on national security and control of space, what expenditures or what cuts would we have in this budget?

Mr. WEBB. I don't think we would be doing anything different from what we are doing, because I think that is precisely the purpose of this plus the military program. At some time this technology will make possible operational systems in the military area, and we will have a choice as to whether we want to go ahead with them.

Dr. WEAVER. You don't know whether we should go ahead strictly in space, with the lunar landing second to that?

Mr. WEBB. I think it would be more expensive. We are developing every technology required for an operational system in space in this program, including the aeronautics. You see to go out and come back you have to go through the air. All of this is a part of a program which has to be faced up to by somebody in the Government.

Dr. WEAVER. Thank you. Thank you, Mr. Chairman.

The CHAIRMAN. Mr. Staebler.

Mr. STAEBLER. Thank you, Mr. Chairman.

Mr. Webb, you should be congratulated on the breadth and the restraint of your program, but Mr. Chenoweth and Mr. Wydler are probing it from one side and I want to poke at it from the other.

It is inconceivable to me that the Russians are not doing something parallel to what we are doing to increase the size of boosters and to accelerate their program for landing people on the moon, and I am

impressed with the fact that every schoolboy still remembers the name Columbus 400 years after the discovery of the New World, and I think it would be of tremendous value in the centuries—not just the years or decades, but in the centuries to come, to have the first man on the moon be named Glenn or Carpenter or Schirra, and not Titov or Gagarin.

Now, when we learn that the Russians are doing something, do you suggest that this is going to be when you see them testing things, testing big boosters? What will be our capacity for speeding up at that point?

Mr. WEBB. Mr. Staebler, you must bear in mind that the advanced Saturn, every unit of which is under contract, every capacity on the ground required for assembly, static test, and launch, is underway. This is 80 times as powerful as the rocket that John Glenn flew and at least five times as powerful as anything that we have seen the Russians fly. Now we know we have one under way and flight schedules for it, and it is of this order of magnitude.

Now we could speed up if we see them begin to move toward the development program of such a large rocket.

I have said many times this is not a crash program. It could be put into a crash program if it were required at that time, but I think the effort that we have cranked up here is so tremendous that they are going to have difficulty to match this.

I would like to point out though, along the line of your statement, that my own view is that before this Congress is over and this committee has completely finished all of its activities it is as likely that you will be pressing me to speed up as it is that you will be pressing me to slow down and take a lower budget. The Russians are not through in this field.

Mr. STAEBLER. Your plans now are such that you can speed up? You have provided the flexibility so that you can accelerate if need be?

Mr. WEBB. That is right, and we have underway the things that are essential, for instance, big engines. Beyond the F–1, which is a big engine, we have underway some very large solid fuel space booster engines, 260 inches in diameter. We are developing studies that would permit the clustering of four of these giant engines. Now if you just visualize an engine that has a diameter of 260 inches and which will be some 66 feet long, something of that kind, here is a gigantic amount of energy in one package, and we are planning to cluster 4 of these for a possible first stage of a Nova.

We have the 1,200,000-pound thrust liquid hydrogen engine underway, the M–1. It takes anywhere from 3 to 5 years to develop one of these engines. Now all of these are underway, but they are not proceeding on a crash basis. These are the elements of space power.

We have enough land at the Mississippi test facility and at Cape Canaveral to launch boosters of a much larger type than we now have in the advanced Saturn, but I think the most likely course of events is that the advanced Saturn which is the main basic unit in our space power system, will be better than anything available to anyone in the world for a substantial period of time.

I think it is highly likely that that will be so, but if it turns out not to be so, we will move ahead.

Mr. STAEBLER. If the Russians turn up with something in tests, will a crash program be more expensive to initiate than the continuance of the present—we don't want to call it a leisurely program, but the program that you are now following.

Mr. WEBB. Yes; any time you put a crash program underway it costs you a great deal in terms of the efficiency of the operation.

We are trying to run the fastest space program that we can run and still keep it efficient.

Mr. STAEBLER. Thank you.

Mr. WEBB. But we also want to be able to slow down or move ahead. I think one of the real innovations of the space program—and I think it will turn out to be something that this committee will be proud of for a long time to come—is that we have actually constructed a machine that is not out from under control. It has got a brake and it has got a throttle, and the processes of our Government can exercise either one, depending upon what the policy at the time should be.

Mr. STAEBLER. Thank you.

The CHAIRMAN. I have timed myself out of any questions. I haven't any questions, but I want to say as a matter of fallout to industry, I received a communication this morning about a preliminary study, from the very respectable Stanford Research Institution in Palo Alto, Calif., in which they spoke of using some of the sensors on Mariner for the location of gold and this may make gold mining possible again. We are not mining gold today because to mine gold costs more than $35 an ounce, but every time you take an ounce of gold out of the ground in this country, you strengthen our economy, and it was quite intriguing to me that perhaps a fallout of the space program may help in the mining of gold in this country.

I want to thank you and Dr. Dryden for being here and to tell you that we always enjoy seeing you and it is always stimulating because you provoke a lot of very good questions.

The committee stands adjourned until 10 o'clock tomorrow.

(Whereupon, at 12:02 p.m., the committee adjourned until 10 a.m., Tuesday, March 5, 1963.)

APPENDIX A

Reprograming Authority of the Department of Defense

The Congress has provided to the Department of Defense as well as to NASA authority to reprogram funds.

Provisions of military construction authorization fiscal year 1963

In the act of July 27, 1962 (76 Stat. 223), which authorizes certain construction at military installations, in sections 103, 203, and 303 identical provisions are made for the Army, Navy, and Air Force. Section 103 under the indicated heading states in part:

Construction for unforeseen requirements

"The Secretary of the Army may establish or develop Army installations and facilities by proceeding with construction made necessary by changes in Army missions and responsibilities which have been occasioned by: (*a*) unforeseen security considerations, (*b*) new weapons developments, (*c*) new and unforeseen research and development requirements, or (*d*) improved production schedules, if the Secretary of Defense determines that deferral of such construction for inclusion in the next military construction authorization Act would be inconsistent with interests of national security, and in connection therewith to acquire, construct, convert, rehabilitate, or install permanent or temporary public works including land acquisition, site preparation, appurtenances, utilities, and equipment, in the total amount of $15,000,000: *Provided*, That the Secretary of the Army, or his designees, shall notify the Committees on Armed Services of the Senate and House of Representatives, immediately upon reaching a final decision to implement, of the cost of construction of any public work undertaken under this section, including those real estate actions pertaining thereto."

In section 602 of the act of July 27, 1962, authorization is made for funds for each of the five titles of the act, namely, Army, Navy, Air Force, Defense, and Military Family Housing. Section 603 states in part:

Transfers among construction projects

"Sec. 603. Any of the amounts named in titles I, II, III, and IV of this Act, may, in the discretion of the Secretary concerned, be increased by 5 per centum for projects inside the United States (other than Alaska) and by 10 per centum for projects outside the United States or in Alaska, if he determines in the case of any particular project that such increase (1) is required for the sole purpose of meeting unusual variations in cost arising in connection with that project, and (2) could not have been reasonably anticipated at the time such project was submitted to the Congress. However, the total costs of all projects in each such title may not be more than the total amount authorized to be appropriated for projects in that title."

In the act of August 9, 1962 (76 Stat. 318), which makes appropriations for the Department of Defense for the fiscal year 1963 the following provision is made under title IV for research, development, test, and evaluation, Defense Agencies:

Transfers for advanced research

"For expenses of activities and agencies of the Department of Defense (other than the military departments and the Office of Civil Defense), necessary for basic and applied scientific research, development, test, and evaluation; advanced research projects as may be designated and determined by the Secretary of Defense, pursuant to law; maintenance, rehabilitation, lease, and operation of facilities and equipment, as authorized by law, to remain available until expended; $444,000,000: *Provided*, That such amounts as may be determined by the Secretary of Defense to have been made available in other appropriations available to the Department of Defense during the current fiscal year for programs related to advanced research may be transferred to and merged with

this appropriation to be available for the same purposes and time period: *Provided further*, That such amounts of this appropriation as may be determined by the Secretary of Defense may be transferred to carry out the purposes of advanced research to those appropriations for military functions under the Department of Defense which are being utilized for related programs, to be merged with and to be available for the same time period as the appropriation to which transferred:"

Also, under title IV of the act of August 29, 1962 the following provision is made for transfers of the emergency fund, Defense:

Emergency fund, Defense

"For transfer by the Secretary of Defense, with the approval of the Bureau of the Budget, to any appropriation for military functions under the Department of Defense available for research, development, test, and evaluation, or procurement or production related thereto, to be merged with and to be available for the same purposes, and for the same time period, as the appropriation to which transferred, $150,000,000, and, in addition, not to exceed $150,000,000, to be used upon determination by the Secretary of Defense that such funds can be wisely, profitably, and practically used in the interest of national defense and to be derived by transfer from such appropriations available to the Department of Defense for obligation during the current fiscal year as the Secretary of Defense may designate: *Provided*, That any appropriations transferred shall not exceed 7 per centum of the appropriation from which transferred."

Additional emergency funds transfer authority is provided by section 537 of the act of August 29, 1962, under the heading indicated:

Transfer of funds, authority

"SEC. 537. During the current fiscal year, the Secretary of Defense may, if he deems it vital to the security of the United States and in the national interest to further improve the readiness of the Armed Forces, including the reserve components, transfer under the authority and terms of the Emergency Fund an additional $200,000,000: *Provided*, That the transfer authority made available under the terms of the emergency fund appropriation contained in this Act is hereby broadened to meet the requirement of this section: *Provided further*, That the Secretary of Defense shall notify the Appropriations Committees of the Congress promptly of all transfers made pursuant to this authority."

NONSTATUTORY PROCEDURES

The Secretary of Defense on January 17, 1963, in transmitting a draft of proposed legislation, "To authorize appropriations during fiscal year 1964 for procurement, research, development, test, and evaluation of aircraft, missiles, and naval vessels for the Armed Forces, and for other purposes," set forth the significance to the Department of Defense of the reprograming procedures established by the Department with the Congressional Committees. In pertinent part the Secretary's letter, which was printed in the Congressional Record at pages 2363 to 2364 states:

Reprograming

"In originating the amendment requiring fund authorization for research, development, test, and evaluation of aircraft, missiles, and naval vessels, the Senate Armed Services Committee stated in its report (S. Rept. No. 1315, 87th Cong., Apr. 2, 1962, p. 3) in pertinent part as follows:

" 'The committee believes that the experience to date under the relatively new procedure requiring authorization of appropriations for procurement of aircraft, missiles, and naval vessels is such that there should be no concern about an extension of this procedure into research and development. When the authorization procedure was instituted doubts were expressed in some quarters about its practicality and there was some alarm that the procedure could result in conflicts and troublesome restrictions. These problems simply have not materialized and the committee believes the procedure has proved constructive.'

"The most significant factor in elimination of conflicts and troublesome restrictions under previous authorization legislation of this type was the adoption by the committees of the procedure that had previously been worked out with the appropriations committees known as reprograming. The principles and basic justification for this procedure were well stated by the House Armed

Services Committee in its report on fund authorization legislation for fiscal year 1963 (H. Rept. No. 1406, 87th Cong., Mar. 7, 1962, p. 10) :

" 'Prior to last year, the Congress had provided a generalized authorization, on a continuing basis, for the major procurement programs of the Department of Defense. Each annual appropriation act has provided funds in general terms for these major procurement programs on the basis of a detailed justification to the committees covering in detail all of the major items. During the period in which these major defense programs are administered, it is necessary to increase or decrease amounts originally justified to the Congress for application to given line items, and to make changes in programs, in order to accommodate changes in requirements. Under the existing procedures for this reprograming, appropriate notice to, or consultation with the committees has been provided. This procedure for authorization and appropriation has provided urgently needed responsiveness to swiftly changing requirements resulting from both technological breakthroughs and varying threats.'

"The Senate Committee on Armed Services has also indicated its adoption and support of the principles and related procedures in Senate Report No. 253, 87th Congress, May 11, 1961, page 3.

"Past experience in the application of the procedure to the various areas of defense programs has indicated that, while the principles should be maintained, the procedures, of necessity, must vary with the nature of the programs; for instance, procurement programs are stated generally in terms of physical line items and associated dollars, whereas, research, development, test, and evaluation programs consist primarily of level of effort, measured in dollars. directed at less finite objectives. Such distinctions should be recognized in working out the adaptation of the principle of reprograming in research, development, test, and evaluation.

"Another important factor in facilitating the administration of the major defense programs under legislation of this type was the clear recognition by the committees of existing appropriation and fund flexibility available to the Department of Defense under the Defense Appropriation Acts as stated by the House Armed Services Committee in its report (H. Rept. No. 380, 87th Cong., May 10, 1961, p. 10) :

" 'While the amounts authorized to be appropriated will constitute ceilings on appropriations which can be made for the procurement of aircraft, missiles, and naval vessels, the committee wishes to make clear that the programs, which such appropriations finance, can also be financed in part by the application of other available funds, such as reimbursements or unused prior year funds. Similarly, should the necessity arise, funds appropriated under these authorizations may be applied to the completion of prior-year programs for the same general purposes.

" 'The committee does not intend that such reasonable degree of transfer authority as the Committees on Appropriations may wish to recommend be inhibited or precluded by these authorizations. We have in mind, for example, the customary transfer provisions in the language of the emergency fund appropriation and similar provisions in section 535 of the 1961 Appropriation Act. Such provisions are essential to permit the Department promptly to take advantage of technological and other developments.'

"Likewise, the Senate committee recognized the importance of maintaining such flexibility in its report (S. Rept. 253, 87th Congress, May 11, 1961, p. 3) as follows:

" 'The committee is aware of provisions in the Department of Defense Appropriations Acts that confer transit authority and flexibility on the Secretary of Defense in expediting certain programs. The committee does not intend that this authorization inhibit the transfer authority contained in the emergency fund appropriation to the Secretary of Defense, or in such provisions as section 535 of the Department of Defense Appropriations Act for 1961. These provisions are essential to permit the Department to take advantage of technological breakthroughs.' "

Similar to the Armed Services flexible reprograming procedures, the Congress has provided comparable authority to NASA. In the act of July 21, 1961 (75 Stat. 216–218), five specific authorities have been provided, namely—

1. *Reprograming within the construction of facilities appropriation.*—Section 1(c) of the act of July 21, 1961, authorized the appropriation of $252,075,000 for the construction of facilities in stated amounts at each of 10 specified loca-

tions, and included therein an amount for "various locations." In addition, it specified an amount for facility design and planning. Section 3 of that act permits $30 million of the funds appropriated, pursuant to section 1(c), to be reprogramed "to construct, expand, or modify laboratories and other installations at any location." It further provides that such funds may be expended "to acquire, construct, convert, rehabilitate, or install permanent or temporary public works, including land acquisition, site preparation, appurtenances, utilities and equipment." The funds may be used for a project for which Congress has denied an authorization.

This authority is limited by two administrative procedures which must precede the commitment of funds:

(*a*) The NASA Administrator must make a determination that the action is necessitated by "changes in the national program of aeronautical and space activities" or by "new scientific or engineering developments" and "that deferral of such action until enactment of the next authorization act would be inconsistent with the interest of the Nation in aeronautical and space activities"; and

(*b*) The NASA Administrator or his designee must file reports with both Houses of the Congress containing a full and complete statement concerning: (1) the nature of the work, (2) its cost, and (3) the reason it is necessary in the national interest.

2. *Transferring research and development funds to the construction of facilities appropriation.*—Section 1(b) of the act of July 21, 1961, authorized the appropriation of $1,305,539,000 for research and development. Section 3 of that act permits 3 percent ($38,775,000) of funds appropriated ($1,292,500,000), pursuant to section 1(b), to be transferred to the construction of facilities account, subject to the same administrative determinations and reports to the Congress as funds reprogramed within the construction of facilities appropriation.

3. *Transferring salaries and expenses funds to the construction of facilities appropriation.*—Section 1(a) of the act of July 21, 1961, authorized the appropriation of $226,686,000 for salaries and expenses. Section 3 of that act permits 3 percent ($6,502,500) of the funds appropriated ($216,750,000), pursuant to section 1(a), to be transferred to the construction of facilities account, for the same purposes and subject to the same administrative determination and reports to the Congress as funds reprogramed within the construction of facilities appropriation. In this case the funds are "transferred" from the salaries and expenses to the construction of facilities account. Only one reprograming in the fiscal year 1962 falls into this category.

4. *Use of funds for research and development for items of a capital nature needed for the performance of research and development contracts.*—Section 1(d) of the act of July 21, 1961, authorizes appropriations for research and development for the fiscal year 1962, to be used for "items of a capital nature * * * required for the performance of research and development contracts." Funds may not be used under this authority for the acquisition of land. There is no ceiling on the amount of research and development funds that can be used for this purpose and no determinations by the NASA Administrator are necessary. However, in cases in which the construction of a major facility is involved, the cost of which, including equipment, is estimated to exceed $250,000, NASA must notify both Houses of the Congress of "nature, location, and estimated cost of" the facility.

5. *Use of funds for research and development for grants to universities and nonprofit organizations.*—Section 1(d) of the act of July 21, 1961, authorizes appropriations for research and development for the fiscal year 1962 to be used "for grants to nonprofit institutions of higher education, or to nonprofit organizations whose primary purpose is the conduct of scientific research, for purchase or construction of additional research facilities." There is no statutory ceiling on the amount of research and development funds that can be used for this purpose. Title to the facilities must remain in the United States, unless the NASA Administrator determines "that the national program of aeronautical and space activities will best be served by vesting title in" the grantee. Each grant must be under such conditions "as the Administrator shall determine to be required to insure that the United States will receive therefrom benefit adequate to justify the making of that grant."

In cases in which the grant calls for the construction of a major facility, the cost of which, including equipment, is estimated to exceed $250,000, NASA must

notify both Houses of the Congress of the "nature, location, and estimated cost of" the facility.

This statement is not intended to provide a complete analysis between NASA and the Department of Defense in the area of flexible reprograming authority; however, it does show that where substantially similar problems in the area of research and development occur comparable reprograming authority does exist in each agency.

In conclusion, we would like to reaffirm our thinking when we reported on H.R. 9737, 87th Congress, which was a bill to amend the NASA Authorization Act for fiscal year 1962. At that time we said,

"Without in any way avoiding its executive responsibility, NASA has fully recognized the responsibilities of the * * * committees of the Congress as the legislative architects of the space program. It is aware of the difficulties that members of the committees face in projecting NASA's authorizations and keeping them in balance with the legislative and fiscal patterns of Government. To assist in this, NASA has always been prepared to explain, justify, and consult in advance, and in depth, with the * * * committees on all phases of its program. Wherever possible it has done this in advance in its annual testimony on authorizing legislation. It has never used the reprograming authority lightly, nor has it abused that power. NASA has reported its actions under the law with meticulous care. It has felt that NASA and the * * * committees must deal together in a spirit of mutual confidence and respect for the difficulty of the work incident to the respective responsibilities of the Congress and NASA. The members and staffs of the space committees have reciprocated fully in these matters, and the civilian peaceful space program has been the beneficiary of these efforts. The question is not what is disclosed to the Congress or to the congressional committees, as NASA's plans, programs, and expenditures are open books. The question is when that information should be disclosed and the effect that disclosure should have on prospective actions."

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1964 NASA AUTHORIZATION

TUESDAY, MARCH 5, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
Washington, D.C.

The committee met at 10 a.m., pursuant to call, in room 214–B, New House Office Building, Hon. George P. Miller (chairman) presiding.

The CHAIRMAN. The committee will be in order. Other members are on their way down so we will get underway.

Dr. Seamans and Mr. Wyatt, we are very happy to welcome you here.

I know that the doctor has a very healthy program here for us, so if you will proceed, Doctor, we will be happy to hear you.

STATEMENT OF DR. ROBERT C. SEAMANS, JR., ASSOCIATE ADMINISTRATOR, NASA; ACCOMPANIED BY D. D. WYATT, DIRECTOR, OFFICE OF PROGRAMS

Dr. SEAMANS. Mr. Chairman, members of the Committee on Science and Astronautics, yesterday Mr. Webb discussed the goals and general plans of the National Aeronautics and Space Administration.

Dr. Dryden has described the major accomplishments in our international program and the future trends of the national space program.

I shall outline the status of current NASA activities, describe the program proposed for fiscal year 1964, and present our budget estimates.

Following my testimony, the directors of our program offices are prepared to discuss their areas in as much detail as you may desire.

GENERAL DESCRIPTION OF NASA PROGRAMS AND CENTERS

I would like to begin my presentation with a brief description of the NASA programs as indicated on the next slide (fig. 8, page 50). The overall program comprises these five areas: manned space flight, space sciences, applications, advanced research and technology, and tracking and data acquisition.

In general, the aims of the manned space flight program are: To carry out an extended earth orbital flight (the last phase of Project Mercury), to develop the techniques of rendezvous and docking in space; and to undertake progressively longer missions building up to the landing of American explorers on the moon during the latter part of this decade.

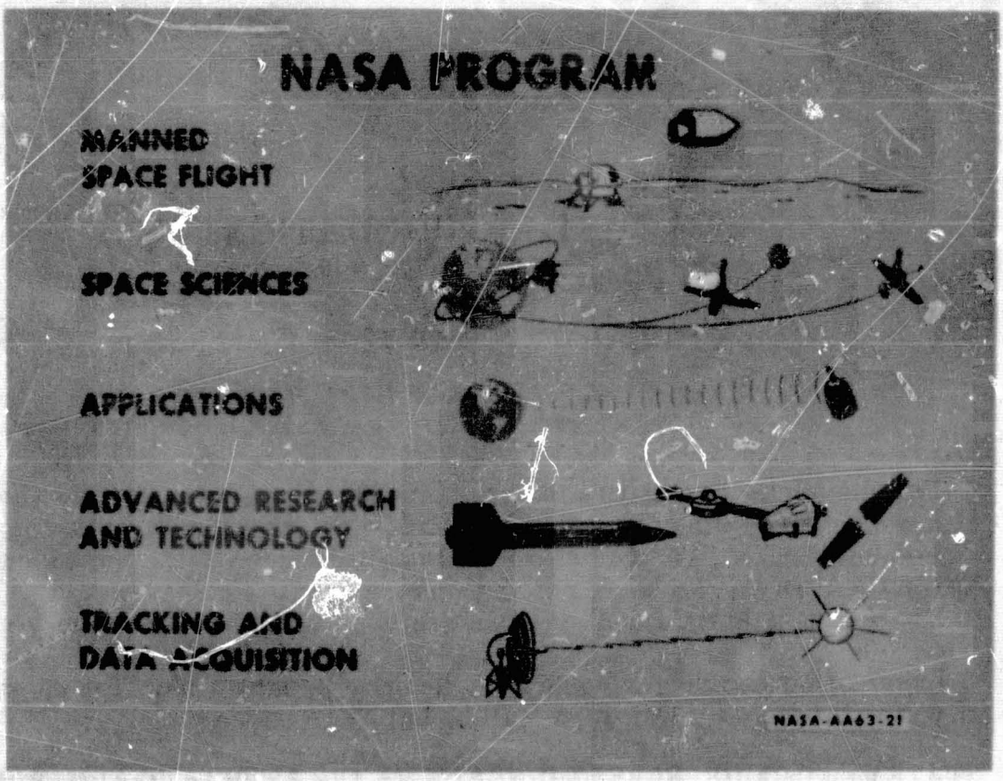

FIGURE 8

Basic to the manned space flight program is development of new large launch vehicles. We are also developing spacecraft large and advanced enough to carry men to the moon and bring them safely home. In the process we must gain new proficiency and techniques for launching spacecraft and for missions deep into space. We must solve many difficult problems involved in sending crews on long space voyages and providing them with life-support systems and tolerable working conditions aboard spacecraft.

In space sciences, NASA is conducting investigations on a broad front; we are examining and analyzing the characteristics of the earth, the near and far regions of space and the sun and the sun's influence on natural phenomena here on our planet. We are intensively studying the moon and the planets nearest us. These studies tell us more about the physical characteristics of neighboring bodies in space.

We also hope to learn whether life in any form exists on them. I would like to emphasize our concern over life in space includes studying how the space environment affects man and other terrestrial life forms, ranging from higher animals to plant and micro-organisms of various types.

In the area of applications, NASA is developing spacecraft that will provide the United States the technology and the competence to establish operational communications and weather satellite systems.

We are also analyzing the results of these and other technological developments of the NASA program so that they can be channeled into industry for the benefit of the economy generally. We have contracted with eight organizations, mostly nonprofit, across the Nation to assist NASA in disseminating information of this type.

The objective of the advanced research and technology program is to provide a sound and broad technological base for this Nation's future aeronautics and space activities. Research is conducted in the many fields related to aircraft, propulsion, launch vehicles, spacecraft, and human factors. It is obvious that only through advances in research today will the United States be able to achieve the national goal—preeminence in aeronautics and space in years to come.

Supporting all manned and unmanned missions, the tracking and data acquisition program furnishes data of various types gathered by stations around the world. It provides the worldwide communications network that ties these stations together. It also operates the automatic data system that screens and reduces the vast amounts of information received each day into a form that scientists and engineers can readily use.

The centers and field stations that support NASA in these five areas are shown on the next slide (fig. 9). The major centers and NASA headquarters are indicated by the white print. The supporting field stations are in black print. By the end of fiscal year 1963 the complements of these centers and field stations will reach an estimated total of 28,547. Not included is the complement of 4,100 at the jet propulsion laboratory in Pasadena, which the California Institute of Technology operates for NASA under contract.

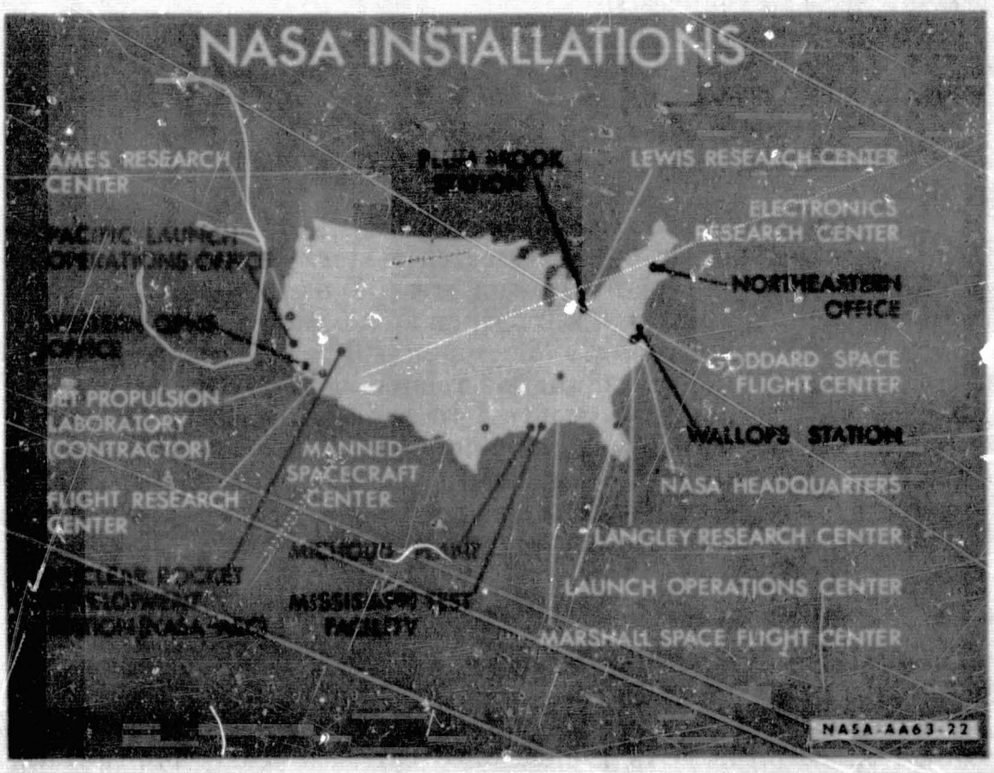

FIGURE 9

The installations concerned mainly with manned space flight—indicated with the red dots—are the Manned Spacecraft Center, the Marshall Space Flight Center and the Launch Operations Center. We also have the Michoud plant and the Mississippi test facility both

operated by the Marshall Space Flight Center which support the development and production of our large launch vehicles.

The centers principally concerned with space sciences and with tracking and data acquisition—identified with green dots—are the Jet Propulsion Laboratory and the Goddard Space Flight Center. Goddard also has prime responsibility for the applications satellite program.

The advanced research installations—identified by the blue dots—are the Langley, Lewis, Ames, and Flight Research Centers.

Research on nuclear systems for propulsion and power production is conducted at the Plum Brook Station, Ohio, which is operated by Lewis.

Nuclear systems development is conducted at the nuclear rocket development station in Nevada, which is operated jointly by NASA and the AEC under the direction of the Space Nuclear Propulsion Office of the Office of Advanced Research and Technology.

The Pacific Launch Operations Office is responsible for launch support and coordination with development groups engaged in launching light- and medium-sized spacecraft into polar orbit from the Pacific Missile Range. This office reports to the Office of Space Sciences at headquarters. The Wallops Island Station, off the coast of Virginia, is used to launch small scientific and research spacecraft on sounding rockets and Scout vehicles.

In August 1962, NASA established the Northeastern Office in Boston. The Northeastern Office is a service office similar to the Western Operations Office in Santa Monica, Calif. Its function is to provide technical and administrative support to NASA programs through liaison with local industry and scientific, educational, and civic organizations.

Before the end of the current fiscal year we propose to take the initial steps to establish a new research center, the Electronics Research Center, in the Greater Boston area. We are requesting funds for the new center which will strengthen advanced work in the highly important field of electronics. The center will be engaged principally in research and development in the related fields of launch vehicle and spacecraft guidance and control, instrumentation, on-board data processing space communications, and ground based electronics associated with space flights. We are locating the center in the Greater Boston area because of its proximity to a major concentration of the Nation's electronic industry and allied university research effort.

MANNED SPACE FLIGHT

The first area I shall discuss in some detail is that of the manned space flight program.

The next slide (fig. 10, page 53) illustrates the three main projects in manned space flight. As I mentioned earlier a 1-day multiorbital flight will complete the Mercury project. Following Mercury, project Gemini will provide answers to important scientific and technological

FIGURE 10

problems associated with rendezvous and with long duration flight, pertinent to project Apollo. Project Apollo will continue rendezvous experimentation about the earth, and has the objective of circumlunar flight, landing men on the moon and returning them safely to earth.

Each project has important specific objectives. In combination, they form a program whose underlying purpose is to establish for our country preeminence in manned space flight. The program provides the technical information and the operational experience to meet potential future national requirements, including military needs.

During 1962, the United States orbited three Mercury astronauts—John Glenn, Scott Carpenter, and Walter Schirra. Glenn and Carpenter each flew three orbits. The Schirra flight completed six. These flights demonstrated man's ability to perform piloting and other assigned tasks under zero gravity conditions. They proved that our technical and operational concepts are sound. They provided valuable flight and flight support experience for future manned missions. In particular, these flights tested and proved satisfactorily the launch operations, the global network of tracking stations, and the recovery systems. All project objectives have been achieved; the experience gained from the three and six orbital flights will be applied directly to the culminating 1-day mission.

The Mercury 1-day mission (fig. 11) will utilize modified Mercury capsules and will enable us at the earliest possible time to observe spacecraft operation and man's performance at zero gravity for a period of in excess of 1 day.

FIGURE 11

Additional life-support equipment was installed as were larger fuel tanks for attitude control and extra batteries for electrical power. To permit these additions, a periscope, a backup automatic attitude-control system, an auxiliary voice transmitter, and a standby telemetry and recording system were removed.

Major Gordon Cooper has been selected for the 1-day mission scheduled for spring 1963 with Commander Alan Shepard as his backup. Preparations are being made for a backup flight should the objectives of this flight not be fulfilled to our satisfaction.

I would like to note here that the Department of Defense has provided great service to the NASA in the conduct of the Mercury program. The cooperative nature of the program is even more extensive in Project Gemini.

Project Gemini: In January of this year, Secretary of Defense Robert McNamara and NASA Administrator James Webb agreed to NASA-DOD programing for Gemini by establishing a joint program planning board. This will assure that the program is planned, executed, and utilized in the overall national interest in such a manner that there will be as little duplication of effort as possible in the field of manned space flight and to insure maximum attainment of both NASA and DOD objectives.

The board shall not only study new scientific and technical requirements but will also monitor programs to see that they are met in plan-

ning experiments, conducting flights, and in analyzing and disseminating results.

NASA will continue to manage Project Gemini. The two agencies have agreed, however, that DOD will participate in Gemini development, pilot training, preflight checkout, launching, and flights to assist NASA and to meet DOD objectives. Specifically the DOD is responsible for the Titan II launch vehicle that will boost the Gemini spacecraft into orbit and the Atlas-Agena to be used in rendezvous flights. DOD will contribute funds toward Gemini program objectives. The amount of DOD support will be determined on the basis of recommendations submitted by the board.

(Fig. 12): Gemini, which is the second major step in our manned flight program, is being developed for two-man earth-orbital missions lasting over 1 week. Let me repeat that such flight will give us invaluable experience with human reactions to many days of alien conditions of space.

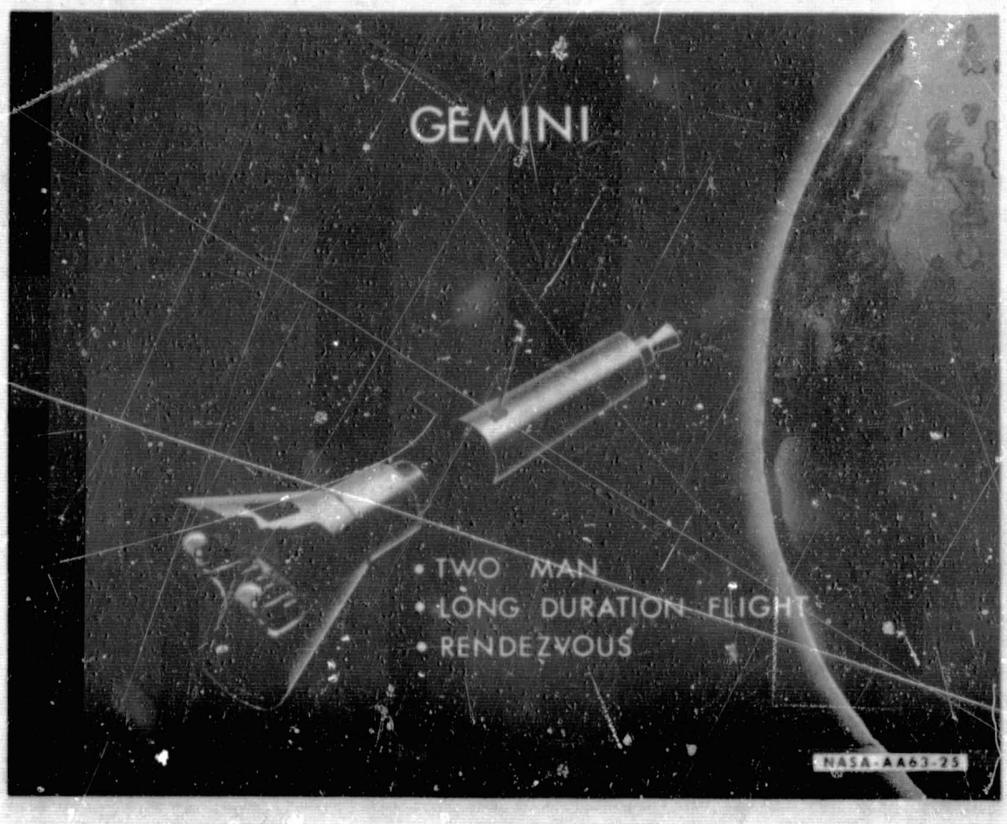

FIGURE 12

We shall also learn rendezvous and docking techniques in earth orbit—all with direct application to Apollo and to future manned space missions. For development of rendezvous, an Agena rocket stage will be launched into earth orbit by an Atlas vehicle. About a day after an Agena is sent aloft and its orbit computed the manned Gemini spacecraft will be launched into approximately the same orbit by the Gemini launch vehicle, a modified Titan II. Through the use of radar for guidance, the astronauts will bring the spacecraft within visual range of the Agena target. With the aid of electronics and visual aids they will bring the rocket and spacecraft together and couple the two. Prior to reentry the astronauts will separate the spacecraft from the Agena rocket.

Initial flights will utilize a parachute for recovery at sea in a manner similar to that employed by the Mercury project. In later flights, a paraglider will replace the parachute so that the astronaut-pilot can maneuver and come in for landings in a preselected ground recovery areas.

The first flight of Gemini, an unmanned ballistic test flight, is scheduled to take place late this year. Long duration manned flights are planned for early 1964 and rendezvous flights are scheduled to begin during the latter part of 1964.

Mr. FULTON of Pennsylvania. Is this calendar year?

Dr. SEAMANS. Yes, it is, Mr. Fulton. When we presented our fiscal year 1965 budget request to you last year, we were planning to accomplish the manned lunar landing by utilizing the method of rendezvous-in-earth-orbit.

Since then, more detailed analysis has indicated that lunar-orbit rendezvous provides advantages in schedule, cost, and development simplicity, while maintaining probabilities of mission safety and success that are equal to or better than those of the mode planned. Later in the year, we decided to alter our plans and adopt the lunar-orbit rendezvous method. The reasons for this were discussed with the committee on July 12, 1962.

The spacecraft and the three principal phases of the Apollo development are illustrated in the next slide (fig. 13). The Apollo spacecraft will consist of three units or modules—the command module, the service module and the lunar excursion module.

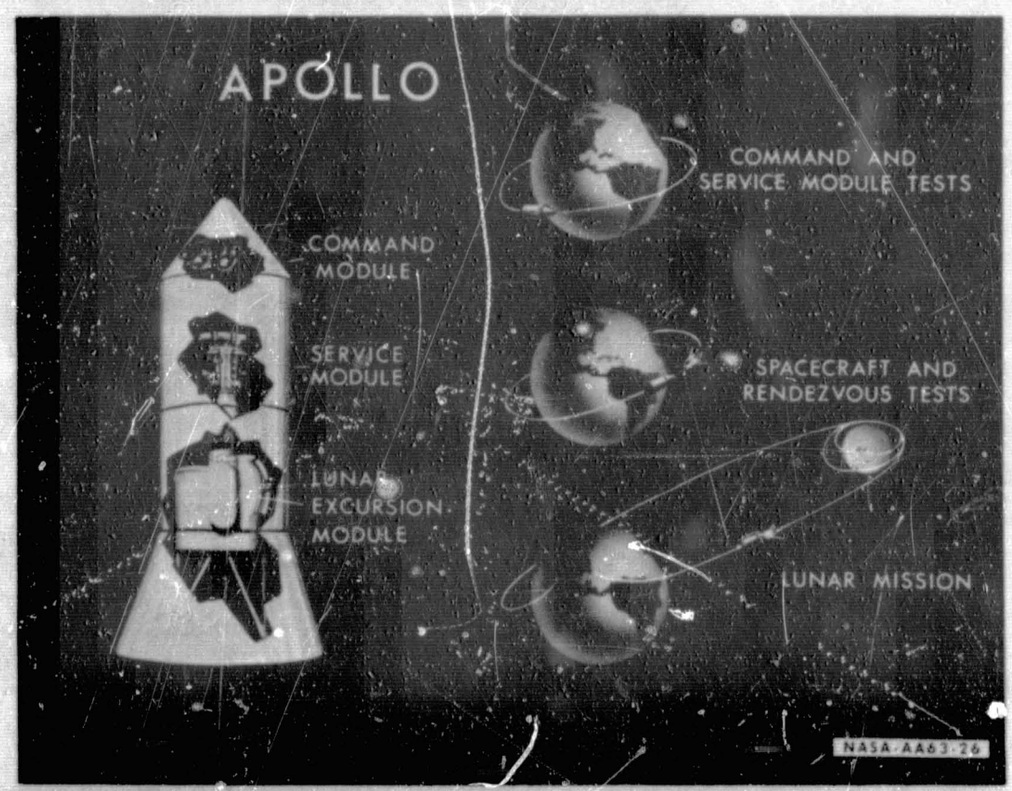

FIGURE 13

The command module, weighing approximately 10,000 pounds, will house the three Apollo crewmen and major systems, such as environmental control, guidance and navigation, stabilization, and communications.

The service module will weigh about 50,000 pounds. It will contain the onboard power generation systems, oxygen for life support and the propulsion systems for midcourse correction, entry into and departure from lunar orbit, and return flight to Earth.

The lunar excursion module or shuttle, will weigh about 26,000 pounds and will transport two crew members to the lunar surface and back to the command module.

Our plans call for Apollo flight development to begin in 1965, with manned Earth orbital flights to the command module and the basic structure of the service module for periods as long as 2 weeks. The Saturn I will be used.

Upon completion of these tests the command, service, and lunar excursion modules will be launched into Earth orbit by the Saturn I–B. A principal objective of these flights will be to conduct separation and docking maneuvers with the lunar excursion module. The first manned flight of the Saturn I–B is planned for 1966.

After completing these development flights, the complete Apollo spacecraft system, weighing nearly 90,000 pounds, will be launched on its flight to the Moon. The Saturn V launch vehicle—previously called Saturn C–5 or Advanced Saturn—will be used for this mission.

On the approach to the Moon, the propulsion system of the service module will be fired to put the spacecraft in lunar orbit. After making the necessary visual observations of the landing site from orbit, two of the crewmen will enter the lunar excursion module and cast off from the command module. Firing the descend engine for braking, the lunar excursion module will descend to the surface of the Moon. Here prepared to stay for a period of up to 3 days they will make scientific and engineering observations and gather lunar surface samples to take back to Earth. These tasks completed they will launch the lunar excursion vehicle back into orbit around the Moon and rendezvous with the command module in which the third astronaut has remained. The propulsion system of the service module will then be utilized to propel the spacecraft from lunar orbit and begin its homeward journey. It should be noted that the lunar excursion module will remain forever in lunar orbit.

Launch vehicles: The launch vehicles required to accomplish the Apollo missions are shown on the next slide (fig. 14, page 58). These vehicles, the Saturn I, the Saturn I–B, and the Saturn V are all under development.

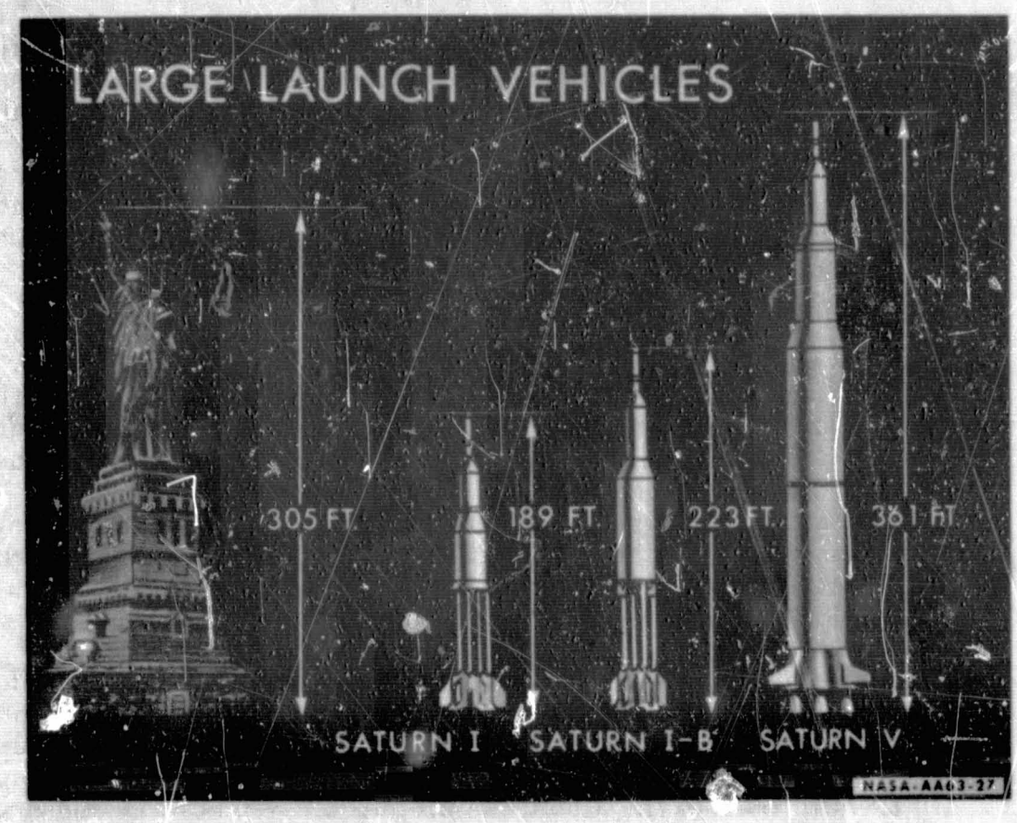

FIGURE 14

Saturn I: The Saturn I is a two-stage launch vehicle. It has eight 188,000 pound thrust liquid-oxygen, kerosene H–1 engines in the first stage to provide a total thrust of 1.5 million pounds. The second stage employs six 15,000-pound-thrust liquid-oxygen, liquid-hydrogen A–3 engines. The first stage of three vehicles—in a development program of 10 Saturn I vehicles—have been highly successful. These tests employed an inert second stage. They proved the feasibility of clustering engines and propellant tanks, confirmed the structural integrity of the vehicle design, checked the guidance and control systems, and demonstrated the adequacy of the ground support equipment.

A fourth Saturn I ballistic flight scheduled for early this year will complete the tests with an inert second stage. Six development flights using active first and second stages are planned for the latter part of this year and 1964.

The CHAIRMAN. Doctor, have you any idea when this ballistic flight will be made this year?

Dr. SEAMANS. It is to be made in approximately a month's time.

The CHAIRMAN. It will be made from Canaveral?

Dr. SEAMANS. It will be made from Canaveral. The stages are at Canaveral now and are being assembled for this flight.

The CHAIRMAN. I thought it might be well for the committee to go down and see this flight.

Dr. SEAMANS. We will be happy to keep your committee posted on the exact date so that you can make suitable arrangements.

The CHAIRMAN. We will see if we can't arrange that. I think this would be an interesting thing for them to see.

Mr. FULTON of Pennsylvania. I think that is a good idea.

Dr. SEAMANS. At least three of these flights will serve a dual purpose. Not only are they launch vehicle development flights, but they will serve to launch full-scale models of the Apollo command module. The Apollo command module tests will be primarily for developing the heat shield and landing system.

We are planning to take further advantage of the launch capability of these development vehicles. In place of ballast, we propose to fly a micrometeoroid detector having about 2,000 square feet of detector surface. This will be an umbrella-like structure that will open up after space flight has been obtained.

The Saturn I will be able to place up to 22,000 pounds in a 100-mile earth orbit. This payload is sufficient to launch the command module and the service module with a small quantity of its propellants.

Saturn I–B: With the selection of lunar orbit rendezvous for the manned lunar landing mission, it was apparent that a vehicle with greater payload capacity than the Saturn I was needed to orbit all three modules of the Apollo spacecraft for rendezvous and docking tests.

Accordingly, we decided last September to proceed with development of the Saturn I–B launch vehicle to accomplish this phase of the Apollo tests. The Saturn I–B vehicle employs the first stage of the Saturn I. As its second stage, it will use the Saturn V third stage which is currently under development. This upper stage uses a single 200,000-pound thrust liquid-hydrogen, liquid-oxygen J–2 engine.

The Saturn I–B will provide the capability of putting about 32,000 pounds in a 100-mile earth orbit. Thus, the complete Apollo spacecraft can be orbited, with sufficient propellant in the tanks of the service module and the lunar excursion module for development tests of systems and techniques for rendezvous and docking. Using this vehicle, we can proceed with Apollo separation and docking tests in earth orbit, as much as a year earlier than would be possible if we were to await the Saturn V.

In addition I might say here that we wanted to utilize the third stage of the Saturn V at the earliest possible time, and this gave us an opportunity to check out this stage using the first stage of the Saturn I, and hence get ahead with the development of the Saturn V.

The Saturn V: The largest launch vehicle under development in the free world is the Saturn V which will be employed for project Apollo's lunar flights.

The Saturn V has five 1.5 million-pound thrust liquid-oxygen, kerosene F–1 engines in the first stage which develop a total thrust of 7.5 million pounds. The F–1 engine has been under development for 4 years. It is scheduled for preliminary flight rating tests in 1964 and final manned flight qualification tests in 1966.

The second stage utilizes five 200,000-pound thrust liquid-oxygen, liquid-hydrogen J–2 engines. Development of the J–2 engine began more than 2 years ago. The engine is scheduled for its final manned-flight qualification tests in 1965.

The third stage, as mentioned earlier, has a single 200,000-pound thrust J–2 engine.

The Saturn V will be able to launch a payload of 240,000 pounds in near earth orbit and 90,000 pounds to the moon.

Current plans call for a 10-vehicle development program. Work is underway on all stages of Saturn V. Its first flight is scheduled for 1966.

Engineering and integration: The manned space flight program has many interrelated operations. Special steps have been taken to develop the resources necessary to establish sound management techniques and to insure that all aspects of the program are properly integrated. The work at the centers can be divided into three areas, spacecraft systems, launch vehicle systems and launch operations. I would like to explain the functions of each area briefly.

Responsibility for manned spacecraft systems rests with the Manned Spacecraft Center at Houston, Tex. (fig. 15). This center designs, develops, and tests the spacecraft, selects and trains the astronauts, and directs the flight operation after launch.

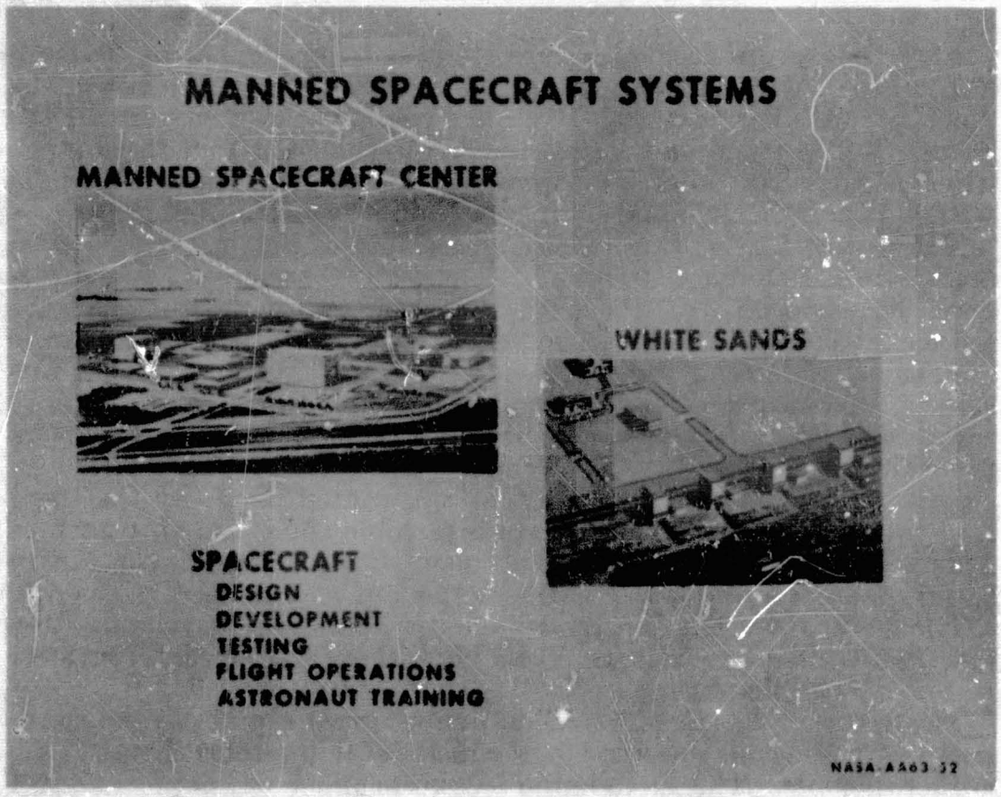

FIGURE 15

The center at Houston, which is presently under construction, will provide experimental test facilities for evaluating and checking out many of the spacecraft components, a mission control center for monitoring and directing the Gemini and Apollo flights and stationary and dynamic space flight simulators for training astronauts.

Under the direction of the Manned Spacecraft Center, facilities to support spacecraft development are also being constructed at White Sands, N. Mex. These facilities will be used for testing the propulsion systems of the Apollo service and lunar excursion modules.

In addition the abort capability of Apollo will be tested at White Sands using the Little Joe II. These two NASA installations will provide the staff and facility resources to support all phases of spacecraft design, development, and operation.

Responsibility for manned space flight launch vehicle systems rests with the Marshall Space Flight Center in Huntsville, Ala., (fig. 16).

FIGURE 16

Work of the Marshall Center comprises design, construction, development, and testing—and supervision of related contractor effort—on large launch vehicles and their components, including the rocket engines, which are utilized in the manned space flight program.

To support these functions, Marshall has direction of the Michoud plant and the Mississippi Test Facility.

Although the first stage of the Saturn I is currently being constructed at Marshall, the Government-owned Michoud plant, New Orleans, La., has been activated and will be used by contractors to construct additional Saturn I first stages, as well as the first stage of the Saturn I–B and Saturn V vehicle.

With the exception of the S–I stages, ground tests of stages and components of these large vehicles will be conducted at the Mississippi test facility, about 40 miles northeast of New Orleans, and then shipped by sea to Cape Canaveral for flight.

S–I stages will be tested using existing facilities at Marshall Space Flight Center. We are currently reviewing the unmanned Saturn I

and Saturn I–B flights to determine whether a sufficient volume exists to warrant construction of static facilities for the S–I stage at the Mississippi test facility.

Responsibility for manned space flight launch operations rests with the launch operations center in Florida (fig. 17).

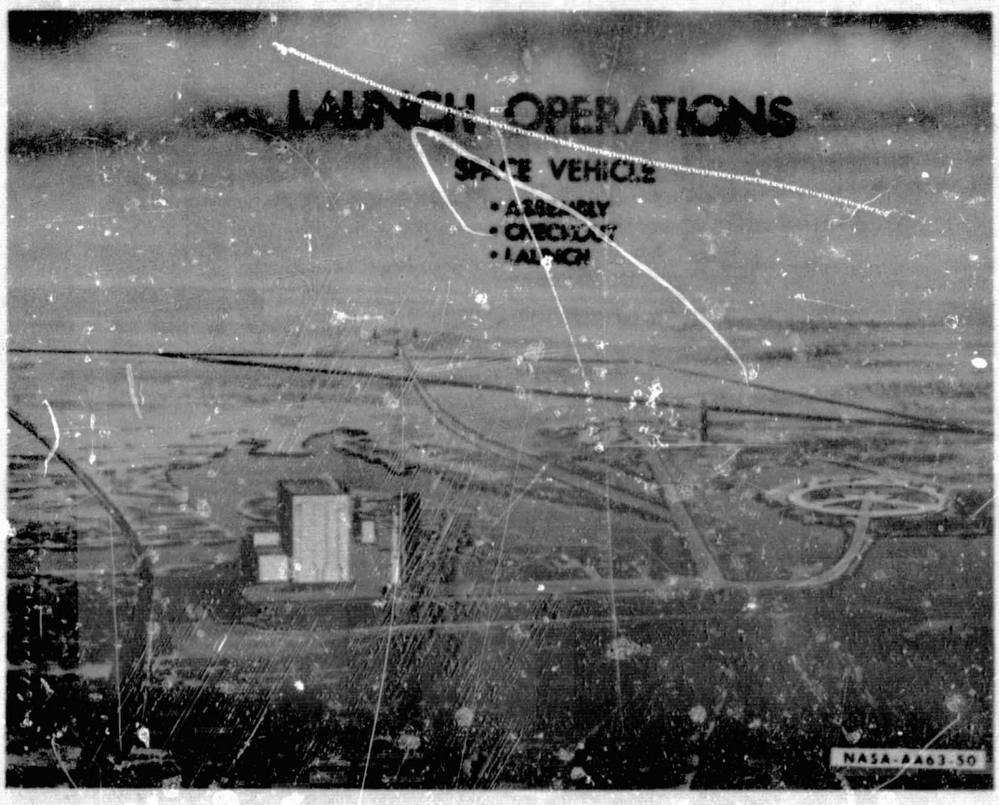

FIGURE 17

The functions of this center are to assemble the space vehicle, to conduct the prelaunch checkout of the vehicle, and to launch it into its desired trajectory.

To accomplish these functions, this center is directing the design and construction of an integrated test and launch facility, the only one of its type in the world. As its nucleus it will have a building with vertical assembly bays about 50 stories high. This complex will include checkout operations, the control room for launch direction, engineering laboratories, and astronaut preparation services.

After the space vehicle is assembled a giant crawler will move the assembled and checked-out vehicle a distance of more than 2 miles to one of three pads.

The launch operations center will be the "spaceport" for launching this Nation's large space vehicles of coming years.

Facilities at these three centers and their associated stations are in the construction phase. When completed, they will constitute a valuable national asset for the development, fabrication, and test of the country's large launch vehicles.

As I mentioned earlier, management techniques have been developed to insure that all aspects of the manned space flight program are properly integrated. I would like to review briefly our overall management concept with the aid of the following slide (fig. 18).

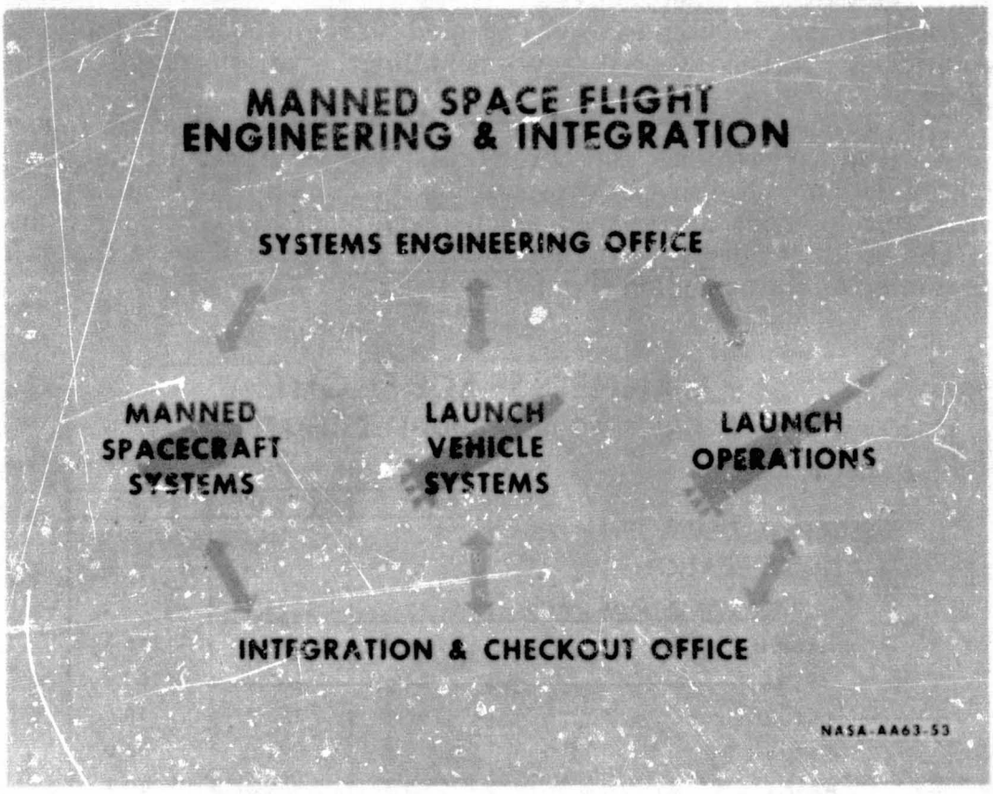

FIGURE 18

Shown schematically is the relationship of the three centers responsible for developing and operating the manned space flight systems in conjunction with the Systems Engineering Office and the Integration and Checkout Office, Office of Manned Space Flight at NASA headquarters.

The Systems Engineering Office provides programwide and detailed technical analysis for missions so that a suitable approach can be selected. In choosing the approach, the greatest care is taken to be sure the system is compatible with the mission objectives and that all elements of the system can be developed within the scope of the project and its schedule.

The Integration and Checkout Office has a dual function. The first is to insure that detailed information on each of the many parts used in the space vehicle system is properly documented. The engineer working on the design of one component can then refer to the design of a mating or related component and thus make sure that his design will be compatible.

The second function of this office is to insure that checkout equipment for all systems of the space vehicle are designed, fabricated, and developed for the various phases of the operation. Checkout equipment is that equipment used to check the condition of the various parts of the space vehicle upon completion of assembly at the manu-

facturers' plant, at the ground test site prior to operation, and at the launch site prior to launch.

Having a single element of the organization responsible for the development of the overall checkout equipment insures compatibility with the various intended uses.

Furthermore, economies can be effected through the use of duplicate components in the checkout equipment for the various stages of the launch vehicle or spacecraft.

The systems engineering and integration and checkout offices report to D. Brainerd Holmes, the Director of Manned Space Flight. His offices also include functions responsible for launch vehicle and spacecraft development, aerospace medicine, and manned flight operations.

The estimated fiscal year 1964 budget for manned space flight is presented on the next slide (fig. 19).

MANNED SPACE FLIGHT

FISCAL YEAR 1964 BUDGET ESTIMATE

(IN MILLIONS)

	FY 62	FY 63	FY 64
RESEARCH, DEVELOPMENT AND OPERATION			
MERCURY (INCL. ONE-DAY	$ 42.3	$ 34.7	$ .2
GEMINI	58.9	246.4	335.3
APOLLO	84.6	462.8	1263.2
SATURN I	257.4	257.9	158.6
SATURN I-B	.5	22.8	76.0
SATURN V	69.5	368.4	799.7
ENGINE DEVELOPMENT	123.9	173.5	192.4
SUPPORTING PROGRAMS	18.9	106.3	291.4
SUPPORTING RESEARCH & TECHNOLOGY	21.8	34.2	76.9
TOTAL RD & O	$ 677.8	$ 1,707.0	$3,193.7
CONSTRUCTION OF FACILITIES	245.4	535 1	564.5
TOTAL MANNED SPACE FLIGHT	$ 923.2	$2 242 1	$3,758.2

NASA-AA63 28

FIGURE 19

The increase in fiscal year 1964 is due primarily to the continued development effort on Project Apollo and related cost growths for launch vehicles, engines, and supporting development. Briefly, the following specifics apply to the trends noted.

The estimated funds, $200,000, in fiscal year 1964 for Mercury represents personnel and operations charges to close out the Mercury project. The funding estimates for Gemini show an increase from $246.4 million in fiscal year 1963 to $335.3 million in fiscal year 1964.

Two-thirds of this estimated increase in Gemini cost stems from continued contractor buildup in spacecraft development effort. This buildup is just now leveling off; fiscal year 1964 is expected to be the peak year for spacecraft funding. Most of the remaining increase is for procuring Titan II and Atlas-Agena launch vehicles.

Major technical decisions have allowed NASA to move forward aggressively on the Apollo project. The cost of $1,263.2 million estimated for fiscal year 1964 reflects our entrance into the major hardware development phase of Apollo.

About half of the estimated increase in the Apollo budget is for development of the three spacecraft modules. Other major increases in expenditure are required in the areas of guidance and navigation equipment and procurement of launch vehicles such as Little Joes, Saturn I, and Saturn I–B. Because Project Apollo is still building up *rapidly*, the personnel and operating costs will increase accordingly.

Saturn I development costs will decrease from $257.9 million in fiscal year 1963 to $158.6 million in fiscal year 1964. In this program we have passed the period of peak investment associated with design, development, production tooling and test equipment. The major effort remaining is that of complete-system flight test and related operations.

Saturn I–B, as I have noted, relies heavily on Saturn I and Saturn V developments. Estimated costs increase to $76 million in fiscal year 1964 to allow for purchase of test stages and engines and to cover anticipated charges for systems integration and systems test.

The Saturn V estimated costs increase from $368.4 million in fiscal year 1963 to $799.7 million in fiscal year 1964.

This funding will cover the rapid buildup of contractor effort and in-house support of development on all three stages of the vehicle and procurement of engines; it will also provide for a supporting development test program. Here, too, NASA personnel and operation expenditures must increase substantially to support the program properly.

Funds required for engine development in fiscal year 1964 are estimated at $192.4 million. The development effort on the J–2 and F–1 engines is maintained at the fiscal year 1963 pace, with the increased expenditures arising from the development of the new M–1 liquid-oxygen, liquid-hydrogen 1.5 million-pound-thrust engine. The higher cost of the M–1 engine development results from entering the component fabrication and testing phase. The M–1 engine is not required for the first manned lunar landing, but it is important that the development of this engine keep pace with large solid motor progress since these two propulsion elements are complementary items for post-Saturn vehicles.

Supporting programs cover a very broad range of activities that contribute directly to the activity just discussed. Included here are such items as range support, aerospace medicine, integration and checkout, and systems engineering. The increase in estimated cost of these activities from $106.3 million in fiscal year 1963 to $291.4 million

in fiscal year 1964 directly reflects the increased workload imposed by the approach of Gemini and the early phasing of Apollo to flight status.

The increased cost of supporting research and technology from $34.2 million in fiscal year 1963 to $76.9 million in fiscal year 1964 also reflects the increased attention required in areas of spacecraft, launch vehicle, propulsion, and launch operations technology directly pertinent to the development effort.

The total estimated cost for research, development, and operations in the manned space flight area amounts to $3,193.7 million in fiscal year 1964.

The budget estimate for construction of facilities for fiscal year 1964 is $564.5 million. This estimate shows the need to time-phase the facilities at the major national centers to the development, testing, and flight operation of manned space vehicles. Major construction activity is planned for the Manned Spacecraft Center, Houston, Tex.; the Marshall Space Flight Center, Huntsville, Ala.; the Mississippi Test Facility in southwestern Mississippi; and the Launch Operations Center, on Merritt Island, Fla.

At the Manned Spacecraft Center the launch environment and antenna test facility, mission simulation and training facility, and a spacecraft control technology laboratory are requested for fiscal year 1964. To support this center, a testing site for the service module is being constructed at White Sands. At the same location a test stand for the lunar excursion module is requested in fiscal year 1964.

Present facilities at Marshall Space Flight Center must be augmented to accommodate large launch vehicles and the associated increase in complexity of electronics, computers, and utilities.

Expansions and extensions to the high-pressure gas and propellent systems, instrumentation and control systems laboratory, components test facility and load test annex are included in the fiscal year 1964 request. The cost of utility installations is the largest single item.

At the Mississippi Test Facility, static test stands are required for the F–1 engine and for the first and second stages of Saturn V vehicle. Waterways with docking facilities, support laboratories, and utilities are also required.

Michoud, which will be the Nation's large vehicle production facility, requires an addition to the production facilities and a component supply building.

At the Launch Operations Center, launch complex No. 39 (from which the 360-foot Saturn V will be launched) and the associated support facilities must be started this coming year to meet the Apollo schedule. A small amount of funds will be required to modify complexes Nos. 34 and 37 to accommodate manned launches.

The total estimated budget of the manned space flight program amounts to $3,758.2 million in fiscal year 1964.

SPACE SCIENCES

I will now move on to our space sciences program.

The tools of the space sciences program and the areas that it covers are illustrated on the next slide (fig. 20).

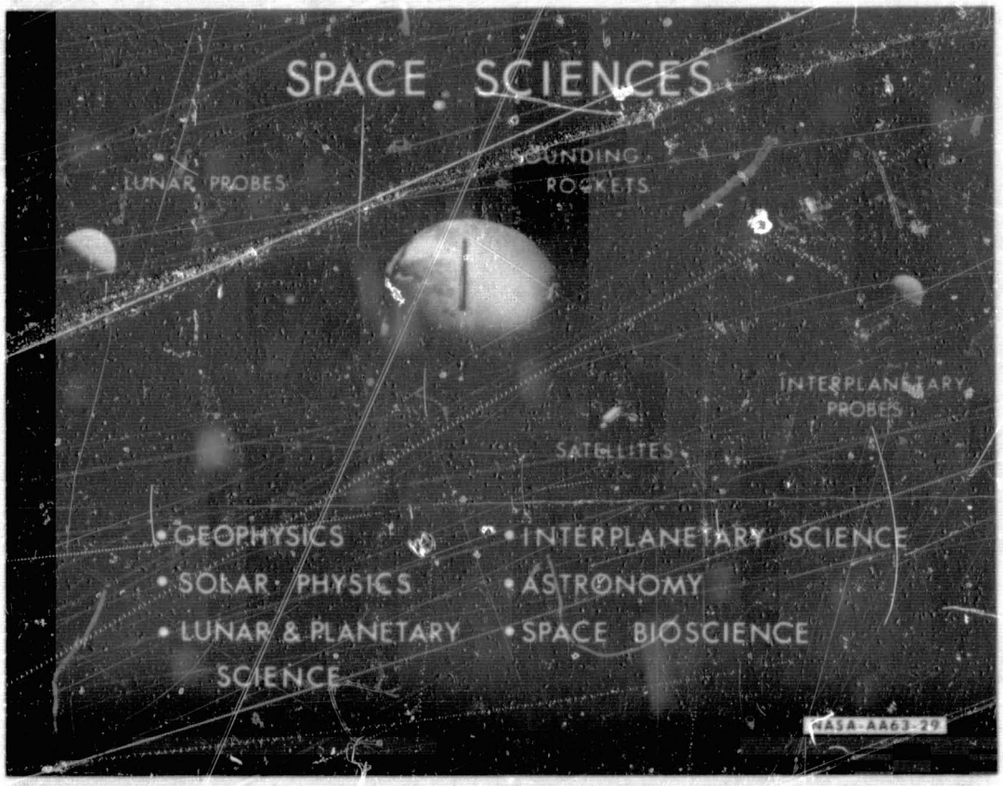

FIGURE 20

This program employs sounding rockets, earth orbiting satellites, lunar probes, planetary, and interplanetary probes.

Areas to which our space science studies are directed include geophysics, solar physics, lunar and planetary science, interplanetary science, astronomy, and space bioscience.

At present, the United States clearly leads the world in geophysics, solar physics, and interplanetary science.

However, within the past year the Russians have launched a major series of geophysical satellites and a planetary probe, the results of which could alter this position materially.

We are continuing to give strong emphasis to this program to make sure that the United States does retain its leadership in this area.

A sounding rocket and two typical small satellites are illustrated on the next slide (fig. 21).

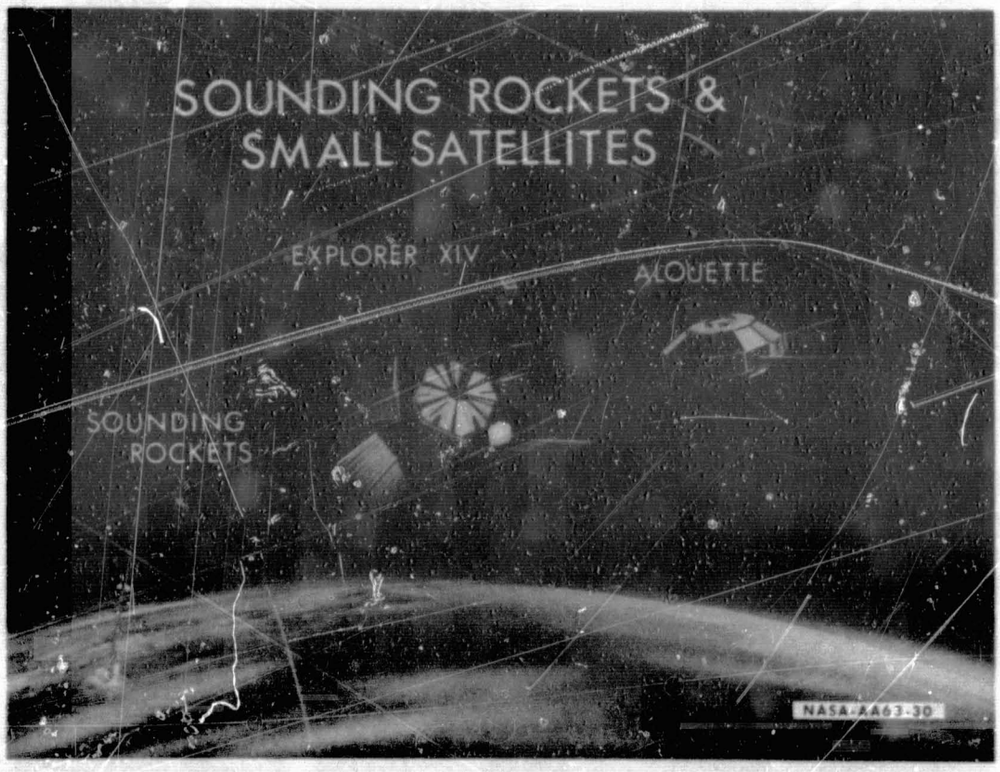

FIGURE 21

Such small satellite payloads and near vertical sounding rocket flights have played, and will continue to play, an important role in the space sciences program. The bulk of the sounding rocket flights is directed toward gathering geophysical data in the earth's upper atmosphere at altitudes between 40 and 160 miles.

Sounding rockets also perform preliminary flight tests of satellite components and instrumentation. In 1963, about 90 flights will be made. In 1964, 110 flights are planned.

Small satellites—Several types of small spin-stabilized satellites are utilized to gather scientific data on the space surrounding the earth. Of major concern are energetic particles, atmospheric structure, and the ionosphere.

These data are not only of scientific significance, but also will provide information pertinent to the design and operation of manned space systems. Some of these projects are conducted in cooperation with other nations, including Canada, the United Kingdom, and Italy.

The Explorer XIV and the Alouette, illustrated on figure 21, were launched successfully in 1962. Actually two Explorers, XIV and XV, were orbited in October 1962 to measure the artificially created radiation belts. In September 1962 the Canadian satellite Alouette was launched by NASA to monitor the earth's ionosphere from above. We expect Canada to participate in a follow-on program of ionosphere monitors.

In 1963 an interplanetary monitoring satellite is scheduled to be launched.

In addition to small satellites such as these, we are also developing Pioneer, a small solar probe, on which work was started in 1962. This probe is relatively simple because it will employ a number of components previously developed for other satellite projects.

The nominal trajectory of the Pioneer, which will follow the approximate orbit of the earth, will provide a separation distance from earth of 30 million miles after 6 months (the design lifetime of the spacecraft).

The data from Pioneer, together with data from an earth orbiting solar observatory and earth measurements, will be used in the design of future solar probes. The Pioneer development effort in the coming year will lead to the beginning of full-scale system tests.

Observatories—Although the small satellites are an important part of our space science program, we are currently augmenting them with three large observatory type satellites, as shown on the next slide (fig. 22).

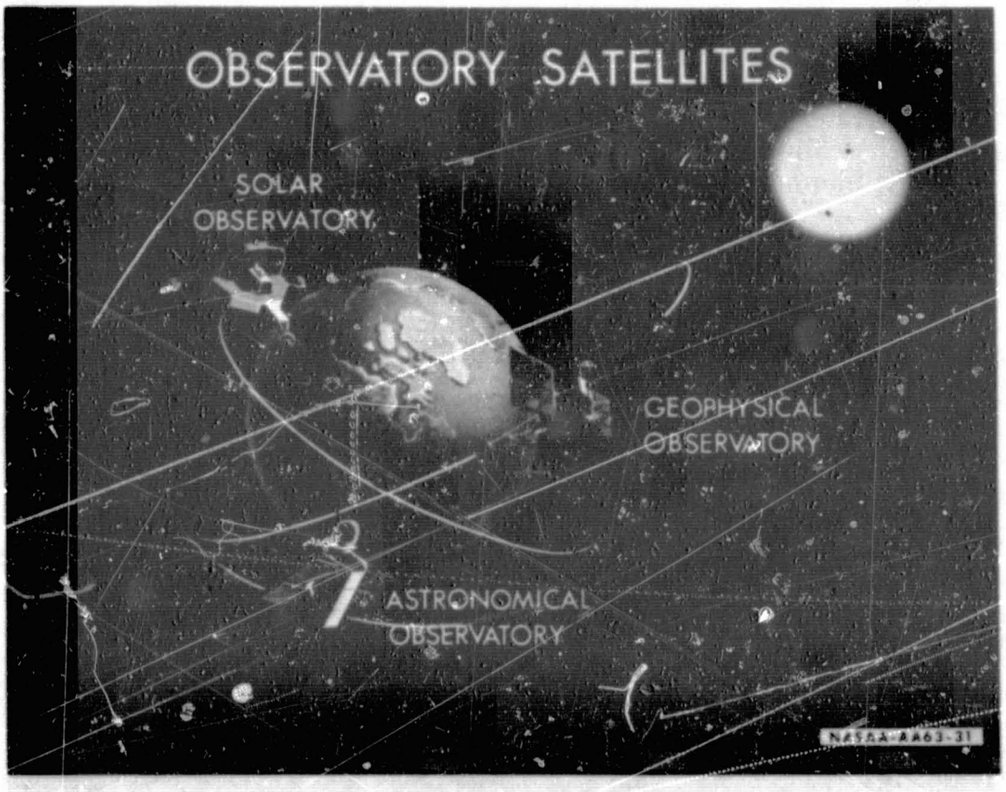

FIGURE 22

They are the solar observatory, geophysical observatory, and astronomical observatory. Each is designed for a specific data gathering role.

The solar observatory will obtain information about the sun and its effects on the electrical and energetic particles in space that, in turn, have an effect on the earth and its near-space environment. The first solar observatory, launched successfully in March 1962, returned useful data on solar electromagnetic radiation during 11 weeks of continuous operation

Data are still being received intermittently. Launch of a second solar observatory is planned for this year, as part of a continuous program to obtain statistical data on solar activity.

Geophysical observatories, capable of carrying as many as 50 experiments, will obtain data on the earth's radiation belts and magnetic and gravity fields.

Information on the radiation belts will help determine shielding requirements and desirable parking orbits for manned space flight. Accurate measurements of the earth's magnetic field and of micrometeoroids density, distribution, and velocity are also important to manned space flight.

Final integration and checkout of the first geophysical spacecraft will take place early this year. The first launch is planned for the latter part of 1963. Three additional flights one in near-equatorial orbit and two in polar orbits, are planned for 1964.

Astronomical observatories are designed to provide a stabilized platform in space for observing the planets, stars, and nebulae in the ultraviolet and radio-frequency ranges that cannot be measured from earth because of atmospheric absorption or distortion.

The first flight planned for 1965 will attempt to map the sky in the ultraviolet light region and to study the energy distribution of individual stars and nebulae over a wide range of the ultraviolet portion of the spectrum.

As a result we expect to see many things in the heavens that have not been visible with our earthbound telescopes.

The unmanned lunar spacecraft shown on the next slide (fig. 23) include the Ranger and Surveyor. The objectives of our lunar experiments, in addition to obtaining valuable scientific data, are the determination of such factors as lunar gravity, topography, and surface-bearing strength, required for the design of the Apollo spacecraft.

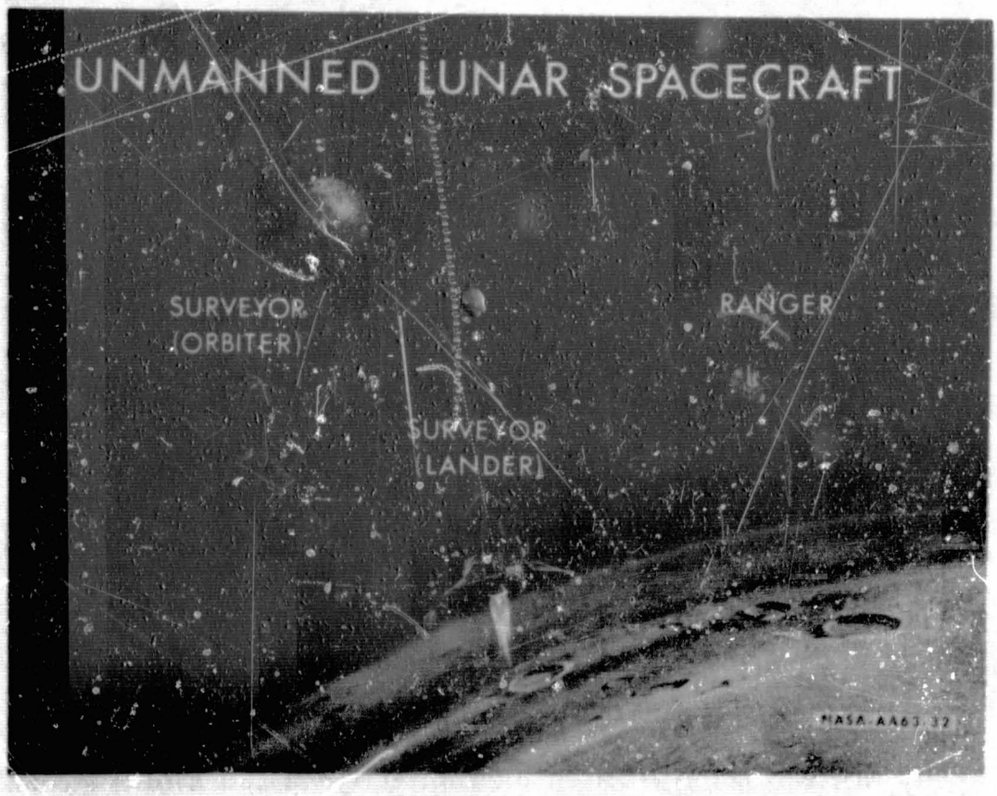

FIGURE 23

The Ranger will take television pictures of the lunar surface, starting at 1,000 miles and continuing all the way down to impact.

The Surveyor Lander will land softly on the moon and make detailed measurements of the lunar surface character and environment. As the name implies, the Surveyor Orbiter is designed to orbit the moon and map the lunar surface. It will also measure such environmental phenomena as gravitational and magnetic fields and micrometeoroid particles near the moon.

In the Ranger series five spacecraft have been launched without success. The first two flights, which were intended to check out spacecraft operation, failed to achieve mission objectives because of malfunctions in the launch vehicle.

Instead of being injected into the planned highly elliptical orbit, they both remained in their low-altitude parking orbit. Nevertheless, some useful spacecraft system operations data were obtained. The third flight also failed due to malfunctions in the launch vehicle.

The fourth and fifth missions failed due to spacecraft malfunctions. A concentrated design review indicated improvements that can and are being made to increase the reliability of the Ranger spacecraft.

Planetary—Our planetary program is centered around the Mariner project (fig. 24). The objective of mariner is to explore the planets Venus and Mars.

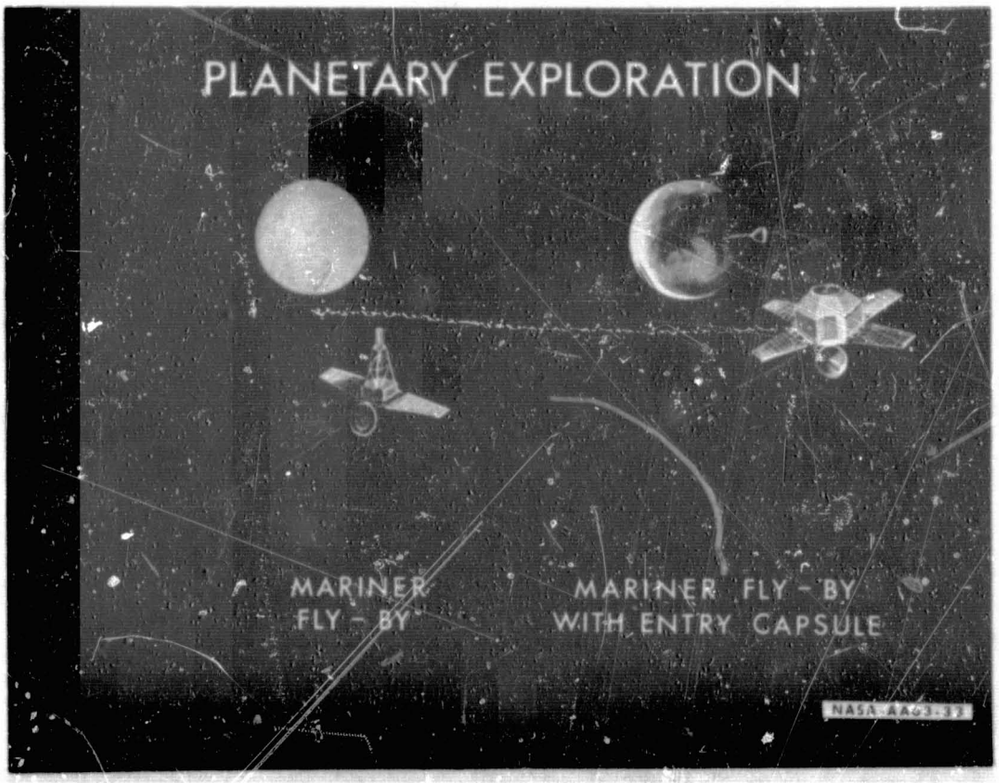

FIGURE 24

As you are aware from Dr. Newell's testimony last week, a great scientific and engineering achievement was accomplished when the Mariner II spacecraft passed within the target area—21,500 statute miles from Venus—on December 14, 1962.

At that time, the spacecraft had traveled for 109 days, for a total distance of 180 million miles along its flight path and 49.3 million miles from earth. Data obtained yielded direct experimental information concerning the following characteristics of Venus: Surface and atmospheric temperature, rotational rate and direction, magnetic field, and trapped particles.

The responsible scientists have reported preliminary results of their findings.

However, continued effort will be required to refine the information and to evaluate its significance.

Mariner continued to transmit data until it was 5.7 million miles past Venus, a distance of 54 million miles from the earth, before the spacecraft became silent. The spacecraft supplied interplanetary data throughout the course of the entire flight.

For the study of Mars, a Mariner flyby similar to the Venus flyby will be made using many components developed in the Mariner II program. The objectives of the flight are to obtain information concerning the surface, atmospheric conditions, possible magnetic fields and trapped particle regions, cosmic dust in the vicinity of Mars.

Television and infrared measurements, when analyzed, will give an indication as to whether life as we know it exists on the planet. Plans call for completing major development in mid-1964 so as to permit launch of two spacecraft to Mars in the fourth quarter of 1964, during the window that is open to us.

The Mariner Lander, a second and later phase of the planetary program, will be equipped to eject a capsule to the surface of Venus or Mars as the spacecraft flies by.

The landing capsule will be designed to obtain detailed information concerning the atmospheres of the planets, to observe the nature of the planet's surface and to detect if elementary life forms, as we know them, exist there.

The preliminary design of this second phase of the planetary exploration program will be completed during the coming year and then procurement of long leadtime systems will begin.

The earliest opportunity to launch the Mariner spacecraft with a landing capsule will be near the end of 1965 when Venus is in the optimum position for such a flight.

Space bioscience—The NASA's research activity in the life sciences is the responsibility of two program offices—Space Sciences and Advanced Research and Technology. The Office of Space Sciences is responsible for basic biological studies. The Office of Advanced Research and Technology is responsible for efforts pertinent to the support and utilization of man in aeronautical and space operations.

I will discuss the effort in the first area now, and will deal with the latter effort in connection with our advanced research program.

The areas of concern and the techniques utilized in the conduct of the space bioscience program are noted and illustrated on the next slide (fig. 25). Of concern are: The search for and the determina-

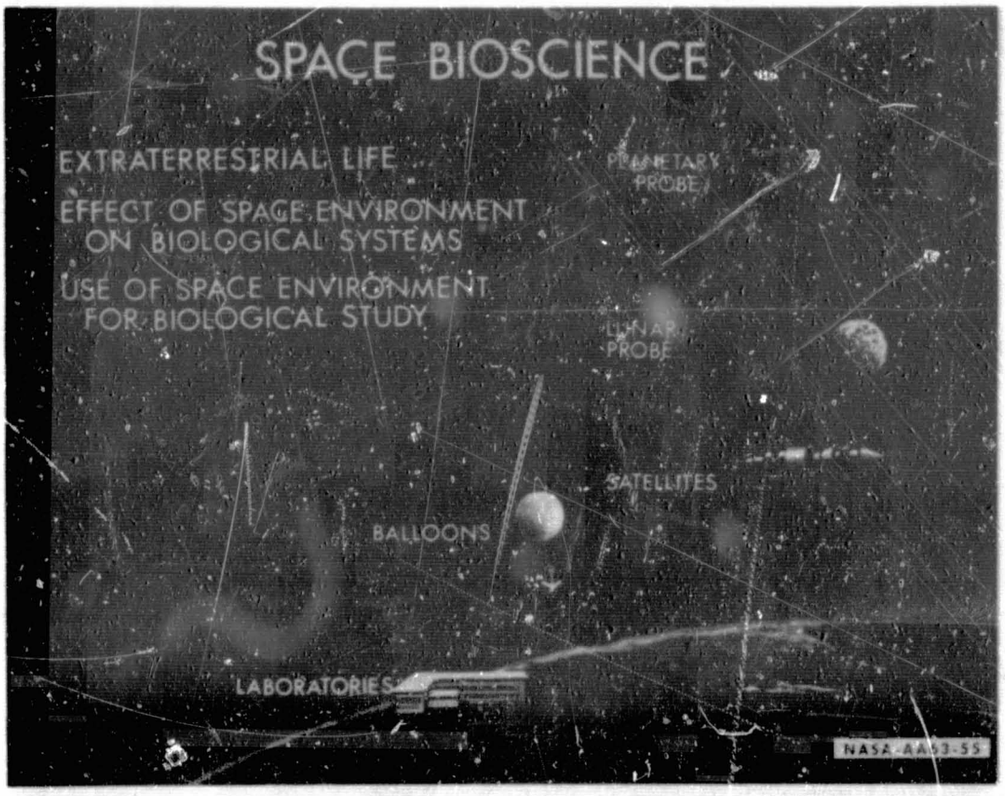

FIGURE 25

tion of the nature of extraterrestrial life; studies of the effects of space environments, including planetary environments, on biological systems; and the use of space environments for biological study pertinent to biological problems here on earth. Ground-based laboratories, balloon flights, unmanned and manned flights of satellites, lunar probes and planetary probes are the possible tools in this program.

Ground-based laboratories at universities, industry, NASA, and other Government agencies, in addition to supporting the bioscience flight programs are, and will continue to be, utilized for analytical studies and research related to developing an understanding of space bioscience. This understanding includes such matters as fundamental life processes on this planet and as they may exist on other planets; and the effects on life processes of space and planetary environments, such as radiation, gravity, and atmospheres.

Balloon flights have been used successfully to detect the presence and nature of bacteria in the upper atmosphere, and to expose specimen of brain and nervous system tissue to heavy cosmic rays for laboratory study. This type of activity will continue.

We are investigating the use of satellites to study effects of zero gravity and space radiation separately and in combination on biological systems. Such flight experiments are required because we cannot—at least as yet—duplicate these fundamental space environments on the ground. The spacecraft, which must be recovered after the

mission, must be able to support biological experiments for several weeks or more.

At this time we are in the process of initiating detailed studies, with several contractors, of space vehicle systems to satisfy these experimental requirements. These studies will permit us to evaluate the feasibility of unmanned satellites and if sufficiently promising will lead to an award of a hardware development contract.

We are also studying the possibility of utilizing the scheduled manned flights of Gemini and Apollo to further implement this program.

We will utilize flights to the nearby planets in our search for and study of extraterrestrial life. Landing on the moon with Surveyors will provide our first operational tests, away from earth, of some of the instrumentation techniques planned for our planetary flights.

The light and medium launch vehicles we need to carry out these and other NASA missions are shown on the next slide (fig. 26). In-

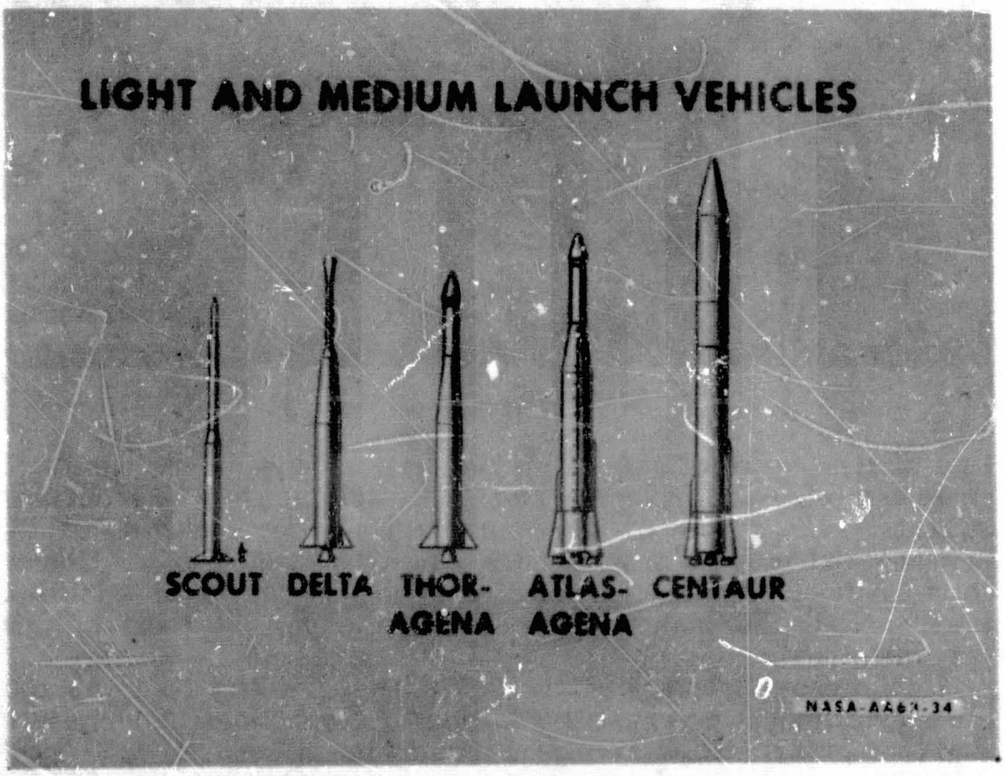

FIGURE 26

cluded are the Scout, Delta, Thor-Agena, Atlas-Agena, and Centaur. These vehicles can place in a 350-mile earth orbit payloads from 220 pounds for Scout to 8,500 pounds for Centaur. With the exception of Centaur, all the vehicles are already developed. We are, however, continually studying and applying improvements to increase performance and reliability of each of these vehicles.

Scout, the smallest of the launch vehicle family, completed development in 1962. All of its four stages use solid rockets. We employ Scout for a number of scientific payloads such as high altitude probes,

reentry experiments, and small satellites. The problems associated with this vehicle have been solved and the last four orbital attempts were successful. Improvements on the Scout during the past year have increased its payload capability in a 100-mile orbit from 150 to 220 pounds.

The Delta is a very reliable three-stage vehicle. The last 15 of a total of 16 launches have been successful. Telstar, Relay, Syncom, TIROS, and the Orbiting Solar Observatory are the principal payloads launched by Delta. Improvements on the Delta during the last year increased its payload capacity in a 300-mile orbit from 500 to 800 pounds.

The Thor-Agena is a two-stage vehicle used for space sciences and applications satellites which require polar orbits and are launched from the Pacific Missile Range. Alouette, the Canadian satellite, is the only spacecraft that NASA has launched with the Thor-Agena. Nimbus, the second-generation weather satellite now being developed, and the polar orbiting geophysical observatory will be the principal users of the Thor-Agena.

The Atlas-Agena is a two-stage vehicle which has so far been employed to launch the Ranger and the Mariner II spacecrafts. It will also serve to launch the astronomical and the eccentric orbiting geophysical observatories. The Atlas-Agena still is not as reliable as we require, since only three of the seven vehicles launched have performed well enough to permit the mission to be accomplished. However, NASA is cooperating with the Department of Defense in standardizing the Atlas and the Agena stages to gain Atlas-Agena reliability.

The Centaur consists of an Atlas first stage and a 10-foot-diameter high-energy upper stage, powered by 2 15,000-pound-thrust liquid hydrogen/liquid-oxygen A–3 engines that produce a total of 30,000 pounds of thrust. It will be used by NASA principally for unmanned lunar and planetary flights.

Based on the results of the first launch and subsequent studies, the configuration of the vehicle is being modified. During 1964 the Centaur program will place chief emphasis on extensive ground tests and developmental flights directed toward an operational capability in late 1964.

The development of the Centaur vehicle is important because it is an integral part of the development of liquid-hydrogen/liquid-oxygen technology contributing to the development of stages of the Saturn vehicle. It provides capability of launching many useful lunar and planetary payloads including the Surveyor and the Mariner B. We are studying the use of the Centaur coupled with the Titan II. Preliminary results indicate that the payload capability is increased 50 percent with no appreciable increase in cost.

Last year, the responsibility for the Centaur development and for procurement of the Atlas-Agena and Thor-Agena vehicles was shifted from the Marshall Space Flight Center to the Lewis Research Center. This was done so that Marshall could concentrate

fully on developing the large Saturn launch vehicles for manned space flight. With the capabilities of the Lewis Center focused on medium launch vehicles, all our launch vehicle programs are receiving increased attention.

Like other scientific endeavors, the space effort relies heavily on the universities. They are the main sources for the production, extension, and communication of new scientific and technical knowledge. In so doing, the universities intimately relate the training of people to the knowledge acquisition process of research. Thus, not only do they yield fundamental knowledge, but also the scientific and technical manpower to carry out the Nation's aeronautics and space program objectives.

Moreover, the universities are uniquely qualified to focus the thinking of multidisciplinary groups on the opportunities growing out of the space program. In this regard, NASA is encouraging universities to work with local industrial, labor, and governmental leaders to develop ways through which tools, materials, and techniques developed for space work can be utilized by nonspace industries and professions. Although this program is in its infancy, it holds substantial promise of furthering economic growth by means of feedback from our aeronautics and space technology.

In addition to this effort, NASA plans to support about 900 graduate students by the end of this year and 1,250 by the end of 1964.

The budget for the space sciences program is shown on the next slide (fig. 27). The budget estimate to conduct the program increased from $634.7 million in fiscal year 1963 to $836.7 million in fiscal year 1964.

SPACE SCIENCE

FISCAL YEAR 1964 BUDGET ESTIMATE

(IN MILLIONS)

	FY 62	FY 63	FY 64
RESEARCH, DEVELOPMENT AND OPERATION			
GEOPHYSICS AND ASTRONOMY	$ 119.8	$ 174.2	$ 232.6
LUNAR AND PLANETARY EXPLORATION	164.6	226.4	331.4
BIOSCIENCE	4.1	25.1	41.3
LAUNCH VEHICLE DEVELOPMENT	100.9	121.5	149.5
FACILITY, TRAINING AND RESEARCH GRANTS	13.5	31.7	56.4
TOTAL RD & O	$ 402.9	$ 578.9	$ 811.2
CONSTRUCTION OF FACILITIES	39.8	55.8	25.5
TOTAL SPACE SCIENCE	$442.7	$ 634.7	$ 836.7

NASA-AA63-35

FIGURE 27

The estimated cost of the geophysics and astronomy program, which includes the sounding rockets, small satellites, international projects and the large observatories, increased from $174.2 million in fiscal year 1963 to $232.6 million in fiscal year 1964. This increase is due mainly to the greater expenditures required for the orbiting observatories whose peak funding will be reached during fiscal year 1964.

The budget of $331.4 million for lunar and planetary exploration reflects $45 million for nine additional Rangers and $81 million for the initiation of full development of the Surveyor Orbiter and Mariner spacecraft that includes a landing capsule. The funds for the other projects remain nearly the same as fiscal year 1963.

The bioscience program, estimated to require $41.3 million, includes intensified development of hardware for orbital flights and development of instrumentation to detect and analyze evidence of extraterrestrial life.

The budget estimate of $149.5 million for launch vehicle development is mainly related to the Centaur vehicle and is associated with the additional testing required to improve reliability. Funds also are included for improving the performance of the Scout and Delta launch vehicles.

Facility, training and research grants refers to our support of the universities in training personnel and in providing facilities to enhance their training capability. The increased emphasis in this area during Fiscal Year 1964 is reflected by the budget estimate of $56.4 million.

Construction funds amounting to $25.5 million are required to support the space sciences program at three installations: The Jet Propulsion Laboratory, the Goddard Space Flight Center, and the Launch Operations Center.

For the Jet Propulsion Laboratory, we are requesting construction of a space flight operations facility, a development engineering building, and an addition to the material services building.

At the Goddard Center several new laboratories and test facilities are planned. These include facilities for a data interpretation laboratory, for a mechanical test and quality assurance laboratory, and for isolated testing of explosive and other hazardous components.

At the Launch Operations Center, we need an addition to the unmanned satellite operations building to support the growing launch activity of the space sciences, applications, and advanced research missions.

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APPLICATIONS

I would like now to discuss the applications program. The two flight development areas of this program—meteorology and communications—are illustrated on the next slide (fig. 28).

FIGURE 28

The objectives of the meteorological program are: development of meteorological satellites for providing worldwide observation of atmospheric conditions and storm centers, and the exploration of the atmosphere at altitudes of 20 to 150 miles as it relates to weather phenomena.

The purpose of the communications program is to provide the technology necessary to establish an operational communications satellite system, and to support the development and expansion of such a communication system through research, development, and flight testing of promising techniques and concepts.

NASA is directing some of its effort toward the identification of future application satellite programs. These efforts consist of studies on the use of a navigational satellite system for civilian use and feasibility studies on the requirements for a satellite system for gathering data around the earth.

In addition to the satellite projects, we have expanded our activities for the identification, cataloging, and the dissemination to industry of new ideas and innovations arising from the space program as a whole. Congress assigned NASA a major responsibility in the field of applications to expand human knowledge in the atmosphere and space so that results of our research and development could be utilized for the general benefit of all mankind.

In the meteorological field (fig. 29) two projects—TIROS and Nimbus—are currently active. As you are aware, the Nimbus will have one significant difference over TIROS—namely, it will be earth-

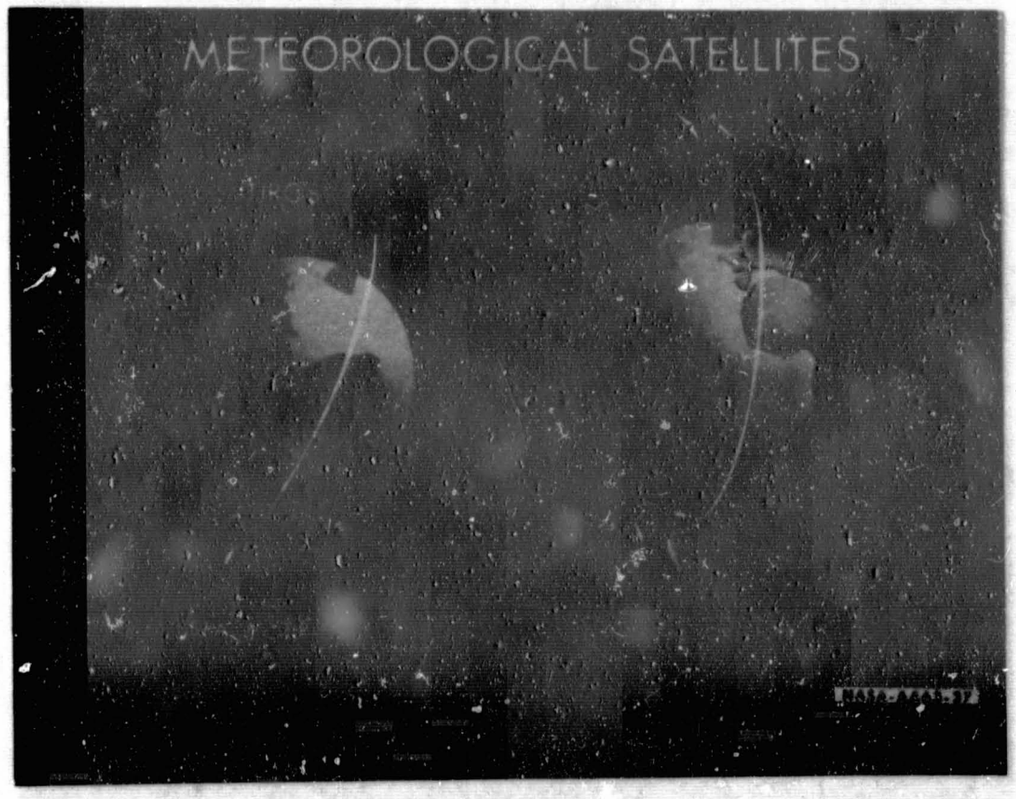

FIGURE 29

oriented rather than space-oriented. In other words, the cameras aboard Nimbus will always be directed toward the earth. Because TIROS is space-oriented, its cameras face the earth only part of each orbit. At other times, the cameras point out into space.

Six TIROS satellites orbited to date have provided the basis for development of Nimbus and for the joint NASA-Weather Bureau planning for an operational weather satellite system. Plans now call for five more development TIROS flights by NASA and two operational flights funded by the Weather Bureau. Three of the development flights will take place during the present calendar year and two in 1964.

Development of the Nimbus satellite continues. Prototypes of the major subsystems are now undergoing environmental tests. A total of four Nimbus development spacecraft are planned, with the first flight scheduled for late 1963. Successful flight testing of the development version of Nimbus will be followed by flights of operational Nimbus satellites.

For several years, NASA and the U.S. Weather Bureau of the Department of Commerce have been coordinating work in developing techniques for establishing the national operational meteorological satellite systems. Although the development satellites will be funded by NASA, the operational Nimbus will be funded by the Weather Bureau. For the operational Nimbus, NASA will launch the satel-

lites and acquire the data. The Weather Bureau will analyze and disseminate the data as well as establish the meteorological requirements for the systems.

The communication satellite program is illustrated in the next slide (fig. 30). Here, we see pictorially the passive satellite Echo, and the active satellites Relay, Telstar, Syncom, and Advanced Synchronous Orbit. The major portion of the NASA communications effort is directed toward active repeater satellites and related technology.

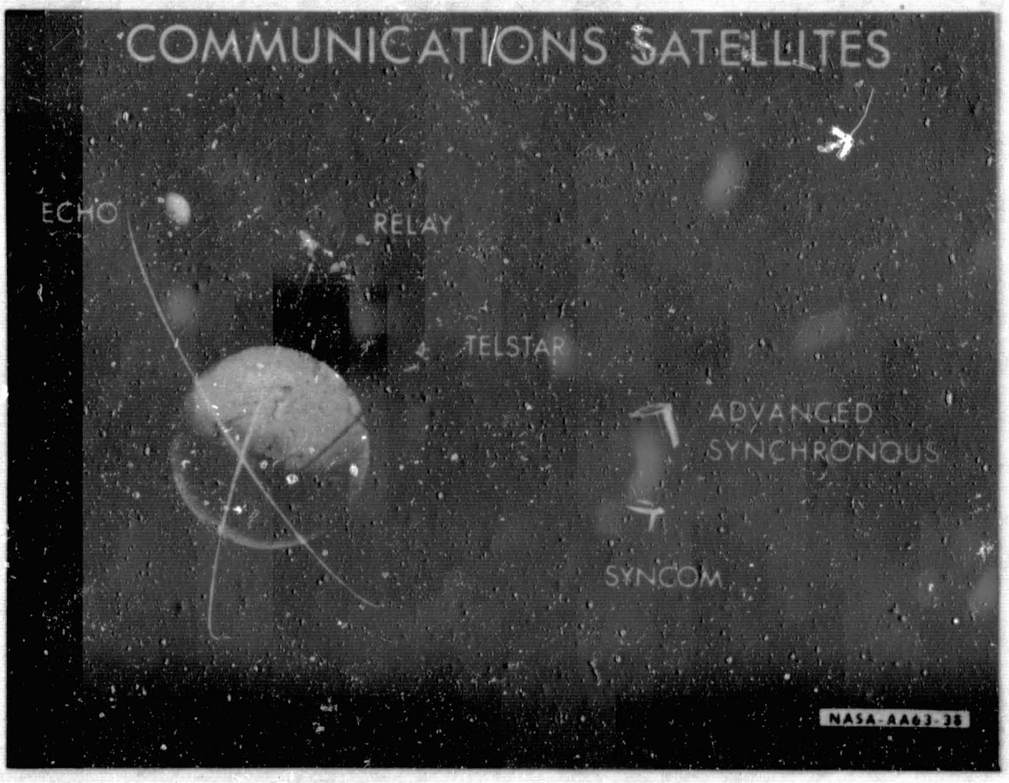

FIGURE 30

Of these, two of the four shown, Relay and Telstar have been orbited. Also the first Syncom was launched last month. The advanced synchronous orbit satellite project will provide a system similar in principle to Syncom—but with a greater communications capability. It will be placed into a synchronous near-equatorial orbit. Development of the critical components was initiated this past year and we plan to initiate the development of the complete satellite in 1963.

On July 10, 1962, NASA successfully orbited the Telstar communications satellite, developed and funded by the American Telephone & Telegraph Co. By the end of calendar year 1962, Telstar had participated in 426 tests during which television, telephone and facsimile reproductions were successfully transmitted back and forth across the Atlantic Ocean.

The original cooperative arrangement between U.S. and foreign governments for joint participation in these communications demonstrations was negotiated by NASA, working with the Department of State. NASA continues to supply all of the ground stations with pointing data for Telstar from our tracking network.

Relay is also a medium-altitude, spin-stabilized satellite. Relay I was launched December 13, 1962, into a nearly perfect, circular orbit. Trouble with the power supply aboard the satellite prevented communications experiments for about 3 weeks after launching. Later, our engineers found that a voltage regulator in the switching circuit was draining the power supply. In time, the trouble cleared enough for a signal to be sent from the ground to the spacecraft, shutting off the faulty circuit. Then, by switching over to a second transponder, in January of this year communications experiments via Relay were able to begin.

Forty-eight separate experiments were planned for Relay. Each of these have been performed successfully at least once. A total of 361 experiments have been performed. Of these, 88 have been between the United States and Europe, 22 between the United States and South America, 3 between Europe and South America, and 248 have been loop tests in which one ground station has both transmitted and received signals to and from the satellite. To date, communications experiments have involved the United States, France, Great Britain, Italy, and Brazil. Germany and Japan will participate later. Two additional Relay flights are scheduled.

The development of an active repeater satellite that can operate in a 24-hour, or synchronous, orbit is the objective of the Syncom project. If the satellite can be maintained in a 24-hour orbit, the satellite will be capable of continuous communication with nearly one-half of the earth. Syncom is the first known attempt at placing a satellite in a 24-hour orbit.

As an experimental satellite, Syncom is designed to flight-test a fairly simple, reliable approach to satellite attitude-and-position control. It should also give us valuable experience in launching satellites into the 24-hour orbit, using apogee kick rockets and existing launch vehicles. Finally, it should give us practical knowledge of the potential scope of communications systems in the space environment of a 24-hour orbit. The Syncom satellite is also spin stabilized.

Ground station arrangements for Syncom have been a responsibility of the U.S. Army Satellite Communications Agency. Radio commands from the USNS *Kingsport*, which is in the harbor of Lagos, Nigeria, control the movement of the satellite from the initial synchronous orbit injection position to its final position over the South Atlantic. Signals from the *Kingsport* also maintain the satellite in its final position and are used for communications experiments. The main ground communication station in the United States is provided by the Department of Defense. The station is located at Lakehurst, N.J., with a backup station at Fort Dix, N.J.

The first Syncom satellite was launched February 14, 1963. During the spacecraft's ascent to apogee range and range-rate data, voice, teletype, tones and music were transmitted through the spacecraft from the USNS *Kingsport*.

Shortly after the command signal to fire the apogee kick motor was transmitted to the spacecraft, the telemetry signal vanished.

Since that time, electronic contact with the spacecraft has been lost. Syncom has been observed with surface optical equipment. The period of Syncom about the earth is 23 hours 44.8 minutes, giving an eastward drift rate of 3.8 degrees per day. Investigations were started immediately following the launching to determine the nature of the electronic failures.

Since the United States currently has two intermediate altitude experimental communications programs in operation; namely, Telstar and Relay, and because the Department of Defense is planning an intermediate altitude program for its own communications system, NASA will direct its advanced communication effort toward the 24-hour satellites requirement rather than the intermediate.

It is yet too early to decide whether the ultimate communications systems will use the intermediate altitude or the high altitudes. The proposed advanced synchronous orbit satellite will incorporate several advances beyond the Syncom technology.

A major improvement will be in the communications equipment on board the spacecraft. Where Syncom uses a narrow band, and therefore limited, communication system, the advanced synchronous orbit satellite is designed around a wide-band system capable of handling a larger number of messages and in a greater variety of forms. The advanced synchronous orbit satellite will also have more highly directional antennas than does Syncom and this will permit more efficient transmission of signals. The type of stabilization system has not yet been determined.

In the area of passive communication satellite technology, the Echo II passive satellite—which will serve as an orbiting radio mirror from which signals are reflected between distant points on the earth's surface—is scheduled for launching into a near-polar orbit in mid-1963.

Echo II is a rigidized sphere, 135 feet in diameter, weighing approximately 500 pounds. It is 35 feet greater in diameter than Echo I which was launched August 12, 1960, and is still in orbit but of little communication value due to the distortion of the sphere.

This size increase, along with its more rigid structure, should result in a communication transmission capability at least twice that of Echo I. In addition to Echo II, NASA will continue in the research and development of ejection and inflation systems for passive satellites along with research on structures and materials. The object of this effort is to devise techniques for erecting structures in space with more efficient reflective characteristics.

Budget for applications: The estimated funding for the applications program is set forth on the following slide (fig. 31).

APPLICATIONS
FISCAL YEAR 1964 BUDGET ESTIMATE

(IN MILLIONS)

RESEARCH, DEVELOPMENT AND OPERATION	FY 62	FY 63	FY 64
METEOROLOGICAL SATELLITES	$ 39.7	$ 64.3	$ 73.1
COMMUNICATION SATELLITES	35.5	49.0	55.8
ADVANCED APPLICATION SATELLITES	0.1	1.0	1.6
INDUSTRIAL APPLICATION	0.9	3.8	6.1
TOTAL RD & O	$ 76.2	$ 118.1	$ 136.6
CONSTRUCTION OF FACILITIES	–	–	4.1
TOTAL APPLICATIONS	$ 76.2	$ 118.1	$ 140.7

NASA-AA63-39

FIGURE 31

The increase in costs of the meteorological satellite program, from $64.3 million in fiscal year 1963 to $73.1 million in fiscal year 1964 results primarily from the increase in Nimbus development funding to its peak level during fiscal year 1964.

In the communications area about $41.1 million of the total communication satellite program cost of $55.8 million is associated with development of the new Advanced Synchronous Orbit Satellite.

Future applications satellite studies are $1.6 million in fiscal year 1964.

Industrial applications estimated at $6.1 million for fiscal year 1964 refers to the studies and work toward industrial applications of technology developed in the course of carrying out the entire NASA program.

The facility funds of $4.1 million are for a building at the Goddard Space Flight Center to consolidate and expand the spacecraft assembly activities.

The total estimated budget requirement for applications is $140.7 million as compared with $118.1 million in fiscal year 1963.

ADVANCED RESEARCH AND TECHNOLOGY

Now, I would like to direct your attention to the advanced research and technology program.

The objectives of this program are the understanding of fundamental phenomena underlying aeronautical and space vehicle technology; reduction of complex theory to design procedures; systematic testing to obtain design data for aeronautical and space vehicles of the future; and the pioneering of carefully selected advanced subsystems to permit rapid development and engineering of future systems in the shortest possible time and at minimum cost.

The areas studied in the advanced research and technology program are shown in the first slide. They include space power, vehicle systems, electronic systems, human factor systems, nuclear-electric systems, nuclear rockets, chemical propulsion, and aeronautics (fig. 32).

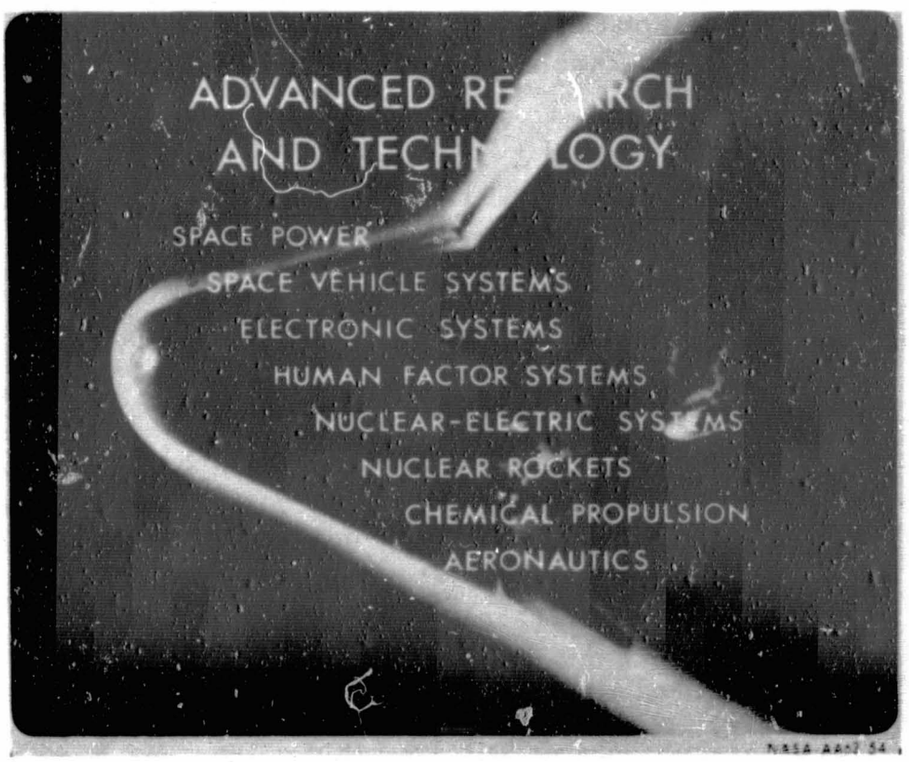

FIGURE 32

The work in these areas is supported by our basic research efforts in physical and mathematical science. For this presentation, the areas have been grouped into four broad categories as shown in the next slide. They are (shown in fig. 33):

(1) Propulsion, where investigations range from conventional chemical systems to advanced nuclear and electric systems;

(2) Space vehicles, which encompass reentry physics, vehicle structures, electronics and communications, and environmental factors including the integration of man in the systems;

(3) Space power, covering conventional solar systems, advanced chemical power generation and nuclear-electric systems; and

(4) Aeronautics, ranging from vertical/short takeoffs (V/STOL) to the supersonic transport and hypersonic aircraft.

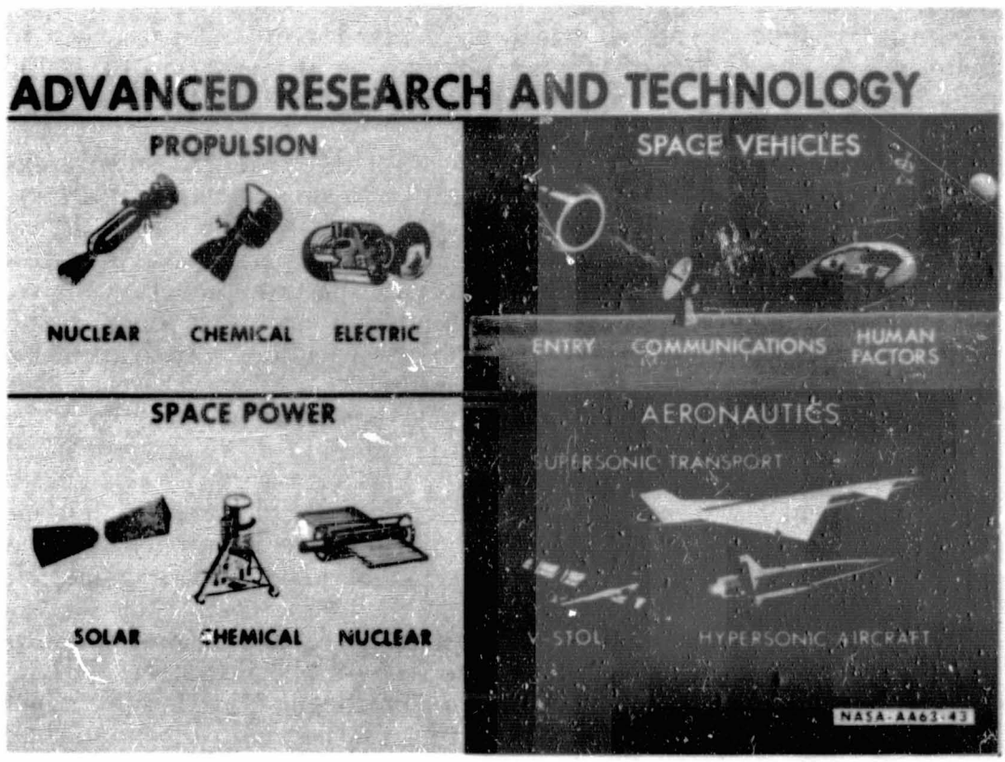

FIGURE 33

Propulsion: The propulsion program is a continuing and expanding program of basic research, component development and hardware flight testing. In nuclear propulsion, research effort is devoted to nuclear rocket components, systems, and operating problems other than those related to the reactor itself.

Reactor development is the responsibility of the Atomic Energy Commission. A major aspect of overall program is the development of the NERVA nuclear rocket engine under the joint efforts of NASA and the AEC.

The chemical propulsion program includes research on both liquid and solid systems. In the liquid propulsion area, continued effort is being expended on work related to combustion instability, experimentation with high energy propellants and new engine concepts.

In the solid propulsion area, work continues on solid propellants such as compounds containing boron, hot-gas valving for thrust vectoring control and start-stop control.

The electric propulsion program is aimed at providing the technology to develop arc-jet and ion engines. This work, which is done primarily in the laboratory, is to be supplemented by flight tests. Within the next few months we shall use a Scout to launch two ion-engines to obtain engine operation data and verify the ground facility test results.

Mr. FULTON of Pennsylvania. When will that be?

Dr. SEAMANS. The flight is scheduled for July of this year.

Mr. FULTON of Pennsylvania. I am interested in that.

Dr. SEAMANS. NASA's space vehicle programs are designed to identify and solve technical problems associated with the many aspects of present as well as future space missions.

For example, our knowledge of reentry physics at earth orbiting satellite speeds of about 17,000 miles per hour is fairly well understood.

Similarly, much progress has been made during the past year to increase our knowledge of reentry phenomena at speeds up to 24,000 miles per hour, the velocity at which spacecraft returning from lunar missions will enter the atmosphere.

Project FIRE, scheduled for flight late this year, will supply experimental information in this speed range to substantiate our analytical and ground-based research. Future work will be aimed at extending our research in reentry physics to speeds up to 31,000 miles per hour, which are associated with return from interplanetary space.

The possibility of damage from micrometeoroids is one of the hazards of space flight. Flight experiments are under way to appraise the probable damage to spacecraft materials and structures. Explorer XVI, which was placed in a near-earth orbit by a Scout in December 1962, is now providing significant data on micrometeoroid penetration.

As was mentioned earlier in the discussion of the Saturn launch vehicle, a large spacecraft to measure micrometeoroid impacts will be launched in 1964 as a piggyback experiment on a Saturn I launch vehicle.

This satellite will expose more than 2,000 square feet of surface area, contrasted to an area of 25 square feet for the Explorer XVI.

In space vehicle communications, a significant step forward has been made with a greater understanding of the radio blackout that occurs during reentry. You may recall that this blackout causes us to lose radio contact with our Mercury astronauts during their entry into the earth's atmosphere at the specific part of the flight which experiences the maximum heating rate. Recent knowledge obtained in that area has indicated techniques that may be employed in future spacecraft to eliminate the communications blackout.

It has been estimated that approximately 70 percent of all spacecraft costs go into electronic systems development. We feel that a concerted research and development effort in the field of electronic systems is required for our rapidly expanding space programs. As I have already noted, we propose to establish a new NASA Electronic Research Center in the Boston area. The center will provide the space effort with a focal point for advanced research and technology not only in electronics but also in related physical disciplines as applied to the space activities. Here, we plan to do research in communications systems, solid state physics, energy conversion, guidance systems, instrumentation, control and information systems.

Human factors systems: Earlier I spoke of our space bioscience program. A companion activity is our human factors systems research and advance technology. Here we are concerned with man—his biological and physiological functioning, his interrelationship with machines, and his life support in aeronautical and space operations. Specifically, the program is devised to provide a better understanding of man's capabilities and limitations under specific operating conditions, to develop technology and design requirements for operational equipment—from space suits to atmospheric environmental control systems to food for space flight—and to achieve the best possible integration of man and machine. This is an area of considerable significance and will receive greater attention in fiscal year 1964. For this effort, we shall continue to draw upon the Department of Defense and other talents of the scientific community. Specifically for the Department of Defense, we are programing about $1.4 million this fiscal year for supporting part of our research and technology program. For example, the Naval Medical Research Center is conducting studies of the implication of space operations on physiological performance, and Brooks Air Force Base is investigating the effects, on man, of prolonged exposure to a 100-percent oxygen atmosphere. This level of program, or greater, will be continued in fiscal year 1964.

Space power: In the general category of space power, our objective is to identify processes by which electricity may be generated in space vehicles and to design and develop lightweight systems with predictable useful lifetimes. Solar energy converted by solar cells and stored in batteries has been the main source of power in our spacecraft to date. We shall continue working to minimize the effects of radiation and thus increase still more the lifetimes of solar energy systems.

We have developed chemical power systems such as fuel cells that show great promise. In fact, the results have been sufficiently encouraging that hydrogen-oxygen fuel-cell power systems are planned for Gemini and Apollo. These systems will be far lighter than the battery storage system currently used for the Mercury spacecraft. Future work in this area will be aimed at further improvements of fuel cells and the development of other promising concepts for generating power in space with lightweight chemical systems.

Perhaps the widest range of electrical output for any spacecraft power system is that generated by nuclear sources. The potentialities range from watts to megawatts. Much NASA research in this area has been applied to development of a 30-kilowatt turboelectric system, known as SNAP–8. We shall continue working toward the development of a flight-rated system, having a long life to provide high power for various space applications.

A large portion of the research and development effort will be directed toward obtaining the technology required for megawatt power-generating systems. This is the work which will establish the criteria leading to the development of long-life nuclear electric systems. The NASA/AEC/DOD have established an agreement for developing systems delivering from 300 to 500 kilowatts. In accordance with the agreement, NASA will provide technological information, DOD will provide military requirements and flight testing and AEC will be responsible for managing the development.

Aeronautics: The aeronautics program is a continuing activity of theoretical and experimental research in the many disciplines asso-

ciated with all aircraft. The research is conducted throughout the flight range from hovering flight to hypersonic speeds. Thus, data are obtained for vertical takeoff aircraft, supersonic aircraft, and hypersonic aircraft as well. The aeronautics program includes work in such areas as air breathing engines, wing and fuselage configurations, controls, air loads, structures, materials and operating problems.

Historically, NASA has provided both military and civilian airplane designers with the necessary research data to select the best design approaches to meet their needs and to shorten development time. An example of our work in aeronautics is the highly successful X–15 project which has made over 70 flights to date.

Some of the research in the coming year will provide aerodynamic data on supersonic flight that will assist in selecting design for such craft as a supersonic transport.

Recently, NASA selected two aircraft manufacturers to conduct concurrent 9-month studies to determine the practicality of four types of aircraft embodying different design concepts for a supersonic transport. These concepts were derived from NASA work over the past years. The studies are expected to provide a basis for evaluating the advantages and disadvantages of the different configurations by considering such items as airworthy requirements, structures, and operating problems. These studies will also serve as guides to help define supersonic transport problems requiring additional NASA research.

Nuclear rockets: Because a major portion of the NASA's advanced research and technology effort centers on nuclear rocket development,

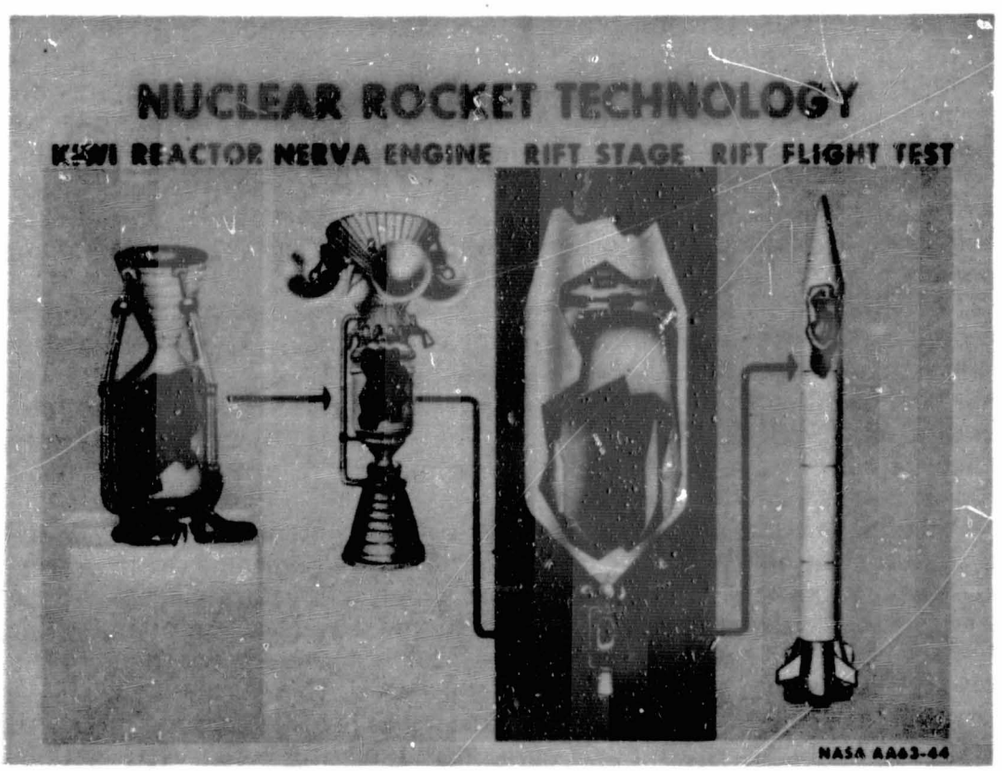

FIGURE 34

I should like to comment on this area in greater detail. This program's objective is to develop nuclear rocket engines that can be placed in service in the Nation's space program. The progression of our nuclear rocket technology from the KIWI reactor to RIFT flight test is illustrated in the slide (fig. 34, p. 88). The objective of Project KIWI—which is funded and manned primarily by AEC—is to provide the basic reactor design for use in the NERVA engine. NERVA stands for nuclear engine for rocket vehicle application. Initial tests of the KIWI reactor have demonstrated the materials technology necessary for rocket reactors, while current tests are intended to demonstrate specific reactor designs for the NERVA engine. In addition to maintaining technical liaison with AEC, NASA also supplies hydrogen propellant used in the KIWI project as well as turbopumps and nozzles for these tests.

The NERVA engine will incorporate a reactor design, based on the results of the KIWI reactor tests. Development of this engine will require solution of the pumping, control, piping, and exhaust nozzle design problems, along with integration of the reactor into the propulsion system. These investigations will continue along with component development. The rate at which this phase of engine development proceeds will be directly dependent on the outcome of the KIWI reactor tests.

Successful development of the NERVA engine will permit its integration into the RIFT (reactor in-flight test). Thus, RIFT nuclear stage development will be paced by the rate of progress on the NERVA engine which in turn—as mentioned before—is paced by KIWI reactor tests. Clearly, then, there will be no major component development for the RIFT nuclear stage until the KIWI tests are completed. However, conceptual stage design work has started and will continue through fiscal year 1964. Engineering data will be obtained on effects of radiation on typical vehicle components such as electrical and thermal insulation, bearings, seals, and lubricating materials.

This work will culminate in flight tests of the RIFT nuclear stage on the Saturn V launch vehicle. Because these tests depend on the KIWI test and NERVA development, a specific flight date cannot be scheduled at present.

The budget for the advanced research and technology program is shown on the next slide (fig. 35). We request that funds be increased from the $496.7 million authorized in fiscal year 1963 to $597.3 million for fiscal year 1964.

ADVANCED RESEARCH & TECHNOLOGY
FISCAL YEAR 1964 BUDGET ESTIMATE

(IN MILLIONS)

	FY 62	FY 63	FY 64
RESEARCH, DEVELOPMENT AND OPERATION			
SPACE POWER	$ 12 2	$ 18.3	$ 25.2
SPACE VEHICLE SYSTEMS	58.9	89.8	111.4
ELECTRONIC SYSTEMS	24 5	44.9	59.3
HUMAN FACTOR SYSTEMS	5 0	14.1	24.4
NUCLEAR-ELECTRIC SYSTEMS	38 2	61.1	89.6
NUCLEAR ROCKETS	38.0	89.2	118 9
CHEMICAL PROPULSION	17 2	25.1	35.1
AERONAUTICS	28.8	44.0	45.1
TOTAL RD & O	$ 222.8	$ 386.5	$ 509.0
CONSTRUCTION OF FACILITIES	37.9	110 2	88.3
TOTAL ADV RES & TECH	$ 260.7	$496 7	$ 597 3

NASA-AA63-45

FIGURE 35

The fiscal year 1964 budget for power sources for space is estimated at $25.2 million. These funds are needed to press on with our research on solar cells, thermionic power technology, solar engine technology, advanced batteries and fuel cells, chemical engines and on-board space power sources beyond the present state of the art.

The estimated increase in funds for space vehicle systems, from $89.8 to $111.4 million, is mostly due to the higher level of effort on the structures, heating, space environment and dynamics problems related both to launch vehicles and spacecraft. Initiation of a flight project on reentry heating at planetary return velocities is also reflected in these larger budget estimates.

The estimated increase of about $14.4 million in the funding level of the electronic systems program also reflects stepped-up level of effort in this area. Principal items on which increased emphasis is being placed include guidance, control, spacecraft communications, ground tracking and data acquisition.

The estimated increase in funding for the human factor systems program, from $14.1 to $24.4 million, reflects a nearly doubled activity. This work, which I outlined earlier, encompasses research on human reaction and performance under various environments and includes man-system integration, life support and protective systems and advanced concepts.

The proposed increase in the nuclear-electric systems funding from $61.1 million in fiscal year 1963 to $89.6 million in fiscal year 1964 reflects the increased effort in both nuclear-electric power and electric propulsion research and technology. Although the SNAP–8 development will be funded at the same level as fiscal year 1963, funding is required to begin design and fabrication of hardware for the SNAP–8 flight evaluation. Increased funding for the space electric rocket test (SERT) program, the flight testing of small arc-jet and ion engines, will also be required.

The nuclear-rocket program funding estimates go from $89.2 to $118.9 million, due to the increased activity described earlier when I discussed KIWI, NERVA, and RIFT.

In the chemical propulsion program, the proposed increase in funding to $35.1 million will support a greater level of effort in research in the areas of chemical propulsion, high energy propellants, advanced launch vehicle engine technology, and advanced spacecraft engine technology.

The cost of the aeronautics program is estimated to remain essentially constant at about $45 million. The major effort on aeronautics is concentrated in the in-house groundbased research and flight research.

The total budget estimate for research, development, and operation thus amounts to $509 million for fiscal year 1964.

A number of research facilities are provided for in the construction of facilities request of $88.3 million. They include a life sciences research laboratory at Ames Research Center, a hot-gas radiation research facility at Langley Research Center and a zero gravity facility at the Lewis Research Center. Development facilities in support of NERVA at the nuclear rocket development station include additions to the engine test stands; additions to the engine maintenance, assembly and disassembly building; and a facility for the handling, decontamination and storage of radioactive materials.

Included in these funds, is $5 million for acquisition of land and the initiation of design and engineering services for the new electronics research center. In addition, $10 million is needed for the advanced facility planning and conceptual design required prior to the request for such new facilities.

Combining the budget estimate for the construction of facilities with that for research, development, and operation gives a total of $597.3 million for advanced research and technology.

Tracking and data acquisition: The major element supporting the space flight programs is the worldwide tracking and data acquisition

system. Space flight missions requiring tracking and data acquisition as shown on the next slide (fig. 36) include earth orbiting manned and unmanned spacecraft, lunar, planetary, and deep space flights.

FIGURE 36

The tracking and data acquisition system must support a variety of present and future orbital missions, lunar missions manned and unmanned, and planetary and deep space probes. Thus, we must not only have many stations around the globe but these stations must be versatile enough to do many things with great accuracy. They must track spacecraft, transmit and receive telemetry, and be able to transmit commands to the spacecraft and provide for two-way voice communication with manned vehicles.

The tracking function is of great scientific importance because it is necessary to know the exact location in space at a given time in order that the data can be properly interpreted.

Precise tracking of orbiting communications satellites is essential so that antennas on the surface can accurately fix on them for maximum reception. Continuous voice communication is a requirement for manned orbiting spacecraft such as those in Project Mercury and Gemini. The early Saturn I flight tests of the Apollo command module, unmanned, require complete command of capsule operation from the ground stations. Most data of these types are acquired from stations with relatively small antennas with diameters ranging from 25 to 40 feet.

When a spacecraft is fired on a course to the moon, precise tracking is required to verify that the acceleration imparted to the spacecraft by the injection rocket is exactly that needed for the mission. Midcourse corrections of unmanned lunar and planetary probes depend on calculations from ground computers and these calculations must be based on data transmitted from the spacecraft.

Information for inserting the unmanned probes in orbit around the moon requires a higher degree of precision. These unmanned lunar missions as well as lunar activities associated with Project Apollo, require stations with the large 85-foot antennas.

As already noted, the recent Mariner II Venus fly-by established a distance record of 54.3 million miles for communications. Although the 85-foot antenna stations were adequate for Mariner II, deep space probes of the future will transmit over greater distances from earth and will send much larger quantities of data. This will require even larger antennas. One such antenna, which will be 210 feet in diameter, is being developed at the Jet Propulsion Laboratory.

The next slide (fig. 37), spots the locations of the major stations comprising the three NASA tracking and data acquisition networks; the manned space net, the deep space net, and the satellite net. The yellow cross-hatched areas show the general locations of the new facilities planned for fiscal year 1964. These facilities are needed primarily for the manned lunar exploration program.

FIGURE 37

The manned space stations, indicated by square symbols, follow Mercury trajectories across the Southern United States, lower Africa, and Australia. The deep space net stations, indicated by the red dots, are in Woomera, Australia; Goldstone, Calif.; and Johannesburg, South Africa. The satellite net stations indicated by circles, extend from Alaska to South America and from Australia to Europe.

Three ships, one in the Atlantic and two in the Indian Ocean, are used as floating tracking stations. In the Atlantic after launch, as the spacecraft is gaining altitude, it must be tracked to obtain the information used to determine insertion into earth orbit. During this

time, the spacecraft is over the horizon from the Western Hemisphere stations but too low in altitude to be acquired by stations on the mainland of Africa. This is why a shipboard station in the Atlantic is employed.

The Apollo spacecraft, on the other hand, will be over the Indian Ocean when it is injected into the lunar trajectory. Because the position of the spacecraft at the injection point varies so much with time of launch, two ships will be needed in the Indian Ocean to assure coverage. These will be fully equipped with special systems peculiar to Apollo and will be completely integrated with the entire network supporting Apollo lunar missions.

Tracking during the lunar transfer trajectory and communication with the spacecraft as it orbits and the lunar excursion module as it lands on the lunar surface will require more 85-foot antenna stations than now exist in the deep space net. The stations used for the lunar mission will be constantly in service from lift-off until the Apollo spacecraft returns to earth. During this period, these stations cannot be employed for any other purpose. Three new stations are requested for fiscal year 1964. The precise sites have not been selected. We have indicated on the map with yellow general areas in southern Europe, in the United States, and in Australia where it would be desirable to locate the new 85-foot antenna stations. Deep space net facilities will be used as backup should a failure occur in a station operation.

Budget: The budget for tracking and data acquisition, shown on the next slide (fig. 38), increases in fiscal year 1964 to $379.2 million.

TRACKING AND DATA ACQUISITION

FISCAL YEAR 1964 BUDGET ESTIMATE

(IN MILLIONS)

	FY 62	FY 63	FY 64
RESEARCH, DEVELOPMENT AND OPERATIONS	$ 83.8	$159.8	$261.6
CONSTRUCTION OF FACILITIES	35.1	36.3	117.6
TOTAL TRACKING AND DATA ACQUISITION	$ 118.9	$196.1	$379.2

NASA-AA63-42

FIGURE 38

The research, development, and operations cost increase to $261.6 million is primarily due to the fact that 4 new stations and 12 augmented stations will become fully operational in fiscal year 1964. Specifically, the satellite network will be modified to handle the high data output rates of our advanced, second-generation satellites. Most of the manned space net stations are being augmented in fiscal year 1963 to meet Project Gemini requirements. They will also be used for the Apollo mission. However, additional modifications, such as single multipurpose transponder systems and improved data handling and data processing equipment, must be added to meet the Apollo requirements.

The deep space net will be modified to meet the goals of the unmanned lunar and planetary programs planned in 1965. More sensitive receivers will be incorporated to improve data reception and antennas will be changed to receive information at a higher rate.

The satellite net will be changed to accommodate the larger quantity of data obtained and transmitted by future spacecraft. Improvements will be made in the data acquisition and command capabilities with addition of equipment that can measure distance and change in distance from earth. Equipment will also be added which lends itself to automatic recording and processing of large amounts of data.

In addition, special-purpose equipment to meet unique mission requirements is needed to assure proper telemetry coverage.

The estimated budget of $117.6 million for construction of facilities includes $90 million for the three tracking ships I mentioned a little earlier. Most of the remaining facility funds requested are for the three 85-foot antenna stations which I have also discussed.

Advanced studies: As part of our effort to place and maintain the United States in the forefront of space endeavors, we are continually conducting studies of possible future missions throughout all NASA program areas. Taken into account are the state-of-the-art accomplishments and long-range scientific and military desires and requirements. These studies help us to determine the best projects, starting dates, design concepts to be followed, and end objectives to be obtained. The facts permit management to consider expected requirements and to plan effectively for an aggressive and well balanced future space program. Some of the major studies are listed on the next slide (fig. 39, p. 96).

Under study is a large vehicle with payload capacity of two to four times that of the Saturn V. We are considering the use of solid as

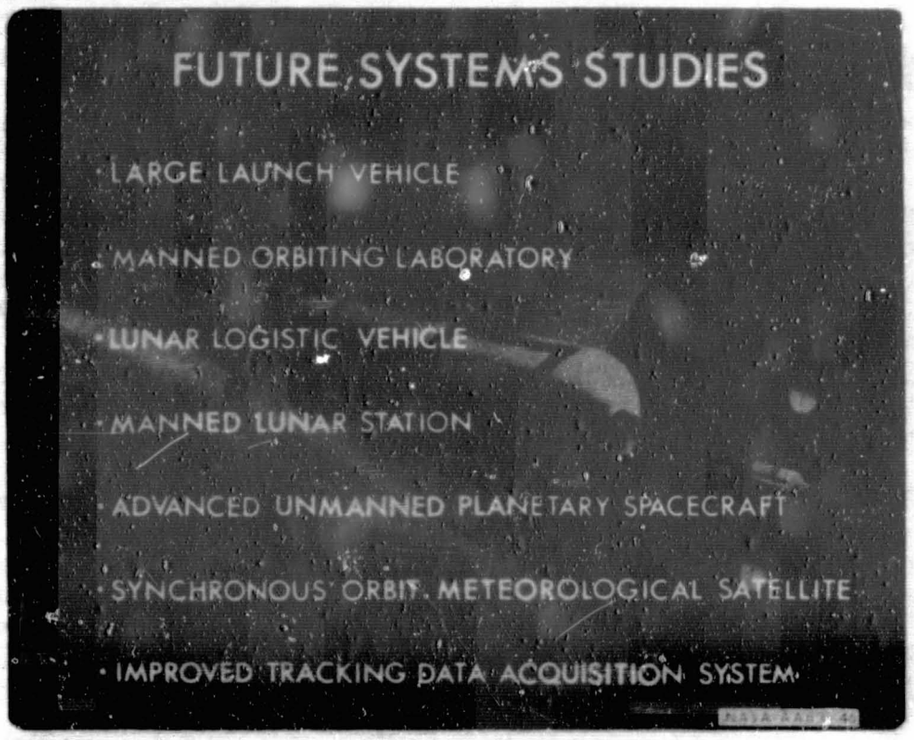

FIGURE 39

well as liquid propellants in the various stages of such a vehicle. This requires that engineering feasibility of solid rocket engines be demonstrated through full-scale tests. NASA has arrived at an agreement with the Department of Defense that the Air Force will provide funds and technical direction in this area. NASA's solid propellent launch vehicle studies are designed to provide information on the rocket-motor/launch-vehicle relationships that will influence the direction of the Air Force solid rocket development program.

The high specific impulse upper stages of such a vehicle might utilize either chemical or nuclear propulsion. Consequently, the effect on the M–1 or NERVA engines as well as advanced research with fuels other than liquid hydrogen directly contribute to these studies.

Manned earth orbiting laboratory concepts are being studied. The studies include consideration of the use of elements of Projects Gemini and Apollo. The possible uses of such a laboratory as well as the size, the configuration, and methods of supply are being studied. This laboratory may well be the first step to manned planetary flight. It will allow tests of men and space vehicle components for long periods, will allow development of assembly procedures in space, and should permit scientific investigations not possible with unmanned spacecraft.

In looking at possible growth of manned lunar exploration beyond Apollo, studies have been initiated on a logistic vehicle system to carry substantial payloads of shelter, life support equipment, scientific in-

struments, and lunar transportation systems to the moon. Such equipment could permit man to remain on the moon for several weeks or months, thus facilitating lunar exploration. Such studies also logically lead to considerations of a permanent manned lunar base.

In the area of unmanned probes, studies will be devoted to concepts of an advanced unmanned planetary spacecraft soft landed on the planets Venus and Mars. Some missions of these types may require the use of electric propulsion systems and other new technology currently being developed.

A synchronous orbit meteorological satellite would be useful to the Weather Bureau and is also under study. Such a satellite in synchronous orbit would be stationary over the surveillance area. Three or four such satellites spaced around the earth would give continuous monitoring of surface conditions and permit detection of short life disturbances such as cyclones, tornados, and thunderstorms.

Systems for gathering more and better information are constantly being studied to make tracking and data acquisition more accurate and reliable. We are reviewing a variety of new techniques for increasing antenna size, receiver sensitivity, and effective bandwidth to permit receipt of greater amounts of data and to operate at greater distances from the earth.

Studies such as these are directed toward providing us with a broad, vigorous program for continued development of manned flight in space, for further scientific exploration of space, and for future applications of space knowledge and technology to practical uses.

Total NASA budget summary: The total budget estimate for the program I have just reviewed is summarized on this slide (fig. 40).

SUMMARY FY 1964 BUDGET ESTIMATE

(IN MILLIONS)

	FY 62	FY 63	FY 64
MANNED SPACE FLIGHT	$ 923.2	$ 2,242.1	$3,758.2
SPACE SCIENCES	442.7	634.7	836.7
APPLICATIONS	76.2	118.1	140.7
ADVANCED RESEARCH AND TECHNOLOGY	260.7	496.7	597.2
TRACKING AND DATA ACQUISITION	118.9	196.1	379.2
TOTAL	$1,821.7	$3,687.7	$5,712.0

NASA-AA63-47

FIGURE 40

95-504 O—63—pt. 1——8

Estimated research, development, and operations costs are combined with the estimated costs of facilities for each program area. The effort proposed for fiscal year 1964, which is estimated to cost $5,712 million, is designed to provide this country with an effective, aggressive program in space and in aeronautical research.

The major increase of $1,521 million in the Manned Space Flight program is required to fund the Apollo spacecraft and associated launch vehicle development. The increase in the Space Sciences estimate reflects the effort to develop already approved orbiting observatories and the initiation of planetary spacecraft with entry capsules. The increase in the Applications area reflects the continued work on meteorological satellites and increasing emphasis on active communication satellites. The Advanced Research and Technology funding reflects a level commensurate with and essential to a growing development program. A portion of the increased funding is to support a greater effort on the NERVA project.

Organization and staffing: The estimated staffing requirements of the Agency for fiscal year 1964 are noted on the following slide (fig. 41). As you might suspect, the largest increment of personnel is

NASA STAFFING

	FY 62	FY 63	FY 64
MANNED SPACE FLIGHT	7,672	11,548	13,389
SPACE SCIENCES	2,638	3,174	4,002
APPLICATIONS	512	735	843
ADVANCED RESEARCH AND TECHNOLOGY	10,187	11,549	12,592
TRACKING AND DATA ACQUISITION	1,007	1,435	1,570
TOTAL	22,016	28,441	32,396

NASA-AA63-48

FIGURE 41

assigned to the manned space flight effort. The reason for the large number of personnel in advanced research is that a large percentage is done inhouse. We believe that we can accomplish the program I have presented with the size of staff proposed, 32,396. The requested increase in staff corresponds to a 14 percent increase as compared with a 55 percent increase in the budget. We believe that to operate with fewer people would prove detrimental to the proper conduct of the program.

To fulfill its broad responsibilities, NASA requires strong management. This past year our organizational lines were modified slightly to provide the definitive management required in the many areas related to field center operation. The changed organizational structure is shown on the next slide (fig. 42). As in the past, the program

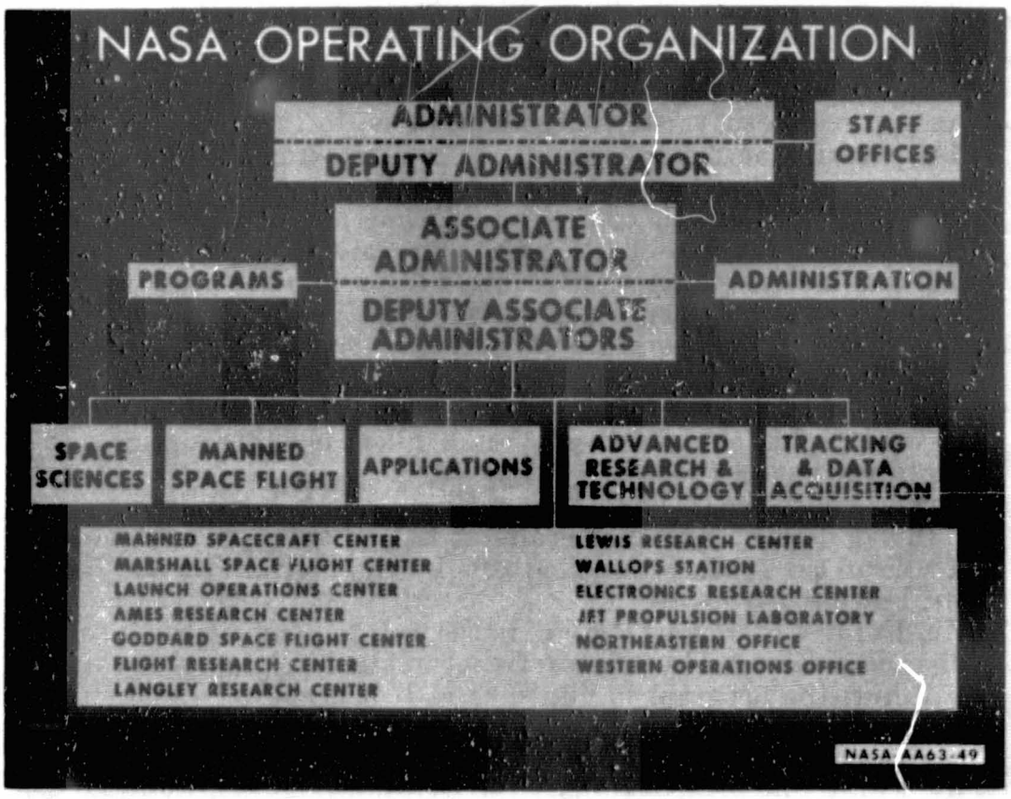

FIGURE 42

directors report directly to me, and the centers are responsible to the cognizant program offices for the conduct of their technical programs. At this time I wish to direct your attention only to changes from the previous lines of organizational responsibility.

The management structure of the organization provides for two Deputy Associate Administrators to support me in the management of the agency's field centers. Mr. Holmes, while maintaining his directorship of the Office of Manned Space Flight, has been made responsible for the institutional affairs of the development and operational centers primarily concerned with manned space flight. These centers are the George C. Marshall Space Flight Center, the Launch Operations Center, and the Manned Spacecraft Center. Institutional affairs include such matters as field center management, organization, staffing, general support facilities, and operating policies. The other Deputy Associate Administrator carries out similar activities for the remaining centers.

In addition, we recently established two Deputy Associate Administrator positions to assist me in carrying out NASA's extensive and vital external relationships. One of these positions is the Associate Administrator for Defense Affairs. This position is occupied by Adm. W. F. Boone (retired) who has extensive experience in both Government and industry. Admiral Boone is responsible for the

coordination between NASA and the DOD on the various activities of vital interest or involvement of both agencies. The last position that we established to strengthen the general management of NASA is that of Deputy Associate Administrator for Industrial Affairs. This position is occupied by Mr. Walter L. Lingle who has had extensive executive management experience in industry. Establishment of this position will provide a full-time member of NASA's general management team to focus on the nature and effectiveness of NASA's relationship with the U.S. industrial community.

As you see, positive steps are being taken to implement the broad and progressive aeronautics and space program under the direction of NASA.

I have discussed with you today the content of our programs, the direction in which we believe the programs must move, and the budget, which in our best judgment is required to progress as soundly and as rapidly as possible toward our national objectives in space.

Our program directors are prepared to bring you more detailed information in each area that I discussed.

The CHAIRMAN. Thank, you Dr. Seamans.

I have heard a lot about these 50-mile hikes, but this is some sort of a record you have set today.

As you know, the other representatives of NASA will be here to go into this in detail. The time is almost 12. If there are any questions that we can ask in the short time left, I will entertain them.

Mr. Fulton.

Mr. FULTON of Pennsylvania. Is the full amount of this proposal budget necessary and by necessary I mean absolutely necessary so that it will hurt the program in vital phases if it is cut?

Dr. SEAMANS. The budget is absolutely necessary to achieve the objectives that I have discussed with you this morning.

Mr. FULTON of Pennsylvania. And that objective is a well-planned, efficient space program that will make the United States preeminent in space; is that correct?

Dr. SEAMANS. Our objective is to have the United States preeminent in space, and this means to us preeminent in space science, in technology, and in flight operations. We believe that the manned space flight program, leading to a manned lunar landing draws much of this program together and gives it real focus. Approximately 75 percent of the NASA budget will really go into the manned lunar landing effort. However, there are important areas that are not part and parcel of manned lunar landing; namely, the communications and meteorological programs and the advanced research program.

Mr. FULTON of Pennsylvania. You have now come up with your last figure for closing the Mercury program. It now adds up over the period of years to about four times the original estimated budget for Mercury.

Likewise we find on the Apollo program and Gemini already some signs that the budget is increasing above estimates. Can you assure us, for example, that on the Gemini program we are not going to get into the same kind of estimates that have happened in the Mercury program, and, secondly, that if we budget these funds we won't be having so much reprograming that we are draining other necessary programs for the manned space flight program.

Dr. SEAMANS. I cannot guarantee that the cost of a program like Gemini will not be over the budget estimates.

Mr. FULTON of Pennsylvania. No, but you are fairly certain?

Dr. SEAMANS. I can only say that the estimates that we are discussing with you today and will discuss with you in your various subcommittees are our best estimates at this time of what the projects will cost, and we have attempted to take into account all factors in the project, and we believe that we have learned from our Mercury experience and the experience of other projects so that we are now including more of the costs that will be involved.

Mr. FULTON of Pennsylvania. We aren't faced with tremendous reprograming?

Dr. SEAMANS. So far as the reprograming, we have taken the position this year, and will continue next year, to reprogram where it is absolutely necessary but at the same time not allow, for example, a manned lunar landing effort to absorb funds from other projects to the point where these other projects become decimated.

We feel that the aeronautics program, for example, and the meteorological, and the communications, to mention three, are extremely important to the United States, and that even though these do not carry a DX priority that these should not be damaged by possible overruns in the manned flight area.

Mr. FULTON of Pennsylvania. And the boron program will not be decimated again this coming year by two-thirds?

The CHAIRMAN. Well, maybe.

I noticed, Doctor, when you got to page 66 of your report you had a sentence in here that you eliminated. You were speaking of tracking data and more efficient acquisition. In your prepared report you spoke of the possibility of using a Laser system being under study to improve accuracy of data from deep space. You did not pursue that? Are you doing anything in this field?

Dr. SEAMANS. Yes, we are. That statement actually is correct in the version of the statement that you have, but I felt that it was really too restrictive and I attempted to generalize my statements to point out that we are studying other techniques as well.

The CHAIRMAN. You are looking to this new technique?

Dr. SEAMANS. Yes, we are.

The CHAIRMAN. That is true but it holds some possibilities. I don't think anyone can say positively, but it certainly is worth while going into.

Dr. SEAMANS. I find that the people who know much more about it than I are most enthusiastic about the possibilities.

Mr. KARTH. Mr. Chairman, just one question.

Doctor, why are we developing a million-and-a-half pound thrust engine when we already have one that is developed?

Dr. SEAMANS. The million-and-a-half pound thrust engine, the M–1, is a high specific impulse upper stage engine and we find that the F–1 engine would not be suitable for upper stage application for a possible future Nova type vehicle.

Mr. KARTH. So your purpose of development is for an upper stage.

Dr. SEAMANS. That is correct.

Mr. KARTH. Which would be used on a Nova type vehicle.

Dr. SEAMANS. A Nova type vehicle will have a relatively low specific impulse first stage, which might be a large number of F–1 engines clustered together. The upper stage is the one where the high specific impulse makes a tremendous difference. Here we will want some form of high specific impulse chemical fuel or a nuclear stage.

Mr. KARTH. I understand that, Doctor; I was just wondering what you were going to use it for. That is all.

The CHAIRMAN. Any other questions?

Mr. Hechler.

Mr. HECHLER. Dr. Seamans, I am still not completely sold on the size of the staff NASA is requesting. I realize that you and others here have discussed the means that you are taking to insure greater reliability, to smooth out the scheduling, to have a checkout system, and you state that to operate with fewer people would prove detrimental to the program. We are going to get into this in a good deal more detail in the subcommittee, but I wonder if you could give us any more general assurance of what you are doing and have tried to do to keep the size of the staff from expanding so rapidly.

Dr. SEAMANS. The administration is taking strong measures to keep down the size of all Government agencies, including our own. The size of each agency is reported on a monthly basis directly to the President. Any increase in NASA must have the concurrence of the Bureau of the Budget. It is necessary for me and my staff to work very closely with the Bureau of the Budget to fully justify any increase whatsoever.

Similarly, in working with our center people, we recognize the problems associated with size, and that if our centers become too large they may become inefficient. We do our very best to determine where there is a real need for growth as opposed to a desire for growth just for growth's sake.

Our Office of Programs and Office of Administration make, on a continuing basis, a detailed study of the requirements of each center and get into all of the areas where manpower may be needed.

For example, we just completed a study of the Launch Operations Center where we had been doing a certain amount of work on contract. It involved about 250 people. It was the feeling of our own staff, and I believe has now been concurred in by the Bureau of the Budget, that we would have a more efficient operation, that would be less costly, if these people were on the civil service payroll, and we are proceeding on that basis. But these are matters that must be reviewed on an individual basis, and this is what we are attempting to do in a very thorough way.

Mr. HECHLER. Mr. Chairman, could I ask just one more quick question?

The CHAIRMAN. It is now 5 after 12. Go ahead, and Mr. Ryan has had his hand up.

Mr. HECHLER. I want to ask a question about Nova. I asked Mr. Webb last year if he thought that we had budgeted enough for Nova, and he said he thought we had, and then. as you know, that was taken out and I think there is sort of a feeling that we may not need this just yet. Are you sure, looking into the future, that we won't be in the same situation that was presented by the reduced size of the nuclear weapon which caused the confidence that we had a big enough launch

vehicle back in the mid fifties? Are you sure that we are not going to run into this same situation that we won't need Nova sooner?

Dr. SEAMANS. Well, that is the reason, of course, that we are spending some $30 million a year on the large solid, as well as approximately that same amount on the M–1 engine, feeling that these are the basic items that will be the building blocks for such a large vehicle.

We also have had two study contracts underway for, I think, approximately 9 months to detail the design of possible Nova configurations, and when I talked about these system studies this is what I was referring to.

We are also looking at it from the other standpoint; namely, what the possible requirements are for such a large vehicle, looking at potential manned flight to the planets, scientific investigation, as well as possible military application. So we are doing our best not to get caught short as we were in the past.

Mr. HECHLER. Thank you.

The CHAIRMAN. Mr. Ryan.

Mr. RYAN. Dr. Seamans, returning to Mr. Hechler's first question, I am concerned and have been that in your effort to hold down the size of your staff and personnel that you are contracting for services with corporations outside and thereby increasing the overall cost of the program. This goes back to the Bellcomm contract and the G.E. contract. Now can you tell us what the cost per year is of the Bellcomm contract as it exists today?

Dr. SEAMANS. I can't give you the exact amount. I think it runs around $10 million.

Mr. WYATT. I am not sure.

Dr. SEAMANS. We will have to give that to you and put it in the record. It is of approximately that magnitude.

Mr. RYAN. Ten million dollars a year.

Dr. SEAMANS. Approximately, yes; and, of course, this is providing us with an extremely important service to our system office and headquarters here.

The Bellcomm contract is estimated to be $7.9 million in fiscal year 1963 and $12 million in fiscal year 1964.

Mr. RYAN. I understand that, but at the same time I was convinced last year that you could accomplish the same result inhouse at a much less expenditure of funds by hiring directly the systems engineers, and I ask this question: Did you this year in presenting your estimates to the Budget Bureau attempt to compute what it would cost to have those systems engineers inhouse?

Dr. SEAMANS. Systems engineers are in very great demand. We are attempting to build up the inhouse competence under Dr. Shea. We have an understanding with Bellcomm that at such time as we can build up sufficient competence and get over this very great peak demand on our system group that Bellcomm will be phased out and it will become entirely an inhouse operation. That is a complete understanding that we have with Bellcomm.

At the moment it would really be quite academic to cost out the carrying out of this work on an inhouse basis, because we could not hire sufficient inhouse competence to handle the job that we face today. We also have, in going to Bellcomm, a flexibility that we would not have otherwise; namely, the use on a part-time basis of people

in the Bell Telephone Laboratories. So we feel that the use of Bellcomm is permitting us to start with maximum drive and energy on this manned lunar program and we could not do it any other way.

Mr. RYAN. Could I ask this question about the G.E. contract: What is the cost of that per year?

Dr. SEAMANS. Now, that is a program that will show a much greater increase than the Bellcomm because it does involve hardware. The Bellcomm does not involve any hardware. It is entirely the conduct of special studies as assigned by Dr. Shea and his group.

Mr. RYAN. Does not the G.E. contract break down into two parts?

Dr. SEAMANS. Yes, G.E. breaks down into two parts. One is the reliability and documentation and general effort of that sort that is associated with the mating of all of the elements of the space vehicle and the reliability analyses of this integrated vehicle.

The other part is the responsibility for the automatic checkout of this total vehicle at Cape Canaveral, and this involves the design and fabrication of the hardware that will be in Complex 39 there at the cape.

Mr. RYAN. Well, can you provide for the record a breakdown of the cost of the two parts?

Dr. SEAMANS. I can provide it for the record.

Mr. RYAN. Can you estimate it?

Dr. SEAMANS. I will put in the record an estimated cost.

Mr. RYAN. I mean can you estimate it right now.

Dr. SEAMANS. The estimate right now for the G.E. program in fiscal 1964 I believe will run over a hundred million dollars, but I would have to check that to be sure.

(The information requested is as follows:)

The GE contract is estimated as follows for fiscal year 1964:

	Millions
Integration	$26
Checkout	91
Reliability	26
Total	143

The CHAIRMAN. Gentlemen, it is now 11 minutes after 12. If there are any other questions——

Mr. CHENOWETH. Mr. Chairman.

The CHAIRMAN. I don't want to cut anybody off, but Dr. Seamans has been talking for about 2 hours. I wanted to give him a little break, too.

Mr. CHENOWETH. Doctor, I want to commend you on this splendid statement, this splendid presentation. I think it is one of the most comprehensive and impressive I have ever seen and certainly you have a very efficient staff to prepare a statement like that. You have presented everything here in a very concise and convincing manner.

You are a good salesman, and you were preceded yesterday by another good salesman.

Dr. SEAMANS. I have a good product, Mr. Chenoweth.

Mr. CHENOWETH. I told him yesterday you have a good product, you are a good salesman, and it is just a question of whether we will have enough money to buy what you are selling right now that will determine whether you can make that sale.

Let me make this suggestion, Doctor, in all good humor: I wonder if it would be asking too much—I just make it as a suggestion for

what it is worth—to have this staff—it is a very efficient staff which has prepared this comprehensive report—to have the staff sharpen their pencils and do a little work on what would happen if Congress in its wisdom, or lack of wisdom, might decide on about a 10 percent cut for these different agencies, including yours, where that cut could best be absorbed without posing a great dislocation.

I just make that suggestion. I don't know what Congress is going to do. I know there is a great deal of discussion up here on this subject.

The President has indicated that he wants a tax cut. He says that is the No. 1 objective this year, and there are a great many who feel that we can't get a tax cut unless there is some reduction in Federal expenditures, and this agency, with the Department of Defense and foreign aid, are those that are prominently mentioned as where that cut would have to come.

I just mention that, Doctor, saying in the best of good faith here, that I think it might be well to have some of your people prepare such a statement, if it comes to that event. I don't know that it will, but there is that possibility.

Dr. SEAMANS. We will take your suggestion under advisement, but do not advise you to take that action.

Mr. FULTON of Pennsylvania. Could I have one comment.

The CHAIRMAN. Well, any others?

Mr. RIEHLMAN. I don't have any.

The CHAIRMAN. All right, we will let you close.

Mr. FULTON of Pennsylvania. I am sorry that you have left out the program for the structure of the universe on deep space probe radar telescopes, which might have used West Virginia possibly—I am adding that on.

The CHAIRMAN. The committee is adjourned.

(Whereupon, at 12:14 p.m., the hearing was adjourned.)

APPENDIX B

MARCH 23, 1963.

Hon. JAMES E. WEBB,
Administrator, National Aeronautics and Space Administration, Washington, D.C.

DEAR MR. WEBB: Reference the NASA fiscal year 1964 authorization request now under consideration by this committee.

In order to fully evaluate the construction of facilities portion of the authorization request, certain data in addition to those provided in the justification presentations will be required as indicated on the attached sheets. To preclude later submission of these data for the record following testimony by the appropriate witnesses, I consider it desirable that such information be submitted in advance as a means toward expediting our review of the program.

Accordingly, I would appreciate receipt of this information at the earliest practicable date, and in any event, no later than April 5, 1963.

Sincerely yours,

GEORGE P. MILLER, *Chairman.*

ITEMS OF A GENERAL NATURE—CONSTRUCTION—REQUIRING INFORMATION FROM NASA

1. Research, development and operations appropriations used for items of a capital nature required for the performance of research and development contracts. (Sec. 1c(i) Public Law 87-584, 76 Stat. 382.) Facilities costing in excess of $250,000 are reported to the Congress. No provision is made for reporting of projects costing less than $250,000.

Provide—(a) Summary of all fiscal year 1963 funds used for this purpose for facilities costing less than $250,000.

2. Maintenance, repairs, alterations and minor construction:

NASA estimate fiscal year 1963 (page A12-1 fiscal year 1963 budget estimate)	$11,694,000
NASA actual/estimated fiscal year 1963 (page OC 25-1, fiscal year 1964 budget estimate, vol. I)	17,424,000
NASA estimate fiscal year 1964 (page OC 25-1, fiscal year 1964 budget estimate, vol. I)	20,918,000

Justification indicates need for routine repairs and alterations plus new construction of an urgent nature which cannot await subsequent legislation for specific authorization. Projects are categorized as "minor" in nature, costing less than $250,000.

Provide—

(*a*) Statement of policies and procedures in effect (to include delegation of authorities) within NASA to control use of these funds.

(*b*) Summary of specific projects by location, facility and amount for which these funds were obligated, or are scheduled for obligation, during fiscal year 1963.

(*c*) Statement as to source of funds used to defray deficit between the $11,694,000 programed, and the $17,424,000 now required for fiscal year 1963.

(*d*) Basis for the fiscal year 1964 estimate of $20,918,000.

3. *Construction design and management.*—An in-house engineering capability exists at certain NASA installations to develop criteria, negotiate, award, and supervise architectural and engineering firms in the design of facilities, and to supervise and inspect construction. At other installations, these tasks are performed by means of construction management contracts, usually of the CPFF variety. At still other installations, the U.S. Army Corps of Engineers are employed for this purpose.

Provide—

(*a*) A statement of NASA policies and procedures with regard to these engineering services.

(*b*) A percentile cost of experience to date indicating a comparison of costs for accomplishing these services by the various means to include engineering, supervision and inspection, overhead, and in-house engineering burden rates for work by in-house means; work by construction management contract; and work by U.S. Army Corps of Engineers.

4. *Design criteria and construction standards.*—Section 1(f), Public Law 87-584, authorizing funds to be appropriated for fiscal year 1963, requires that NASA use design criteria and construction standards of the General Services

Administration, Navy Bureau of Yards and Docks, or the Army Corps of Engineers, to the fullest extent practicable, pending development of uniform criteria by NASA.

(*a*) Has NASA developed uniform criteria and standards for repetitive-type facilities?

(*b*) If not, when may this committee expect these criteria to be in effect?

(*c*) To what extent have the criteria of the three other Government agencies mentioned in the law been applied in developing the fiscal year 1964 program? (Provide list of projects contained in the fiscal year 1964 program for the record, to which existing standards and criteria were applied in project formulation.)

5. *Advance design funds.*—Provide a list of construction projects included in the fiscal year 1964 program to which advanced facility planning and design funds authorized in fiscal year 1963 have been committed.

Include location, project title, estimated project cost, and design funds committed.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION,
OFFICE OF THE ADMINISTRATOR,
Washington, D.C., April 22, 1963.

Hon. GEORGE P. MILLER,
Chairman, Committee on Science and Astronautics,
House of Representatives,
Washington, D.C.

DEAR MR. CHAIRMAN: The attached information is furnished in response to your questions, accompanying your letter to Mr. James E. Webb of March 25, 1963, which concern the National Aeronautics and Space Administration fiscal year 1964 authorization request for construction of facilities. We hope this information will be helpful to the committee.

Sincerely yours,

PAUL G. DEMBLING,
Director, Office of Legislative Affairs.

ITEMS OF A GENERAL NATURE—CONSTRUCTION—REQUIRING INFORMATION FROM NASA

Tab No.

1. Research, development, and operations appropriations used for items of a capital nature required for the performance of research and development contracts. (Sec. 1c(i) Public Law 87–584, 76 Stat. 382.) Facilities costing in excess of $250,000 are reported to the Congress. No provision is made for reporting of projects costing less than $250,000.

   Provide:

   (*a*) Summary of all fiscal year 1963 funds used for this purpose for facilities costing less than $250,000 ..... A

2. Maintenance, repairs, alterations, and minor construction:

   NASA estimate fiscal year 1963 (p. A–12–1 fiscal year 1963 budget estimate), $11,694,000 .....

   NASA actual/estimated fiscal year 1963 (p. OC 25–1, fiscal year 1964 budget estimate, vol. I), $17,424,000 .....

   NASA estimate fiscal year 1964 (p. OC 25–1, fiscal year 1964 budget estimate, vol. I), $20,918,000 .....

   Justification indicates need for routine repairs and alterations plus new construction of an urgent nature which cannot await subsequent legislation for specific authorization. Projects are categorized as "minor" in nature, costing less than $250,000.

   Provide:

   (*a*) Statement of policies and procedures in effect (to include delegation of authorities) within NASA to control use of these funds ..... B

   (*b*) Summary of specific projects by location, facility, and amount for which these funds were obligated, or are scheduled for obligation, during fiscal year 1963 C

   (*c*) Statement as to source of funds used to defray deficit between the $11,694,000 programed, and the $17,424,000 now required for fiscal year 1963 ..... D

   (*d*) Basis for the fiscal year 1964 estimate of $20,918,000 ... E

3. Construction Design and Management: An in-house engineering capability exists at certain NASA installations to develop criteria, negotiate, award, and supervise architectural and engineering firms in the design of facilities, and to supervise and inspect construction. At other installations, these tasks are performed by means of construction management contracts, usually of the CPFF variety. At still other installations, the U.S. Army Corps of Engineers are employed for this purpose.

Provide:

(a) A statement of NASA policies and procedures with regard to these engineering services.

(b) A percentile cost of experience to date indicating a comparison of costs for accomplishing these services by various means to include engineering, supervision and inspection, overhead, and in-house engineering burden rates for: Work by in-house means, work by construction management contract, and work by U.S. Army Corps of Engineers. F

4. Design criteria and construction standards: Section 1(f) Public Law 87-584 authorizing funds to be appropriated for fiscal year 1963, requires that NASA use design criteria and construction standards of the General Services Administration, Navy Bureau of Yards and Docks, or the Army Corps of Engineers, to the fullest extent practicable, pending development of uniform criteria by NASA.

(a) Has NASA developed uniform criteria and standards for repetitive type facilities?

(b) If not, when may this committee expect these criteria to be in effect?

(c) To what extent have the criteria of the three other Government agencies mentioned in the law been applied in developing the fiscal year 1964 program? (Provide list of projects contained in the fiscal year 1964 program for the record, to which existing standards and criteria were applied in project formulation.) G

5. Advance design funds: Provide a list of construction projects included in the fiscal year 1964 program to which Advanced Facility Planning and Design funds authorized in fiscal year 1963 have been committed. Include location, project title, estimated project cost, and design funds committed. H

Facilities of a Capital Nature Required for the Performance of Research and Development Contracts

Facilities approved under subsection 1(c)(i) of the National Aeronautics and Space Administration Authorization Act for the fiscal year 1963 whose estimated cost exceeds $250,000 are reported separately to the Congress in individual notification letters. Projects whose estimated cost is less than $250,000 and which are required for the performance of research and development projects at NASA installations are included in the listing of repair, alteration, and minor construction projects attached as a separate listing to this report. With the exception of the two projects listed below, all other fiscal year 1963 minor construction projects whose estimated cost is less than $250,000 and which are required at contractor plants for the performance of research and development contracts have been authorized as part of the facility packages in excess of $250,000 already reported to the Congress.

Location and project	*Amount*
Manned Spacecraft Center:	
Rehabilitation of Hangar No. 225 and Warehouse No. 229, Navy Auxiliary Airfield, El Centro, Calif	$149,800
Modification of hangar, Hanscom Air Force Base, Bedford, Mass	39,699
Total	189,499

[NASA Circular No. 107, Oct. 4, 1960]

PRIOR APPROVAL BY NASA HEADQUARTERS OF PROPOSED PROCUREMENTS AND MINOR CONSTRUCTION AND REPAIR PROJECTS

1. Purpose

This circular prescribes interim procedures for headquarters approval of proposed procurements and minor construction, repair and alteration projects (hereafter referred to as R. & A. projects) pending development of NASA fiscal regulations.

2. Applicability

The provisions of this circular are applicable to NASA Headquarters and field installations.

3. Scope

(*a*) The provisions of this circular establish procedures covering prior approval of projects and proposed procurements (as defined herein) formerly covered by the "requisition list" procedure in NASA Management Instruction 18–50.1 (par. 5 which has been deleted).

(*b*) This circular does not supersede or remove any requirements for Headquarters review and approval of—

(1) Contract approvals as required in NASA Procurement Regulations, chapter 18.

(2) C. & E. project activities.

4. Definitions

For the purposes of this circular, the following terms will apply:

(*a*) R. & A. project means any minor modification, alteration, repair or construction of a NASA facility, equipment, or related system whether funded by S. & E. or R. & D. appropriations individually or in combination.

(*b*) Proposed procurement means any proposed plan to obtain outside services incident to the operation, maintenance, or support of the installation.

5. Procedures

(*a*) *R. & A. projects requiring prior approval.*—Prior approval of R. & A. projects is required for:

(1) R. & A. projects involving a total estimated cost in excess of $50,000.

(2) R. & A. projects less than $50,000 involving significant alteration of the architectural appearance of a facility or related system, including, for example: new structures, demolition of existing structures, and laying of new or relocation of roads and parking areas.

(*b*) *Proposed procurements requiring prior approval.*—Approval prior to issuing an invitation for bid, request for proposal, or purchase order, as appropriate, is required when proposed procurement, regardless of total cost, involves:

(1) Personal services (excluding only renewals of existing housekeeping contracts such as for grounds keeping).

(2) Utilization of transport services or equipment.

(3) Lease or rental of real estate.

(4) Initial purchase or annual rental of automatic data processing equipment.

(*c*) *Submission.*—Requests for prior approval of R. & A. projects and proposed procurements will be submitted in memorandum form, in triplicate, containing a detailed description of the proposed project or proposed procurements, to the appropriate program director to be reviewed for conformance with assigned missions. If approved by the program director, the request will be forwarded to the Director of Business Administration for final headquarters action.

6. Approved requests

Each approved project will be assigned a specific number for follow-up purposes and identification. The requests indicating action taken by headquarters will be returned to the initiating installation through the office of the appropriate program director.

7. Rescision

Circular 103, September 12, 1960.

ALBERT F. SIEPERT, *Director of Business Administration.*

[NASA Management Manual, Circular 107, October 10, 1960]

MATERIAL TRANSMITTED

1. Circular 103 (reference 3–5) was revised to delete reference to Jet Propulsion Laboratory in paragraph 2 "Applicability." Requirements for renovations and alterations at the JPL are handled within the context of the JPL contract, NASw–6.
2. Circular 103 is canceled and superseded by Circular 107.

FILING INSTRUCTIONS

Remove Circular 103 (reference 3–5) and insert Circular 107. This transmittal sheet may be retained.

JUNE 9, 1961.

Memorandum for the Director, Office of Administration.
Subject: Modification of NASA Circular No. 107; Prior approval by NASA Headquarters of proposed procurements and minor construction and repair projects.
Reference: NASA Management Manual Instruction No. 256 dated June 5, 1961.
NASA Management Manual Instruction No. 257 dated June 5, 1961.

1. In accordance with the delineation of functions between the Office of Administration and the Office of Programs as prescribed by reference instructions, it appears appropriate to suggest that subject circular be modified to designate the Director, Office of Programs, as the organizational level for final approval of minor construction, repair, and alteration projects.
2. With your concurrence, I would like to advise the Program Directors of this change by memorandum with formal notification to follow by revision of Circular No. 107.

D. D. WYATT,
Director, Office of Programs.

Enclosure.
1. Circular No. 107.

Approved: with respect to items under 5a in Circular No. 107 providing a copy of each approved document is furnished to this office.

ALBERT F. SIEPERT,
Director, Office of Administration.

JUNE 15, 1961.

Maintenance, repairs, alterations, and minor construction (funded from the fiscal year 1963 "R.D. & O." appropriation)

Location and project	*Obligated or scheduled for obligation as of Feb. 28, 1963*
Ames Research Center:	
Aluminum shade screens for offices of airplane hangars and shops	$3,936
Installation of laboratory fixtures and equipment at Charleston Road bioscience laboratory	58,930
Concrete entrance for basement of instrument research laboratory	4,387
Gas cell calibration	9,342
Photographic laboratory paging system	1,966
Jet simulation air system for unitary wind tunnel	18,849
Installation of 50 conductor electric cable for 14-foot wind tunnel	3,733
Construction of protective partition in flight operation laboratory	25,183
Housing for maxitron 300 X-ray unit	10,372
Partitions for property and supply office	2,000
Acid storage building	5,250
2d story on heat transfer building for Space Science Division	120,500
Intercom system for administration building	6,500
High pressure air piping unitary wind tunnel	1,825
Safety ventilation in Butler Building used for research activities	2,540

Maintenance, repairs, alterations, and minor construction (funded from the fiscal year 1963 "R.D. & O." appropriation)—Continued

Location and project	*Obligated or scheduled for obligation as of Feb. 28, 1963*
Ames Research Center—Continued	
Pressure vessel for wind tunnel	5,569
Concrete foundation and slab at hypersonic tunnel	3,839
Compressor installation and piping for 6-ft. hypersonic tunnel	6,569
Underground duct installations for flight operations laboratory	2,875
Air conditioning for life sciences laboratory	2,460
Construction of engineering psychology laboratory	37,368
Arc-heated hypervelocity wind tunnel high-voltage instrumentation	5,689
Demolition of existing compressor foundation	1,981
Pit and floor modifications for fluid mechanics	1,837
Electrical work for biosatellite laboratory	17,318
Install heating, ventilation, and air conditioning for biosatellite laboratory	10,950
Biosatellite laboratory structure	30,064
Calibration laboratory for use with engineering psychology laboratory	5,190
Modification of old cafeteria for Pioneer project	24,335
Miscellaneous projects under $1,000	4,246
Repair and maintenance of heating, ventilating, and cooling systems	50,000
Repair and maintenance of electrical systems	16,000
Maintenance of buildings and structures	38,000
Maintenance and upkeep of grounds	23,000
Estimated projects for balance of the fiscal year	
Total	562,594
Flight Research Center:	
General storage warehouse	59,750
Paint spray building	28,100
Jet runup and aircraft park area	189,000
Resurfacing and blacktop	15,000
Air filter maintenance	1,000
Building modification	59,000
Elevator maintenance	1,000
Electric, plumbing, and air-conditioning services	84,000
Installation of ceiling and door repairs	1,000
Auto sprinkler system (warehouse)	17,000
Service, maintenance, and renovation of 500,000-gallon water storage tank	13,000
Air compressor for warehouse and shop	25,000
Lights in machine shop	8,000
Heating installation	2,000
Estimated projects for balance of the fiscal year	45,200
Total	548,050
Goddard Space Flight Center:	
Satellite tracking station	40,000
Optical tracking observatory	74,000
Ground-plane facility	85,000
Rehabilitation of Beltsville building	105,395
Installation of supplemental air-conditioning unit, raised flooring, and other alterations to the College Park building	52,200
Repair of sidewalks and stairways	19,890
Reconstruction and repair of roads	64,116
Electrical services	32,455
Maintenance of ventilating, exhaust, and air-conditioning systems	58,185
Miscellaneous alterations to buildings	159,729
Building alterations to accommodate computer equipment	13,825
Alterations, maintenance, and repair to leased space	29,000
Estimated projects for balance of the fiscal year	1,539,500
Total	2,273,295

Maintenance, repairs, alterations, and minor construction (funded from the fiscal year 1963 "R.D. & O." appropriation)—Continued

Location and project	*Obligated or scheduled for obligation as of Feb. 28, 1963*
Langley Research Center:	
Addition to loads calibration laboratory	78,000
Alteration to building at the impact basin	114,000
Shop and instrumentation building for the 41- and 60-ft. spheres	43,000
Addition to the analysis and computation building	30,000
Various small projects—$5,000 or less	53,000
Painting	100,000
Maintenance of utilities	90,000
General repair and building maintenance	210,000
Repair of roads, sidewalks, and parking areas	50,000
Estimated projects for balance of the fiscal year	120,000
Total	888,000
Launch Operation Center:	
Installation of alpha trainer in hangar D	20,809
Construction of interim Apollo warehouse	212,000
Design of test for autopilot and stabilizer laboratory	2,185
Modification to frame building in hangar D	7,225
Construction of parking lots	33,430
Construction of culverts	2,715
Construction of crew quarters control center	43,740
Miscellaneous partitions and electrical changes	4,883
Emergency interior lights	7,300
Relocation of generator room in hangar D	4,000
Installation of photographic lighting in hangar AM	7,040
Installation of raised floor for computer	8,300
Interior modifications to hangars	92,044
Assembly of prefabricated buildings for temporary office space	248,000
Theodolite building for Complex 37–B	22,000
Theodolite building for Complex 34	22,000
Construction of gyrostabilizer laboratory	40,000
Parking area for hangar AF	35,000
Construction of weatherproof shelter for launch Complex 17	53,000
Repairs and alterations to buildings and launching facilities	182,997
Maintenance of water and sewage systems	20,181
Maintenance and repair of roads and grounds	46,363
Maintenance of electrical systems	133,089
Miscellaneous painting, carpentry, and mechanical work	105,362
Maintenance and repair of air-conditioning systems and equipment	66,544
Estimated projects for balance of the fiscal year	163,400
Total	1,583,607
Lewis Research Center:	
Expansion and modifications of computer center	50,500
Demolition of frame structure on Guerin property	1,500
Turbine facility DeSite controls and piping alterations	65,000
Construction of temporary office space and warehouse storage building	195,000
Models preparation building extension	181,500
Expansion of cafeteria facility building	120,700
Construction of liquid hydrogen transfer and dewar storage site	34,500
Liquid metals components cleaning area	20,500
Reparation of room CW–12 engine research building for SNAP–8 research	1,382
Alteration of propulsion system laboratory high-pressure pumphouse	25,600
Modification to space propulsion chamber SNAP–8 simulator group	26,320

Maintenance, repairs, alterations, and minor construction (funded from the fiscal year 1963 "R.D. & O." appropriation)—Continued

Location and project	*Obligated or scheduled for obligation as of Feb. 28, 1963*
Lewis Research Center—Continued	
Modification to room W–10 engine research building and control room	29,150
Concrete base and drainage pad at the electric propulsion research building	340
Metal dividing wall at test cell W–6 engine research building	3,840
Modification to control room for test cell W2–B engine research building	18,000
Repair of roads, sidewalks, and parking areas	26,000
Roof repairs	15,000
Masonry repairs	10,000
Miscellaneous painting	183,000
Lawns, shrubbery, and landscaping	43,000
Minor building repairs	76,000
Estimated projects for balance of the fiscal year	41,900
Total	1,168,732
Manned Spacecraft Center:	
Interim thermochemical test facility, Ellington Air Force Base	81,316
Radiological calibration and waste storage facility at Clear Lake	55,800
Translation and docking simulation facility at Clear Lake	168,500
Arc-jet radiant heating and acoustical laboratory at Clear Lake	107,000
Image generation equipment building, Ellington Air Force Base	75,000
Rehabilitation of hangar building 276 for use of MSC flight research aircraft at Ellington Air Force Base	133,006
Modification to hangar building 135 for use by Technical Services Division at Ellington Air Force Base	85,824
Rehabilitation of building 338 for use by Flight Crew Operations Division for training purposes at Ellington Air Force Base	58,552
Rehabilitation of barracks buildings at Ellington Air Force Base being converted for use as office space, laboratories, and shops	627,966

Building No.:		Building No.—Con.	
15	$34,749	326	$19,919
122	2,219	328	487
129	1,144	330	16,911
203	119	331	17,761
205	20,135	332	18,806
212	28,035	333	13,847
222	29,880	336	18,879
223	3,884	339	30,221
224	1,445	340	36,958
226	773	341	34,083
227	13,640	345	19,448
233	2,589	347	380
234	2,740	348	740
239	170	349	1,325
240	100	350	784
241	14,674	363	110
265	185	364	8,739
316	1,141	365	12,381
317	52,300	384	275
318	52,302	388	240
319	40,784	389	240
320	43,120	431	25,128
323	1,344	643	2,832

Maintenance, repairs, alterations, and minor construction (funded from the fiscal year 1963 "R.D. & O." appropriation)—Continued

Location and project	*Obligated or scheduled for obligation as of Feb. 28, 1963*
Manned Spacecraft Center—Continued	
Repair to parking lots	32,573
Repairs and minor modifications to leased space including such work as the following: installing and moving of partitions, electrical, carpentry, plumbing, masonry, painting work, installation of doors, lights, electrical fixtures, test equipment, repairs to heating and air-conditioning equipment, tile flooring, etc.:	
Farnsworth Chambers property	137,258
Lane Wells property	339,384
Rich property	311,256
Houston Petroleum and Trade Center	2,507
East End State Bank	1,417
Stahl Meyers	28,127
Franklin development	117,416
University of Houston	131,262
Peachy Bldg	16,353
Canada Dry	97,683
Minneapolis-Honeywell	47,206
Office City	22,352
Veterans' Administration Bldg	106,842
Estimated projects for balance of the fiscal year	40,000
Total	2,824,600
Marshall Space Flight Center:	
Modify partition and lavatory of shop and laboratory facility	673
Modify communication facility building	3,955
Addition to wind tunnel building	10,023
Construction of visitors' control building	47,500
Addition to heat and air conditioning for blockhouse	22,849
Addition to photographic laboratory	1,577
Addition to pattern and engraving shop	959
Repair and modification to leased building	5,000
Modification of doors in structural fabrication shop	50,590
Modification of cafeteria in assembly shop	40,990
Modification of door in assembly shop	85,539
Modification of storage building	60,900
Modification of supply substore building	735
Air conditioning of cafeteria	2,500
Modification of flight simulator in Computer Division laboratory	133
Modification of office space in storage building	106,464
Modification of parking area for automatic data processing center	27,637
Modification of compressor room in Computer Division laboratory	14,079
Modification of office space in administration and engineering office	228,302
Modification of cleaning and processing line in surface treatment facility	14,351
Construction of support services office building	240,000
Modification of structural fabrication shop	79,024
Modification of test support building	297
Modification of communications facility	179
Modification of 2d floor of Computer Division laboratory	12,610
Construction of temperature and humidity control test unit	19,785
Modification of heating system in test unit	21,204
Modification of conference area in Test Division engineering building	16,000
Extension of welding shop in structural fabrication shop	20,725

Maintenance, repairs, alterations, and minor construction (funded from the fiscal year 1963 "R.D. & O." appropriation)—Continued

Location and project	*Obligated or scheduled for obligation as of Feb. 28, 1963*
Marshall Space Flight Center—Continued	
Construction of applied chemistry laboratory in engineering offices building	92,364
Drilling of elevator foundation holes in structural fabrication shop	2,000
Modification of space simulator chamber building	30,000
Modification of air-conditioning system in machine shop	30,000
Construction of liquid hydrogen trailer parking area	35,000
Modification of computer facility	150,000
Modification of office space in warehouse	245,000
Construction of parking area at maintenance division	40,000
Modification of elevator in astrionics engineering building	25,000
Construction of aircraft hangar	200,000
Construction of parking area at quality division	20,000
Installation of sprinkler system in automotive maintenance building	30,000
Installation of humidity control in electric shop	20,000
Modification of laboratory in beryllium facility	46,000
Construction of facility for S–IC stage liquid oxygen slosh test	45,000
Installation of evaluation area in structural fabrication shop	15,000
Construction of explosive-forming facility	23,000
Construction of Saturn mockup building	124,000
Maintenance and repair of roads and grounds	222,700
Painting of buildings and facilities	158,800
Reroofing of structures	40,300
Paving of roads and parking areas	18,900
Maintenance and repair of installed equipment	118,500
Maintenance and repair of utility system	412,900
Minor repair and alterations projects under $5,000	459,900
Estimated projects for balance of the fiscal year	582,297
Total	4,321,241
Mississippi Test Facility:	
Alteration of Rouchan house	5,700
Estimated project for balance of the fiscal year	----------
Total	5,700
Wallops Station:	
Construction of addition to assembly shop	245,000
X-band radar pad	20,000
Miscellaneous minor construction	40,000
Construction of bleachers	30,000
Construction of transmitter building	170,000
Construction of parking lots	20,000
Construction of telemeter building	250,000
Addition of office space in warehouse	35,000
Maintenance of buildings	165,000
Repairs to streets	20,000
Maintenance of dikes, seawall, and beach areas	85,000
Maintenance and repair to storm sewers and drainage systems	10,000
Renovation of range engineering building	135,000
Maintenance and repair of utilities	55,000
Rehabilitation of runway lights	104,000
Renovation of utility building	10,000
Renovation of office space for technical services research	65,000
Renovation of laboratory plating shop	10,000
Remodeling of hangar to provide office space	60,000
Renovation of photo laboratory of cafeteria building	35,000

Maintenance, repairs, alterations, and minor construction (funded from the fiscal year 1963 "R.D. & O." appropriation)—Continued

Location and project	*Obligated or scheduled for obligation as of Feb. 28, 1963*
Wallops Station—Continued	
Lawns, shrubbery, and landscaping	30,000
Road paving	20,000
Renovate dormitory	25,000
Remodeling of Aerobee launcher	225,000
Estimated projects for balance of the fiscal year	----------
Total	1,864,000
Western operations office:	
Office partitioning	5,000
Painting and redecorating	3,000
Estimated projects for balance of fiscal year	----------
Total	8,000
NASA Headquarters:	
Repairs and alterations to office space for moving and installing partitions, electrical outlets, and painting at the following buildings:	
Federal Office Building No. 6, 400 Maryland Ave. SW	55,000
1520 and 1512 H St. NW	11,300
801 19th St. NW	7,000
4th floor, 7th and D Sts. SW	500
Building L	800
1815 H St. NW	400
Repairs and painting to building L prior to occupancy	75,000
Estimated projects for balance of the fiscal year	----------
Total	150,000
Northeastern office:	
Alterations to rental space	1,015
Estimated projects for balance of the fiscal year	----------
Total	1,015
Total	16,198,834
Maintenance and repair of equipment, instrumentation, and vehicles not included in above	3,996,549
Amount to be reprogramed for purchase of equipment	478,000
Amounts included in above listing for minor construction projects funded from research and development program accounts	—3,249,383
Fiscal year 1963 column of fiscal year 1964 budget estimates for maintenance, repairs, alterations, and minor construction (vol. 1, p. OC–25)	17,424,000

The explanation as to source of funds used to cover the increase in the fiscal year 1963 requirements for maintenance, repairs, alterations, and minor construction of facilities can best be described by an excerpt from Dr. Seamans' statement during the posture hearings "* * * I would like to emphasize at the outset that a meaningful comparison between the operating plan and the budget request is best made in the context of the total program. During the time that elapsed between the preparation of the fiscal year 1963 budget in December 1961, and the final congressional action in September 1962, modifications of resource allocations became necessary as a consequence of the dynamic activity in our programs. Some of these changes were major, as for example our decision to use the lunar orbit rendezvous mode for the lunar landing program rather than the direct or Earth orbital rendezvous modes being considered at the time the budget was submitted in late 1961. Other changes of lesser magnitude resulted

from our continuous evaluation of the programatic impact of mission successes, mission failures, development breakthroughs, and unexpected developmental roadblocks.

"We considered all of these factors for fiscal year 1963 together with the reductions in the final appropriation bill, in arriving at an operating plan structured to meet current program needs. As a consequence, the operating plan represents the total evaluation of our program needs and priorities rather than a piecemeal patchwork of changes from an earlier budgetary base. Therefore, while we can explain the changes and the reasons for the changes in each project it is not meaningful to relate specific increases in resources for one project to decreases from others. * * *"

The fiscal year 1964 estimate for facility maintenance, repairs, alterations, and minor construction is $15,820,000, the remainder of $5,098,000 of the $20,918,000 subcategory on page OC 25–1 being for maintenance and repair of instruments and equipment.

The basis for the estimate is a projection by each installation director of the requirements to accomplish specific minor construction projects, costing less than $250,000, such as a hydrogen storage area at the Lewis Research; explosive storage facility, construction of road extensions, data transmission facility, modification of dynamic test stand, security vault annex, and an acoustical test laboratory at the Marshall Space Flight Center; addition to instrumentation building at the Langley Research Center; and facility alterations at the Ames Research Center to conduct life science projects. Maintenance, repairs, and alterations costs are projections of the amount required for upkeep of heating, ventilating, cooling, electrical and utility systems, roads and hardstands, building maintenance such as painting, reroofing and masonry, and upkeep of grounds. These latter costs are predicated on the most recent experience, making appropriate allowance for (1) the increasing number of facilities, (2) the aging of existing structures, and (3) changes in construction cost indexes.

Construction design and management costs

[Percent of project cost]

	Design and engineering services	Construction, supervision, and inspection	Total
In-house [1]	5.8	3.6	9.4
Construction management contract [2]	7.9	5.7	13.6
Corps of Engineers [3]	4.7	6.1	10.8

[1] Because of the need to consider only completed projects if meaningful percentiles were to be developed, the cost experience has been limited to 20 projects at 4 centers totaling about $55,000,000 approved in programs for the fiscal years 1957 through 1960. These projects vary widely in complexity and the sample, therefore, is considered reasonably representative. The percentiles shown include the costs for all architect-engineer services and all direct in-house costs which could be attributed to the individual projects for criteria development, design or design review, construction management, and construction inspection. The percentiles do not include overhead costs for the research centers or for NASA Headquarters since the NASA accounting system does not provide for collection and distribution of such costs to individual projects.

[2] These figures apply to construction at the Nuclear Rocket Development Station where facilities are being provided both by AEC and NASA. The Space Nuclear Propulsion Office at the Lewis Center is responsible for the development of criteria and design utilizing architect-engineer firms. The engineering services figures used cover only engine test stand No. 1 and the Engine Maintenance, Assembly and Disassembly Bldg., both highly complex projects, totaling $29,182,000 in estimated construction cost. Construction management and inspection are performed under AEC contract with the Catalytic Corp. NASA participates in this contract. The percentile figure of 5.7 for construction supervision and inspection covers $6,100,000 of work put in place. The percentile figures do not include NASA or AEC overhead.

[3] Includes 6 months cumulative costs through the 2d quarter of fiscal year 1963 and covers the Jacksonville, Mobile, Fort Worth, Los Angeles, Sacramento, and Albuquerque districts performing work for NASA. The construction percentage covers costs for $22,000,000 of work put in place while the engineering services data has been compiled from over $108,000,000 of estimated cost projects. The corps cost system covers essentially the same costs in engineering services and construction supervision as the NASA system. The major difference is the inclusion of overhead. The 10.8-percent figure includes 0.2 percent and 1.6 percent overhead applied to engineering services and construction supervision respectively to cover the overhead for corps' district and division offices and the Office, Chief of Engineers. Overhead comprises fiscal, personnel, legal, safety, supply, and similar general office services which cannot be charged directly to specific projects. Thus, if corps costs are to be compared percentagewise with the NASA and construction management contract costs represented above, 1.8 percent should be deducted from the corps' figure leaving a net of 9 percent. However, for comparative purposes, it should be remembered that this 9 percent figure does not include required NASA overhead costs involved in processing and handling the corps' managed projects.

Design Criteria and Construction Standards

The National Aeronautics and Space Administration has taken a number of steps in implementation of section 1(f) of Public Law 87-584 which requires the establishment of NASA-wide uniform design criteria and construction standards. Beginning in July 1962, a systematic review of criteria and standards in use at major field activities was conducted. It was determined that the criteria and standards in use for project formulation and project execution at the Launch Operations Center, the Manned Spacecraft Center, the Mississippi Test Facility, and the Marshall Space Flight Center are basically U.S. Army Corps of Engineers criteria and standards modified as required to meet "state-of-the-art" developments, particularly for unique and highly specialized program-oriented facilities. At the older NASA centers such as the Lewis, Langley, and Ames Research Centers, criteria and standards in use for project formulation and project execution have been locally developed utilizing the Army Corps of Engineers, the Navy Bureau of Yards and Docks, and the General Services Administration criteria and standards as available and as appropriate to the specific needs of each center.

As a major step in the development of a NASA-wide uniform system of criteria and standards, an architect-engineer firm has been engaged to develop basic criteria and standards and outline specifications in a single handbook. Thereafter, as subsequent steps, selective guide specifications and engineering manuals will be developed where specifically required. This approach to development of a NASA-wide system tailors existing technology and organizes published material to fit NASA's requirements. By use of cross references, duplication of already widely distributed authoritative publications and the extensive existing body of design and construction knowledge will be minimized.

The NASA-wide system will be used as the basis for formulation of the fiscal year 1966 construction program and in the actual design of fiscal year 1965, 1964 and prior year projects to the maximum extent practicable.

It is the policy of NASA that facilities will continue to be designed on an austere basis using the established design criteria and construction standards of the Army Corps of Engineers, the Navy Bureau of Yards and Docks, and the General Services Administration to the maximum extent practicable until the NASA-wide system is developed.

Construction projects in the fiscal year 1964 program to which facility planning and design funds authorized in the fiscal year 1963 program have been committed

	Estimated project cost	Design funds committed
Ames Research Center:		
Administrative management building	$1,375,000	$71,000
Life sciences research laboratory	4,880,000	240,000
Space environment research facility	3,600,000	[1] 70,000
Flight Research Center:		
High temperature loads calibration facility	1,157,000	60,000
Goddard Space Flight Center:		
Meteorological systems development laboratory	4,103,000	170,000
Data interpretation laboratory	5,390,000	229,500
Jet Propulsion Laboratory: Addition to the space flight operations facility	1,000,000	54,800
Langley Research Center:		
Addition to the vehicle antenna test facility	1,758,000	73,300
Electronic instrumentation laboratory	2,850,000	[1] 109,000
Utility installations	1,249,000	[1] 70,000
Launch Operations Center:		
Utility installations—new area	23,755,000	117,000
Advanced Saturn supporting facilities	9,309,000	[1] 225,000
Cafeteria	899,000	[1] 26,000
Central instrumentation facility	31,508,000	[1] 260,000
Manned spacecraft facilities	6,512,000	[1] 225,000
Range instrumentation sites	4,823,000	[1] 25,000
Lewis Research Center:		
Alteration of the space power chambers	5,665,000	550,000
Addition to the spacecraft propulsion research facility (Plum Brook Station)	3,500,000	[1] 335,000
Manned Spacecraft Center:		
Mission simulation and training facility	2,216,000	147,000
Spacecraft control technology laboratory	6,106,000	278,000
Atmospheric reentry materials and structures evaluation facilities	2,915,000	[1] 220,000
Center support facilities	5,162,000	[1] 370,500
Launch environmental and antennas test facilities	7,482,000	[1] 217,000
Ultrahigh vacuum space chamber facility	2,685,000	[1] 307,000
Marshall Space Flight Center:		
Acceleration test and calibration facility	1,700,000	90,000
Acoustic model test facility	2,000,000	[1] 60,000
Additions to the components test facilities	3,875,000	[1] 200,000
Hangar for vehicle components	2,800,000	[1] 150,000
Hazardous operations laboratory	500,000	[1] 27,000
Modification to the vehicle assembly building	1,800,000	[1] 86,000
Utility installations	5,000,000	[1] 115,000
Mississippi Test Facility:		
Advanced Saturn second stage (S-II) static test facilities	19,148,000	2,925,000
Security control facilities	675,000	45,000
F-1 engine systems test stand	9,000,000	[1] 459,000
Maintenance facilities	5,987,000	[1] 240,000
Transportation and parking facilities	7,585,000	[1] 338,000
Waterways and docking facilities	4,242,000	[1] 283,000
Nuclear Rocket Development Station: Additions to the engine maintenance, assembly, and disassembly building	4,500,000	250,000
Various locations:		
Facilities for S-IVB stage program	5,300,000	195,000
Facilities for H-1 engine production	1,500,000	90,000
Instrumentation ships	90,000,000	500,000
Lunar excursion module test facility	15,000,000	500,000

[1] Actual release of funds to field centers awaiting completion of congressional notification procedures.

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1964 NASA AUTHORIZATION

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HEARINGS

BEFORE THE

SUBCOMMITTEE ON MANNED SPACE FLIGHT

OF THE

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U.S. HOUSE OF REPRESENTATIVES

EIGHTY-EIGHTH CONGRESS

FIRST SESSION

ON

H.R. 5466

(Superseded by H.R. 7500)

MARCH 6, 7, 13, 14, 20, 21, 26, 27; APRIL 1, 2, 3, 4, 8, 9, 10, 22, 24, 28, 29; MAY 1, 5, 6, 7, 8, 11; JUNE 6, 1963

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1964 NASA AUTHORIZATION

WEDNESDAY, MARCH 6, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON MANNED SPACE FLIGHT,
Washington, D.C.

The subcommittee met at 10 a.m., Hon. Bob Casey presiding.

Mr. CASEY. I am Bob Casey, substituting for Mr. Teague this morning.

Congressman Teague, chairman of this subcommittee, is ill and unable to be with us.

We are privileged to start off this morning with D. Brainerd Holmes. I called you "doctor" and I believe you stated you earned your "doctor" by experience and not degree. We are pleased to have you in this program.

Mr. Holmes is Deputy Associate Administrator for the Space Program and Director of the Office of Manned Space Flight.

So, Mr. Holmes, we will turn it over to you, sir, and be pleased to have your presentation this morning.

(The biographical sketches of Mr. D. Brainerd Holmes, Mr. George M. Low, and Mr. William E. Lilly are as follows:)

D. BRAINERD HOLMES, DIRECTOR OF OFFICE OF MANNED SPACE FLIGHT

Born in Brooklyn, N.Y., May 24, 1921, D. (for Dyer) Brainerd Holmes earned a bachelor of science degree in electrical engineering in 1943 from Cornell University. In 1943–44 he did graduate study at Bowdoin College and the Massachusetts Institute of Technology.

He assumed his duties as Director of Manned Space Flight for NASA November 1, 1961, and is responsible for direct program supervision of the manned space flight activities at NASA centers and in industry. This includes eventual manned lunar landings embraced in Project Apollo, the two-man Project Gemini program and Project Mercury. In October 1962 he was given an added responsibility as a Deputy Associate Administrator, in charge of institutional and operational matters at the field centers directly involved in the manned space flight program. These installations are Marshall Space Flight Center, Huntsville, Ala.; Manned Spacecraft Center, Houston, Tex.; and Launch Operations Center, Cape Canaveral, Fla.

Prior to his appointment with NASA, Holmes was general manager of the Radio Corp. of America, major defense systems division, where he provided technical direction and management of advanced military electronic systems in the fields of detection and warning, aerospace, and command and control. In this role, he also served as the ballistic missile early warning system (BMEWS) project manager for RCA, the weapons system contractor, and was responsible for coordinating for the Air Force a vast effort involving the Government and some 2,900 American companies.

His work with RCA, 1953–61, included earlier responsibilities as project manager of both the land-based system for the Navy's Talos missile and Atlas launch control and checkout equipment development.

Holmes was with Western Electric Co. and Bell Telephone Laboratories between 1945 and 1953 where he initiated and developed the first precision recording

transmission measuring set and other test equipment for the black and white television coaxial system.

During World War II he served in the U.S. Navy as a radar specialist officer.

He and his wife, Dorothy Ann, have two daughters, Dorothy and Katherine.

GEORGE M. LOW, DEPUTY DIRECTOR FOR PROGRAMS, OFFICE OF MANNED SPACE FLIGHT

George M. (Michael) Low is Deputy Director (Programs), in the NASA Office of Manned Space Flight and is responsible to the Director of Manned Space Flight for direct program supervision of NASA's manned space flight activities. His specific responsibilities include the development of spacecraft and launch vehicles, and the management of manned space flight operations and space medicine programs for Projects Mercury, Gemini, and Apollo. He was appointed to this position in February of 1963.

Low was born in Vienna, Austria, in 1926. He earned a bachelor of aeronautical engineering degree in 1948, and a master of science in aeronautical engineering degree in 1950, both from Rensselaer Polytechnic Institute.

Low joined the National Advisory Committee for Aeronautics, predecessor of NASA, at the Lewis Research Center in Cleveland, Ohio, in 1949. There he specialized in research in the fields of aerodynamic heating, boundary layer theory and transition, and internal flow in supersonic and hypersonic aircraft. During his years at the Lewis facility, he was Head of the Fluid Mechanics Section and later Chief of the Special Projects Branch. In October 1958, when NASA was established, he was assigned to the Headquarters Office as Chief of Manned Space Flight, and later was named Assistant Director for Manned Space Flight programs.

Early in 1961, Low was chairman of the select committee which performed the original studies leading to the manned lunar landing program. Later, in the same year, he was appointed Director of Spacecraft and Flight Missions in the newly organized Office of Manned Space Flight.

The author of numerous technical papers and articles, Low is an associate fellow of the American Institute of Aeronautics and Astronautics. He was awarded NASA's outstanding leadership award and the Arthur S. Flemming Award for his contributions to Project Mercury.

Low is married to the former Mary R. McNamara. Mr. and Mrs. Low and their four children live at 7204 Broxburn Drive, Bethesda, Md.

WILLIAM E. LILLY, DIRECTOR OF PROGRAM REVIEW AND RESOURCES

William E. Lilly has been Director of Program Review and Resources Management for the Office of Manned Space Flight, NASA Headquarters, since 1961. In this capacity he is responsible for providing the total financial, administrative, and business management support and services for the Office of Manned Space Flight and for administration and direction of approved facility projects in support of the manned space program.

Lilly joined NASA, February 15, 1960, as Chief, Plans and Program Coordination, Office of Launch Vehicle Programs.

Prior to joining NASA, Lilly was Assistant to the Director, Plans and Programs, Special Projects Office, Department of the Navy, from 1956 to 1960. He was Deputy Budget Officer at the National Bureau of Standards from 1954 to 1956, head of Estimate and Analysis Section at the Navy Bureau of Ordnance from 1952 to 1954, and a budget and program analyst with the Navy Ordnance Test Station, California, from 1950 to 1952.

Lilly graduated from the University of California in 1950 with highest honors in the school of political science. He is a member of Phi Beta Kappa and Pi Sigma Alpha. Lilly also completed a year of graduate work at the University of California.

Lilly served in the Navy from 1940 to 1946 as chief radioman and holds the Navy Unit Commendation and served in the American, Asiatic-Pacific, and Philippine Liberation campaigns.

Lilly was born at Liberty, Tex., August 25, 1921. He is married to the former Blanche E. Bromert. The Lillys have two children and live at 3489 South Utah Street, Arlington, Va.

STATEMENT OF D. BRAINERD HOLMES, DEPUTY ASSOCIATE ADMINISTRATOR AND DIRECTOR, OFFICE OF MANNED SPACE FLIGHT, NASA; ACCOMPANIED BY GEORGE M. LOW, DEPUTY DIRECTOR (PROGRAMS), WILLIAM E. LILLY, DIRECTOR OF PROGRAM REVIEW AND RESOURCES MANAGEMENT, AND CLYDE B. BOTHMER, EXECUTIVE ASSISTANT

Mr. HOLMES. Thank you, Mr. Chairman.

Mr. Chairman and members of the subcommittee, I would like to read my prepared statement and to digress from time to time in reading it to elaborate on certain points. Because the statement is rather long, and I hope comprehensive, I would suggest you might wish to interrupt to clarify points as I go along. Of course, I will leave that up to you.

Mr. CASEY. You present it as you see fit, and we will interrupt you whenever we think that we need a little more explanation.

Mr. HOLMES. All right. With your permission, I would like to introduce my testimony by showing a film we have prepared which I think, in a very short period of time, gives a succinct and yet fairly detailed review of what we have accomplished since about November 1961. So, if I may, I would like to start with the film.

The text of the film entitled "Manned Space Flight—A Year of Progress," follows:

NARRATION SCRIPT: MANNED SPACE FLIGHT—A YEAR OF PROGRESS

1. Title; Saturn Launching Overprint: "Late in October 1961, the first Saturn vehicle was successfully launched at Cape Canaveral."

2. Saturn launch: "Three days later, the Office of Manned Space Flight was formed. This film will show the steady progress that has occurred in manned space flight in the months that have followed."

3. Michoud footage: "Within a few weeks, Chrysler prepared to produce Saturn S–I stages at Michoud, La. Actual production was to start as soon as the research and development phase was completed at the Marshall Space Flight Center."

4. RL–10 firing: "Midway through November 1961, the RL–10 liquid hydrogen-liquid oxygen engine successfully performed in a preliminary flight-rating test."

5. Apollo command and service modules: "Nine days later, NASA selected North American Aviation, Inc., to design and build two units—the command and service modules—of the Apollo spacecraft that will be employed in the first exploration of the moon."

6. Enos, as he is led to NASA truck: "At the close of that month, a spacecraft carrying a chimpanzee named Enos made two orbits around the Earth."

7. Gemini mockup with men: "Early in December, NASA put its final approval on Project Gemini—the two-man spacecraft program designed specifically to provide experience in long-term weightlessness and rendezvous procedures."

8. Boeing footage from Michoud: "Then, on December 15, a Boeing Industrial team was chosen to produce the giant first stage of the Saturn V at Michoud."

9. S–IV stage: "Within days, engineers from Douglas Aircraft began work on modification of the Saturn S–IV stage, for use in the third stage of Saturn V."

10. Saturn V model: "At this time, the second stage was already under contract and, the configuration of the Saturn V launch vehicle was firmly established. The first stage was five F–1's, the second stage was five J–2's, and the third stage was one J–2."

11. Management council: "On December 21, the Office of Manned Space Flight held the first meeting of a management council established to assure thorough coordination of all manned space flight activities."

12. Aerojet facilities: "January of 1962 saw Aerojet-General start development work on the M–1. This liquid hydrogen-liquid oxygen engine will be capable of developing 1,200,000 pounds of thrust."

13. GE headquarters at Syracuse: "Early in February NASA selected General Electric to supply equipment at Merritt Island, Fla., for integrated space vehicle checkout and to support NASA in its reliability assessment and integration analysis."

14. Glenn in flight: "On February 20, Astronaut John Glenn went into orbit to circle the earth three times."

15. Bellcomm engineers at blackboard: "Two days later, Belcomm, Inc., was signed to provide overall systems engineering support for the manned space flight program."

16. Pentagon: "To improve interagency communications, the Air Force established an office for liaison with the Office of Manned Space Flight through the appointment of a deputy commander, Major General Ritland."

17. Gemini mockup with men: "Before the end of the month, a mockup of the Gemini capsule was completed at the McDonnell plant in St. Louis."

18. Houston center buildings: "Also in March, the NASA Manned Spacecraft Center moved from Langley Field, Va., to Houston, Tex."

19. Second Saturn launch: "On the 25th of April, the second Saturn was successfully launched. This included an experimental test explosion of water-filled tanks at high altitude at the end of the flight."

20. Guidance component work: "Early in May, the separate contracts, to produce the major components of the Apollo guidance system was awarded to three separate companies—A. C. Spark Plug, Raytheon, and Kollsman Instruments will work together with MIT, in charge of system development.

21. Work on Little Joe II at Convair: "About the same time, Convair was chosen to design and manufacture Little Joe II—a launch vehicle for Apollo spacecraft suborbital test flights."

22. Carpenter: "May was also the month when astronaut Malcom Scott Carpenter successfully made his three-orbit flight around the earth."

23. Engine test: "Before the end of May, the F–1 engine was fired at full thrust for the first time. It happened at Edwards, Calif."

24. Saturn test stand: "Moving into June, the Greenhut Construction Co., contracted to modify the Saturn test stand at the Marshall Center. The modification provided two test positions."

25. Slidel Center: "Shortly afterward, a computer center to service the Michoud operation was established at Slidel, La."

26. Webb at press conference: "On July 11, Space Administrator James E. Webb announced the decision to base the planning, research, development, and procurement."

27. Dr. Seamans, Mr. Holmes, Dr. Shea: "* * * of its space program on a lunar orbit rendezvous mode of flight to the moon."

28. Shea demonstrating "the Bug": "The vehicle was informally named the "Bug." At the same time as this planning decision on lunar orbital rendezvous, NASA announced that there would be an improved launch vehicle, the Saturn I–B, and instituted studies of a larger Nova vehicle than previously contemplated."

29. Men working at Houston: "A few days later, it was announced that the new control center located at the Manned Spacecraft Center in Houston, Tex., would be the primary Earth station for the control of manned space flight missions."

30. "IBM computer: "Shortly after, IBM was awarded a contract to develop and supply the computer facilities for the Mission Control Center."

31. Views of launch complex 39 model: "On July 21, the design of the Saturn V launch complex was selected to include a vertical assembly building and an earth crawler to carry the 350-foot vehicle to the launch pad in an erect position."

32. Towing command module: "Off the California coast, the first full-scale model of Apollo spacecraft underwent a successful preliminary flotation test in August."

33. Astronauts stepping off bus: "September 17, 1962: The selection of nine new astronaut candidates was announced in Houston."

34. White Sands: "NASA approved plans for static and flight testing of the Apollo spacecraft propulsion and abort systems at the White Sands Missile Range in New Mexico."

35. Mississippi test facility drawings: "Late in September, plans were approved for the development of a test facility in Mississippi, which will be used

for firing the large launch vehicle stages produced at the Michoud plant in New Orleans."

36. Schirra recovery: "On October 3, Walter Schirra successfully orbited the earth six times. He made his landing in the Pacific Ocean."

37. Test firing: "A few days later, the Saturn S–IV stage successfully completed its first full-duration static firing test—a 7-minute run at Sacramento."

38. Donning Apollo suits: "At this time, teams from Hamilton Standard and International Latex were contracted for work on the development of spacesuits for Apollo spacemen."

39. J–2 firing: "Within the week, the J–2 engine underwent a full duration 4-minute static firing test at Rocketdyne."

40. Paraglider in action: "Toward the end of the month, a test pilot flew a paraglider over Edwards, Calif. It was a successful development test for the Gemini recovery system."

41. Test stands: "At that same location, three separate contractors began work on a complex of three stands for testing the big F–1 rocket engine."

42. Model of Lem: "By the 7th of November, Grumman was selected for development work on the lunar excursion module of the Apollo spacecraft. NASA announced its confirmation of lunar orbit rendezvous as the selected mission mode for Apollo."

43. Test firing: "On November 9, the S–1 first stage of the Saturn was test fired at a full thrust of 1½ million pounds. Previous firings have all been 1.3 million pounds, but this was in preparation for the first two-stage flight, to be launched in 1963."

44. Cooper talking to men: "On November 14, Astronaut Gordon Cooper was selected for a 1-day orbital flight to take place this spring. Alan B. Shepard will be his back-up."

45. Saturn third test flight: "Within a few days, the third test flight of Saturn succeeded. This included a second high water explosion."

46. Saturn on barge: "At the Marshall Space Flight Center, the Saturn IV stage arrived for dynamic tests. It had completed a 23-day voyage from the west coast, coming by way of the Panama Canal, the Mississippi, Ohio, and Tennessee Rivers."

47. View of Aerojet plant: "Late in the month, the first successful firing of a development engine for the Apollo spacecraft service module took place at the Aerojet General plant."

48. Corps of Engineers conceptual footage: "In December, NASA contracted with the Army Corps of Engineers to study the problems involved in constructing a base on the moon."

49. Command module at NAA: "At the end of 1962, North American Aviation completed the fabrication of an Apollo Command Module. It was delivered to Northrop for installation of the parachute landing system, and will be used for the first unmanned flight test."

50. "With this background of accomplishment in the maned space flight program, NASA looks forward to 1963 as another period of continuing progress." Overprint: NASA logo

Mr. HOLMES. Mr. Chairman, I have with me at the table my Deputy for Programs, Mr. George M. Low, and the Director of our Program Review and Resources Management in the Office of Manned Space Flight, Mr. William E. Lilly.

The film you have just seen highlights accomplishments in the program since we last reported to this committee.

The thing that it does not emphasize, but that I think is the single most important accomplishment perhaps of the last year or 14 months, is the pulling together of a program that is scheduled, planned, and organized to an extent that of course it could not be a year ago, and second, the pulling together of an organization in which the communication lines have been shortened, the responsibilities have been clarified, and, in which, I think we can now say we have a team working together.

Just as a fisherman can sense the weather, or a machinist can sense whether something is going well, I personally believe that a professional manager can somehow sense how an organization is going.

Considering myself a professional manager—whether that is right or wrong—my sense is that this group of men which carries the responsibility for you and for the United States for our manned lunar program, have now formed a team. It is hard to say how you sense this, but I think you can feel it; I think you can see it, I think you can almost taste it if you live with it, and have management experience.

The United States has achieved much in space in the 5 years since Explorer I was launched in January 1958. My colleagues in NASA will report to the committee on our successes in scientific investigation, in development of practical applications, in advancement of technology, and in flight missions, such as the historic rendezvous with Venus attained by Mariner II last December 14.

It is my responsibility to report on the American accomplishments in manned space flight. Much has been done in this area and we have grown stronger over the last year.

I think the motion picture highlights some of those things in this rather full year in the manned space flight program.

However, it is a sobering fact that another nation has been able to demonstrate longer duration manned flights, manned flights utilizing spacecraft weighing more than three times that of Mercury, and a simultaneous flight of two astronauts in space in separate spacecraft.

And of course I refer to the Soviet Union.

As this committee well knows, the Soviet Union started well ahead of us in the development of large rockets, so necessary for manned flight. The Soviets have been ahead of us, and are still ahead of us in their ability to reliably launch large masses to Earth orbit.

Over the next few years, we must anticipate that the Soviets will demonstrate even more impressive accomplishments than they already have shown in such categories as long-duration flight and the precise timing of manned space flight launchings.

They have made very good use of this rocket they have of about 850,000 pounds thrust in launching it over and over again for many applications.

Nevertheless, with the acceleration of our own progress and by the establishment of our program on a sound engineering basis, we can, we believe, surpass the Soviets in time and clearly establish U.S. preeminence in manned space flight.

What do we mean by preeminence? We mean that we intend to occupy first place among the nations of this world in science, in technology, and in man's conquest of space.

We intend to conduct scientific investigations in the unknown areas that the power of the rocket enables us to explore, to provide us with knowledge of conditions in space, to let us solve some of the mysteries of the unexplored sea.

We intend to advance our technology in propulsion, in control and navigation, in power generation, in life support systems, and in the transmission of large quantities of information over long distances.

We intend to develop powerful launch vehicles, advanced spacecraft, and adequate facilities on earth to provide the operational capability required for preeminence. We intend to obtain a great deal of flight experience.

We intend to know how to maneuver in space and rendezvous with other spacecraft. We intend to develop the techniques of landing on

another astronomical body, and of reentering the Earth's atmosphere at increasingly great speeds.

In addition to all of this, we intend to acquire the ability to fabricate, inspect, assemble, and check out flight hardware and ground equipment that will provide space vehicles that are safe, economical, and unsurpassed in operational proficiency.

The objectives of the program we shall describe today are to progress so rapidly along these lines that, by the end of this decade, our envelope of manned flight competence will extend out a quarter million miles from the Earth.

In other words, it will extend out to include the Moon.

The manned lunar landing program, Project Apollo, at present provides an organizational focus for the development of the capabilities required for the attainment of national preeminence in space. Moreover Project Apollo provides an opportunity to conduct our space program in such a manner that U.S. preeminence will be clearly evident to the world.

Let us now turn to the manned space flight program. In our testimony we shall deal first with questions of management and then with the technical phase of our efforts. We shall conclude this discussion with a description of a manned flight to the moon and back, as we now forsee it. Finally, we shall make a few remarks about planning for advanced programs.

At present, there are three manned space flight programs—Mercury, Gemini, and Apollo, as shown on the first slide (fig. 1.).

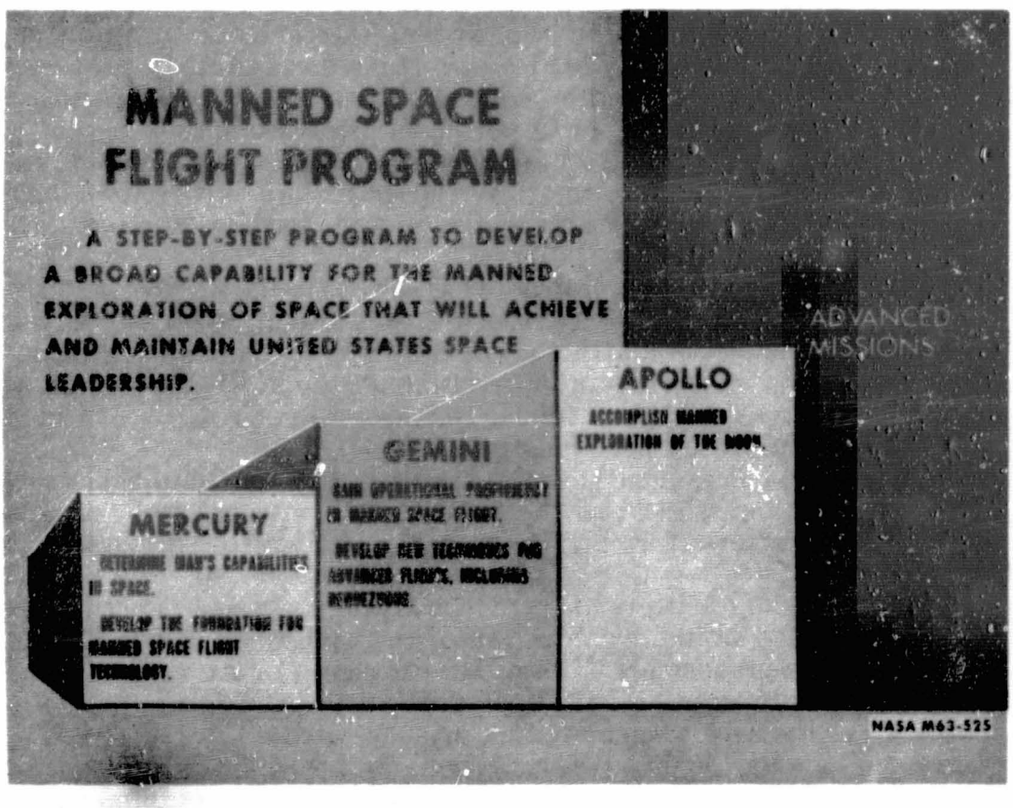

FIGURE 1

They constitute a step-by-step program to develop a broad capability for the manned exploration of space. They are designed to achieve and maintain U.S. space leadership.

We have some slides which will go along with my text and testimony in order to clarify the points I am trying to make.

In Project Mercury we have adequately established man's ability to perform effectively in the environment of orbital flight and have developed the foundation of a manned space flight technology. In three flights last year, the time under conditions of zero gravity was extended to almost 9 hours and, this May, we plan a mission of more than a day's duration.

Our planning is for 22 orbits which would be about 33 hours' duration.

In Project Gemini we will gain operational proficiency and develop new techniques, including rendezvous.

In Project Apollo our objective is to achieve U.S. preeminence and to develop the ability to explore the moon before the end of this decade.

The exploration of the moon will be a beginning, not an end, however. It will open the way for wider explorations of space and our solar system, whose end cannot be foreseen.

In later years, we shall have available the capacity to undertake substantial efforts in programs to carry out more advanced missions, should the Nation so decide.

PROGRAM MANAGEMENT

These programs constitute a very great national effort, as you are all well aware. The bulk of the work is carried out by industry. More than 90 percent of the funds appropriated to NASA for the current fiscal year are expended on contracts with industry, universities, private laboratories, and other Government agencies.

However, we are building a powerful organization of managers, engineers, scientists, and administrative specialists in NASA to supervise the contractors' work and to make certain that the taxpayers get full value for their investment.

NASA research and development centers throughout the country supervise most of the work performed by the contractors. Only a small proportion of the contractor effort is directly managed in Washington. As you know, overall direction of the NASA program is carried out in Washington in four major program offices, one of which is the Office of Manned Space Flight.

The program offices have the responsibility for the technical supervision of projects assigned to the centers. On institutional matters, the center directors formerly reported directly to the associate administrator.

By "institutional matters" I mean the support of the actual plant—the review of the actual organization of the centers—whereas in program management matters I mean the effecting, or carrying out, of specific assigned responsibilities such as the development of an Apollo spacecraft or the development of a Saturn booster.

As Dr. Seamans reported in his testimony last fall, in addition to my duties as Director of Manned Space Flight, I was appointed to the post of Deputy Associate Administrator with direct responsibility for

the institutional operations of the three Centers primarily concerned with manned space flight. These are the Manned Spacecraft Center, Houston, Tex.; the Marshall Space Flight Center, Huntsville, Ala.; and the Launch Operations Center, Cape Canaveral, Fla.

The logic behind that organizational shift was not to either increase my responsibilities or, really, to give me additional duties; but it was a shift which I personally wished to see happen since each of those three centers has by far the greatest proportion of its work in the manned space area. In the case of the Marshall Space Flight Center and the Manned Spacecraft Center, 95 to 100 percent of their work is in this program. At Cape Canaveral, the Launch Operations Center, there are many other important projects there. But as far as their day-to-day work—the new construction work, the planning—over 90 percent of that is also in manned space flight. So the additional post given me tends to pull together the team in a much more integrated way than having separate channels for institutional and program matters.

In the management of the manned space flight program as we reported to this committee last year, we employ the Management Council, a body consisting of the Directors in the Office of Manned Space Flight and the senior officials of the three Centers just mentioned.

The Management Council, on which I serve as chairman, meets every month for an evening and all the following day. These meetings of the keymen responsible for the Nation's manned space flight activities have proven to be an extremely useful management tool. As the tangible result of these meetings, the Management Council generates the fundamental program decisions and program policy.

In addition the mutual understandings and better communications that have been achieved bear directly upon the efficiency with which our organization functions.

The Director and the Deputy Director of each of these Centers, these three Centers which I mentioned, serve on the Management Council. My two Deputies in the Office of Manned Space Flight and the other Directors in the Office of Manned Space Flight serve on the Management Council.

I think a word here about the Management Council's operation is worthwhile.

These men come to a table once a month bearing the full responsibility for the total manned space flight program.

Wernher von Braun does not come to the table responsible only for the Saturn booster or engine developments, nor does Bob Gilruth come responsible only for the Apollo spacecraft.

In that way we have achieved a tremendous increase in our communications and our feeling of responsibility for the whole program. Further, we have instilled these feelings not only in those men who would feel it anyway, but through them in all of the men in their organization.

This way we can obtain a much closer working relationship among these people; achieve the result of having a body of men working toward a common goal. Of course it helps to have this common goal to which we are dedicated. That is making us first in the world as far as manned accomplishment in space.

Another important management concern is our working relationship with the armed services. Extensive cooperation between NASA

and the Department of Defense continues to be a fundamental necessity.

In Project Mercury, for example, the Army, the Navy, and the Air Force have contributed support in many ways. We employed an Army rocket, the Redstone, for the suborbital flights. We use an Air Force launch vehicle, the Atlas, for the orital flights. Our flights are launched from a range operated by the Air Force and we rely on the Navy for recovery operations.

Those are but a few of the contributions the armed services have made to date to our program.

We reported last year that the Air Force Systems Command had established direct liaison with the Office of Manned Space Flight. Maj. Gen. O. J. Ritland carries out this function as Deputy Commander, Manned Space Flight.

Together with a staff of senior officers, General Ritland occupies space within the Office of Manned Space Flight.

In fact he is in the same building that I am and my people are. This association has resulted in close coordination between the Systems Command and the Office of Manned Space Flight.

It has served to provide rapid and efficient Air Force support for the NASA program. At the same time it has made readily available to the Air Force such information about the NASA program as its high officials believe may be beneficial to Air Force plans and operations.

NASA and the Department of Defense also coordinate their space programs with the use of the Aeronautics and Astronautics Coordinating Board. The AACB has a Manned Space Flight Panel on which I serve as Chairman. Through General Ritland's office and the AACB Panel, the Department of Defense receives prompt and complete reports of the results of NASA research and development. Our object is to keep the DOD constantly in a position to take whatever action the national interest requires.

In January 1963 Secretary of Defense McNamara and Mr. Webb agreed on joint DOD–NASA arrangements for the most effective utilization of the Gemini program to assure the fulfillment of both NASA and DOD requirements in the planning of experiments, the conduct of flight tests, and the analysis and dissemination of results.

NASA will continue to manage the project. However the Department of Defense will take part in development pilot training, preflight checkout, launch operations, and flight operations. The DOD will contribute funding as appropriate, in an amount to be determined later.

Now this last statement could be a little misleading so I will interpret it. It means that we will meet regularly with the Air Force. We will accommodate, to the degree we can without impairing or delaying our program, experiments that they want.

We will keep them informed of all of our operations, but the executive management of Gemini, including the pilot training and all of these things, will be accomplished by NASA solely. The Air Force will be kept informed and will participate, and we will incorporate their suggestions and ideas into the program as much as possible.

At the same time, NASA and the Department of Defense reached a new agreement on the responsibilities for operations on the Atlantic Missile Range. The DOD will continue to be the single manager of

the range and the Air Force will still be the host agency responsible for the old Cape Canaveral area. However, NASA will manage and serve as the host agency for the Merritt Island launch area to the north of Cape Canaveral.

This, as you know, is the additional approximately 85,000 acres of land which will be not only the experimentation base for the research and development launchings of our manned space flight vehicles but it also will be the operational base.

The activities of other NASA offices and installations also contribute to the manned space flight program. The space science program is very closely related. To properly plan our manned flights, we need the information that science can provide in understanding the nature and distribution of radiation in space, and the density and velocity of meteoroids and space dust.

As another example, we will benefit considerably from space science programs such as Ranger and Surveyor, which will make investigations of the gravity and topography of the Moon and will provide information concerning lunar surface characteristics.

In a reciprocal manner, as we have noted previously, much information can be gained for science from manned space flight.

We are working closely with the Office of Space Sciences and with the general scientific community to plan the scientific measurements and experiments that will be conducted in both Projects Gemini and Apollo.

Recently NASA formed a working group, consisting of personnel from the Offices of Space Sciences and Manned Space Flight, in order to assure coordination with the scientific community.

The group, headed by Dr. Eugene Shoemaker of the Office of Space Sciences, will be responsible to both the Office of Space Sciences and the Office of Manned Space Flight.

The working group will recommend programs of scientific exploration in future manned flights, define the information desired from unmanned flights in support of manned flights, and maintain general liaison and coordination.

There are two aspects of this from the operational standpoint, if I can use that term broadly. We want to get men to the Moon and bring them back safely, and to do this we want to get all the information that the scientific community can give us about the Moon and about the environment.

The other aspect is that the scientific community is, of course, tremendously interested about what a man, once going into this unknown environment, can learn. Therefore, the type of experiments which we can carry within our limited payload capacity for carrying experiments, the type of observations that should be made during the brief stay on the Moon, all of these things should be maximized to give us the most effective operation.

We achieve these purposes best by listening to the scientists of this country as to what they think are the most important things to observe and to learn.

The manned space flight program also benefits from the advanced research and technology investigations, particularly those conducted at the NASA Research Centers. Indeed, it was Dr. John Houbolt, a

scientist at the Langley Research Center, who began detailed study of the idea of lunar orbit rendezvous in 1960.

The technologies studied in the NASA Research Centers today are those we will employ in the design of our launch vehicles and spacecraft in the next decade. Without this work we would be proceeding rapidly down a road with a blank, sterile future.

In other words, this group of people in advanced research and technology must be looking at the period 10 to 15 to 20 years out, since our programs go out almost 10 years. Otherwise we will be rushing pell-mell up to that period without having kept up with advances that could have been made in the art in order to take the next steps.

Manned space flight makes use of worldwide networks of tracking and data acquisition stations, which serve all of our programs. Deep space instrumentation network stations around the world, such as that at Goldstone, Calif., which tracked Mariner II to Venus and beyond, will enable us to communicate with astronauts on the Moon.

Managing this program is a task of unparalleled scope. That is a big statement, I don't know that it has unparalleled scope, I know it is a very large job. Many thousands of people will be at work at locations throughout the country. Thousands of events must occur at the proper time and at the proper place.

In research and development we are often exploring unknown areas and it is not always possible to predict how long each phase of the job will require. There is an ever-present hazard that bottlenecks in small things will interfere with the progress of major phases of the program.

If we provide the means to identify problems, preferably before they arise, we are frequently able to prevent this kind of bottleneck. It should be recognized that everything we propose to do is well within the short-term growth capacity of our technology, assuming that our estimates of the environment are correct.

In other words, it is within the state of the art, that much overused phrase. We mean that we don't have to, for instance, develop much greater accuracy for navigational systems than we presently have in our ballistic missile programs. That is a typical example.

This is true throughout the lunar program, as long as our estimates of the environment are correct, and as long as our estimates of man's reaction to the environment are correct. I refer specifically there to weightlessness, where we believe that a man can stay operationally proficient for the period of time of going to the Moon and back.

These are assumptions that we believe are valid, but that we plan to verify through additional Mercury flights, through Gemini, and then through Apollo in Earth orbit.

The only major breakthroughs required are in the area of management. Indeed, we believe that the national experience of managing a research and development program of this magnitude is an added benefit, beyond the technological dividends that we shall obtain from the manner lunar landing program.

If you look back a decade at the largest programs that were then awarded to any given group of individuals they were tiny by comparison. I would like to suggest that had those programs not been done, and the management techniques such as those used in the ballistic missile program, as an example, been developed, we would not be in a position to do this program today. Similarly, in doing this program we

will be in a position to undertake other even larger programs in the future.

That growth in management capability, the capability to organize programs on a large scale, is of great benefit to this Nation.

I can go back to my own experience, and recall the contractor with which I happened to work. The largest program they had ever received was the Talos land base system which I managed. That was a big program in those days, and that entire program totaled under $40 million. That is the kind of thing I mean. You put your good people on a program of that size then. Now you could not possibly put your best people on a program of that size.

Mr. CASEY. You say the only major breakthroughs required here are in the areas of management, you still have progress to make, then?

Mr. HOLMES. Yes, we still have a way to go. Yes, I think we do. We have to coordinate several hundred thousand people toward this common goal and do it efficiently and well or we will just squander time and squander money.

Mr. CASEY. Of course that, I think, is some of the criticism that we will be subjected to in our large request this year for the continuation of these programs; that is, whether or not there is a lot of waste. Naturally since you state that the program is of such magnitude that it has never been tried before, I am sure you can look back and see some of this waste, due to management problems such as you have overcome. But you feel that you are making progress in that direction now, to weld this program together?

Mr. HOLMES. Yes, I feel we are making progress. I feel the program is under control and I feel our estimates are quite real.

In my subsequent testimony I will tell you some of the things that we are doing to substantiate that statement of why I believe it is under control; why I believe I can say to you we need this money to do this job, and if we don't have this money we are not going to do this job on this time scale. If we just make these statements they are just words. But if you back them up with hard schedules, and hard-spending curves, and hard-man-rate curves versus time, both predicted and actual; if you show that you are keeping control of these schedules and spending rates; and if you then couple all that with experience in other programs; then they are not just words. They are then facts; and that is what I hope to be able to demonstrate.

Mr. FULTON of Pennsylvania. Mr. Chairman, could we have a chart placed in the record at this point to show how these councils and boards operate, and how the management lines run?

If we could, I would like to see that.

Mr. HOLMES Yes, we will prepare one for that purpose and supply it.

Mr. FULTON of Pennsylvania. Thank you.

Mr. CASEY. The composition of the Space Council and your Management Council that you referred to.

Mr. FULTON of Pennsylvania. Right; and how you fit these things into management. If you have a maze of boards and councils, you will find yourself coordinated and advised to death. I want to make sure that we are being efficient.

Mr. HOLMES. I agree with what you said. The next series of charts (figs. 2, 2a, 2b, and 2c) show the internal organization of the Office of Manned Space Flight and the Centers which I mentioned pre-

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

OFFICE OF MANNED SPACE FLIGHT

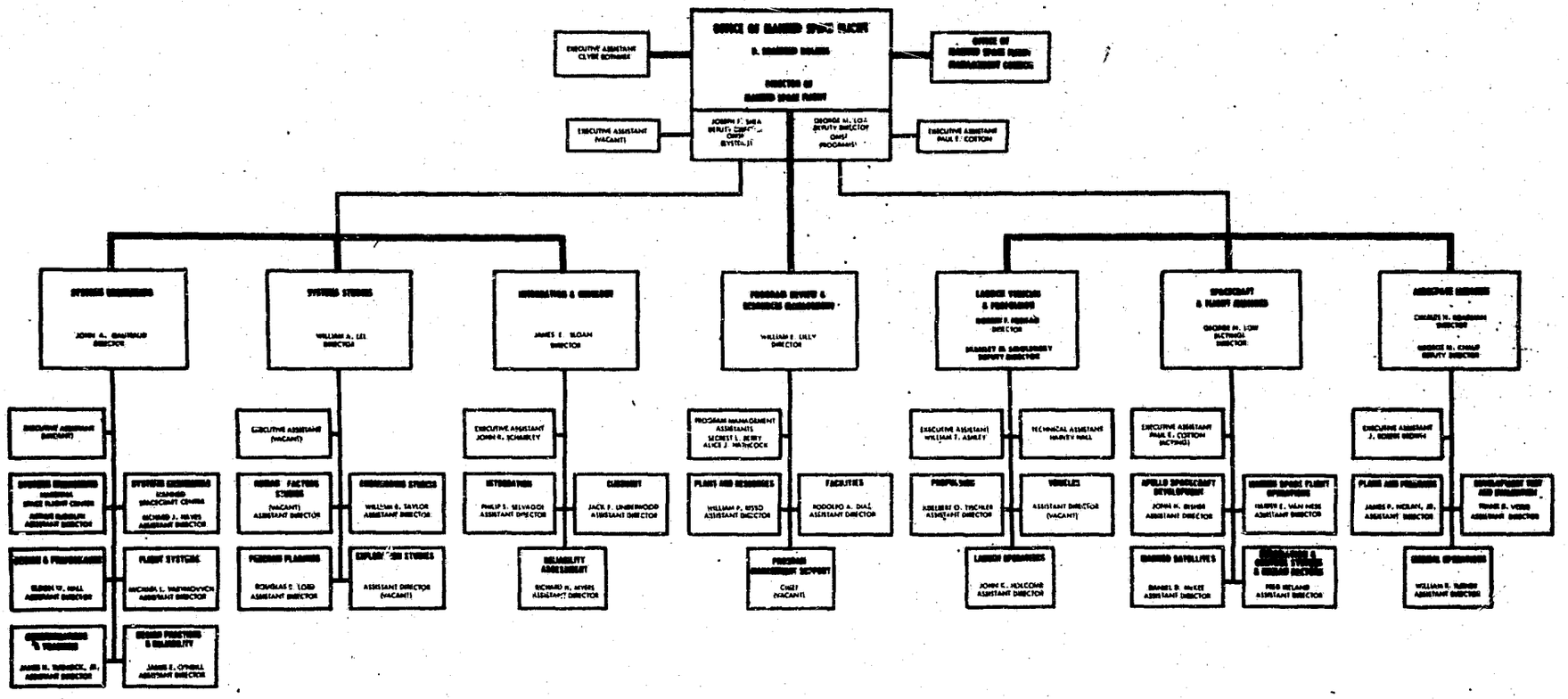

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FIGURE 2

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MANNED SPACECRAFT CENTER

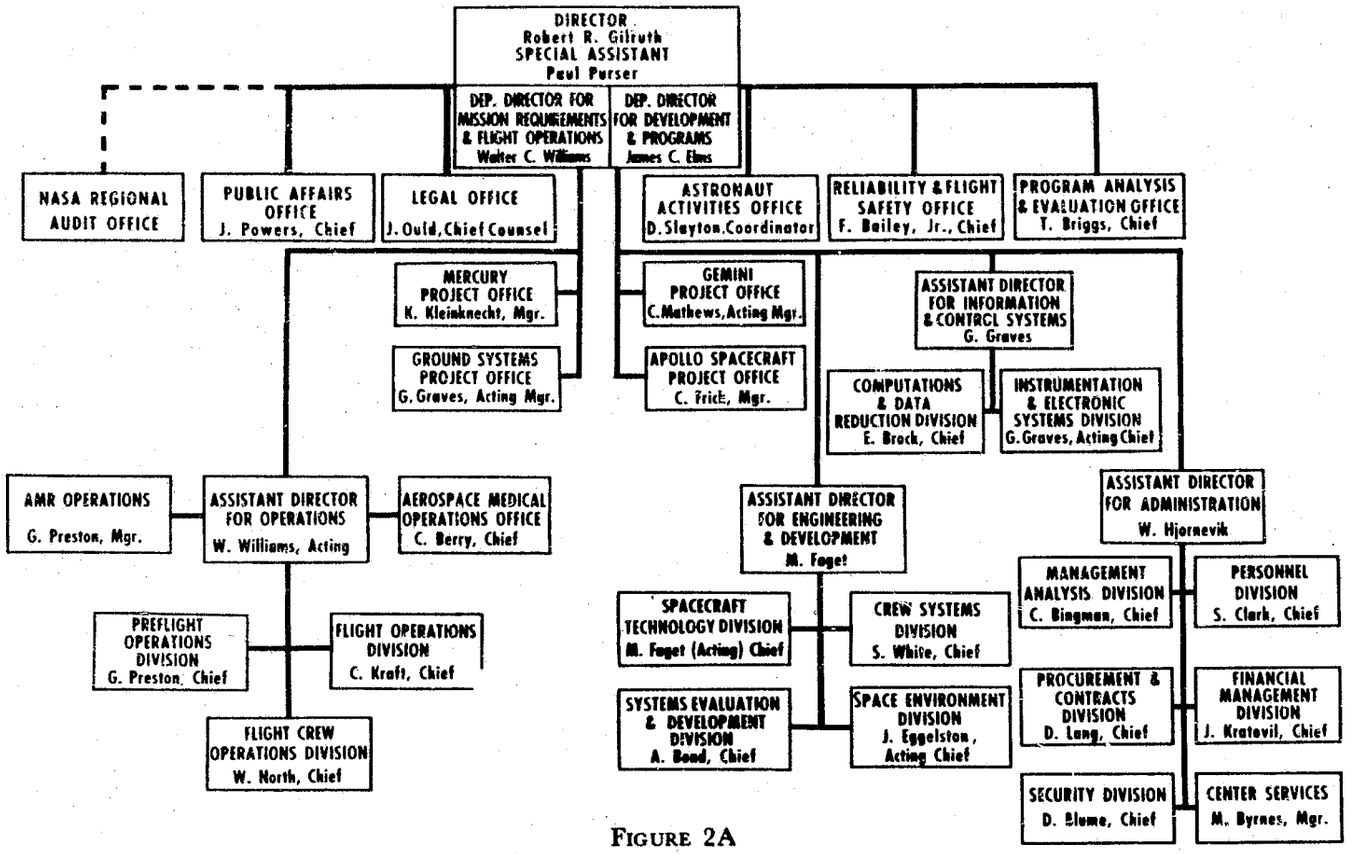
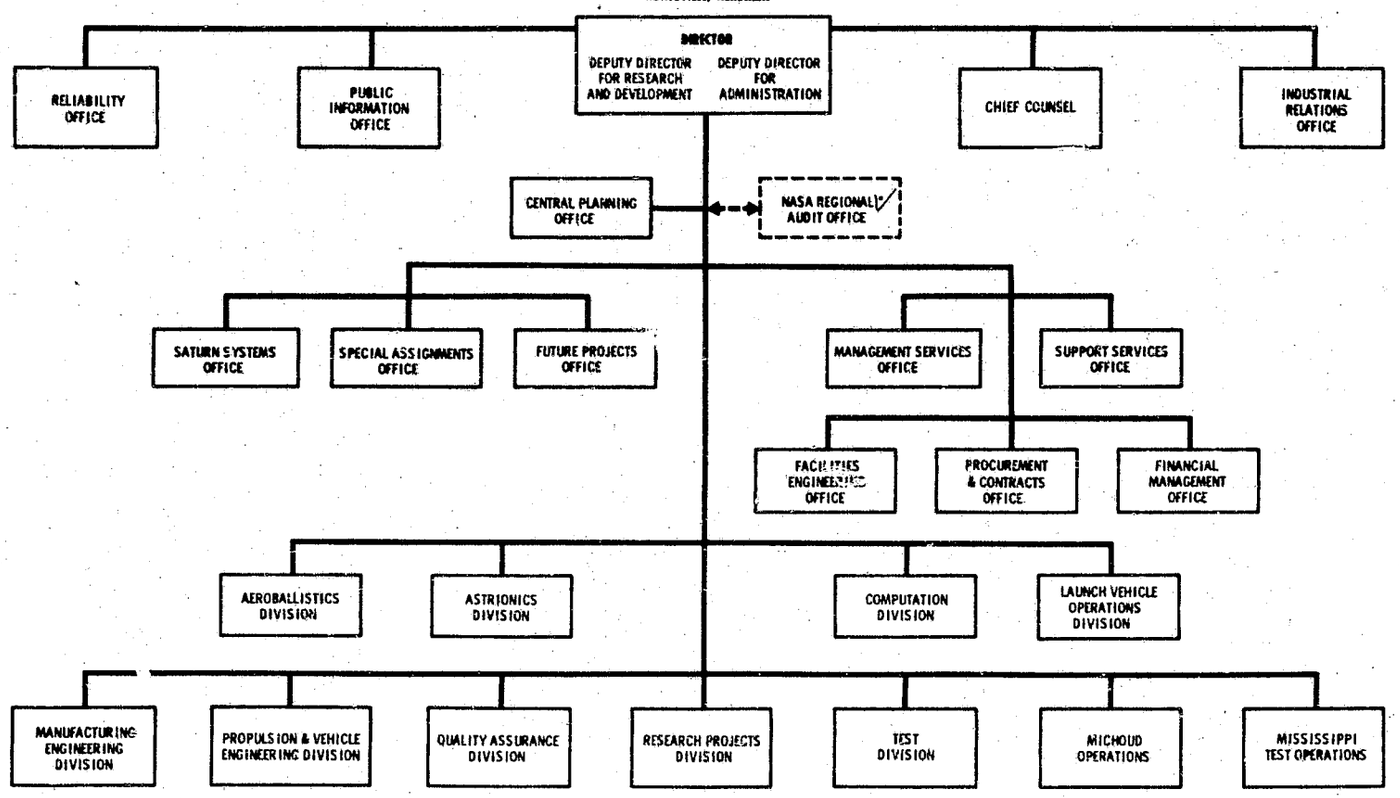


FIGURE 2A

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

GEORGE C. MARSHALL SPACE FLIGHT CENTER

HUNTSVILLE, ALABAMA



APPROVED _____
ADMINISTRATOR, NASA

DATE 26 1963

✓REPORTS ADMINISTRATIVELY AND TECHNICALLY TO DIRECTOR OF AUDITS, NASA, WASHINGTON, D.C.

FIGURE 2B

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

LAUNCH OPERATIONS CENTER

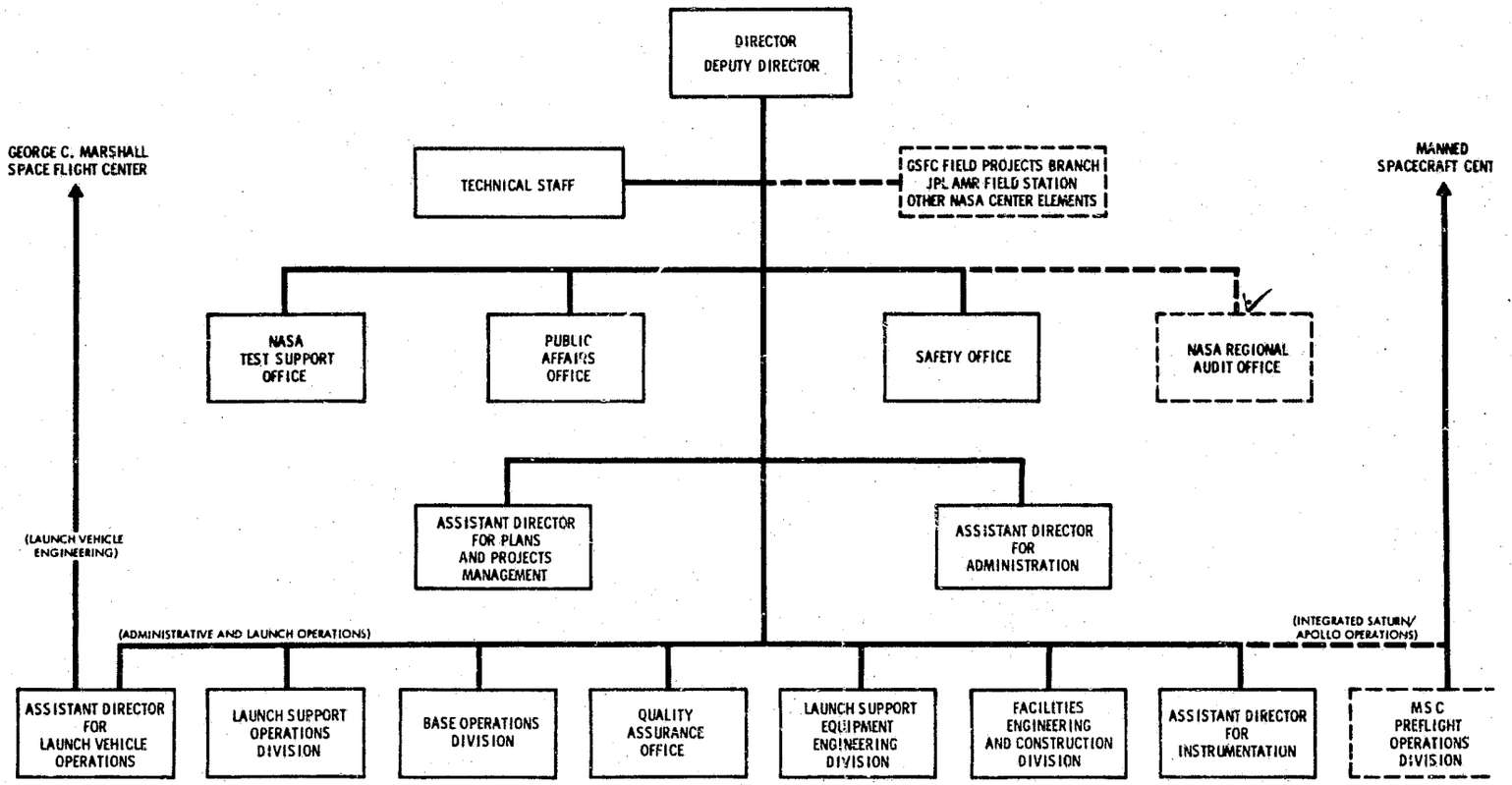


FIGURE 2C

✓ REPORTS ADMINISTRATIVELY AND TECHNICALLY TO DIRECTOR OF AUDITS, NASA, WASHINGTON, D.C.

viously. It also illustrates the relationship between the Management Council and my office. The unique aspect of this so-called Management Council—which is a fancy name for a group of men sitting around the table—is that this is not just a group of people meeting as a committee who make a decision and then go away. Every one of these men has to live with the decisions; they are responsible for them, and they must carry them out. That helps materially. Let me give you some background on our Management Council.

The Manned Space Flight Management Council was established in December 1961. I serve as Chairman of the Management Council. Membership includes the Deputy Directors and Program Directors in the Office of Manned Space Flight and the Directors and Deputy Directors of the Manned Spacecraft Center, the Marshall Space Flight Center, and the Launch Operations Center. The members of the Management Council are as follows:

Mr. D. Brainerd Holmes, Director, OMSF, Chairman, Management Council.

Mr. Clyde Bothmer, executive assistant to the Director, OMSF, executive secretary of Management Council.

Mr. Kurt H. Debus, Director, Launch Operations Center.

Mr. J. C. Elms, Associate Director, Manned Spacecraft Center.

Capt. Robert F. Freitag, Director, Launch Vehicles and Propulsion, OMSF.

Dr. Robert R. Gilruth, Director, Manned Spacecraft Center.

Mr. William E. Lilly, Director, Program Review and Resources Management, OMSF.

Mr. George M. Low, Deputy Director (Programs), OMSF.

Mr. Eberhard Rees, Deputy Director, George C. Marshall Space Flight Center.

Dr. Charles H. Roadman, Director, Space Medicine, OMSF.

Mr. Albert F. Siepert, Deputy Director, Launch Operations Center.

Dr. Joseph F. Shea, Deputy Director (Systems), OMSF.

Mr. James E. Sloan, Director, Integration and Checkout, OMSF.

Dr. Wernher von Braun, Director, George C. Marshall Space Flight Center.

Mr. Walter C. Williams, Associate Director, Manned Spacecraft Center.

The monthly meetings are held in Washington, Houston, Huntsville, or Cape Canaveral on a rotating basis.

The Manned Space Flight Management Council provides a focal point for determining program policy and for reaching major decisions. During these meetings problems are identified and resolved as rapidly as possible. In addition program goals, approaches, schedules, and progress are discussed. The form of the Management Council assures that decisions are based on the best interests of the program and that they are reached in a coordinated and timely manner. The members bear the responsibility for executing decisions of the Management Council.

As I mentioned, the members have the dual responsibility for reaching and carrying out their decisions.

Mr. FULTON of Pennsylvania. That is what we want to hear, how it works.

Mr. HOLMES. Yes, sir.

To aid us in managing this program, the Office of Manned Space Flight and the three centers most closely associated with its program use scheduling and review procedures, in which we have established a uniform and integrated scheduling system.

The three elements of scheduling (fig. 3) are technical progress, funding, and manpower. The three centers and contractors directly responsible to the Office of Manned Space Flight prepare their schedules by analyzing information compiled by other contractors and subcontractors.

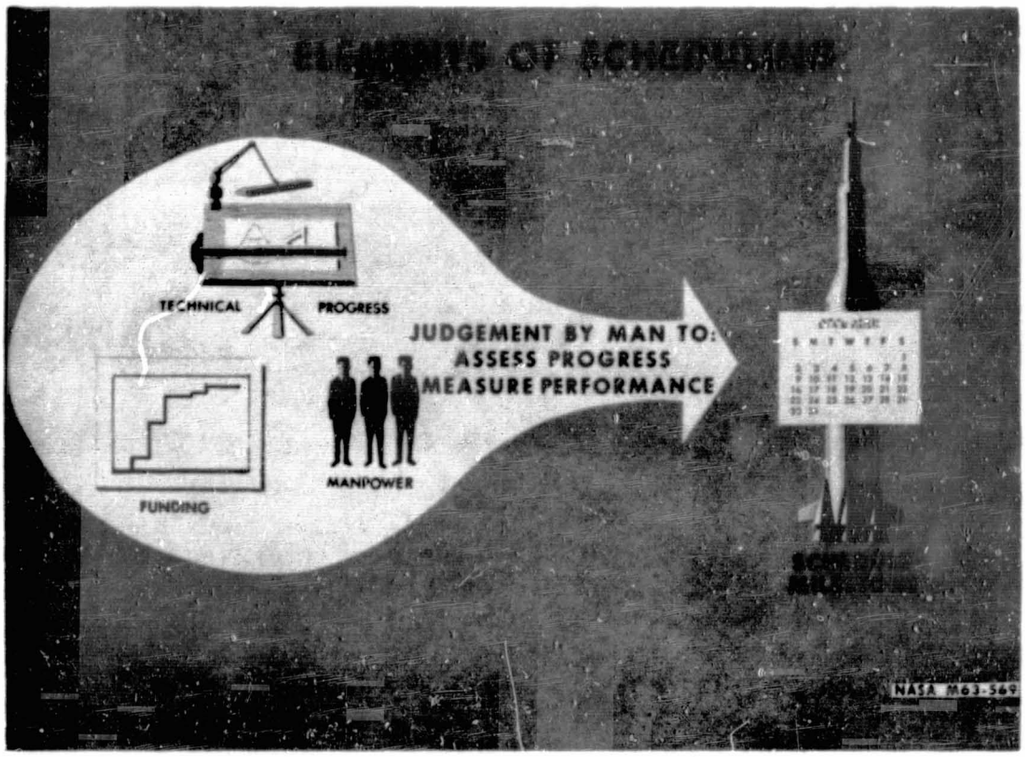


FIGURE 3

In the next (fig. 4) we see that the program evaluation review technique (PERT), the companion cost system, and other modern management methods are used extensively in the preparation of these detailed schedules.

Then the information from the three centers is combined in the Office of Manned Space Flight.

Now what that shows, and I am going to describe the scheduling system because I think it is a key management control for the program, what that tries to show graphically is thousands and thousands of elements which have to be scheduled. Where possible we use computers at lower levels. The information however funnels into a four-level system, which I will describe, with the top level being something that shows flight schedules. As you go down to lower levels you always show the information through a typical bar chart which you would use or I would use to plot your thoughts. That is, these are the events I must accomplish, and these are the times at which I must

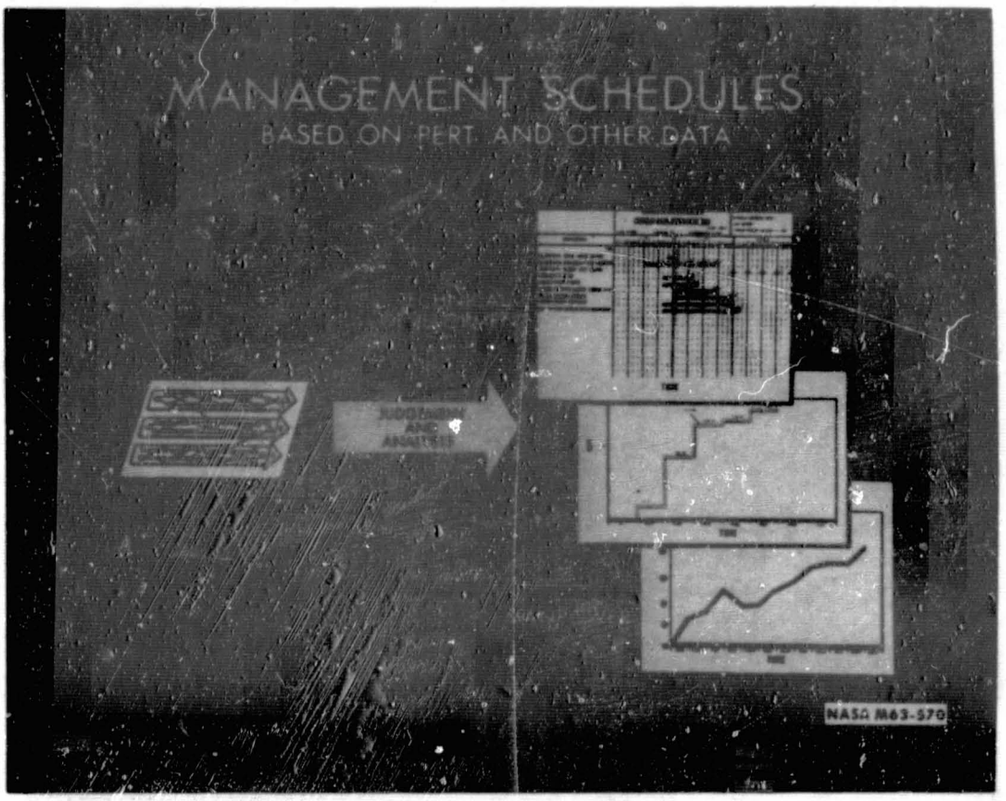


FIGURE 4

do them; in other words, milestones versus time supported by funding and spending rate curves and manpower curves.

Indeed if you look at all three together you have a much better picture than if you look at a sterile chart.

You can be fooled with a chart, but it is awfully hard to fool someone as to an ongoing program where you look at accomplishments versus time; at what was said at the start of the program as to manpower and fund requirements as compared to current facts.

The scheduling procedure covers study efforts, system engineering, development and production of equipment, construction of facilities, and the flights themselves. It provides information on the status of hardware at all levels for management at all levels. To accomplish this we maintain and continually bring up to date comprehensive reports of the status of work.

In this (fig. 5) we see that the reports are made on several levels. The vehicle on the left illustrates the first, or highest, level, that of program launches. Level 2 covers projects; two are shown, the spacecraft and the launch vehicle.

Level 3 is called systems and consists of spacecraft modules and launch vehicle stages. The fourth level, at the right, is subsystems. We can see a spacecraft module at the top and a launch vehicle stage below, broken up into a number of these subsystems.

Now this is like the maintenance manual for your lawnmower. In a hardware program I think it is a good way to schedule. This shows Apollo here as a typical example. You see the flight schedules or program launches—that is in white, it is hard to see—as level 1.

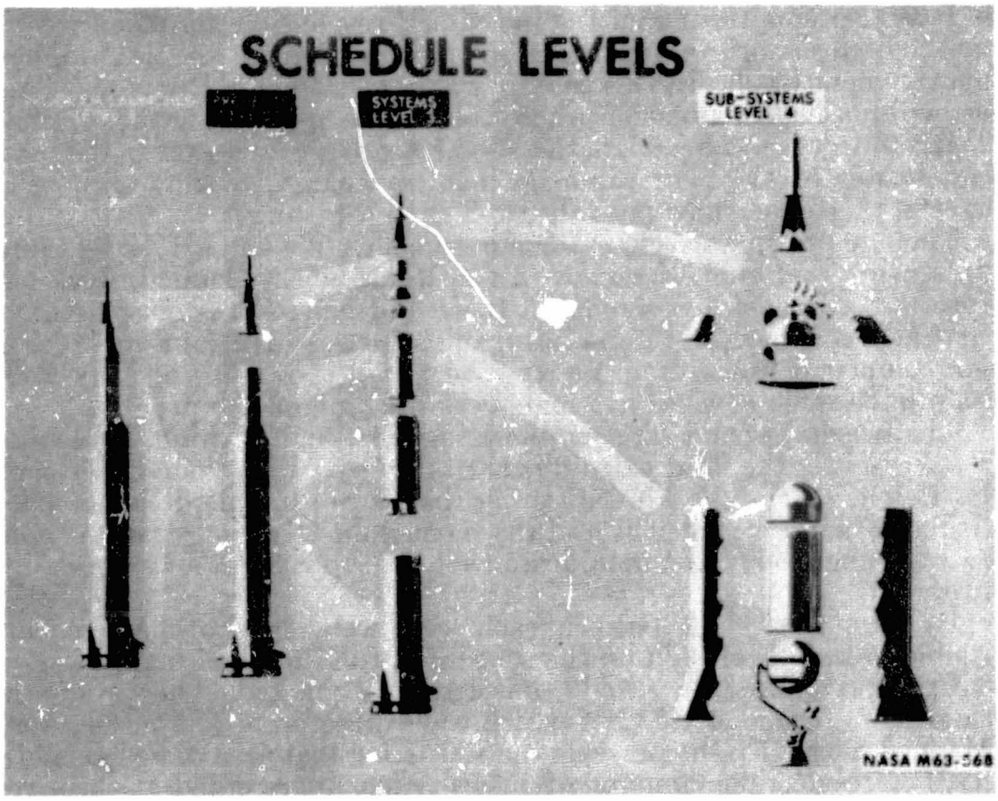


FIGURE 5

So now you have a set of charts you can look at that are not too numerous—because they are level 1—and get a scan of the whole program of when you are going to do what.

A key factor is that we have slippages shown in such a way that any significant slip at a lower level will kick up to the next level, and then the next level. So in theory, and in my experience, to a large extent, in practice, one can look only at the top levels and manage by exception.

Now the breakdown is that you have overall flight schedule at level 1. Then next, at level 2, overall large programs like the Apollo spacecraft.

Then the next level, level 3 of the charts, splits that down, so the Apollo spacecraft is divided into its command module, service module, and lunar exploratory module—that I call the bug. The Saturn splits into the stages—the first stage, second stage and the third stage.

The fourth level, which is as far as I believe we have to go, splits down the command module to its several elements like a navigation system, a communications system, and an environmental system.

Now there are several keys to this system: First, it is set up so that it is kept up to date at all times—with a body of clerical people and without burdening the project management people; second, the management people at the lowest possible level are responsible for their charts; they review them with top management. For example, a project engineer will have a lot of data from a contract on a given system, he will have a level 4 chart for the system with his name on it.

It is also important that the individual responsible for a chart cannot change the original chart. This must be done at the next higher management level. In this case, it would be a Center Director, This we will not have a situation where you just keep changing the original chart and never know what the actual history is. However the man responsible for the chart can make monthly changes to show slippages, et cetera. He can show facts; he can't change history.

Then he presents his chart to management. We had a 2-day session, presenting this kind of review to the Management Council, week before last. If a fellow stands up there and has to present something that he has signed off on monthly, and which is his program, if he is not competent it shows up pretty soon. If it shows up this way we'll soon have some new project managers working on the program.

The reason I spend time emphasizing this kind of thing, is because I believe it is the kind of thing that all of you with your experience have done. It is the kind of thing that is not unique, it is not particularly brilliant, but it is awfully darned effective in getting people to work together, to communicate well, and to control a hard-hitting program.

By using this review pattern, each accountable level of management is able to keep firm hold on the schedules, funding, and manpower.

Progress against the schedules is carefully checked. Once a month, there is a formal review, at which each directorate of the Office of Manned Space Flight presents the status for that area of responsibility. A tremendous amount of information is presented at these reviews. For the most recent review, for example, we prepared about 1,500 charts.

We are preparing additional fourth-level charts that will increase this total to about 2,000. These charts summarize the information in thousands of additional detailed charts and schedules supplied by contractors.

Another key element which I did not mention in this kind of system is that these are the working charts, that they are not hypothetical charts that some project engineer is using—if it is at this level. He is using these and he signs off on them.

If the system does not accommodate what he wants to do, we will change the system, but we will change it altogether for this body of people in Government, these three Centers in the Office of Manned Space Flight, not piecemeal.

It took a long time to get this scheduling procedure and review program set up. Longer than I would have liked. It stands about so high in paper [indicating].

We produce two separate volumes, they happen to be pink and blue. One has costs in it and one does not, because the cost information here is highly proprietary Government information. These are the cost estimates that we make in Government. They are not just what a contractor might have said costs would be. We can then distribute the volumes without costs more broadly.

The volumes are further broken down by elements of the program so that instead of taking this tremendous volume of information and giving it to everyone, a person that needs all of the volumes such as the Center Director would have all of the volumes and a person that needed only the Apollo volumes would get just the Apollo volumes.

Not every event, of course, occurs precisely at the time we have

planned it. Events on these schedules have varying degrees of priority. In some cases, it is essential to meet a deadline because an event is part of a sequence.

The highest priority events are along the so-called critical path—a sequence of events that determines the minimum length of time required to complete an overall schedule. In other cases the loss of time may be of less concern.

In the day-to-day management of the programs, we anticipate that we will periodically encounter problems that endanger the overall schedule. When this happens, it is essential that the problem come immediately to the attention of management at the level necessary to take corrective action.

To expedite the proper consideration of such problems, we have established an urgent action message procedure. There is nothing particularly new about this except it works. If the Director or Deputy Director of one of the three Centers determines that a problem warrants this priority handling, the Office of Manned Space Flight is notified by teletype.

Now it is necessary to restrict this type of action to a fairly high level type of responsibility or pretty soon it breaks down and everything is called urgent.

The status of urgent action messages is posted daily in my office. Within 24 hours a teletype reply must go out describing what is being done. If final action is not accomplished within 48 hours, the responsible Director must provide a detailed status report. With procedures like these, we are pacing manned space flight activities to maintain established schedules.

THE MANNED SPACE FLIGHT PROGRAM

Now that we have discussed some of the management methods, let us turn to the technical program. We believe technical responsibility should be exercised at as low a level in the organization as is in keeping with the nature of the work.

Decisions on the design of hardware should ideally be the responsibility of those who are physically present where the hardware is being produced.

Insofar as possible, the individual contractors and subcontractors are responsible for producing hardware that meets the specifications established by the NASA Centers.

Now I should indicate here in order not to mislead you virtually all of the NASA Centers are working on the manned space flight program.

The three I have emphasized are the ones that are essentially working 100 percent on the manned space flight program, or a very large percentage. But, indeed, it would be unfair to those Centers to not say that they are all making major contributions in one way or another.

The contractors' work on the design, development, manufacturing, and testing of all elements of the system is directed by the technical staff at each Center. Center personnel are responsible for execution of the flight missions.

But the manned lunar landing program is too vast in scope to be managed by a single Center. A central organization is required to

integrate and to direct the efforts of the three principal Centers, to coordinate these efforts with those of other elements of NASA, and to deal with technical matters that encompass the entire program. That central function is provided by the Office of Manned Space Flight in Washington.

And it is for these very reasons that I resent it when my people call it a headquarters operation. We do have a headquarters function which is an important and real function, but our basic and most responsible function—if we are to succeed—is that of a program office. This is a different thing. A program office does not just get funds for Centers; its primary job is to integrate them toward one welded team working together.

SYSTEMS ENGINEERING

U.S. experience in conducting complex research and development programs of steadily increasing magnitude over the last two decades has shown that a strong central systems engineering team is required to establish the overall systems concept and to provide continuing critical technical review.

For a program of the scope of the manned lunar landing, the requirement for overall systems engineering is especially apparent.

In the Office of Manned Space Flight, we need such a systems engineering activity to provide programwide technical analysis for management. We need it also to insure that the functional and performance requirements placed upon all elements of the system are compatible with the mission objectives, and that all elements of the system can be developed within the scope of the project.

Within the Office of Manned Space Flight, the Office of Systems fulfills the requirement for systems engineering and provides, among others, the following functions:

It would indeed be a tragedy if we committed this Nation, to the many years ahead that this program will require, to the tremendous contribution of our most skilled technical manpower, to the tremendous contribution of our resources, and then find we are on the wrong highway, that we had taken the wrong path.

Systems engineering, which provides comprehensive analysis in depth of mission operations studies, mission profile studies, and analytical studies, not just handwaving studies, does the best that we know how to assure us that we are on the right path. God willing, we are.

The functions are: Determination of broad specifications and conceptual designs of major elements of a program—including the establishment of weight-control specifications for Project Apollo and all future manned space flight programs.

Review of on-going programs to identify and evaluate possible alternative courses of action that may become desirable because of unanticipated technical developments. Study of the impact of funding, schedule, and technical changes on the overall program.

Development of the overall reliability and system test plans for Apollo and future manned space flight projects. Preparation of a long-range plan, implementation of necessary long-range studies, and participation in the establishment of project development plans for future manned space flights projects.

For the last year the Office of Systems has been carefully recruiting a strong team of scientists and engineers.

We now have about half of our planned total complement of 125 members of the technical staff on board. That is the technical staff in this immediate systems engineering office.

There are major contributions from the Centers working with this Office to form the total in-house or in-Government systems engineering staff

In February 1962 NASA requested the American Telephone & Telegraph Co. to assist in this systems engineering effort. We asked A.T. & T. to provide an organization of experienced men able to employ the most advanced analytical procedures necessary to develop the factual bases needed by responsible NASA officials to make the wide range of decisions required for the successful execution of the manned space flight program.

A.T. & T. responded to this request by forming Bellcomm, Inc., in March 1962. We expect the total technical staff at Bellcomm to be approximately 175 people by the end of this year. More than a third of these scientists and engineers are now on board. Actually there are about 75 on board. We should have about 90 on board by the first of April.

Bellcomm provides skilled and experienced assistance to enable NASA systems engineering to exercise its responsibility and authority in an effective manner.

It is important to note that the Bellcomm organization assists and supports a technical office within the Government rather than an administrative office. This important distinction makes it possible for the Government to properly carry out its total technical responsibility, utilizing a contractor for assistance, but maintaining the final technical, engineering, and procurement judgments within the Government itself, to be made by Government employees.

I think that is an important distinction. It certainly is a distinction that sets apart the way that we have operated from some arrangements, which have been criticized in the past, where the technical decisions were left to an organization that was outside of Government, and which then became the technical director of the program.

Here what we have tried to do is set up in Government technical competence and then support it with analysts, technicians, and scientists. But the decisions—the final decisions—are made by technically competent people within Government.

Mr. FULTON of Pennsylvania. Let me ask, Mr. Chairman, what is the technical structure of Bellcomm, Inc.?

Mr. HOLMES. I did not understand.

Mr. FULTON of Pennsylvania. What is the technical structure, the corporate structure of Bellcomm, Inc.?

Mr. HOLMES. It has a president, Dr. John Hornbeck, who then has directors below him. It is owned by Western Electric and A.T. & T.

Mr. FULTON of Pennsylvania. Jointly?

Mr. HOLMES. Jointly—and I don't know whether it is fifty-fifty or what the percentage is, Mr. Fulton.

Mr. FULTON of Pennsylvania. What capital is there?

Mr. HOLMES. I don't know. I would have to get you that for the record.

Mr. FULTON of Pennsylvania. Let us have that so we can see what the structure of that is.

Mr. HOLMES. I certainly will.

(The information requested is as follows:)

Bellcomm, Inc., provides systems analysis and study, planning, and technical support for the manned space flight program. The firm performs technical factfinding and evaluation, analytical investigations, consulting effort, and related professional activities in support of manned space flight and related programs of NASA. Its functions include, but are not limited to, the following activities:

(1) Studies of mission objectives.
(2) Studies of methods by which mission objectives can be achieved.
(3) Recommendations concerning broad specifications and conceptual design of major subsystems.
(4) Objective evaluation of the technological states-of-the-art to assess the developmental potential of various system elements.
(5) Objective evaluation of the technical status of programs in light of systems objectives.
(6) Trade-off studies to provide data required to reach management decision on technical problems.
(7) Conduct of detailed and fundamental analyses of systems.
(8) Definition of reliability studies.

In addition to these continuing general activities, Bellcomm performs special tasks, at the request of NASA, in instances where particular emphasis is required for some segment of work because of the nature of the subject matter, the timing, or the level of activity involved.

The following men are directors of Bellcomm:

R. R. Hough (chairman of the board), A.T. & T.
H. W. Bode, Bell Telephone Laboratories.
R. L. Cook, Western Electric.
J. A. Farmer, A.T. & T.
C. M. Mapes, A.T. & T.
J. A. Hornbeck, Bellcomm, Inc.
K. G. McKay, Bell Telephone Laboratories.
H. G. Mehlhouse, Western Electric.
W. J. Whittaker, Bellcomm, Inc.

Bellcomm's officers are:

J. A. Hornbeck, president.
W. J. Whittaker, vice president and general manager.
G. A. Brill, comptroller.
F. C. Childs, general attorney, secretary-treasurer.

The capital structure is established in the following manner:

Capital stock authorized (no par) (shares)	100,000
Capital stock issued (shares)	7,000
Owned by A.T. & T	3,500
Owned by Western Electric	3,500
Capitalization of company	$700,000

The Office of Systems occupied a central role in the selection of the mode of flight for the first manned lunar landing. When we testified before the committees of Congress last year, we were proceeding under an assumption that we would employ the Earth orbit rendezvous mode of flight.

However, as we see from this slide (fig. 6) three possible ways of implementing the program were still under study—direct ascent and lunar orbit rendezvous, as well as Earth orbit rendezvous. Much study work had gone into each of these approaches, and each had its strong technical advocates.

I believe in testifying before this subcommittee last year I indicated that although for planning purposes we were going with Earth orbital rendezvous with a backup of direct ascent, we had not made that decision finally and were still studying these things in depth.

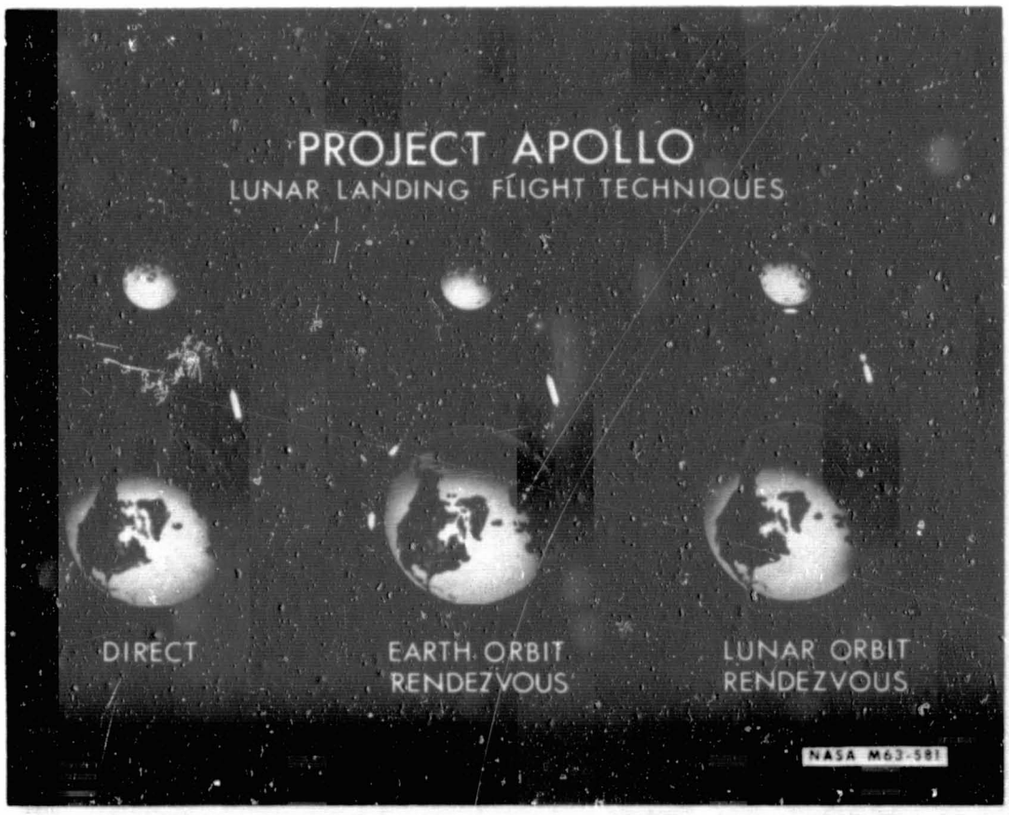


FIGURE 6

Indeed, I believe we reported that we had let contracts which would not commit us to any one of these modes, but would let us go on with the program in an efficient way. It was for this reason that when we reported to you we had neither let contracts for a lunar landing stage—which would have been necessary for either direct ascent or for Earth orbit rendezvous—nor had we let contracts for the Bug—the lunar exploratory module—which would be necessary for lunar orbit rendezvous.

The Office of Systems reviewed the data available and defined the additional studies required to provide mission data.

We see there the three modes which I believe you are all familiar with. In direct ascent, one would have to develop a vehicle much larger than the present Saturn V, with a payload capability of approximately twice that. In both direct ascent and Earth orbital rendezvous one would have to develop a lunar de-boost, and a lunar landing stage over and above what we had under contract. In lunar orbit rendezvous one would have to develop this Bug, or lunar exploratory module.

These studies were conducted both at NASA centers and by contractors under the direction of the Office of Systems. By June, the results of all the previous study activity had been analyzed against the criteria of schedule, cost, complexity, growth potential, mission success, and mission safety. We differentiate there. Mission success meaning going to the Moon with the astronauts and bringing them back safely. By mission safety we mean we did not carry

out the whole mission, but through an abort were able to save the lives of the astronauts.

The analysis of more than a million man-hours of technical work showed that lunar orbit rendezvous was the most desirable mode of flight.

Lunar orbit rendezvous was found to provide advantages in schedule, cost, and development simplicity, while maintaining probabilities of mission safety and mission success that are equal to or better than those of the other modes studied.

Additional studies conducted through the summer confirmed this decision. Meanwhile, a request for proposals on the development of the third Apollo spacecraft unit, the lunar excursion module, was issued, and the contractor was selected in November. Thus we were able to study the question further without delaying our development schedule.

Present systems engineering activities center on developing specifications for Project Apollo that assure that each system element will be developed in accordance with the overall system requirements.

The specifications will be continually reviewed and brought up to date throughout the life of the program to reflect the current status of the development and to certify that all elements, when assembled, will function in proper relationship to perform the mission.

In fact, on the technological side I think we can think of the systems specifications in all its elements as being somewhat analogous to the scheduling and funding system that we set up on the funding side.

As development progresses, the Office of Systems will continually review the program to anticipate problems and effect solutions. It will evaluate new technical developments to determine whether they can benefit the program. It will arbitrate technical conflicts between major elements of the program. In sum, the Office of Systems will provide a staff to assure that the technical status of the program is sound.

Mr. GURNEY. Mr. Holmes, let's go back a little bit to the selection of the means of reaching the Moon.

In making this selection, were military aspects taken into consideration at all, or the contribution to military programs as to whether the Earth-orbit rendezvous or the lunar-orbit rendezvous was a better method?

Mr. HOLMES. Yes, we did, Mr. Gurney. We reviewed this with the Department of Defense and with the Air Force and I believe it was the consensus of their opinion—in fact, they so stated—that neither one of these offered more of an advantage to the military than another. Even though they could not state the specific military requirements, they felt this way. I think part of the reason is that the rendezvous requirements are just about as great, carrying out lunar-orbit rendezvous as they are in Earth-orbit rendezvous.

In lunar orbit you have to experiment with the lunar excursion model or Bug and with the mother craft. We plan to do many Earth-orbit missions. What we will not do is rendezvous—a big tanker stage with another stage and refuel in Earth orbit.

Mr. FULTON of Pennsylvania. Mr. Chairman, could I have one more question?

On page 16 you refer to the advantages in schedule, costs, and development simplicity of the lunar-orbit rendezvous. Obviously you

were comparing different things in the first two instances than you were in the third. Could you show in more detail how you got development simplicity?

Would you put that in the record at this point?

Mr. HOLMES. Yes, sir; I would be glad to.

Mr. FULTON of Pennsylvania. I would like to see what you are comparing.

Mr. HOLMES. Yes, sir; we would be glad to do that.

Mr. FULTON of Pennsylvania. Thank you.

(The information requested is as follows:)

The selection of lunar orbital rendezvous for manned lunar landing and return was the culmination of long months of study and analysis. We recognized that detailed studies were necessary before the Nation's resources were committed to this goal. We also realized that a single operational plan had to be chosen to insure efficient allocation of resources and timely development of the program. With these points in mind, major systems and engineering studies, involving both Government and contractor scientists and engineers, were conducted.

Within the Office of Manned Space Flight, the Office of Systems directed a major study effort on the contending mission modes. Scientists and engineers from NASA headquarters and centers, other Government agencies, and industrial concerns devoted over 1 million man-hours of study to comparison of the modes. Three approaches were considered in detail: direct flight (DF), Earth orbital rendezvous (EOR), and lunar orbital rendezvous (LOR). Each mode was evaluated against criteria of developmental simplicity, mission safety, mission success, time, and cost.

Developmental simplicity was an important factor in our evaluations of the potential modes. It was vital to select an approach that took full advantage of the state of the art and minimized complex developmental requirements. Two versions of the direct flight mode were evaluated. One required use of a Saturn V vehicle and a new, stripped-down command module with a two-man crew. This approach proved marginal in terms of technical feasibility, even using cryogenic fuels, which present more difficult developmental problems than the present Earth-storable fuels. The second version of direct flight relied on the present three-man command module and a new booster, the NOVA, capable of accelerating 150,000 pounds to escape velocity. This technique entails development of the gigantic NOVA, which has not yet reached the preliminary design stage. In addition, both direct flight approaches required the development of a [illegible] module for lunar landing and takeoff. Earth orbital rendezvous was [illegible]ed in several versions. One version involved separate launchings of the [illegible]raft and a fueled escape stage, which would be joined in earth orbit for [illegible]rip to the Moon. It was evident early in the studies that the weight of the [illegible]eled escape stage prevented a logical distribution of payload. The alternate [illegible]proach relieved this imbalance by using separate launchings of the spacecraft plus the unfueled escape stage and a fueled tanker. After rendezvous in Earth orbit, the tanker would supply the escape stage for the flight to the Moon. Earth orbital rendezvous necessitated development of the tanker system, transfer of liquid oxygen, and operation of cryogenic fuels in space. It also necessitated development of a complete spacecraft capable of lunar touchdown and takeoff.

The third manned lunar landing technique, lunar orbital rendezvous, involved launching a three-unit spacecraft from the Earth into lunar orbit. This lunar landing technique differs from the approach of the other two modes, which use the large landing module for touchdown. In the lunar orbital rendezvous technique a new module, the lunar excursion module (LEM), is used for touchdown and takeoff. Two of the three-man Apollo crew enter the LEM, activate the descent engine, and land on the Moon. The command and service module continues to orbit the Moon. After the exploration period, the astronauts launch the LEM, rendezvous with and return to the command module, and prepare for the return flight to Earth. Therefore the lunar orbital rendezvous technique eliminates the need to land a complete spacecraft on the Moon. In view of the fact that touchdown on the Moon's surface is the most exacting maneuver of the Apollo mission, the simplicity of this approach enhances the probability of a successful mission. Since the LEM does not reenter the Earth's atmosphere,

we can concentrate on a design that maximizes the probability of successful lunar landing. In addition LOR offers a significant saving in weight over the other two modes.

Comparative analyses revealed that the three contending modes were relatively equal in terms of mission safety. The lunar orbital rendezvous mode was estimated to have a slightly higher probability of mission safety; however, the differences were small.

Measurements of the probability of mission success showed more pronounced differences among the three modes. Earth orbital rendezvous' dependence on two Saturn V launches reduced its probability of success by about two-thirds as compared with the other two modes. Lunar orbital rendezvous and direct flight ranked approximately the same; however, LOR again had a slight edge.

The time required to achieve a manned lunar landing mission was also analyzed in the comparative mode studies. The direct flight mode necessitated the development of either cryogenic propulsion systems for the spacecraft or the NOVA launch vehicle. Therefore it was estimated that manned lunar landing with the direct flight technique would take up to 20 months longer than the lunar-orbit rendezvous approach. Earth orbital rendezvous required at least twice the number of Saturn V launch vehicles and involved an estimated 6 to 15 months more than lunar orbital rendezvous.

The question of cost was also a significant factor in evaluating the three mission approaches. At a conservative estimate, lunar orbital rendezvous will run about 10 percent less in overall costs than direct flight, which requires more extensive hardware development, or Earth orbital rendezvous, which requires at least twice as many launch vehicles for test and operational flights.

We are confident that our decision to use the lunar orbital rendezvous mode for manned lunar landing will lead to successful accomplishment of this national goal. We reached the decision on the basis of the best available evidence and the most experienced judgment. We are now conducting Project Apollo in such a manner that we can react promptly to new factors, if necessary. We have marshaled an outstanding team from Government, industry, and universities to achieve manned lunar landing and return and to establish the preeminence of the United States in space technology.

Mr. HOLMES. Now our mission profile for going to the Moon.

At this point, let us review briefly the lunar-orbit rendezvous mission profile, to illustrate the systems engineering considerations that entered into its selection.

At the time this mode was selected last year, the United States had under development two large launch vehicles of the Saturn class, and the opportunity to improve the smaller of the two by adapting to it an upper stage of the larger vehicle.

That is a little confusing. What we are saying here is we had the Saturn I with which you are familiar and of which, as you know, we have launched the first stage. We had the Saturn V which you have seen in this big lunar vehicle. We had the opportunity to provide another vehicle, with quite a lot of capability, by using the first stage of the Saturn I but substituting for its second stage the third stage of the Saturn V.

I think we will see that in the slides.

Mr. FULTON of Pennsylvania. Say that again.

Mr. HOLMES. We have now the Saturn I which has an S–1 first stage with eight H–1 engines. It has, for its second stage, a 90,000-pound-thrust stage using six hydrogen engines of the A–3 type.

Over here we have the Saturn V. It has its first big stage—under development by Boeing—with 7½ million pounds of thrust. It has a second stage with a million pounds of thrust, and a third stage with a single hydrogen engine, and 200,000 pounds of thrust.

All right, now, take that 90,000-pound-thrust second stage off this Saturn I and put in its place this third stage from the Saturn V, this 200,000-pound-thrust stage. Thus you get a vehicle that can put to

Earth orbit 32,000 pounds instead of the 22,000 pounds that the other could.

Mr. FULTON of Pennsylvania. That is the Saturn I–B?

Mr. HOLMES. That is the Saturn I–B; yes, sir. Maybe if I just read on I would have done better. I am sorry.

The two vehicles are the two-stage Saturn I, planned to be operationally available in 1965, which will provide the power to boost about 11 tons of payload into low Earth orbit, and the three-stage Saturn V, phased about 2 years later than the Saturn I, which will lift approximately 120 tons into the same orbit.

This (fig. 7) shows these two vehicles at the right and left. It is perhaps easier to keep the relative lifting power of these vehicles in mind if we compare them with the Atlas, which we employed to boost into orbit the Mercury spacecraft weighing 3,000 pounds.

So there we see the size, the scale in feet at the right, your right, on the chart, of the other three vehicles, and the payload in hundred-mile orbit.

That may be too small to reach. It shows 22,000 pounds under the Saturn I, 32,000 pounds under the Saturn I–B, and 240,000 pounds under the Saturn V.

What I have just said is we are hard pressed with Mercury to get 3,000 pounds into orbit, so you can see the tremendous increase necessary in order to take on the program that we have established.

It also shows applications there and those applications are restricted to Apollo.

In the later description of the launch vehicles themselves we show other applications for which one might use them.

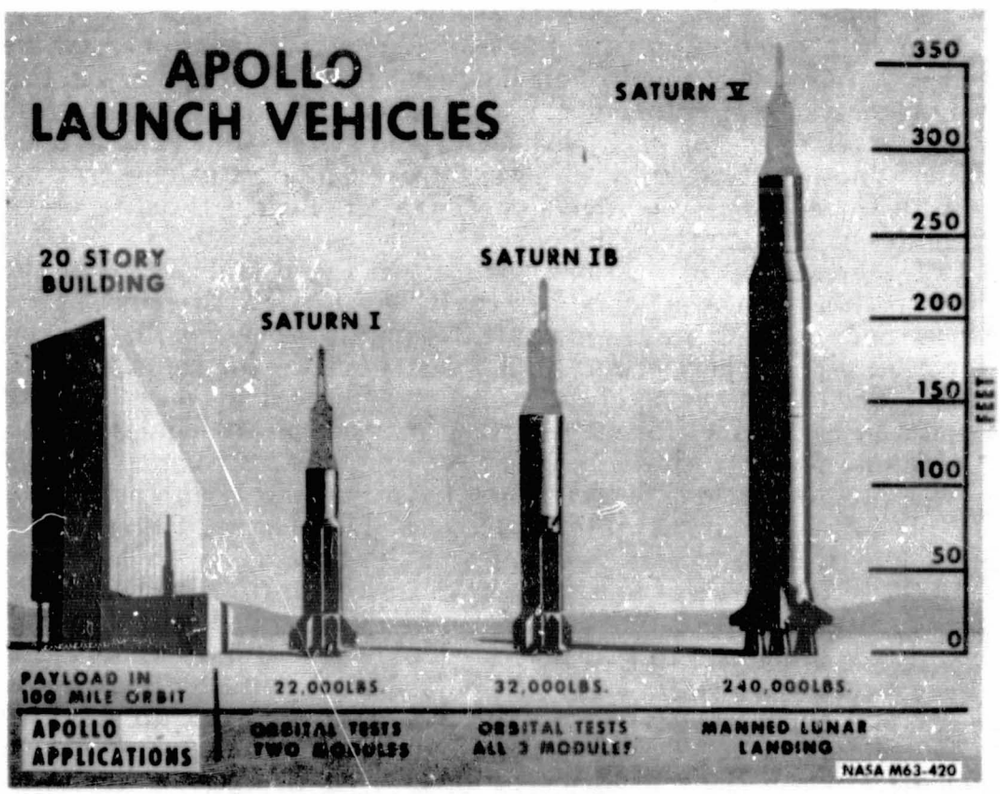


FIGURE 7

Mr. ROUDEBUSH. Before you continue there, Mr. Holmes, how much of a safety factor on these manned space flights do you require?

In other words, if you have a capability, for example, as in the Atlas to place a 3,000-pound vehicle in orbit, how much safety factor do you require? That is not the maximum weight that you can accelerate to orbital speed, is it? Certainly you would not take something that was marginal. You have a safety factor here; isn't that true?

Mr. HOLMES. Normally when we quote a figure it is the lower 3-sigma figure. By "lower 3-sigma figure," I mean, if you took a probability curve you would have 99 percent probability of reaching that velocity before you would run out of that fuel.

Mr. ROUDEBUSH. I see.

Mr. HOLMES. Ninety-nine and a fraction. Is that right?

Mr. LOW. Yes.

Mr. HOLMES By combining the first stage of the Saturn I and the third stage of the Saturn V, we will be able to produce the Saturn I–B, with about 45 percent more lifting power than the Saturn I, which will be available about a year earlier than the Saturn V.

The Saturn I will lift the equivalent weight of somewhat more than seven Mercury spacecraft. The Saturn I–B will boost the weight of almost 11 Mercury spacecraft. The Saturn V will provide a quantum jump to about an equivalent of 80 Mercury spacecraft.

Another important number for the Saturn V is how much payload it will accelerate to the speed of about 25,000 miles an hour required to reach the Moon. In other words, that is injection speed for the Moon. That figure is some 90,000 pounds.

All of the weight-control specifications for Project Apollo are based on 90,000 pounds as the maximum capacity that can achieve the needed velocity.

I think in mentioning this it is apparent why I mentioned before that an important element of the systems engineering activity is this weight control or monitoring on a total basis. We keep a weight bank which is reviewed for each element of the system and is controlled either by the Centers or by this weight bank in systems engineering.

With these vehicles available, we have established three series of flight missions in Project Apollo.

In the first series of missions, the Saturn I will launch two of the three modules of the Apollo spacecraft into low Earth orbit. That is the command and service module, to qualify them for flight—and to obtain flight experience up to 2 weeks or more for the three-man crew. The Apollo spacecraft fuel tanks will carry only a small amount of rocket fuel for maneuvering in space on these missions.

This means that with the Saturn I we can put up a command and a service module as long as we don't have much fuel in the service module. We have that capacity and we will do that as soon as we can in order to start our experiments in Earth orbit.

In the second series of missions, the Saturn I–B will launch the complete Apollo spacecraft into Earth orbit to qualify the lunar excursion module for flight and to rehearse the deployment and docking of this unit. Again, the fuel tanks will be only partially filled. But as soon as we have the Saturn I–B we will use it so we can put up all three vehicles, doing some of this rendezvous and other experimentation which I answered to Mr. Gurney, in answer to his question, in Earth orbit.

In the third series of missions, the Saturn V will launch the fully fueled Apollo spacecraft on missions into orbit around the Moon, and to the lunar landing itself.

The Saturn V launch vehicle (fig. 8) will consist of three stages—the S–IC first stage, the S–II second stage, and the S–IVB third stage.

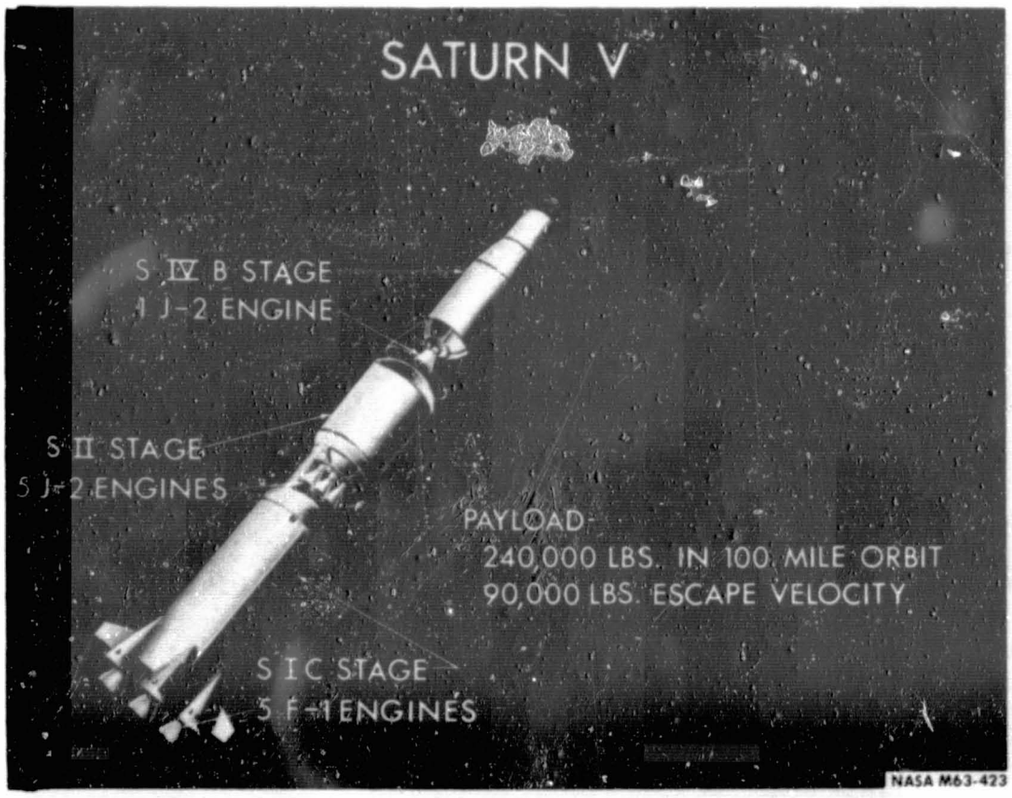


FIGURE 8

The Apollo spacecraft (fig. 9) will consist of the command module, which houses the three astronauts on the trip to and from the Moon; the service module, which provides the propulsion to maneuver spacecraft into and out of lunar orbit; and the lunar excursion module.

Mr. FULTON of Pennsylvania. Why don't you call that the lunar sport model; it is small and sporty.

Mr. HOLMES. Yes, sir. The Bug transports the lunar explorers to the surface of the Moon and back to rendezvous with the command module in orbit around the Moon.

In addition a launch escape rocket system is attached to the top of the command module to enable the astronauts to get away quickly in the event of trouble during the initial phase of flight upward through the Earth's atmosphere. Or indeed off the pad if they had to escape from that rocket from the pad.

All elements of the space vehicle will be assembled and checked out in the vertical assembly building of the launch Complex 39 at Merritt Island, Fla. (fig. 10).

The checkout procedure will make extensive use of automatic equipment to assure that all elements of the system are ready for the mission.

Then the launch vehicle, 360 feet tall, will be transported in vertical

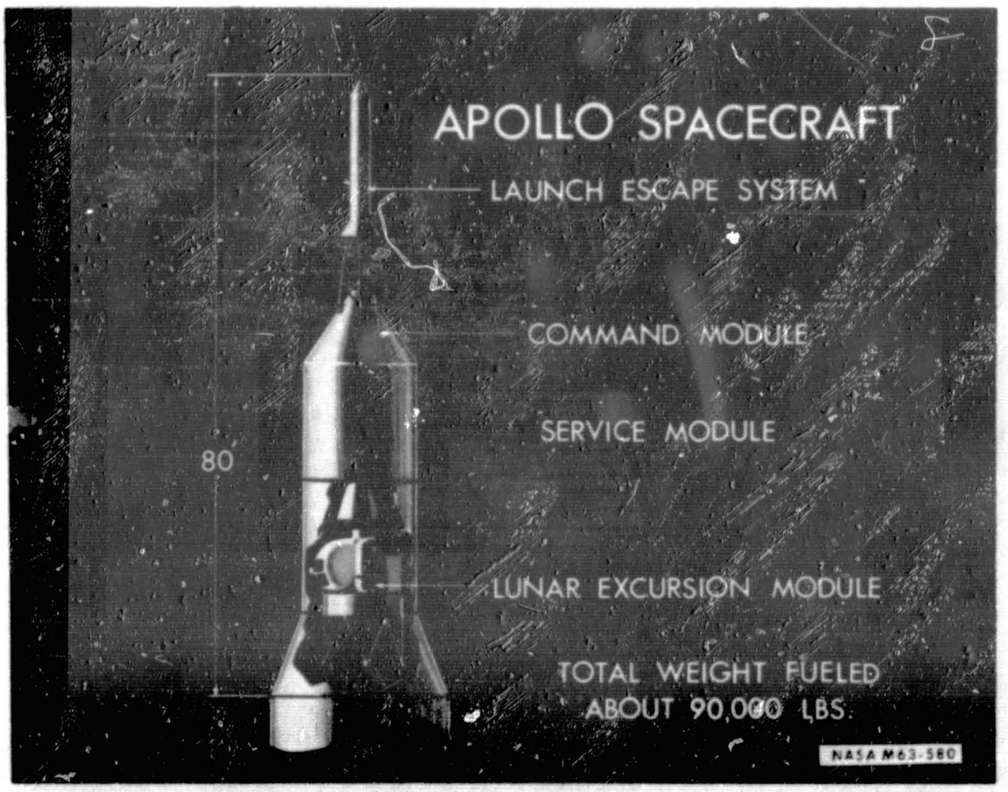


FIGURE 9

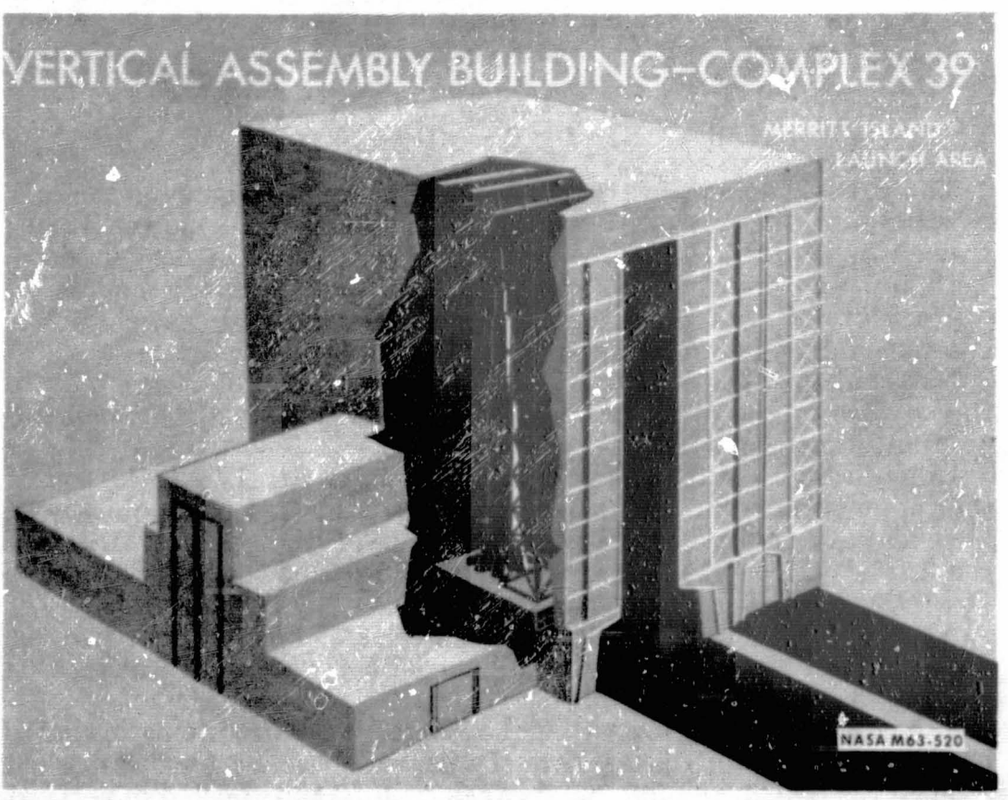


FIGURE 10

position more than 3 miles to the launch pad by a crawler tractor. The vehicle will remain at the pad only a few days before the astronauts climb aboard and prepare to launch.

This is a rapid highlight of the mission profile. We will go back and examine each one of these facilities in my testimony.

The three-stage launch vehicle will lift off and place the spacecraft on a trajectory that will carry it to the vicinity of the Moon. The propulsion system in the spacecraft's service module will follow the commands of the guidance system to provide necessary course corrections and, on arrival near the Moon, a maneuver into lunar orbit.

Then two of the three astronauts will climb into the lunar excursion module, separate from the rest of the spacecraft, and use its propulsion system to descend to the surface, where they will remain about 24 hours.

The lunar excursion module will have two propulsion stages, one of which will remain on the Moon. The other will boost the spacecraft from the Moon's surface to rendezvous with the mother spacecraft.

After the lunar explorers return to the command module, the lunar excursion module will be detached, to remain in orbit about the Moon. The service module will provide the thrust to accelerate from lunar orbit for the return flight to Earth and will power the necessary course corrections en route back to Earth.

The service module will be jettisoned before reentry into the Earth's atmosphere. The command module will reenter alone and will descend to the Earth by parachute.

Later we shall describe the mission profile and the equipment involved in considerably greater detail.

FLIGHT MISSIONS, SPACECRAFT, AND SPACE MEDICINE

Now let us turn to the major elements of the manned space flight program. The first such element will comprise flight missions, spacecraft, and space medicine.

PROJECT MERCURY

Our initial manned missions have been in Project Mercury. Its primary objective—manned orbital flight—was achieved last year (fig. 11).

The names of John Glenn, Scott Carpenter, and Wally Schirra are now listed in the history books of our Nation. But it was not our intention, at the outset of Project Mercury, merely to produce names for history books; our goals were to take the first step in the manned exploration of space, to determine man's capabilities in space, and to develop the foundation for the technology of manned space flight.

Now that both Glenn and Carpenter have flown for nearly 5 hours in space, and Schirra for 9 hours, let us examine how well we have achieved our goals, and what we have learned from Project Mercury (fig. 12).

We have learned how to design, build, and test a spacecraft: to take man more than 100 miles from the surface of the Earth; to withstand the high accelerations of a rocket launching; to provide a habitable atmosphere in the hostile environment of space; to maintain its own

FIGURE 11

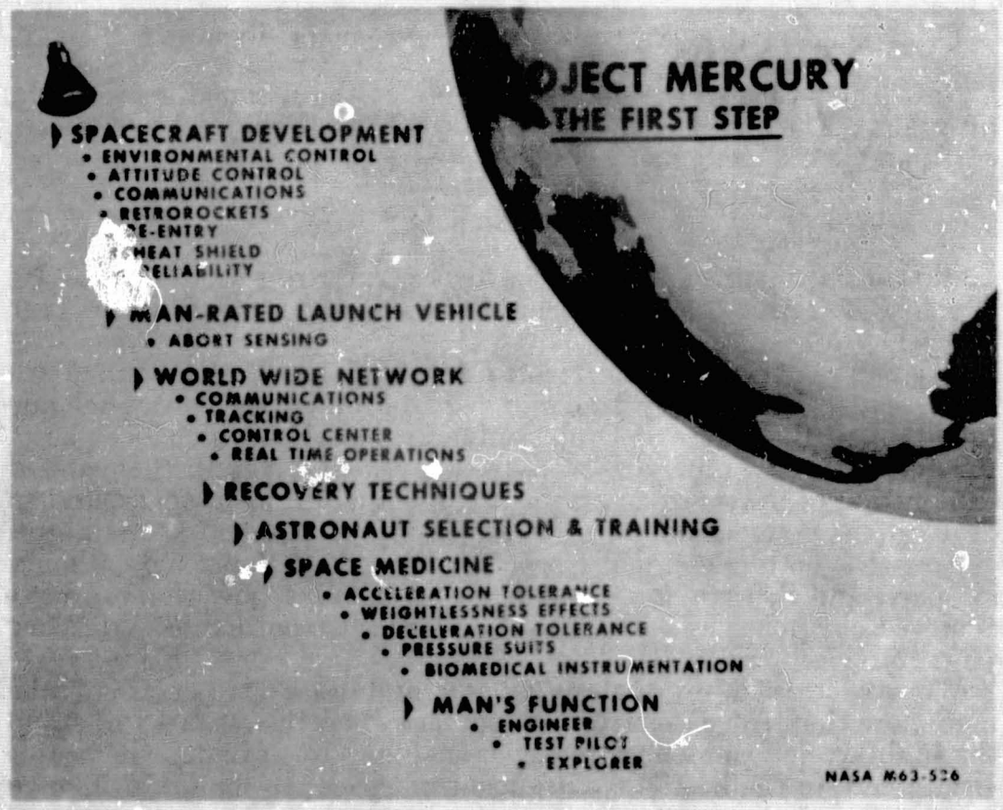


FIGURE 12

orientation in space; to provide the thrust to initiate reentry toward the Earth's surface; and to withstand the searing heat of reentry.

We have learned how to adapt a launch vehicle, never intended for manned flight, so that it is sufficiently safe and reliable to be used for manned flight; and how to incorporate in this launch vehicle an intricate system for sensing an impending malfunction so that the spacecraft could be safely separated from the launch vehicle in emergency.

We have learned how to operate a worldwide network of radio and radar stations, linked to a control center by an elaborate net of communications systems, to keep track of a manned spacecraft and remain in constant communication with its pilot. We have learned how to conduct manned flight operations in real time, based on information received at the control center from thousands of miles away, sometimes on the other side of the Earth.

We have learned how to pinpoint the spacecraft's location once it has landed in the ocean, and how to recover it from the ocean in a very short period of time.

We have learned how to select and train astronauts so that they can perform in space as well as a test pilot can perform in the Earth's atmosphere; and we have learned what controls and what displays should be provided in the spacecraft so that the pilot can manually back up his automatic systems.

We have learned that man can withstand the high accelerations of a rocket launching, a prolonged period of zero gravity, and then a period of high deceleration during reentry; and that none of these forces exerts any deleterious effect on his ability to do his work for periods lasting as long as 9 hours. We have developed and proven the concepts of spacecraft life-support systems, of pressure suits to be used in space, and of biomedical instrumentation that can allow a flight surgeon on the ground to assess the physical condition of a pilot who is hundreds of thousands of miles away.

Perhaps most important of all, we have learned that man can materially contribute to the exploration of space. He can enhance the systems reliability through his capabilities as an engineer and as a test pilot, and he can act as a scientific observer in space.

These demonstrations of man's ability to judge, to reason, and to cope with the unexpected enable us to proceed with confidence that man can assume the role of an explorer in space just as he has been an explorer on the surface of the Earth.

Mr. YEAGER. Mr. Chairman, may I ask a question here?

Mr. Holmes, according to the lunar experts, if we are to do more with the manned lunar landing than put someone down and bring him back, it would be extremely important to hit the right spot and to have someone along who can perform the scientific missions.

At the same time, we hear criticism from scientific people that we plan to do this entirely with astronauts who have been trained as quasi-scientists and we have had suggestions that perhaps one of the Apollo crew ought to be a scientist trained to perform astronaut functions.

Would you care to comment on that whether or not this is a thing which has been considered, or has it been considered and adjudged to be unnecessary.

Mr. FULTON of Pennsylvania. Would you yield? If it is a scientist, it could as well be a woman as the third astronaut.

Mr. HOLMES. We have considered having a male scientist aboard and still are considering that as a possibiiity. We would not have to train such a man at this point in time. We still have time to make that decision.

However it is our strong and considered opinion at present that we cannot in anyway—I am searching for the right word—we cannot in anyway minimize our chances for success by failing to have physically qualified, flight qualified people for the mission on the first attempts.

Now as I proceed with this testimony I will touch upon what one must do for longer stays on the Moon. The first stay on the Moon is so short that you might get in only 6 hours of effective work in a full day's stay, if you take time for the men to sleep. Thus an astronaut, properly trained, probably could obtain about as much scientific data as the scientist would.

I am sure that will get comments from scientists. But I think to do a really thorough exploration job is going to take a longer period on the Moon. This, in turn, will require some of the things I will describe later, such as a logistic-type system to support greater stays on the surface of the Moon.

Mr. FULTON of Pennsylvania. Thank you.

Mr. HOLMES. We have planned one additional flight in Project Mercury (fig. 13).

This flight is scheduled for May of this year; Astronaut Gordon Cooper has been selected as its pilot, and Alan Shepard as his backup.

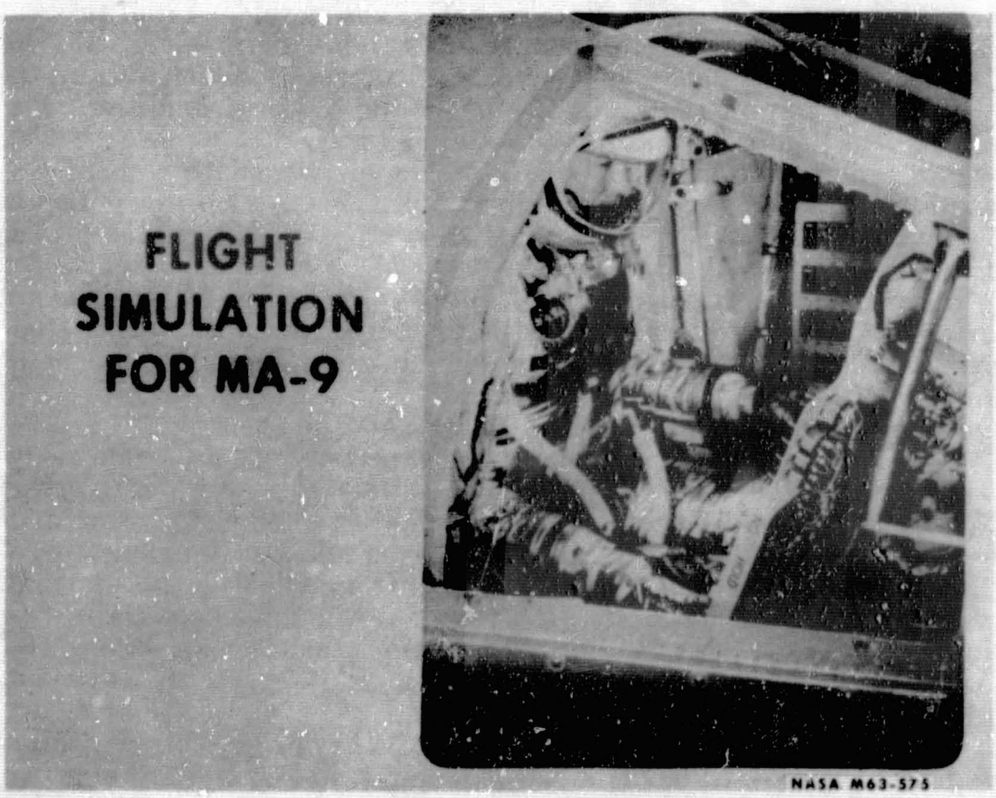


FIGURE 13

If all goes well, the duration of the flight will be 22 orbits—about 34 hours. This long-duration mission will stretch the capabilities of the Mercury spacecraft systems, while retaining ample reserves of cooling water, oxygen, and reaction control fuel to cope with contingency situations. We will be able to get a detailed assessment of man's reaction to this longer time in space flight, and will perform further scientific experiments in space. Beyond this flight we have available spacecraft and Atlas boosters for two additional Mercury flights. These are currently scheduled only as backup missions to the 22-orbit flight.

Mr. ROUDEBUSH. Mr. Chairman. Mr. Holmes, why the delay in this last Mercury flight? I know it was originally scheduled for, I believe, April 2—I think that date is correct—and then we were advised it would be delayed something like 30 or 60 days. What was the technical reason for the delay?

Mr. HOLMES. The technical reason was in the Atlas booster.

Mr. ROUDEBUSH. Wasn't this a similar booster to what we had used before?

Mr. HOLMES. Yes, it was a similar booster. But in the continuing reliability studies which the contractor, General Dynamics, has done on Atlas and is continuing to do, it was found that the manner in which wires were connected to what could be called the autopilot, the control system, was not as safe as they would like to see it. When more than one wire, in fact several wires, come to a connecting point at the back of a connector, they used a little adapter—a little socket with a little male prong on it. That adapter had the wires soldered into it and then the adapter in turn, was soldered to the connector. During the second operation there was a possibility of chilling the solder and causing a cold-solder joint. So it was discovered in the step-by-step continuing reliability analysis. Any time something like this is brought to our attention we feel the decision should be to maximize the safety of the flight even at the cost of time.

Mr. ROUDEBUSH. How long ago was that called to your attention?

Mr. HOLMES. Just a day before we made the announcement; I guess it was 3 or 4 weeks ago. George, do you remember?

Mr. LOW. As I recall, it was around the first of February.

Mr. HOLMES. Mr. Low says around the first of February. We made the announcement of the delay within a matter of a few days, maybe not more than 24 hours, after it was brought to our attention. Is that a correct statement?

Mr. LOW. That is right.

Mr. HOLMES. I have concluded my description of Project Mercury.

Now as I went through this almost litany, of what we have learned—to build, to fly, et cetera—it went through my mind that our first manned orbital flight was just February 20 of last year. So I think—and I don't mean this to apply to NASA or my group, but to the Nation—we can say that a great deal has been accomplished in the growth of this Nation toward its capability to fly man in the last 12 months.

PROJECT GEMINI

Following hard on the heels of Project Mercury will be Project Gemini. This project, which has been underway for more than a year, forms an integral part of a step-by-step development program

starting with Mercury and leading to the achievement of a manned lunar landing in Project Apollo. The basic objectives of the Gemini project are to increase our operational proficiency and our knowledge of technology required for manned space flight and to develop both rendezvous and long-duration manned-flight capabilities.

Although we have learned much from Project Mercury, this first program must be considered as only a tiny step in our manned exploration of space. An Apollo lunar mission will last at least five times as long as the next Mercury mission. The Apollo spacecraft will have the capability to maneuver in space, to correct its course on the way to the Moon, and to perform the all-important rendezvous maneuver in orbit about the Moon. In Mercury only the craft's orientation can be changed. Its orbital path is fixed in space.

For these reasons the Gemini program was conceived and is being implemented to bridge the technical gap between Mercury and Apollo (fig. 14). The Gemini spacecraft resembles Mercury in many important details. The aerodynamic shape of the Mercury spacecraft has been retained, but the size of the pressurized compartment has been increased to accommodate two astronauts. The space for equipment has been greatly increased by arranging to carry the adapter section into orbit. To proceed with the Gemini program at the earliest possible time, the prime spacecraft contract was awarded to the McDonnell Aircraft Corp., which so successfully developed the Mercury spacecraft. Many of the Mercury subsystems have been retained and, of course, the operational and flight experience achieved in Mercury will be directly applicable to the Gemini program.

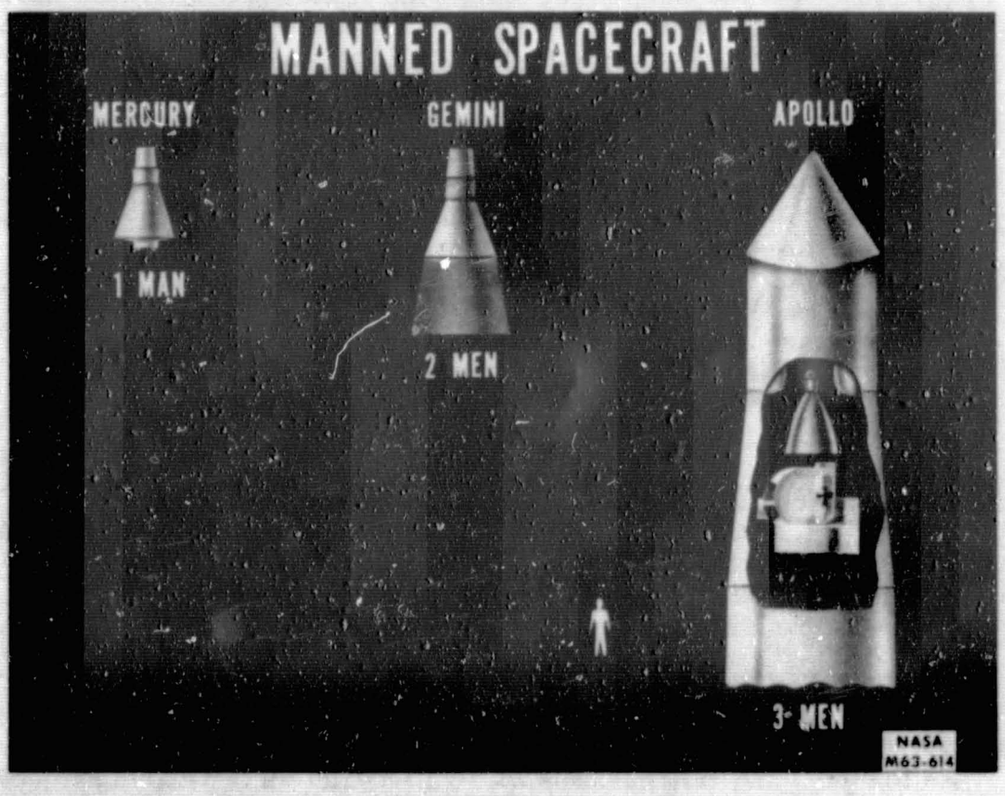


FIGURE 14

The step from Gemini to Apollo will be a very large one, but, to the maximum extent possible, the Gemini developmental effort has been directed toward common use of technology for Gemini and Apollo. In many instances, the same subcontractors have been selected for both projects. For example, on both Gemini and Apollo spacecraft, Rocketdyne Division, North American Aviation, is developing the reaction control systems, AiResearch Division of the Garrett Corp., is developing the life-support systems, and Minneapolis-Honeywell is developing the attitude and maneuver control electronics.

In the area of ground systems development, very nearly the same network of ground stations will be used in Gemini rendezvous and Apollo orbital missions. Much of the automatic checkout equipment that is now being developed for Apollo will see its first use in checking out the Gemini spacecraft.

The planned Gemini missions will provide operational experience that will be directly applicable to future Apollo missions. Gemini will be capable of executing space flight missions of up to 2 weeks, longer than any presently planned Apollo lunar mission. The Gemini program will contribute importantly to Apollo in the major phases of a rendezvous maneuver: launch-on-time, maneuvers in space, acquisition in space, and docking, all of those being elemental to successful rendezvous.

A highly skilled and experienced operational team is essential to any manned space flight program. The experience gained in Mercury is being applied in Gemini. The more advanced experience in Gemini will fulfill a critical requirement for such experience in carrying out the much more difficult task of controlling operations in Project Apollo.

Our astronauts will learn how to perform most of the maneuvers required in a lunar landing mission in training flights using the Gemini spacecraft, before attempting the more difficult Apollo missions.

The Gemini two-man spacecraft (fig. 15) will be approximately 30 percent larger than the Mercury spacecraft and will weigh about 7,000 pounds. We are still very much payload limited. This will use the Titan II. A fundamental concept of the spacecraft design will be the use of modular equipment, which provides subsystems that are independent and readily accessible. Accordingly, maintenance and checkout difficulties will be minimized, and product improvement as well as mission adaptation will be simplified.

In other words, in that Gemini capsule the pressure shell houses the astronauts and very little more. All around the pressure shell is located the equipment, to which one has access through hatches.

As you know, part of our difficulties in Project Mercury on the launch pad resulted from having some valve or something else stick, and it always was either under the couch or behind the heat shield where one had to dismantle the whole operation. This will certainly provide us much better access. I think it will provide us a lot greater reliability, and, further, it provides us an operational platform on which we can fly other test subassemblies for use in later flights—in Gemini or in Apollo.

Several new subsystems will be introduced in the Gemini spacecraft. Aircraft-type ejection seats will be provided for astronaut abort in case of emergencies. An inertial guidance system, together with a

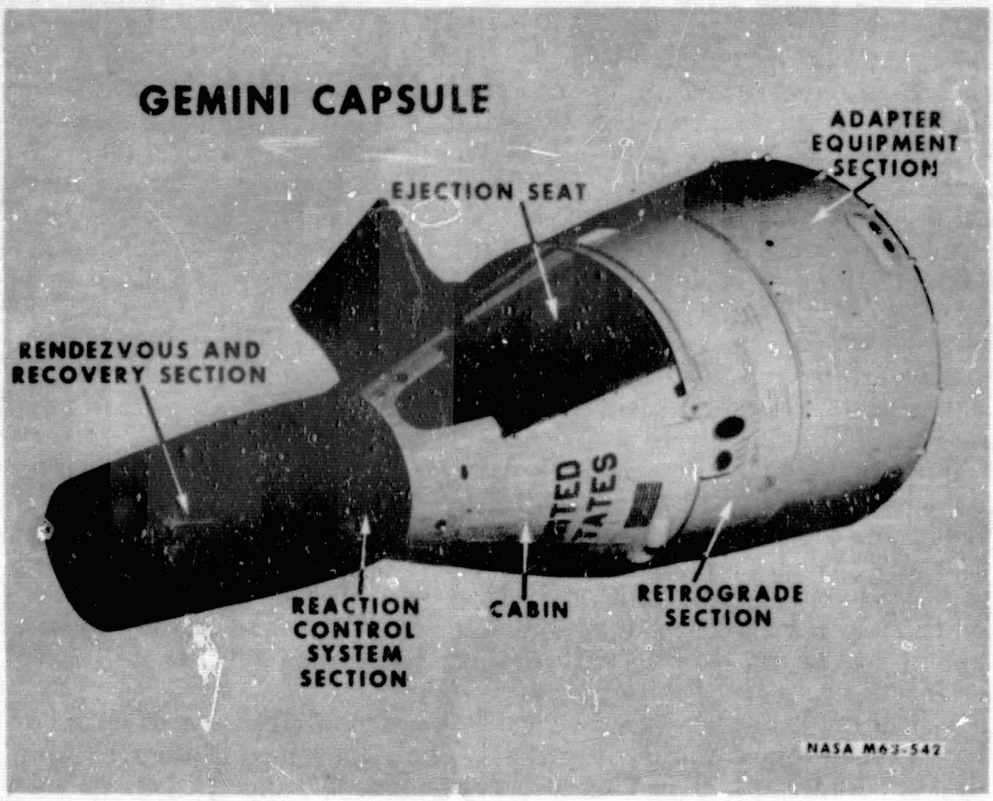


FIGURE 15

rendezvous radar, will provide information for the spacecraft to carry out the rendezvous with its target vehicle. The inertial guidance system also will provide information for directing the spacecraft to a predetermined recovery site, and will serve as a back-up for the Gemini launch vehicle guidance system. For the first time in a U.S. spacecraft, a fuel cell, similar to the one to be used in Apollo, will serve as a primary source of electrical power. Also for the first time, we shall have to make provisions for food storage and waste handling.

While the Mercury spacecraft circled the earth in fixed orbits without maneuvering capabilities, the Gemini spacecraft will carry small thrust units which will be used to modify its orbital path, and to permit rendezvous and docking maneuvers. A paraglider, or parawing, deployed from the spacecraft at about 50,000 feet altitude, will be substituted for the parachute in later flights to allow the Gemini spacecraft to come down on land in much the same manner as a motorless aircraft.

During fiscal year 1964, five Gemini spacecraft will be delivered. Funds will be used also for the production of other spacecraft, and for development tests including those of the paraglider, launch services, and spacecraft reliability.

The Titan II, an excellent launch vehicle, modified to increase reliability and astronaut safety, will be employed as the primary launch vehicle for Project Gemini (fig. 16). To facilitate rendezvous, this launch vehicle will be required to insert the Gemini spacecraft into a precise Earth orbit with a minimum of launch delays. The Titan II is now being developed by the Air Force as an interconti-

FIGURE 16

nental ballistic missile. Critical components of the Gemini version of the Titan II, such as the malfunction detection system, will be flight-tested on Air Force Titan II ICBM's during the developmental program. Fifteen Titan II's are being procured for the Gemini program from the Martin-Marietta Corp., through the Air Force Space Systems Division. The first five Titan II vehicles will be delivered during fiscal year 1964. Requested funds will be used for the production of additional vehicles, launch support services, propellants, and preflight testing.

Mr. YEAGER. Mr. Chairman, may I ask a question there? The last thing I read about the Titan was its blowing up shortly after launch from a silo. Do you know whether they have overcome the problem that was encountered there?

Mr. HOLMES. The report indicated that it was a result of the effects from the silo launch. We have covered carefully the ones launched from the cape in the manner that we will launch them.

Although there were some problems which I reported to the full committee on longitudinal vibrations, we believe that they are licking these, and that the launch vehicle is going to be ready for the time scale on which we need it.

Mr. YEAGER. By the time that you are ready to launch a man in the Gemini capsule, do you know if NASA or the Air Force will have had experience with the Titan launch vehicle comparable to what you had with the Atlas before Glenn was launched?

Mr. HOLMES. Not as many flights. Mr. Low, would you comment.

Mr. LOW. Well, the number of flights of the Titan II before our manned flight will be perhaps only a half or a third of those that were flown on the Atlas before the manned flight.

On the other hand, the Titan II is a much simpler launch vehicle than the Atlas. The wiring circuits, the plumbing, all of the mechanical elements have been simplified greatly, so that we believe a fewer number of flight tests will be adequate for this purpose.

Mr. YEAGER. Thank you.

Mr. FULTON of Pennsylvania. Mr. Chairman.

The question comes up, is the Cooper flight necessary? First, it is being taken with the Atlas, which is more complicated than the Titan II. Second, if we don't do the two later Mercury shots, it will be the last flight that goes without automatic check-out equipment.

Wouldn't it be better to just go ahead with the Gemini program and save the money, and save the risk on the last projected Mercury flight. We would probably learn everything in the Gemini flight that we could learn in the last Mercury flight. It will actually be testing components, navigation, and some scientific observations.

Mr. HOLMES. Yes, sir, I think that one of the major reasons for going ahead—although there are several—is that we would like as rapidly as possible to have data on man's reactions to as extended a mission as possible.

It is true the Russians have flown 3 and 4 days, and it is somewhat comforting in knowing that they didn't appear to be sick. However, we have very little data on it. So our people would like to have that information in order to not only perturb, if necessary, the Gemini design, but the Apollo design.

Further, the kind of experiments, and the kind of observations that we were able to make in our last flights were somewhat rushed. The astronauts were terribly busy, particularly in the three-orbital flights, a little less so in the six-orbital one.

We believe that the data that a man can bring back by having that period of time in space will give us other information which will be useful in the ongoing program.

All of those things added together lead us to the conclusion it is a very worthwhile thing to do, to do this Cooper flight.

Mr. FULTON of Pennsylvania. Even with the Atlas-Agena programs not measuring up to expectations in four out of seven instances on nonmanned flights, you nevertheless think that it is worthwhile for its scientific results, as well as in view of the expense?

Mr. HOLMES. Yes. Of course, we don't use the Agena here as you know. But the Atlas itself has performed very well for us, as you know, for manned flights.

Mr. FULTON of Pennsylvania. It certainly has.

Mr. HOLMES. We always are concerned during launch, whether it be with an Atlas or anything, because it is a dangerous element of the flight. But I think we feel it is worth going ahead.

Mr. FULTON of Pennsylvania. My last point is this: Last year I thought we could cut $3 million out of the Mercury program. After I had some conversations, I felt that it should be cut $2 million in this committee, and the House Science and Astronautics Committee approved the $2 million cut.

Then we went to the Senate, and they convinced me to make the cut only $1 million. I agreed to that because I didn't want to hold the program back.

Then on my visit to Houston, I was surprised to find that $3 million was transferred and reprogramed out of the Mercury program in the current fiscal year.

Mr. HOLMES. Not to my knowledge. Do you have the figures here? I think there was some confusion when you were at Houston. At least it was reported back to my people as far as——

Mr. FULTON of Pennsylvania. Well, don't do it here.

Mr. HOLMES. Last year for the first time—at least to my knowledge for the first time—we put the institutional funds in with the R. & D. funds. Now in the books this year they are broken out separately, and brought together, at the bottom.

To put institutional or Government employee salary expenses in the R. & D. funds, one has to be somewhat arbitrary. I think, unfortunately—and I am somewhat embarrassed about it—when the committee visited Houston our people forgot this had happened, and they were hard pressed to explain what the funds were.

I think we have all the data and that we didn't transfer funds.

Mr. FULTON of Pennsylvania. I want the Congress and the taxpayers to know that we are careful about these funds. We want to know that everything that is being given NASA is necessary, and that they will use it efficiently.

Mr. HOLMES. Yes, sir.

Mr. LILLY. In answer to your specific question, Mr. Fulton, our estimate for Mercury last year, the R. and D. cost, excluding prorated institutional costs, was $3½ million.

This year we have currently programed and are spending $3,342,000 of that. There has only been a reduction of $158,000.

Mr. FULTON of Pennsylvania. Then we ought to have in the record why the Mercury program, with the final cost figure of $200,000 coming in 1964, actually is four times its original cost estimates.

Mr. HOLMES. We can comment on it or supply it for the record.

Mr. FULTON of Pennsylvania. If you can do it shortly, all right. I do not want to take too much time on it.

Mr. HOLMES. Our figures don't show it as four times, but why don't we supply it for the record for you.

Mr. FULTON of Pennsylvania. Thank you.

(The information requested is as follows:)

In January 1959, Dr. T. Keith Glennan, then Administrator of NASA, indicated that the total cost of Project Mercury would exceed $200 million. In November 1959, after a more detailed assessment of requirements, the cost of Project Mercury was estimated at $346 million. This estimate included $293 million for research and development and $53 million for the tracking network. The estimate of of $346 million excluded prorated institutional costs. The current estimate for Project Mercury, including the 1963 runout cost, is $312 million—$34 million below the November 1959 estimate. This amount includes $259 million for research and development and $53 million for the tracking network; it excludes prorated institutional expenses. If 1-day mission costs ($35 million) are added to the Project Mercury estimate, the combined Mercury/1-day mission cost totals an estimated $347 million, including $1 million for facilities.

Mr. CASEY. Excuse me, Mr. Holmes; Congressman Miller, chairman of our full committee, is with us this morning.

Chairman MILLER. You have talked about the trouble that DOD has had with the Titan II. They have corrected that trouble, and in correcting it they have put a military warhead on it, haven't they? However, when we use the Titan II for Gemini isn't it much heavier than the military warhead?

Mr. HOLMES. Well, yes, their corrections have been such as to accommodate us because they said they were not worried about the vibrations for the military payload. But we couldn't stand the vibrations for our spacecraft and astronauts, so the corrections they have made——

Chairman MILLER. The corrections that you are figuring on here will take care of all of the NASA payload?

Mr. HOLMES. Yes, sir.

Chairman MILLER. It is much heavier.

Mr. HOLMES. Are they flying a payload equal to ours on the Titan II now?

Mr. LOW. I am not sure of the military payload weight. The reason for needing less vibration in the manned flight is because man himself cannot tolerate the high vibrations that the equipment could tolerate.

Mr. ROUDEBUSH. Are you through, Mr. Chairman?

Chairman MILLER. Yes.

Mr. ROUDEBUSH. To carry on with that, how many unmanned Gemini flights—I get from your testimony that you are planning some unmanned Gemini flights—how many do you plan?

Mr. HOLMES. One, suborbital flight.

Mr. ROUDEBUSH. Are you having a mechanical man or something in it?

Mr. LOW. There are no plans for a mechanical man at this point in time.

Mr. ROUDEBUSH. Just one suborbital flight?

Mr. HOLMES. Yes; to check reentry, and so forth.

Mr. ROUDEBUSH. Thank you.

Mr. HOLMES. Yes, sir.

The Titan II, modified to increase reliability and astronaut safety, will be employed as the primary launch vehicle for Project Gemini. To facilitate rendezvous, this launch vehicle will be required to insert the Gemini spacecraft into a precise Earth-orbit with a minimum of launch delays. The Titan II is now being developed by the Air Force as an intercontinental ballistic missile. Critical components of the Gemini version of the Titan II, such as the malfunction detection system, will be flight-tested on Air Force Titan II ICBM's during the developmental program. Fifteen Titan II's are being procured for the Gemini program from the Martin-Marietta Corp., through the Air Force Space Systems Division. The first five Titan II vehicles will be delivered during fiscal year 1964. Requested funds will be used for the production of additional vehicles, launch support services, propellants, and preflight testing.

The Gemini target vehicle will be a modified Agena vehicle, which will be boosted into Earth-orbit by an Atlas (fig. 17). Modifications to the Agena will include supplying a capability for multiple restarts, so that rendezvous maneuvers can be performed. A radar transponder will be added to send signals to the radar receiver on the Gemini spacecraft. Eight Agena target vehicles are being developed

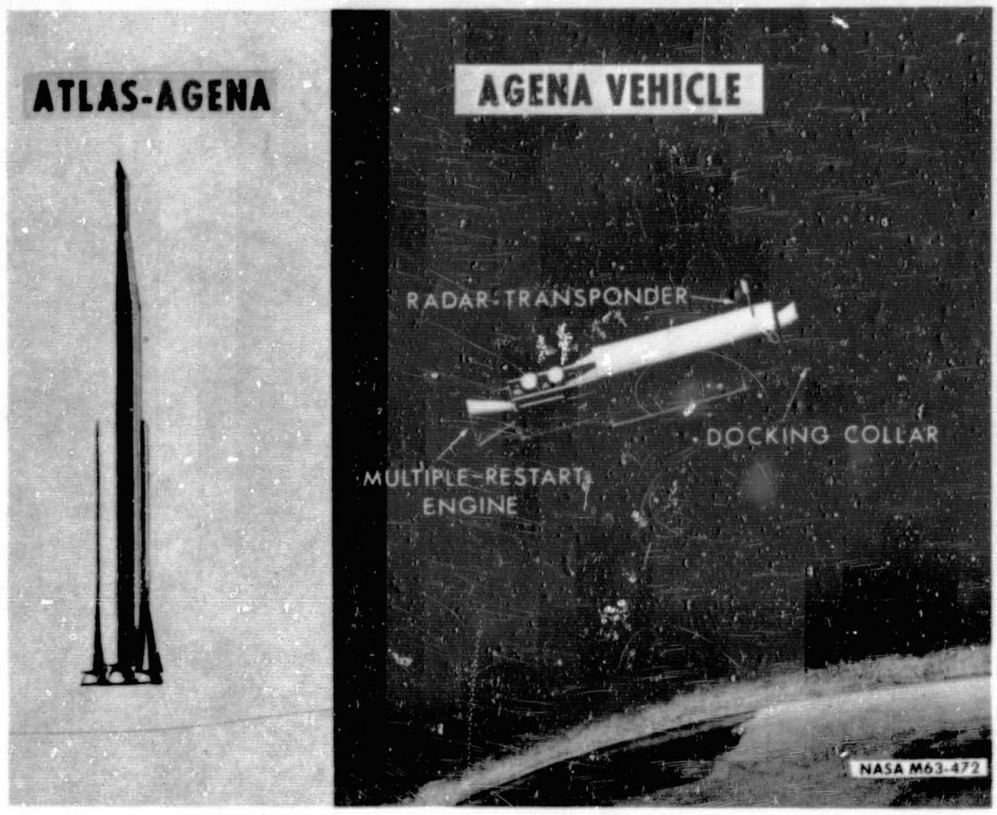


FIGURE 17

by, and procured from the Lockheed Missiles and Space Co. through the Air Force. The Atlas vehicles are being procured, again through the Air Force, from the Astronautics Division of the General Dynamics Corp.

Fiscal year 1964 funds will be used to purchase Atlas boosters for the first Atlas-Agena launchings. For the Agena, funds will be used for vehicle manufacture, test site support, development testing, and the delivery of one vehicle.

Early Gemini flights will be long-duration missions lasting up to 2 weeks. In these missions, we shall investigate the physiological effects on the crew of zero gravity, artificial environment, limited mobility, and varied work plans for prolonged periods of time, preceded by high acceleration and intensive vibration, and followed by high deceleration. The Gemini program will provide an early evaluation of man's efficiency under such conditions. The program will provide experience in the maintenance of a proper atmosphere in the spacecraft for long periods.

Here we see work in progress at the Manned Spacecraft Center on the development and testing of possible designs for the Gemini spacesuit (fig. 18). That doesn't give you a very good look. We have another slide later that gives you a better look.

Seated at the left is an engineer wearing a new Air Force suit being evaluated for mobility characteristics. Next to him, another man is wearing a Mercury-type suit. On the right is one type of advanced suite being evaluated for the Gemini program.

FIGURE 18

We expect that spacesuit used in Gemini (fig. 19) will cover the torso, head, upper arms, and upper thighs. However, it will be possible to remove the covering from the lower legs, forearms, feet, and hands during most of the mission. In the event cabin pressure is lost during flight, it will be possible to don these additional garments in time to avoid any hazard to the astronauts.

The construction of the Gemini suit will permit the wearer to open it sufficiently to accommodate normal body functions. The pre-prototype suits have been evaluated by our biomedical engineers. Negotiations are in progress for the fabrication of a sufficient number of suits to meet test and training needs. In its final form, the Gemini spacesuit will provide a capability for short-duration life support outside the spacecraft. At present, we are studying how we will use this spacesuit to explore the problems to be encountered in operations outside of the spacecraft in Project Apollo.

Fiscal year 1964 funds will be used for the continued development of the extravehicular suit, purchase of production pressure suits, and the associated maintenance and procurement of production food and waste management systems.

Mr. CASEY. Mr. Holmes, I think that we will stop at this point before you go into some other matters since we would have to stop before long anyway.

Gentlemen, what is your pleasure? Are you available this afternoon?

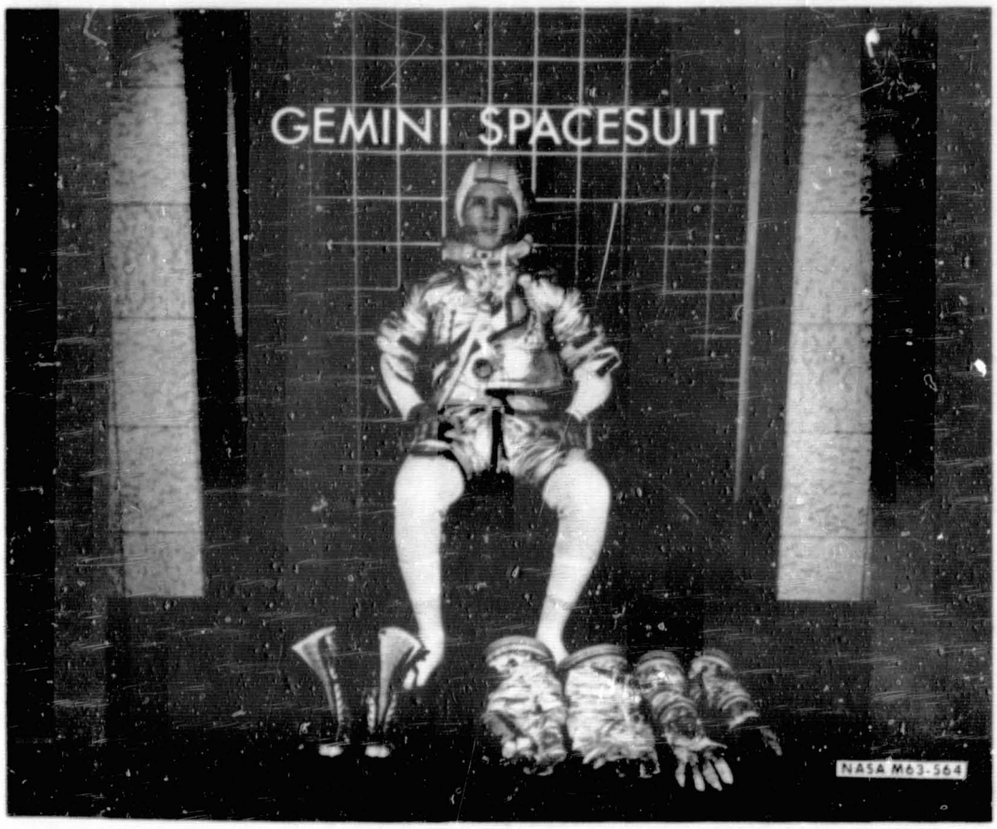


FIGURE 19

Mr. HOLMES. Yes.

Mr. RIEHLMAN. I think we have two important matters on the floor.

Mr. CASEY. We will adjourn then until tomorrow morning at 10 o'clock.

Mr. HOLMES. Yes, sir; thank you, Mr. Chairman.

Mr. CASEY. Thank you, Mr. Holmes.

(Whereupon, at 12 noon, the subcommittee adjourned until 10 a.m., Thursday, March 7, 1963.)

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1964 NASA AUTHORIZATION

THURSDAY, MARCH 7, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON MANNED SPACE FLIGHT,
Washington, D.C.

The subcommittee met at 10 a.m., Hon. Emilio Q. Daddario presiding.

Mr. DADDARIO. The meeting will please come to order.

Mr. Holmes, if you would be kind enough to proceed from the place you left off yesterday. I understand you would like to change your method of procedure. Instead of reading the report verbatim, you would like to just insert portions of it in the record. The Chair is perfectly agreeable if you do so.

STATEMENT OF D. BRAINERD HOLMES, DEPUTY ASSOCIATE ADMINISTRATOR AND DIRECTOR, OFFICE OF MANNED SPACE FLIGHT, NASA; ACCOMPANIED BY GEORGE M. LOW, DEPUTY DIRECTOR (PROGRAMS), WILLIAM E. LILLY, DIRECTOR OF PROGRAM REVIEW AND RESOURCES MANAGEMENT, AND CLYDE B. BOTHMER, EXECUTIVE ASSISTANT

Mr. HOLMES. Thank you, Mr. Chairman.

Mr. Chairman, members of the committee, yesterday in my testimony I believe we reached the point of the last paragraph on page 30.

A variety of experiments of scientific and engineering significance will be conducted during the periods of extended flight. By deploying a small piggyback target, important phases of the rendezvous problem will be explored in the very early phases of Gemini flights.

Later, the complete rendezvous operation will be conducted by placing an Agena target vehicle in a circular orbit approximately 185 miles above the earth (fig. 20).

One day after launch of the target, the Gemini manned spacecraft will be placed in an elliptical orbit in which it reaches a maximum altitude of 185 miles. Through precise timing and control of the flight path of the manned spacecraft in the launch phase, the number of corrections to rendezvous with the target vehicle will be minimized.

The propulsion system on board the Gemini spacecraft will be capable of small midcourse corrections as well as terminal guidance and docking maneuvers. Target vehicle propulsion may also be used to assist the rendezvous maneuvers. During the docking operations (fig. 21) most of the maneuvers will be accomplished solely by the manned spacecraft under manual control of the astronauts.

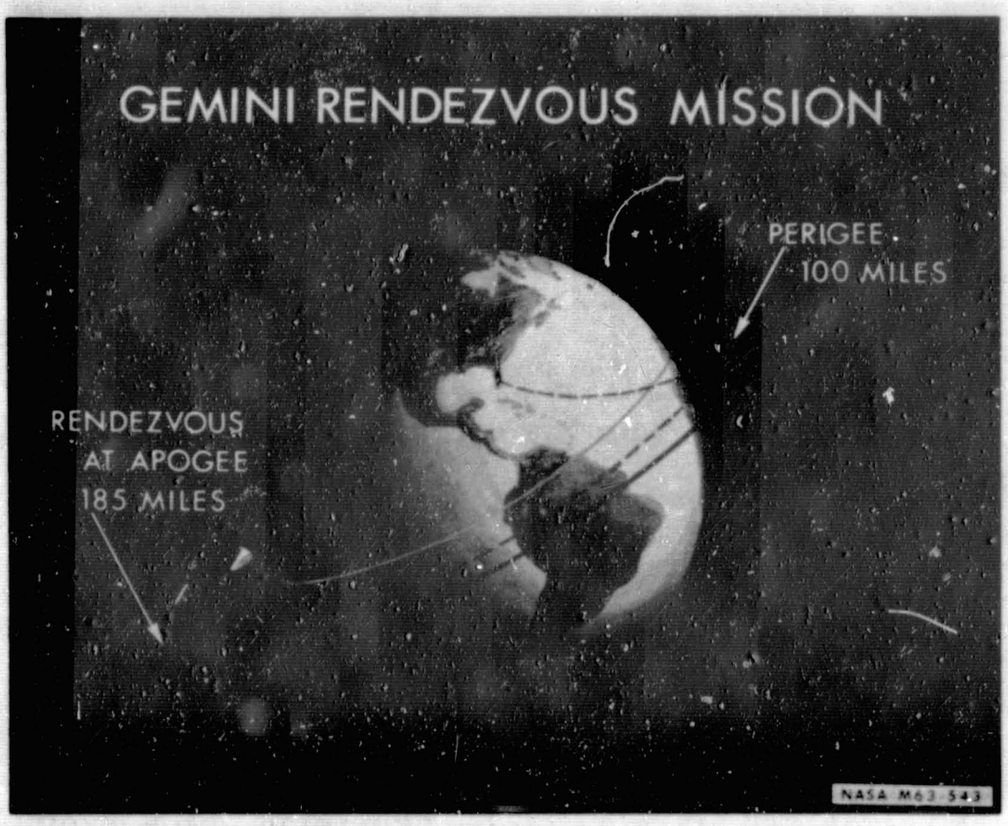

FIGURE 20

FIGURE 21

An exception may be the orientation of the target vehicle. After docking, the Agena propulsion system will be used to develop techniques for the checkout and firing of large engines in space, for orbit change maneuvers, and for navigation.

On completion of the orbital flight portion of the mission, the Gemini spacecraft will return to earth for landing at the preselected ground site. During reentry, modification of lift with roll maneuvers will make it possible to alter the ballistic flight path and thus to maintain a degree of control over the selection of a landing area.

These roll maneuvers will make it possible to shift the landing point several hundred miles along the flight path and a few dozen miles laterally from where the spacecraft would land without such maneuvers.

The maneuvers will enable the Gemini astronauts to land within an area about 10 miles on a side. Between the altitudes of 40,000 and 50,000 feet, the paraglider recovery wing will be deployed for a glide to a controlled landing on skids.

Under conditions of zero winds the paraglider will carry the spacecraft about 20 miles in any direction from the point at which it is deployed.

An example may clarify the situation. Suppose a pair of Gemini astronauts were in an orbit that would enable them to land in the area to be selected in one of the Southwestern States. The error in their retrorocket firing might put them on a trajectory heading to a landing in another part of the State. With the roll control, they could shift their flightpath back to the desired area and come down to the lower atmosphere within a radius of 10 miles around the selected landing point. Then they could use the paraglider to sail the rest of the way. Here (fig. 22) is a drawing of the Gemini paraglider in flight.

Project Gemini was approved in December 1961, and a contract for the development of 12 spacecraft was awarded to McDonnell Aircraft Corp. during the same month.

A full-scale mockup of the Gemini spacecraft was completed in August of 1962, and the first Gemini spacecraft are in production (fig. 23). Production of the Gemini launch vehicles is also in progress (fig. 24), and the Agena target vehicle is well underway. The first suborbital Gemini flight is scheduled around the end of this year. The first manned Gemini flight is scheduled for early 1964. Rendezvous flights are to follow late in the same year.

APOLLO SPACECRAFT

Following Gemini, we are developing the Apollo spacecraft as the vehicle for lunar exploration. This spacecraft will be composed of three separate modules, each designed to fulfill specific mission requirements (fig. 9, p. 154).

The command module will house the three-man crew, will serve as a control center for spacecraft operations, and is designed to safely reenter the earth's atmosphere at velocity of about 25,000 miles per hour upon return from the moon. The service module will house many of the spacecraft's life support systems and a major propulsion system for mission abort, midcourse corrections and injection into and out of lunar orbit. The lunar excursion module will be a special pur-

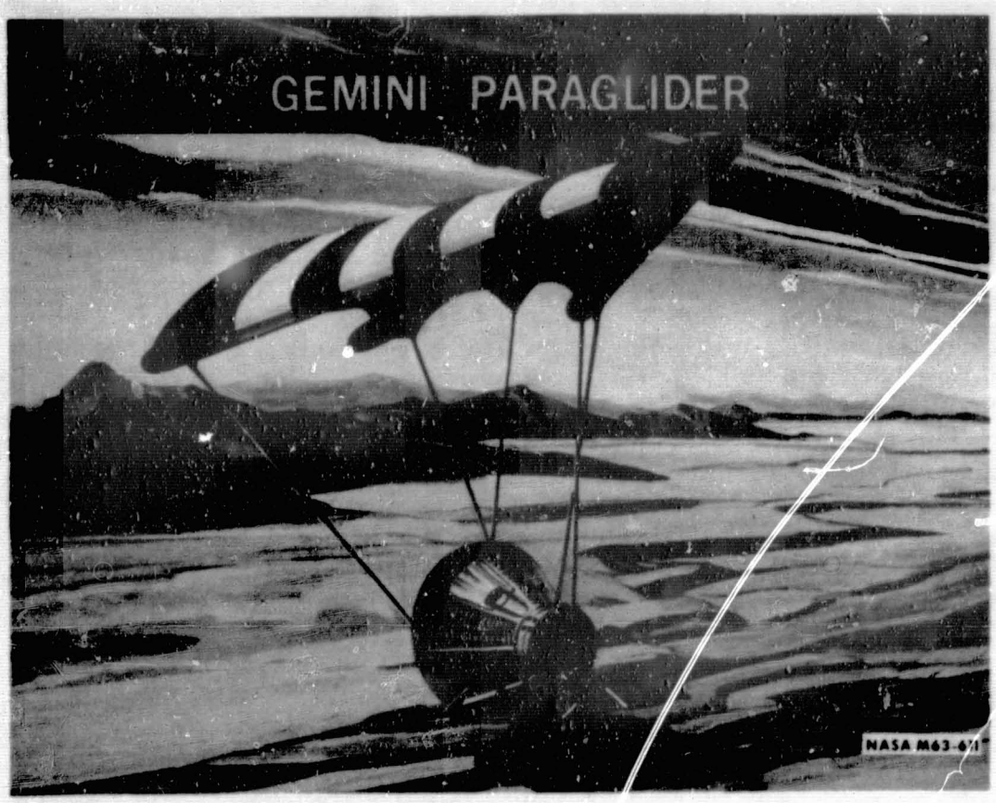

FIGURE 22

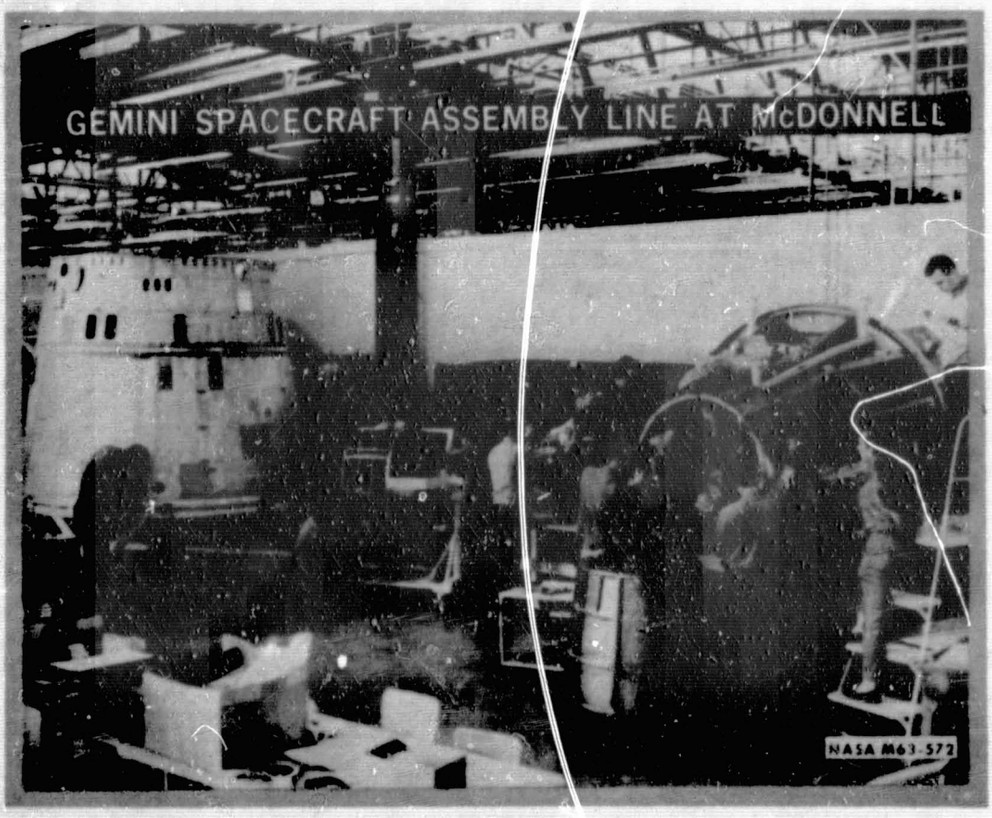

FIGURE 23

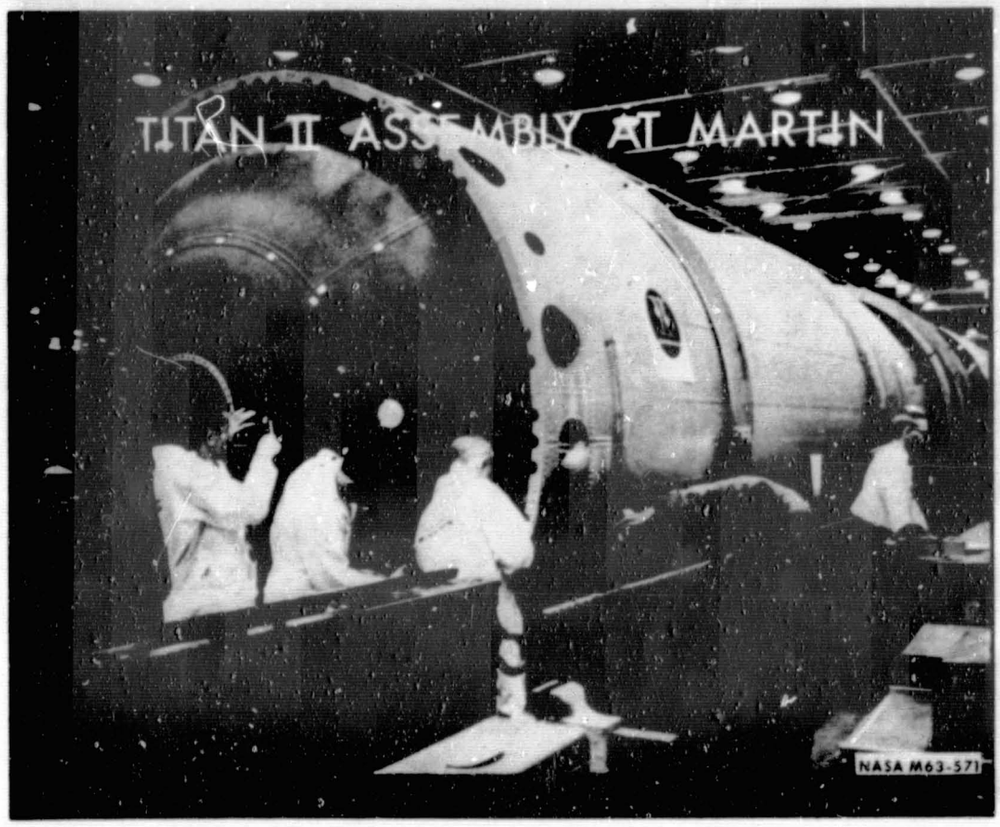

FIGURE 24

pose shuttle, or space ferry, for the two men making the lunar landing. The excursion module will contain the necessary systems for descending from lunar orbit, performing the lunar landing and takeoff, and accomplishing the lunar orbit rendezvous with the command and service modules.

We have here scale models of the escape rocket, the command module with its shroud removed, and the service modules, all to a sixth scale.

I would like to point out if we had the booster here to the same scale and the total assembled it would reach some 60 feet high.

We have here also the lunar exploratory module; unfortunately to a slightly smaller scale, as you see.

The three modules, together with the launch escape system, will be 80 feet tall. When we compare this spacecraft with the Project Mercury hardware (fig. 26), we find that the Apollo spacecraft will be nearly as big as the Mercury spacecraft and its Atlas launch vehicle together.

The empty weight of the Apollo spacecraft will be nearly one and one-half times the empty weight of the total Mercury-Atlas combination.

A contract for the Apollo command and service modules was awarded to the Space and Information Systems Division of North American Aviation, Inc., in December 1961.

The command module (fig. 27), is a blunt, conically shaped body that has an aerodynamic lift-drag ratio of approximately one-half. It is 13 feet in diameter and weighs approximately 5 tons. It will be

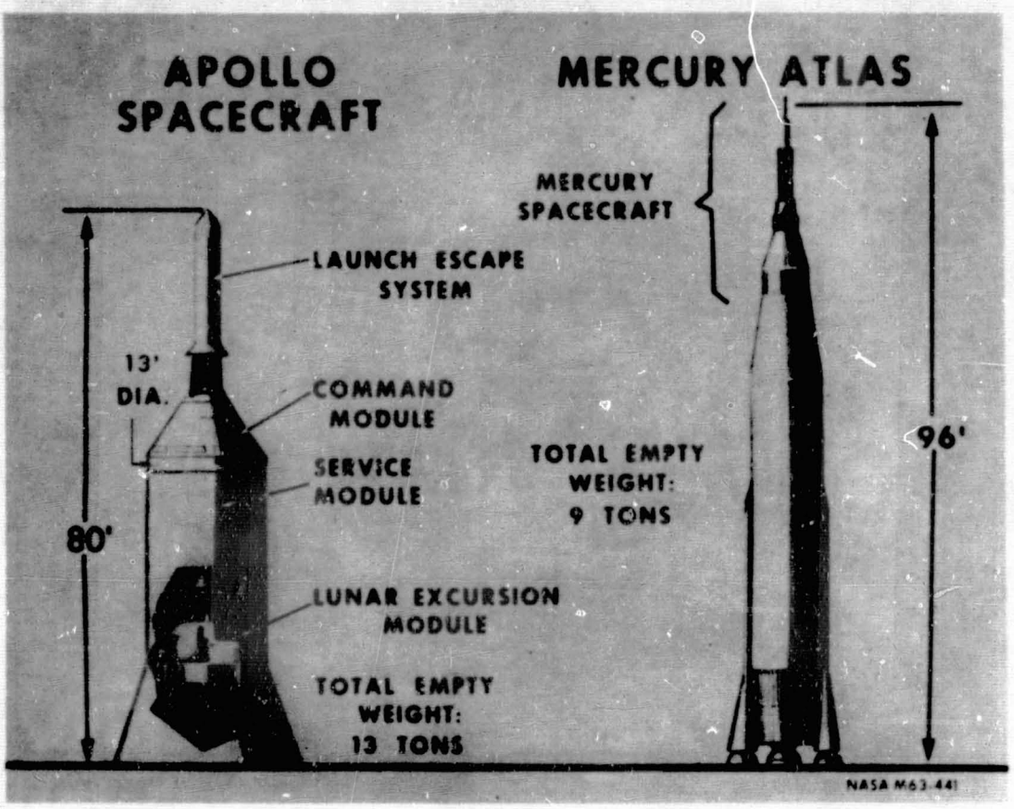

FIGURE 26

FIGURE 27

protected from the heat of reentry by a special material fastened to its external surface, which ablates—or boils to a gas—on exposure to very high temperatures.

The command module structure, heat shield, and internal equipment arrangement will protect the astronauts from the hazards of radiation in space. The module will contain subsystems to provide electrical power, communications, orientation control, orientation stabilization, environmental control, earth-landing, and crew-support subsystems.

Also contained within the command module will be the guidance and navigation system and the instrumentation displays. Here (fig. 28) we see a view of the interior. The internal volume provided for the three-man crew will be approximately 300 cubic feet. Attached to the command module, but jettisoned after staging of the first stage of the launch vehicle, will be a launch escape system similar to the escape tower used in Project Mercury.

The service module (fig. 29) will contain a 22,000-pound thrust rocket propulsion system, an orientation control system, hydrogen-oxygen fuel cells for electrical power supply, radiators for spacecraft cooling, radar, and the supplies of oxygen for the life-support system and the electrical power supply, as well as hydrogen for the power supply.

The service module will weigh approximately 25 tons fully loaded with propellants, and approximately 5 tons empty. It is 13 feet in diameter and 20 feet long.

In fiscal year 1964, command and service module development efforts will be devoted to intensive component and subsystem fabrica-

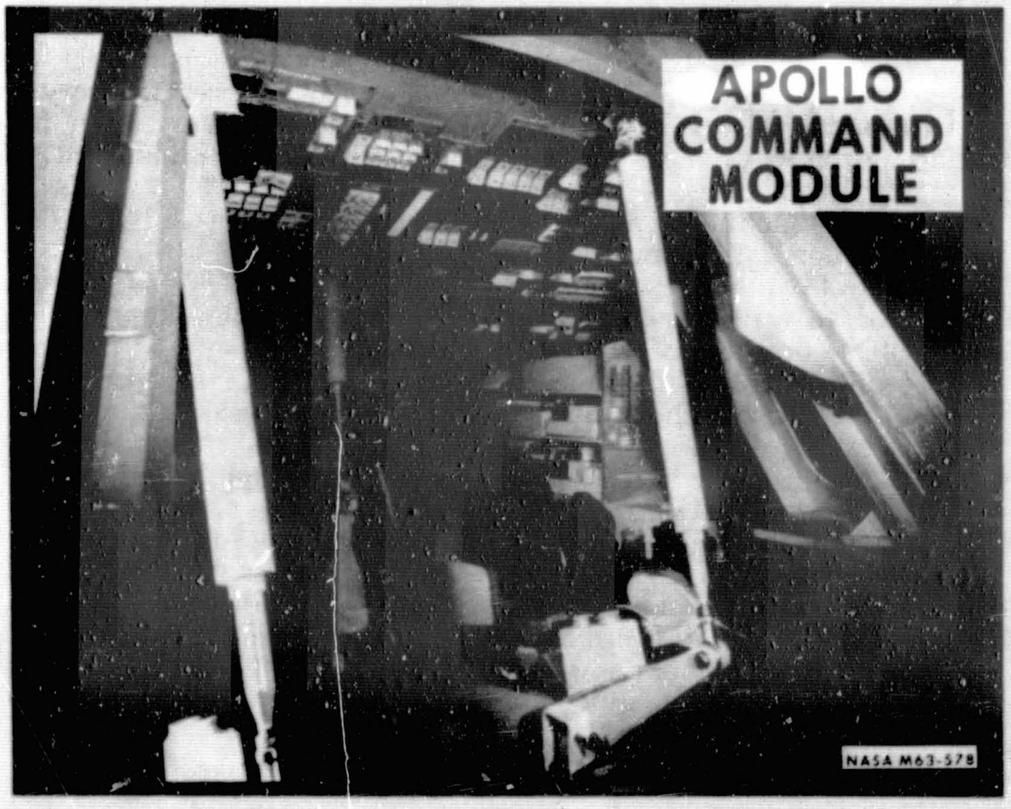

FIGURE 28

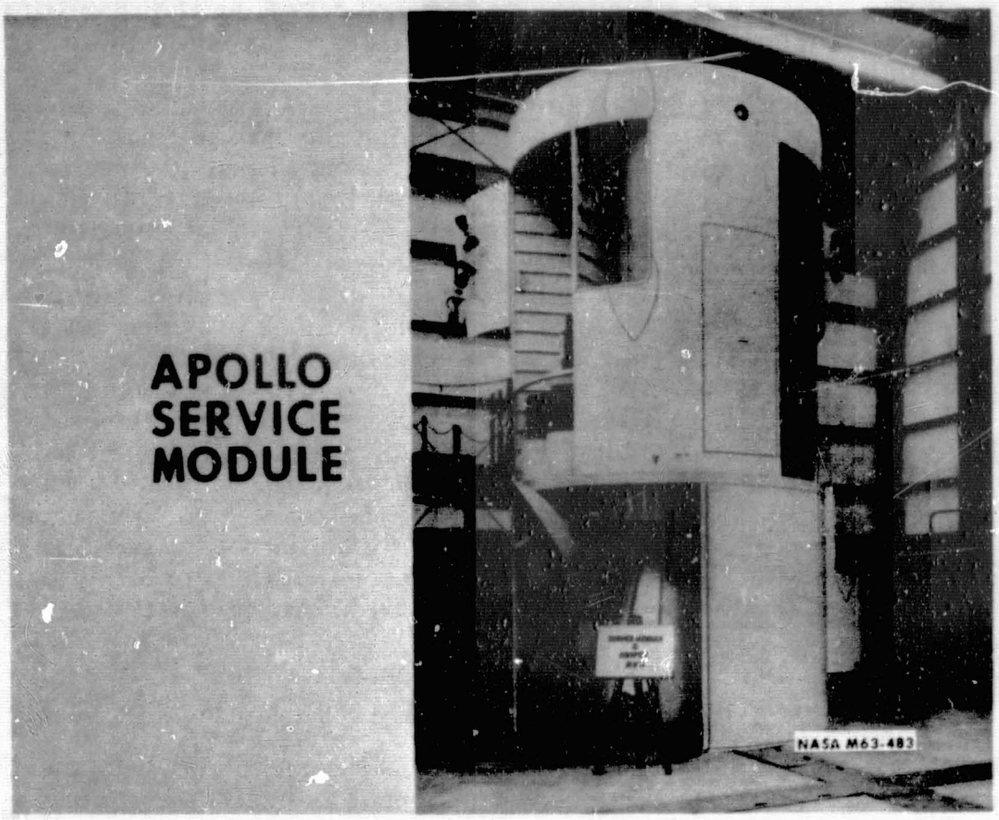

FIGURE 29

tion, testing, and qualifications, and fabrication of 12 spacecraft, to support a delivery schedule of a man-qualified spacecraft every 3 months during fiscal year 1965. Most spacecraft subsystems for manned orbital flight will have completed ground qualification testing by the end of fiscal year 1964.

The service module will weigh approximately 25 tons fully loaded with propellants, and approximately 5 tons empty.

It is 13 feet in diameter and 20 feet long.

In fiscal year 1964, command and service module development efforts will be devoted to intensive component and subsystem fabrication, testing, and qualification, and fabrication of 12 spacecraft, to support a delivery schedule of a man-qualified spacecraft every 3 months during fiscal year 1965. Most spacecraft subsystems for manned orbital flight will have completed ground qualification testing by the end of fiscal year 1964.

The lunar excursion module (fig. 30) has been under development by the Grumman Aircraft Enginering Corp. since January 1963. It will be able to perform separation, lunar descent, landing, lunar ascent, rendezvous and docking, all independent of the command module. The lunar excursion module will weigh about 12 tons and will contain its own electrical power, guidance and control, communications, propulsion and crew-support subsystems.

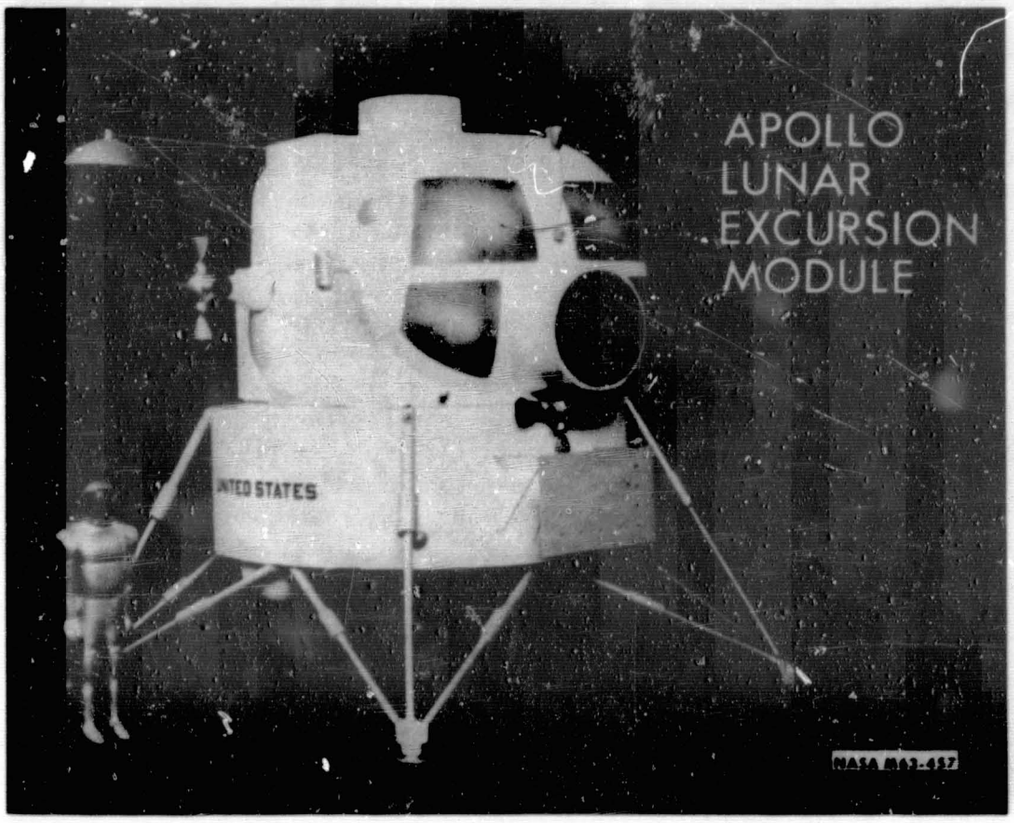

FIGURE 30

The Moon has a relatively weak gravitational field (about one-sixth that of Earth) and no atmosphere. Consequently, the lunar excursion module will not have the same structural and heat-resistance requirements as the command module, which must reenter the Earth's atmosphere and be recovered on the Earth's surface.

The design of the lunar excursion module will be optimized for lunar landing, takeoff, and rendezvous. Windows with a broad view will provide visual reference for the astronauts during these critical maneuvers, which they will perform while sitting upright. The lunar excursion module will have two propulsion stages. The stage used to land on the Moon will remain there. The other stage will be employed for the takeoff from the Moon's surface and rendezvous with the mother spacecraft.

During fiscal year 1964, a throttleable rocket engine will be constructed for tests of the lunar excursion module landing stage propulsion system, which will be designed to permit the spacecraft to hover above the Moon's surface while the astronauts select a landing site.

A spacecraft model will be constructed for tests of the basic structure design and to investigate provisions required to protect the

astronauts from the hazards of radiation and meteroids. With another model, tests will be initiated to develop the landing gear for landing on the lunar surface.

The manufacture of lunar excursion modules for use on flight tests boosted by Little Joe and Saturn vehicles will also begin during fiscal year 1964. In addition, we will begin the manufacture of ground-test and hover-test vehicles, which will be used to test the landing characteristics of the vehicle in a simulated lunar environment.

For Project Apollo, a special spacesuit is being developed for operations on the lunar surface. In the suit shown on this slide (fig. 31) the astronaut, carrying his life support in a pack on his back, will leave the ship to make scientific measurements on the surface of the Moon.

The current technological work in the spacesuit area is being directed toward improving structural integrity, reliability, and durability, while at the same time providing greater stay time, functional capability, mobility, and comfort for the suited astronaut.

At the left of the next slide (fig. 32) is a subject at Manned Spacecraft Center suited in a current Mercury-type suit and a mock-up of the portable life support system.

One of the practical problems is making certain that the hatches of the Gemini spacecraft and the Apollo spacecraft command and lunar excursion modules are large enough to allow the astronaut to climb through easily both under zero-gravity conditions and on the Moon.

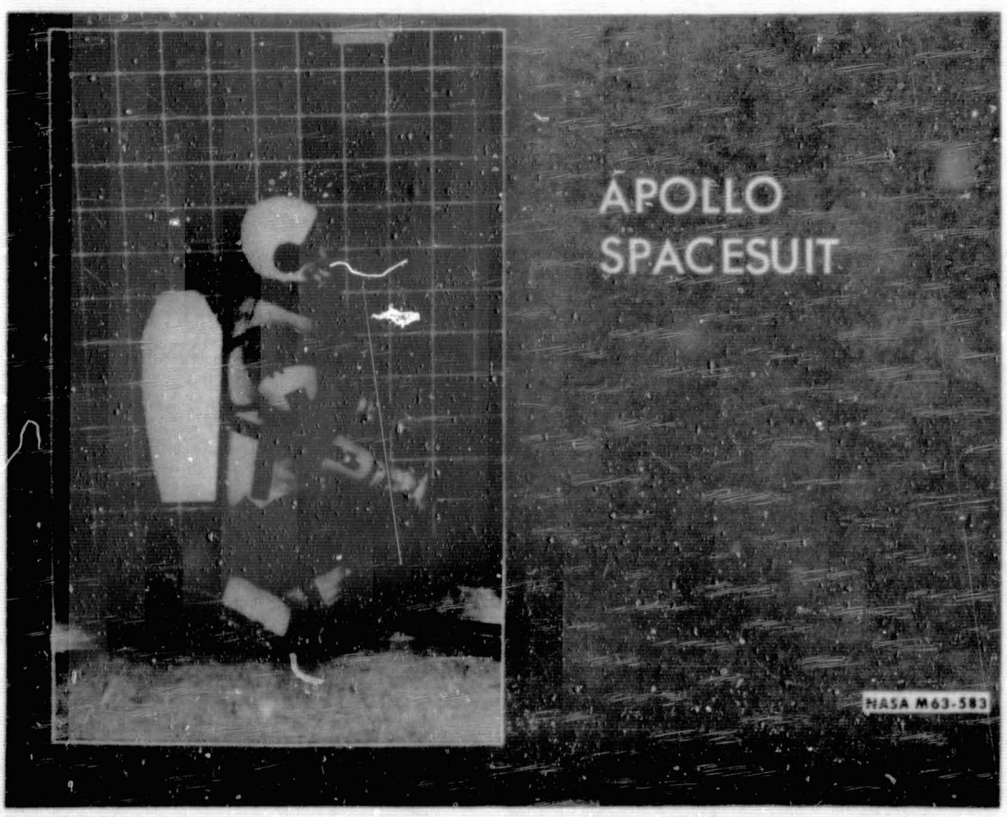

FIGURE 31

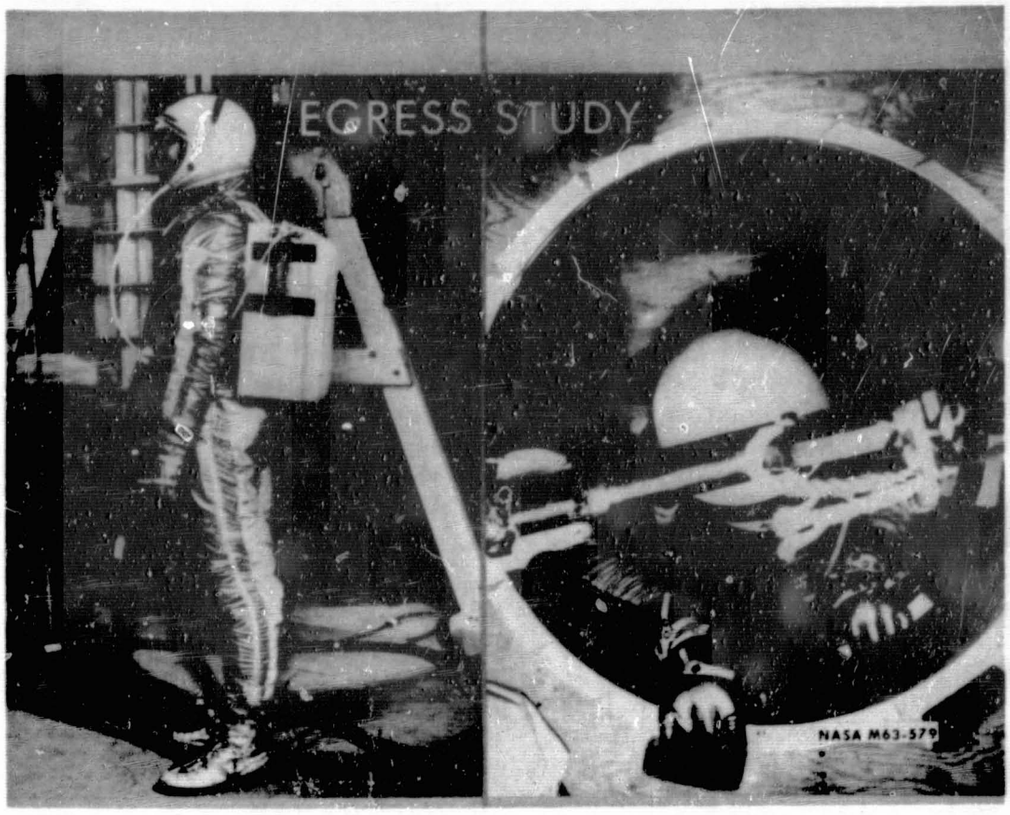

FIGURE 32

The Manned Spacecraft Center is running tests to simulate these situations. At the right side of the slide we see the same man attempting to climb through a simulated hatch, wearing the life support pack on his back.

In the Apollo lunar mission, we can expect to be brought face to face with a problem area completely new to manned flight—the space radiation environment and its effect on flight crews traversing the space between the Earth and the Moon. We are making every effort to define this environment adequately with information obtained in the unmanned space science flights, together with recorded observations of solar flare activity.

Based on this information, we have established radiation shielding design criteria for the spacecraft. We have applied dose limits postulated by our space medical staff, assisted by the Space Science Board of the National Academy of Sciences.

We feel confident that adequate shielding can be provided for the flight crew within the allowable weight limits of the Apollo vehicle. Radiation dosimeters developed and flight-tested in Project Mercury will be subjected to more rigorous testing during the Project Gemini flight program.

The Apollo guidance and navigation system has been under development since 1961, at the Instrumentation Laboratory at the Massachusetts Institute of Technology. In mid-1962, industrial contractors were selected to support the MIT effort and to produce the operational guidance and navigation systems. This team includes the AC

Spark Plug Division of the General Motors Corp., the Raytheon Corp., and the Kollsman Instrument Corp.

The functions of the Apollo guidance and navigation system (fig. 33) are to determine the position, velocity and trajectory of the spacecraft; and to control the spacecraft's engines and reentry lift for the precise maneuvers required for each phase of the mission: flight to the moon, lunar orbit, lunar landing, takeoff from the moon, lunar orbit rendezvous, and the return to earth at a preselected landing site.

The system consists of three major components: The inertial subsystem, the guidance computer, and the optical subsystem. The inertial subsystem employs gyroscopes to establish directional reference in space and accelerometers to measure course corrections applied by the propulsion system or by aerodynamic maneuvers.

The guidance computer calculates the trajectory, computes required velocity changes, sends start and cutoff signals to the propulsion system, and signals for the proper use of the aerodynamic lift during atmospheric entry.

The optical subsystem, consisting of a scanning telescope and a space sextant, finds the craft's position in space and alines the inertial platform for each maneuver.

During fiscal year 1964, prototype guidance systems will be developed and intensive ground testing will be underway.

Work on the command and service modules is well advanced.

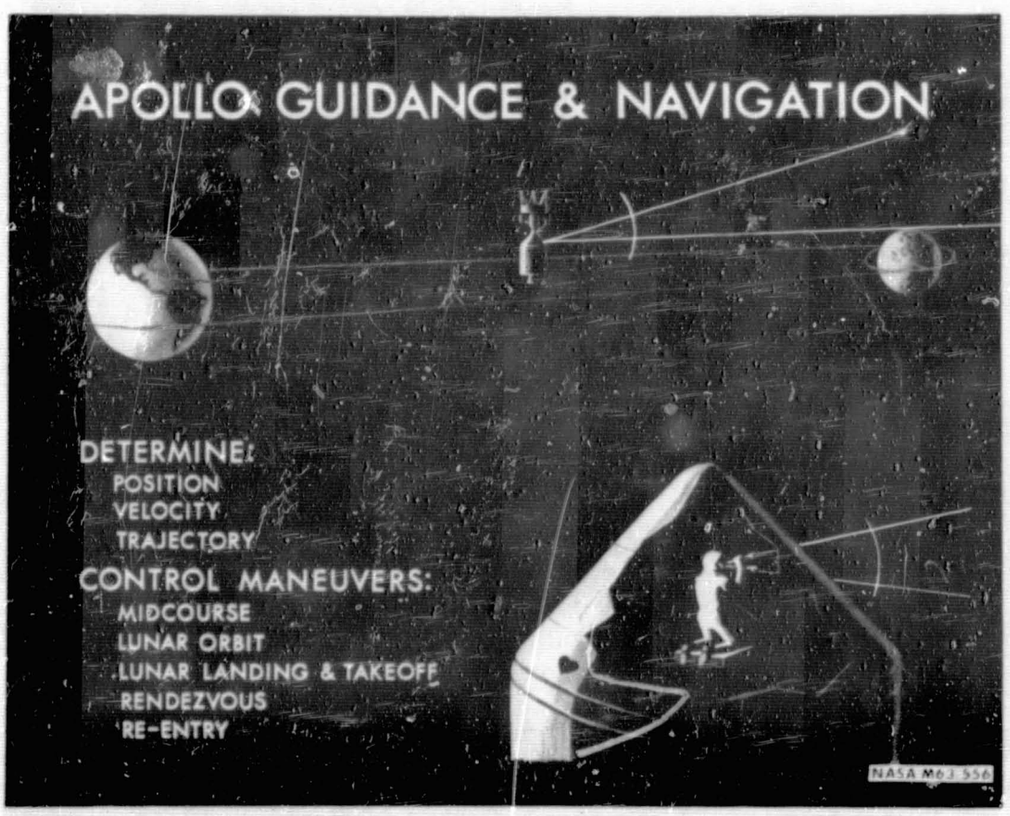

FIGURE 33

Here (fig. 34) some of the command module development accomplishments are portrayed. A full-scale mockup was completed in December 1962. The first boilerplate spacecraft have been manufactured, and testing of water-handling qualities, earth-landing qualities, water impact, and parachutes, is in progress.

To assure a high degree of reliability, an intensive test program for components, subsystems, modules, and complete spacecraft is required (fig. 35).

At the bottom of the pyramid will be the test of components and subsystems, performed by the responsible contractors.

This pyramid tends to give the type of testing on components and subsystems and then to higher levels of systems required in order to assure a reliable flight program.

Next, spacecraft modules will be tested at the North American plant at Downey, Calif., and at the Grumman plant at Bethpage, N.Y. The performance and functioning of each will be verified and compliance with the specifications will be assured.

The most rigorous phase of the Apollo spacecraft ground test program will take place at the Manned Spacecraft Center in Houston. There we are building major facilities that can duplicate many of the conditions encountered in space flight.

In these facilities, we can conduct tests and learn of flaws that otherwise would not be discovered until the flight tests. Constructing and operating these facilities is a less expensive and often faster and safer means of obtaining the necessary test results. In these

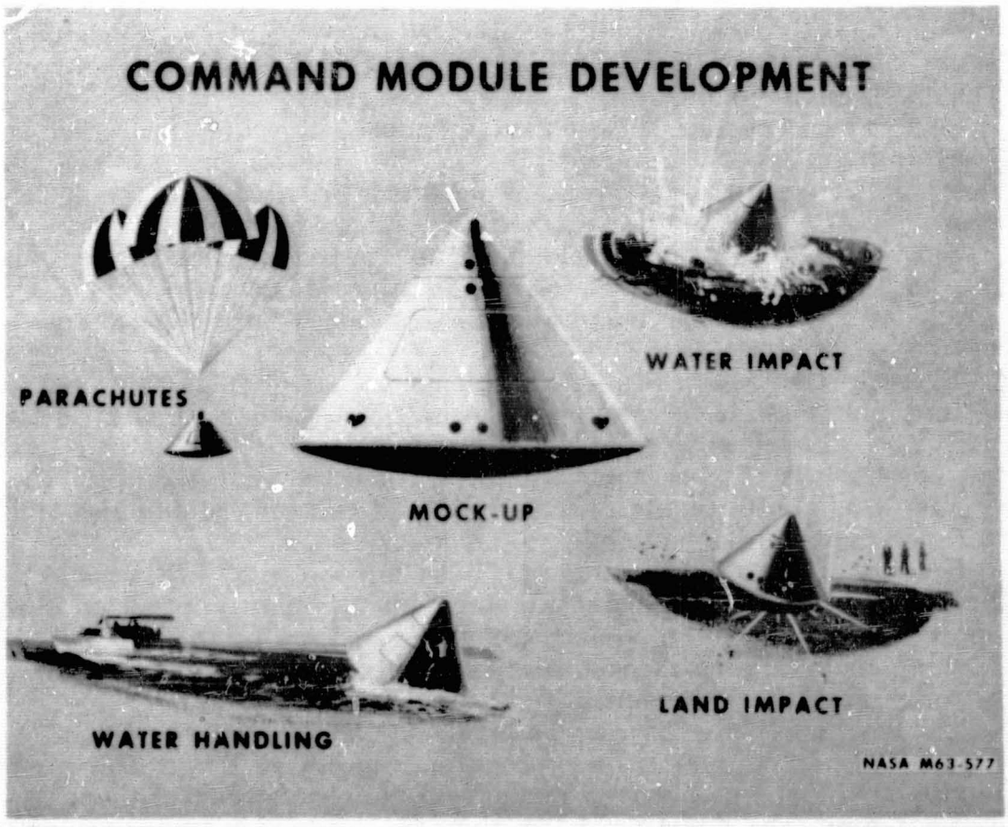

FIGURE 34

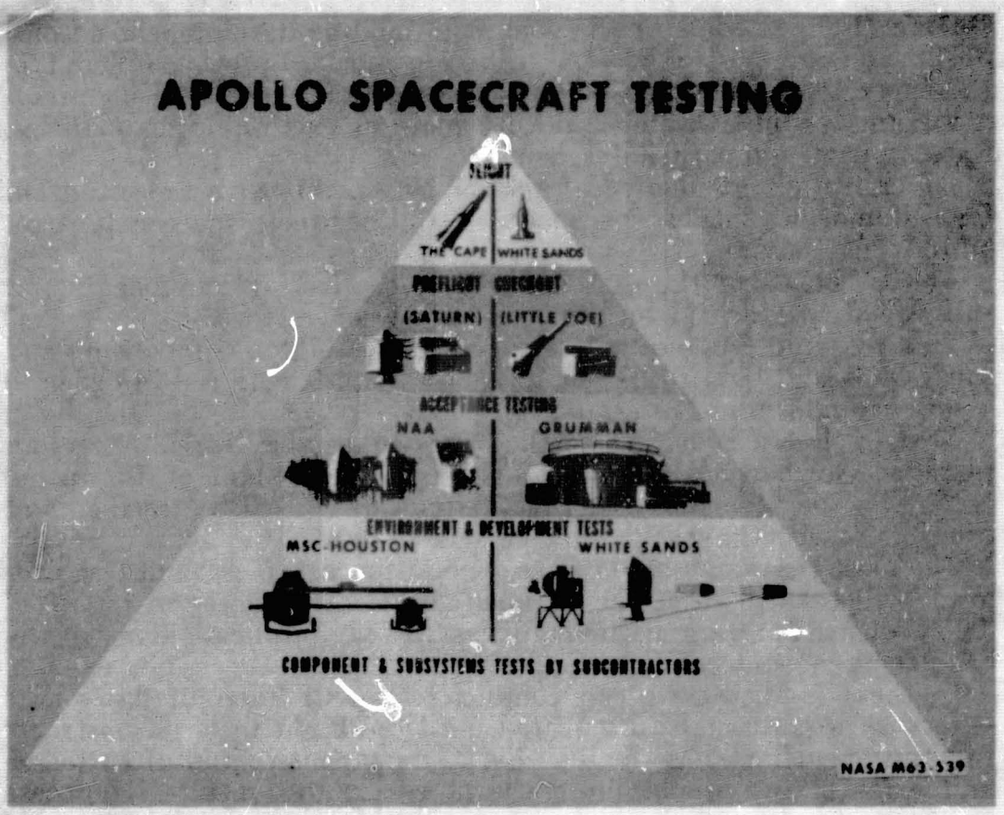

FIGURE 35

ground tests a spacecraft will be subjected to environments much more severe than those encountered in space, for periods of time far longer than a single lunar mission.

Our experience has shown that we must subject a spacecraft to heat and cold, to vacuum and pressure, to vibration and to noise, to achieve the degree of assurance we require to know that the spacecraft can function for the entire period of its mission.

Spacecraft propulsion development and testing will be carried out at the White Sands Missile Range in New Mexico. Highly toxic propellants are being used in all three modules of the Apollo spacecraft.

These are the so-called earth storable propellants.

It is not possible to develop and test these systems at any of the existing test locations.

Consequently, a spacecraft propulsion development facility is being built at White Sands for the command and service modules, and for the lunar excursion module propulsion systems.

Final checkout of the spacecraft must be performed in the vicinity of the launch site. During the preflight preparation period, the spacecraft will be weighed and balanced, fitted with pyrotechnics and landing devices, and checked and rechecked to assure perfect functioning of all the components.

The first Apollo flights are scheduled for this calendar year (fig. 36). In the first test, the launch escape system concepts will be verified in a simulated off-the-pad escape maneuver. Later in the year, we will begin testing the functioning of the launch escape system at high

FIGURE 36

altitude on flights powered by Little Joe II, a special solid-propellant launch vehicle.

The Little Joe II is similar in design to, but much larger than, the Little Joe I, which was used so successfully in the Mercury flight test program. Both the pad-abort tests and the Little Joe II tests will be carried out at the White Sands Missile Range in New Mexico. In 1964 we will begin flights of Apollo boilerplate spacecraft from Cape Canaveral, powered by the Saturn I vehicle. The first manned flights, also powered by the Saturn I, are schedule for 1965.

On the first manned flights, the Saturn I launch vehicle will allow us to fly the command and service modules, and the service module will carry a small amount of fuel for exercises in maneuver. Following these flights when the Saturn I–B becomes available, we will launch into earth orbit all three modules of the Apollo spacecraft, with a partial fuel supply in both the service module and the lunar excursion module.

The reason for the partial fuel supply is that we are still weight-limited even by the Saturn I–B.

On these flights, scheduled to begin in 1966, our astronauts will be able to develop the operational techniques of deployment and docking of the lunar excursion module.

Since the second stage of the Saturn I–B is also the third stage of the Saturn V, which will be employed for the lunar flights, we shall be able to test in earth orbit a large portion of the system to be employed for the lunar landing.

In other words, the entire spacecraft that we talk of here as well as the third stage of the Saturn V, all of that that we will inject toward the moon we will be able to put into earth orbit and test as a complete assembly on the Saturn I–B.

Here we see how much the two vehicles have in common (fig. 37).

You can see from the horizontal line across, from there up we have essentially identical assemblies.

There are some minor differences but very minor.

In this phase of the program we expect to obtain a significant amount of experience in earth orbit in the kind of operations we must conduct in the neighborhood of the moon.

The opportunity to gain this experience adds greatly to our confidence that we can carry out the lunar landing mission successfully.

LAUNCH VEHICLES AND PROPULSION

To travel into space it is first necessary to reach a very high speed. By attaining a speed of about 18,000 miles an hour, we can place a satellite in earth orbit, and by increasing this speed to 25,000 miles an hour we can overcome the gravitational force of the earth. To place a spacecraft weighing 90,000 pounds in a translunar trajectory requires a tremendous amount of power.

Another way of saying this is to accelerate a mass of 90,000 pounds to 25,000 miles an hour requires a lot of power.

FIGURE 37

For example, the maximum generating capacity of the Potomac Electric Power Co. in Washington is 1,639,000 kilowatts of electric power.

That is the maximum rate of generation.

The first stage of the Saturn V will produce a thrust equivalent to 110,000,000 kilowatts; over 68 times the maximum PEPCO rate.

To power the three Saturn vehicles previously mentioned requires development of a series of engines suitable for application to the stages of which the vehicles are comprised.

Shown here (fig. 38) is the engine family now under development. As can be seen, the thrust levels range from 15,000 to 1,500,000 pounds.

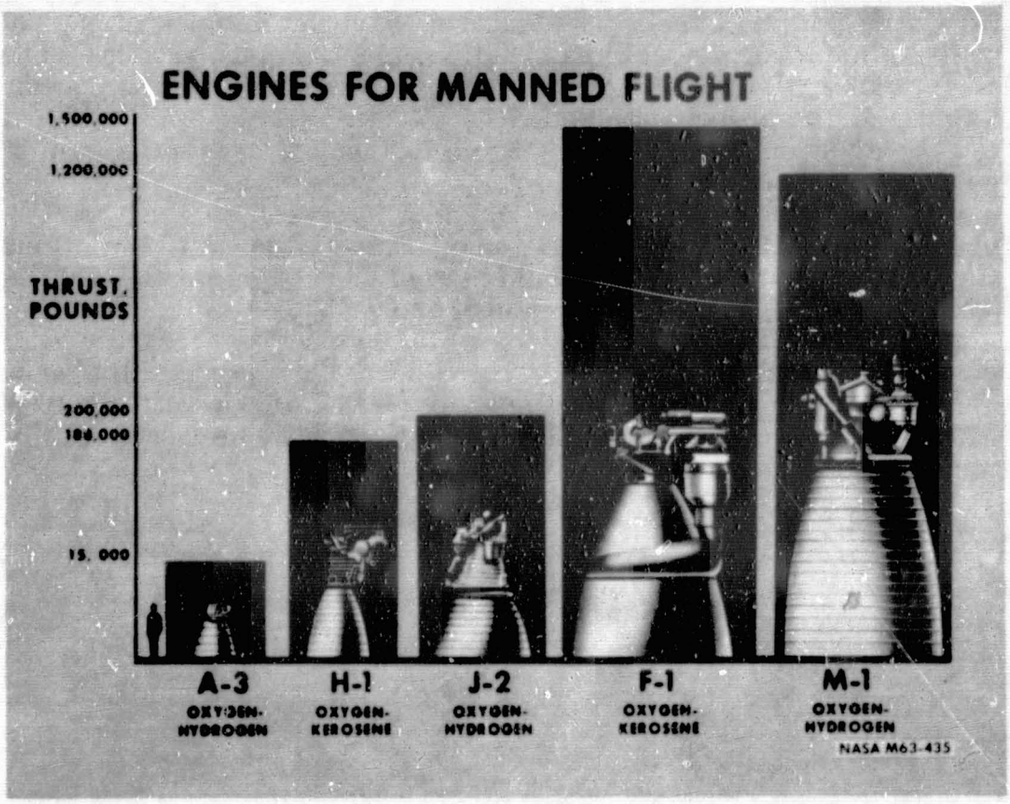

FIGURE 38

Smaller rocket engines of the 1950's broke the space barrier and made possible the early satellites and the first probes into outer space. In the 1960's, the chemical rocket is reaching maturity with this series of engines, which opens the way for manned exploration of space and its first great step, the exploration of the moon.

Two of these engines are for first-stage application and utilize kerosene as fuel. These are the H–1 for Saturn I, and Saturn I–B, and the F–1 for Saturn V.

The other three engines are for upper stages and use liquid hydrogen. The A–3 is used in the second stage of Saturn I; the J–2 in the second stages of Saturn I–B and V, and in the third stage of Saturn V.

The M–1 is for the second stage of a post-Saturn vehicle. It will be noted that all of these engines use oxygen, which is carried in the vehicle tanks in liquid form.

The M–1 engine then is not a part of our first lunar assault, but it is rather starting an engine development because these take so long so that as the time comes when we go to a larger vehicle, which must come in a few years ahead, the engine development for it will have been initiated for the upper stages.

We are still very seriously considering for the first stages solid propellants as well as liquid propellants.

Now the use of kerosene as a fuel is derived from its successful application in military programs.

Indeed, the H–1 engine itself is derived from military programs. However, liquid hydrogen offers advantages over kerosene as a fuel. It gives 40 percent more specific impulse—that is, 40 percent more thrust per pound of fuel. The hydrogen-oxygen combination is especially valuable for the second and third stages of launch vehicles. The performance of upper stages is sensitive to changes in the specific impulse of the propellants used.

The payoff in using liquid hydrogen as fuel is a substantial gain in payload capability.

We began the development of our first hydrogen engine, the A–3, in 1958. It is now being produced in quantity by the Pratt & Whitney Co. at East Hartford, Conn., and is tested at West Palm Beach, Fla. This engine weighs 290 pounds and is about 6½ feet long.

Six A–3 engines, each producing 15,000 pounds of thrust, will power the Saturn I second stage, the S–IV. This engine will also be used on the Centaur vehicle. The first series of static firing tests on the six-engine cluster (fig. 39) for the S–IV have been successfully completed at the Sacramento, Calif., test site.

FIGURE 39

The series included two full-duration firings, each of more than 400 seconds. A second series of ground tests is now underway to further debug and assure the reliability of the complete stage. In this series, one firing at full thrust and full duration of 8 minutes 6 seconds has been accomplished successfully.

The first flight of the S–IV stage containing the A–3 engines will take place this summer on the fifth Saturn I flight.

Work to be funded in fiscal year 1964 also includes further development of a variable thrust model of the A–3 engine.

The kerosene-fueled H–1 engine is the descendant of the engines that power the Atlas, Thor, and Jupiter missiles. Each engine will produce 188,000 pounds of thrust, and eight of them will power the first stage of the Saturn I and I–B.

After 10 years of test and refinement, the H–1 engines are probably the most reliable large liquid propellant engines in the United States. Their reliability was demonstrated in the three successful Saturn I flights when all eight H–1 engines in each test performed to design specifications (fig. 40).

To date 100 H–1 engines have been delivered. Most of these have been manufactured by the Rocketdyne Division of North American Aviation at Canoga Park, Calif. Recently, however, flight engine production has been transferred to the Rocketdyne plant at Neosho, Mo. Here (fig. 41) we see an engine in the assembly area at Neosho. The H–1 is approximately 10 feet long and weighs about 1 ton. During the coming fiscal year, we will continue the development effort to solve problems discovered during flight testing, and will complete qualification for manned flight.

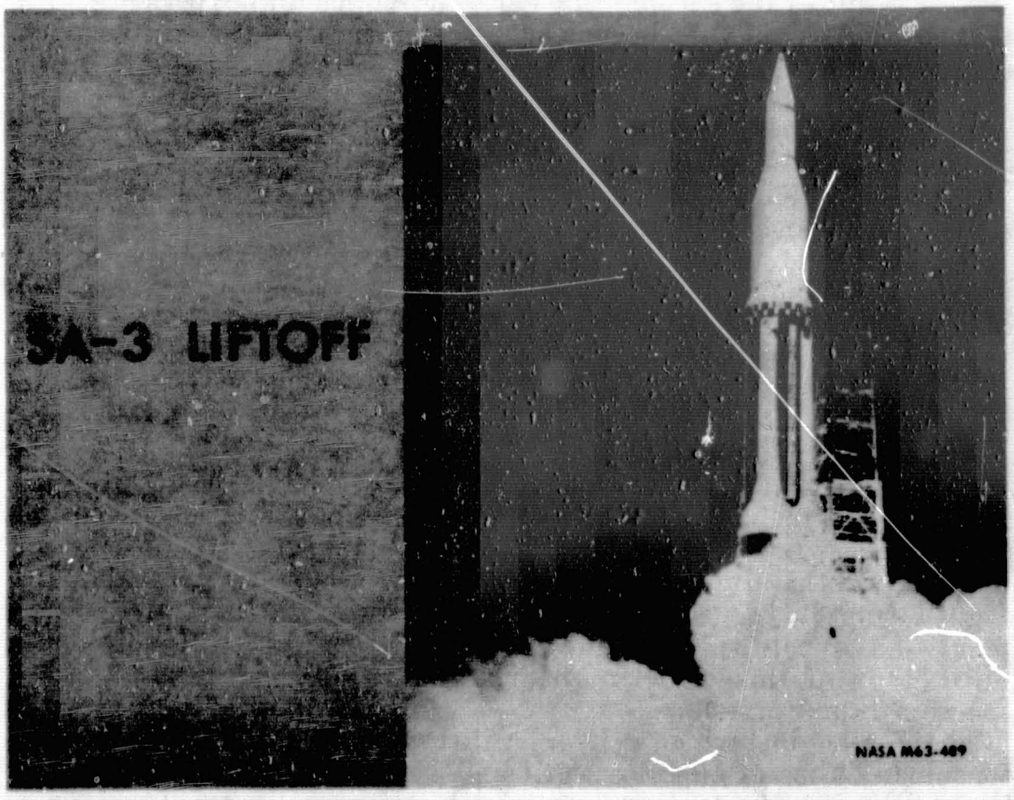

FIGURE 40

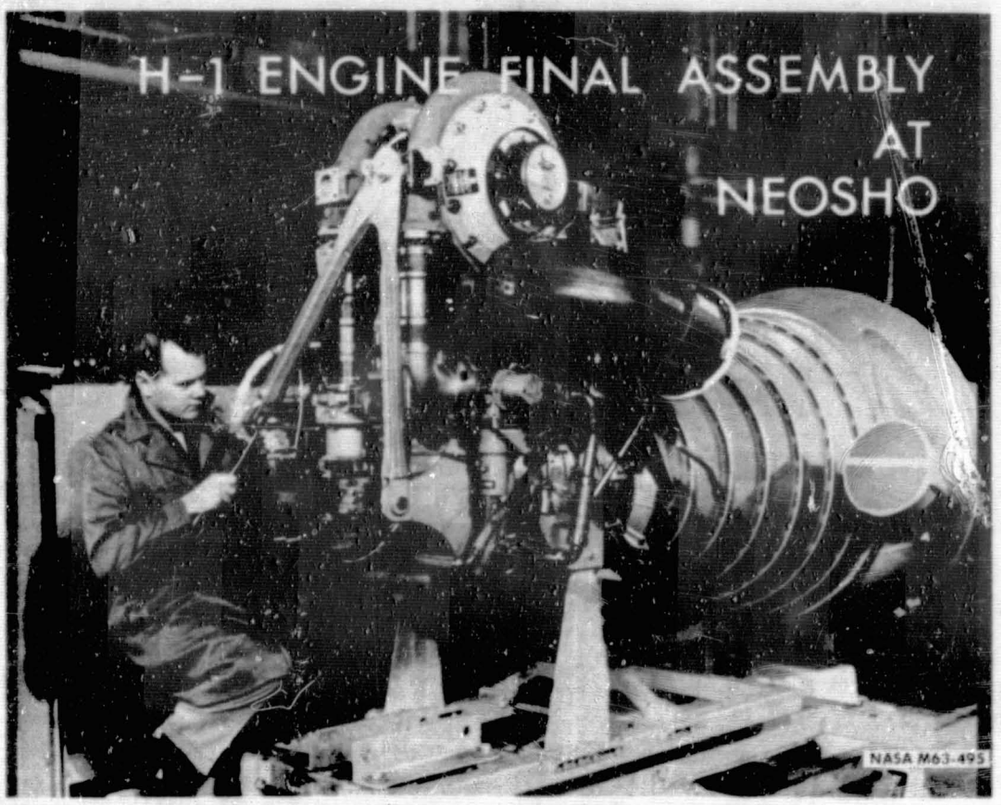

FIGURE 41

As a result of the encouraging early developmental experience with the A–3, NASA in 1960 began the development of a second hydrogen engine, the J–2. This engine will develop 200,000 pounds of thrust, more than 13 times as much as the A–3.

The J–2, which weighs about a ton and a half, is also being developed by the Rocketdyne Division.

The illustration (fig. 42) shows a mockup of the J–2 in the assembly area at the Canoga Park plant of Rocketdyne.

To date, the J–2 engine has been fired 140 times, primarily for the investigation and development of the ignition system and for checkout of the pumps and other subcomponents. There has been one 4-minute, full-duration, full-thrust firing. During the coming year, the test activity on the J–2 engine will be greatly augmented by putting an additional stand into service to supplement the two stands now available.

This additional capability will permit us to schedule over 300 engine systems tests, including altitude simulation, gimbaling, malfunctions, and others.

We expect that the engine will be brought to the state of preliminary flight rating during this time. Five J–2 engines will form the powerplant of the Saturn V second stage, while one J–2 will power the third stage of this vehicle, which will be employed in the Apollo spacecraft lunar missions.

The F–1 engine, which delivers a thrust of 1½ million pounds and consumes 3 tons of liquid oxygen and kerosene every second, is the largest kerosene-fueled engine under development in the free world.

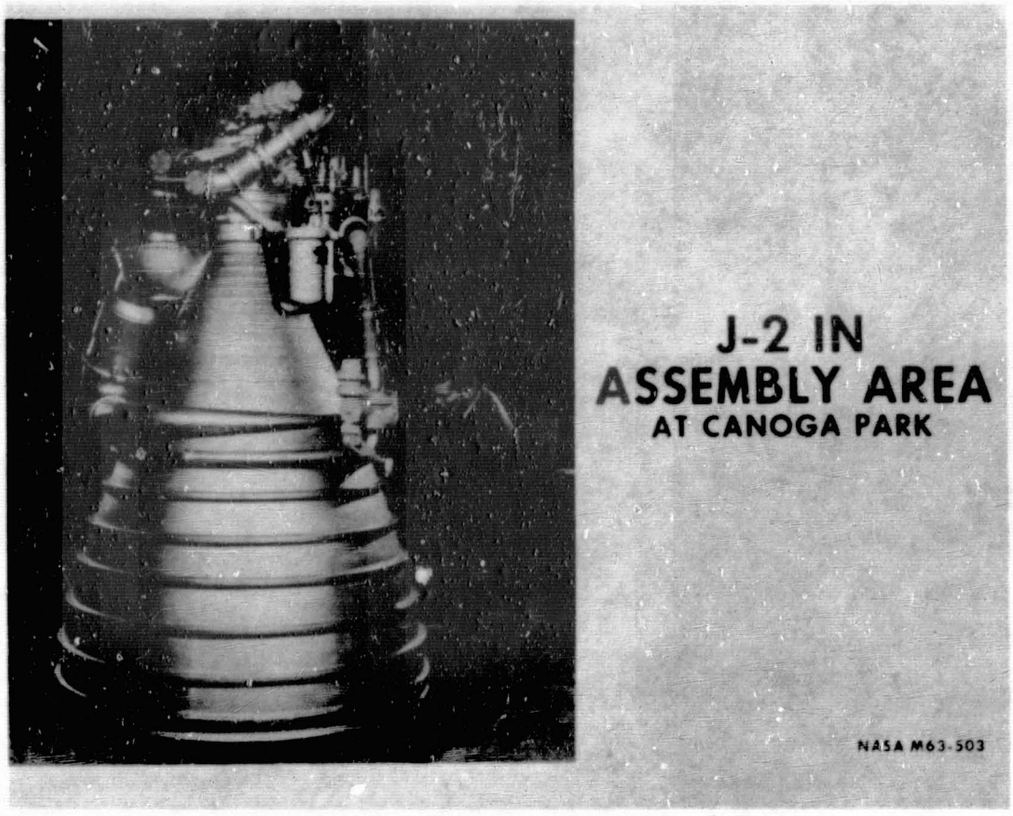

FIGURE 42

It stands 18 feet high and weighs 10 tons. Here (fig. 43) we see a worker standing next to an F–1 in the assembly area of the Rocketdyne plant at Canoga Park, Calif. Five of these engines will power the S–IC stage, the first stage of the Saturn V. We began the development of the F–1 engine in 1958, and in the past 4 years approximately 250 engine firings have been completed.

Here (fig. 44) we see one of the tests. Many firings, especially in the early part of the program, were of short duration and had the objective of checking out the operation of various components such as turbo-pumps, injector designs, and cooling systems. In six recent firings the engine has demonstrated its full thrust of 1½ million pounds over the full 2½ minutes of operation.

During the coming year, we will continue the development of the engine and we will make more full-thrust, full-duration runs, culminating in preliminary flight rating test.

By the end of this year, we will commit the engines for the beginning of ground tests of the S–IC stage of Saturn V and we will be furnishing engines for fabrication of the early developmental flight test stages.

The major problem remaining in the F–1 engine program is the existence of the phenomenon known as combustion instability, which is characterized by pressure oscillations in the combustion gas inside the engine. The resulting vibration can destroy the entire engine.

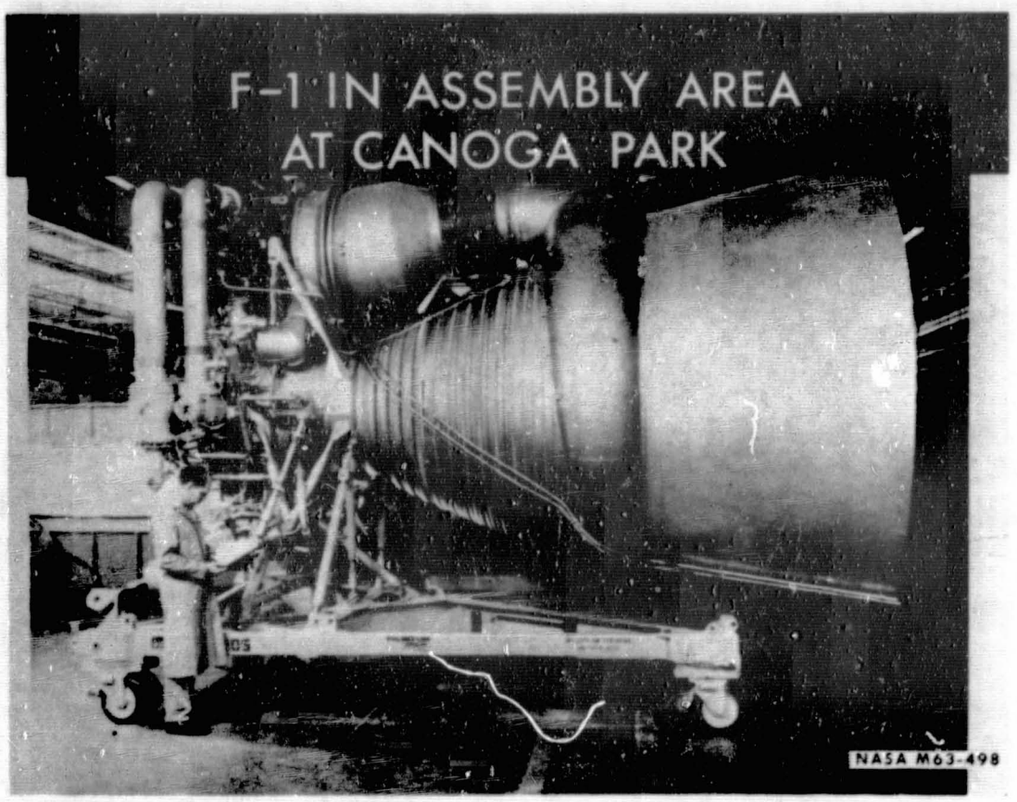

FIGURE 43

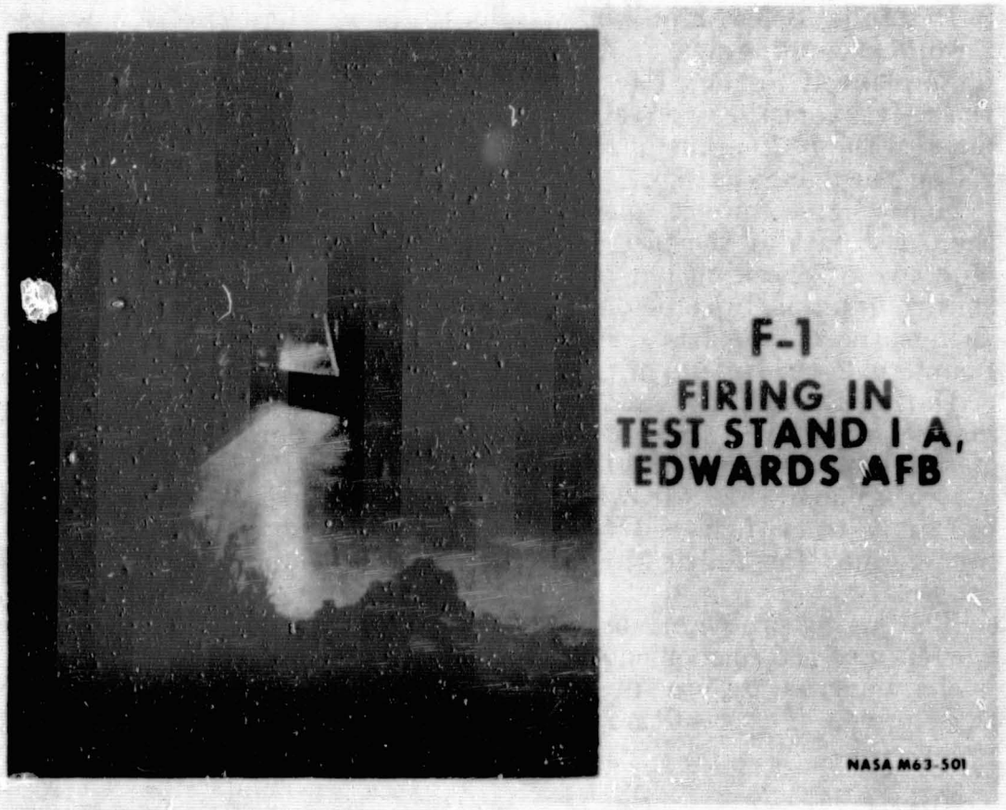

FIGURE 44

Although combustion instability has developed in only 7 of the 250 F–1 firings in the last 2 years, even this small incidence cannot be tolerated.

Consequently, we are placing major emphasis on solving this problem. The source of instability in liquid propellant engines has been the subject of considerable research, since most engines exhibit instability in the early stages of their development.

One of the most likely sources is the injector, the engine component which mixes the liquid oxygen and the kerosene within the thrust chamber so that the propellant can burn completely.

The usual means of conquering instability is to change the design of the injector by changing the location or the size of the injector holes.

We have a continuing program of fabricating modified injector designs, which are fired extensively in highly instrumented thrust chambers and engine test stands.

Another suspect part of the engine is the large dome through which the liquid oxygen flows. Here, our instruments have revealed pressure oscillations, which could be transmitted to the gases in the chamber. We are redesigning this dome to provide a smoother flow and we are installing baffles to damp out flow oscillations. Still another approach being followed is to introduce a special kind of injector hole, called a cavitating venturi. This device should prevent oscillations from the combustion gases feeding back into the liquid or vice versa.

We are confident that we will solve the instability problem on the F–1 engine, just as it has been solved for all other liquid propellant engines in use, and we are confident that we can achieve the flight rating and delivery schedules.

We are, however, giving this matter our closest attention and bringing to bear the knowledge and judgment of the most qualified experts in the United States.

These experts are drawn from Lewis Research Center, Marshall Space Flight Center, various engine companies and universities, and others who have conducted research in this area.

For the future, we are establishing a consulting body of experts to assure a continuing national program to develop more information on this phenomenon and methods of prevention.

The latest and the largest hydrogen engine to be placed under development is the M–1. It will be designed to deliver a thrust of 1.2 million pounds. The M–1 will be 25 feet high, and 15 feet across the nozzle exit. It will weigh about 10 tons.

Here (fig. 45) we see M–1 combustion chamber fabrication in progress at the Aerojet-General plant in Sacramento, Calif. Now (fig. 46) we see the construction of a test facility for thrust chambers and gas generators.

The M–1 is destined for missions beyond the capability of the Saturn vehicle. We have started the M–1 development because, as mentioned earlier, a long period of time is required to develop and qualify an engine. It will require about 6 or 7 years of work to bring an engine of the M–1 size to its first flight test.

An orderly development program has been initiated which will lead to preliminary flight rating approximately 4 years from now; the engine will be ready for flight test about 2 years later.

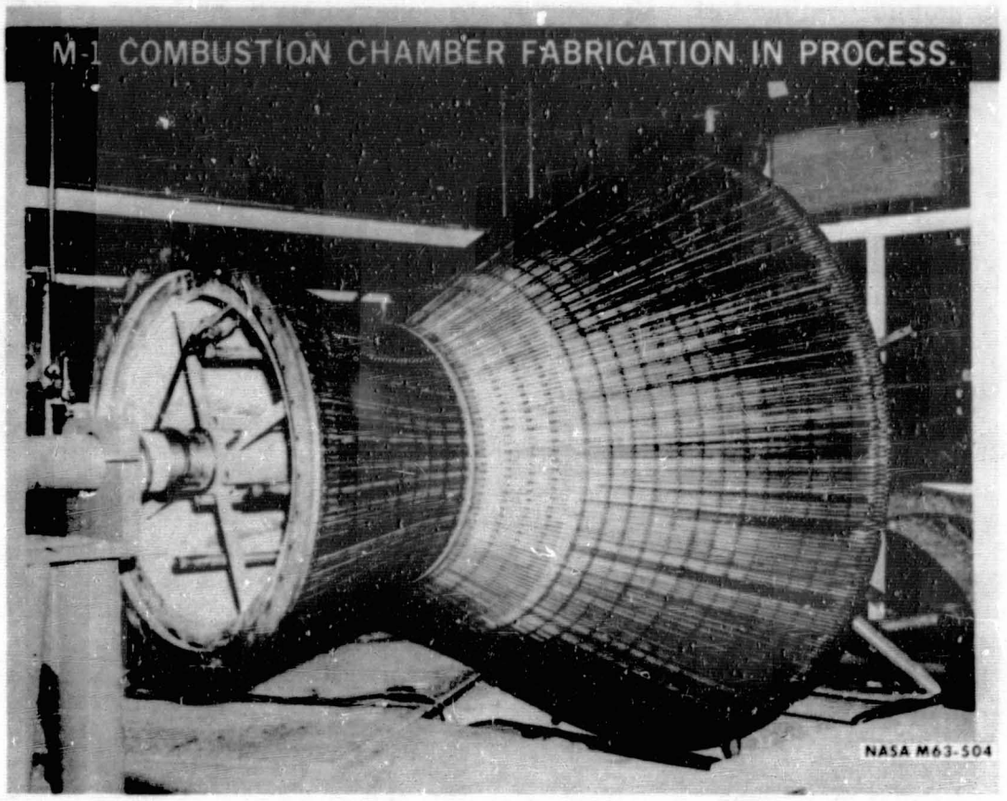

FIGURE 45

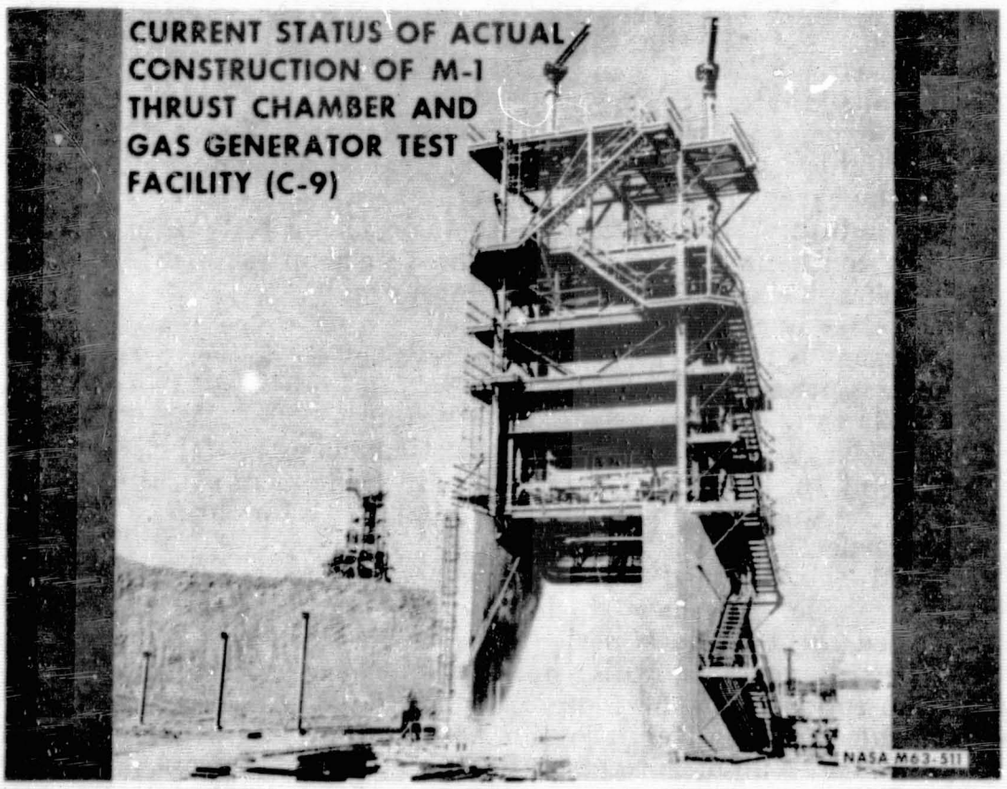

FIGURE 46

By starting an M–1 engine development program, we have taken a first step, which will permit us to institute programs to further increase our launch vehicle payload capabilities in future years.

In addition to the liquid propellant engines for our launch vehicles, we have work underway on propulsion for spacecraft. Here, instead of kerosene or hydrogen and oxygen we are concentrating on storable propellants which are hypergolic—that is they have the characteristic of igniting as soon as the oxidizer and fuel are brought into contact.

Employment of these propellants simplifies design, since an ignition system is not required. We find that they are especially applicable to the propulsion used on board the spacecraft because they can be stored for a long time without boiling away and because of their self-igniting characteristics.

For this reason, they are employed in the Gemini spacecraft and will be used in all primary propulsion systems of the Apollo spacecraft.

We have given very careful study to the place of solid propellant rockets in our program and find that the reliability of solid rockets is especially attractive for components such as the escape system, or for retrorockets needed for stage separation, and for providing the retrograde propulsion needed to slow the spacecraft for return to earth from orbit.

We are also very much interested in the future use of very large solid rocket motors for application to the first stage of large launch vehicles. Just recently, a program which will demonstrate the feasibility of these giant engines was initiated in cooperation with the Department of Defense.

This national large solid motor program is funded and managed by the Air Force Space Systems Division. NASA supplies the motor size and performance specifications to the Air Force. NASA is currently supporting studies and technology efforts pertaining to the application of solid motors for possible future use in manned vehicle stages.

Mr. YEAGER. I have a question, Mr. Chairman.

Mr. Holmes, is the A–3 engine for the second stage going to be tested on the Saturn V?

Mr. HOLMES. Yes. That will be the first flight test of the second stage, which has six of these A–3 engines. That will be on the Saturn V this summer.

Mr. YEAGER. Is the A–3 in condition now that you feel you will be able to do it on schedule?

Mr. HOLMES. Yes, it is working very well. We have fired all six of these engines in an S-IV stage full duration. This is about 7 minutes, and it is amazing how long 7 minutes is for one of these blasts to be continuing.

Mr. DADDARIO. Mr. Holmes, the question Mr. Yeager has asked calls to my attention a question that I wanted to ask on the A–3.

Someone had mentioned earlier the throttling capacities of the A–3 engine. Could you just touch on that for a moment and tell us what the significance of that might be?

Mr. HOLMES. Yes, I can. We are doing development work and experimental work as to how we can throttle that engine. I believe

we have throttled it now to about 3 to 1. In other words, from full thrust down to one-third thrust, with that limitation having been imposed by the particular test facilities that Pratt & Whitney was using in Florida.

We expect to throttle it over a 10 to 1 ratio. We are also working on throttling earth storable engines, where the A–3 is, of course, a cryogenic type.

The significance of this will be particularly applied. Initially the significance of throttling capability will be realized in the lunar exploratory module. We want to be able, as you set down on the moon, to control the thrust, so that we can move down and then hover.

In fact, we would like to be able to hover there for a minute and translate to a maximum of maybe a thousand feet, before setting down. This is important because we probably won't have as much data as we would like to have on the lunar surface before we will have to touch down.

Does that answer your question, Mr. Chairman?

Mr. DADDARIO. Yes, just to clarify it, then, the real significance of throttling is the capability for it to choose a better landing site on the moon than you might be able to otherwise choose if you had to land without having the opportunity to hover and choose your site.

Mr. HOLMES. In the initial and immediate applications we are thinking of right now, yes.

In the longer term, just as we have to vary the thrusts in our automobile or in an airplane, we are going to have to be able to vary the thrust of these rockets in order to have man really be proficient in space operation.

Mr. DADDARIO. Then it does have further significance in adding to the capability of inflight use of the space vehicle.

Mr. HOLMES. Yes, sir; it does.

Mr. DADDARIO. Thank you.

Mr. HOLMES. While engine development necessarily leads the way in expanding ability to explore space, actual capability results from development of appropriate launch vehicles using these engines.

Repeating this earlier slide (fig. 47) we see the three launch vehicles in the Apollo program.

Both the Saturn I and Saturn I–B play supporting roles in development of a complete system for landing explorers on the moon and providing for their return.

This is a similar slide to one we showed yesterday, modified slightly to be more inclusive to show general application of these vehicles rather than just the Apollo applications.

The first Saturn I was successfully launched from Cape Canaveral in October 1961, a little over 3 years after initiation of the Saturn program. Since that time, we have successfully launched two additional flights, both of which yielded significant information about its performance and reliability.

Here (fig. 48) we see statistics indicating the performance on the launching of the third vehicle last November. Now, we should like to show some slow-motion film of that flight.

Before we start the film, I should point out that these pictures were taken at 200 frames a second, from the umbilical tower on Complex 34, looking downward toward the launch pad.

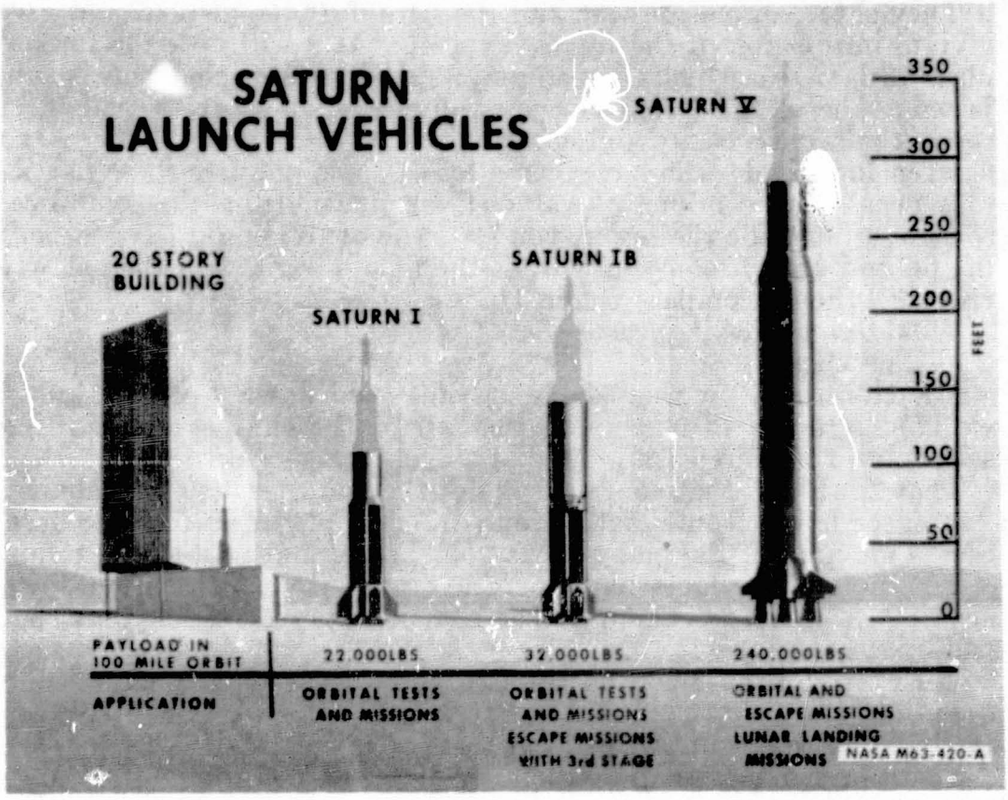

FIGURE 47

SATURN SA-3 STATISTICS

NOVEMBER 16, 1962 1245 EST

LAUNCH COMPLEX 34

	PREDICTED	ACTUAL
COUNTDOWN DURATION	600 MIN.	645 MIN.*
8 ENGINE TOTAL IGNITION TIME	0.30 SECONDS	0.30 SECONDS
ENGINE CUT-OFF INBOARD	140.2 SECONDS	141.2 SECONDS
ENGINE CUT-OFF OUTBOARD	147.8 SECONDS	149.0 SECONDS
RETROROCKET IGNITION	152.2 SECONDS	152.3 SECONDS
ALTITUDE	103.6 MILES	104.1 MILES
PROJECT "HIGHWATER" BURST TIME	292 SECONDS	292 SECONDS
MEASUREMENTS	613	610

ST-124 GUIDANCE PLATFORM RIDING AS PASSENGER PERFORMED SATISFACTORILY.

*45 MIN. HOLD AT T MINUS 75 MIN. DUE TO GROUND OPERATOR POWER FAILURE.

NASA M63-582

FIGURE 48

They show engine ignition and the lift-off of the vehicle, and give a vivid impression of the forces involved. You will note the intense blast of flames to which the pad and its holddown mechanisms is subjected as the vehicle lifts past your vantage point. Yet, we can effect repairs relatively easily and cheaply.

Even for people who have seen a lot of these pictures these particular ones are exceptional. As you look down, from this umbilical tower, right beside the tower, you see some of the liquid oxygen boiling off and pretty soon you will see the flames begin, and then slowly rise until they encompass you in Hades.

Would you show it please?

[Films shown].

Mr. HOLMES. Now the vehicle is being held down. As you know, we hold it down to make sure that all of the engines are burning smoothly prior to releasing the first stage.

That "puffing" that comes off is not the main jet, but the exhaust.

You see how it comes out at four different places around the base. She is moving off the pad now as you can see and rising toward us.

Now notice the flame impingement on the pad and the holddown arms. Notice the tremendous blast that is being exerted against that padding.

We protect it as much as possible and with each launch we find that the refurbishment for the next launch costs us less. We keep fairly accurate accounting of what these costs are.

I believe in SA–2 we did something over $200,000 worth of damage to the pad that we had to refurbish and in SA–3 we are down to $160,000.

I bring this out because we have to constantly keep in mind that a thousand dollars or $10 thousand is a lot of money. Just because we are spending millions of dollars we do not get into the frame of mind that $10,000 is insignificant.

This is something that management has to be constantly on the alert for and I say that with complete sincerity.

Mr. DADDARIO. What were some of the steps that you took to reduce the damage of that order?

Mr. HOLMES. There were several.

One was changing the connections from the umbilical tower, so that they swung away from the blast. Thus we had no damage to them.

The other was rerouting fueling pipes for the cryogenics, rerouting wiring, putting in protective covering. We wanted to have a minimum of things exposed directly to the blast.

The fourth in a series of 10 development and demonstration flights is scheduled within a month. Later, in the summer we will start flight testing a full two-stage Saturn, the second stage of which is already undergoing ground tests by the contractor.

The later flights in this series will carry boilerplate versions of the Apollo spacecraft as part of the development leading to the launch of the first manned Apollo in 1965. In the first manned flights, the Apollo command module, carrying the astronauts, together with the service module, will be launched into a low earth orbit.

Fabrication and assembly tools for continued production of the Saturn S–I stage are now being provided by the Chrysler Corp. in

that company's portion of the Government-owned Michoud plant at New Orleans. Here (fig. 49) we will see work on the tail assembly of the S–I stage for a Saturn I flight next year.

The Michoud plant includes a fabrication building with 43 acres of floor area and a ceiling 40 feet high, fully air conditioned, and is served by rail, highway, air, and water transportation.

FIGURE 49

Here (fig. 50) we see the second stage of the Saturn I vehicle—the S–IV stage—which is being developed and produced by the Douglas Aircraft Co. in Santa Monica, Calif.

This stage utilizes liquid oxygen and liquid hydrogen propellants and contains six RL–10 A–3 engines. The next slide (fig. 51) shows the Douglas production line.

The Saturn I launch vehicle will be capable of placing 11 tons in low earth orbit.

However, to make orbital tests of the entire Apollo spacecraft, including the lunar excursion module, a launch vehicle of greater capability is needed. Such a vehicle is being developed through modification of Saturn I, by increasing the power of the second stage.

The new second stage, called S–IV B, is shown on this slide (fig. 52). It contains a single J–2 engine, producing 200,000 pounds of thrust. The use of this stage will increase our orbital payload capability from 11 tons on the Saturn I to 16 tons on the Saturn I–B.

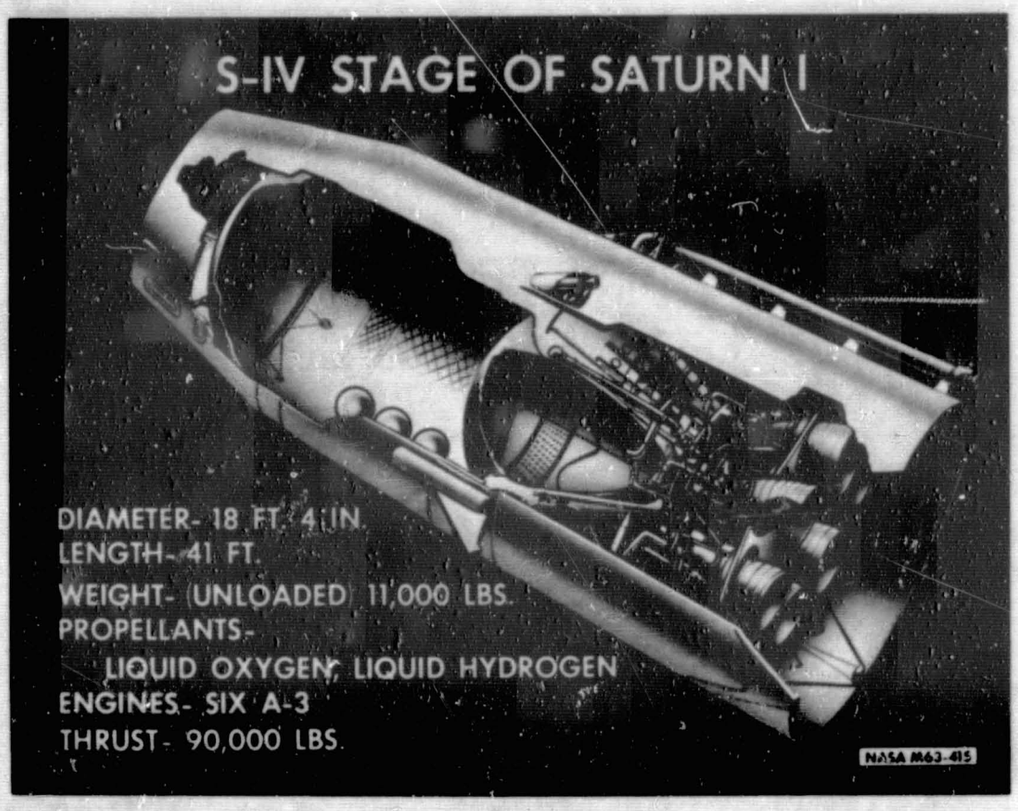

FIGURE 50

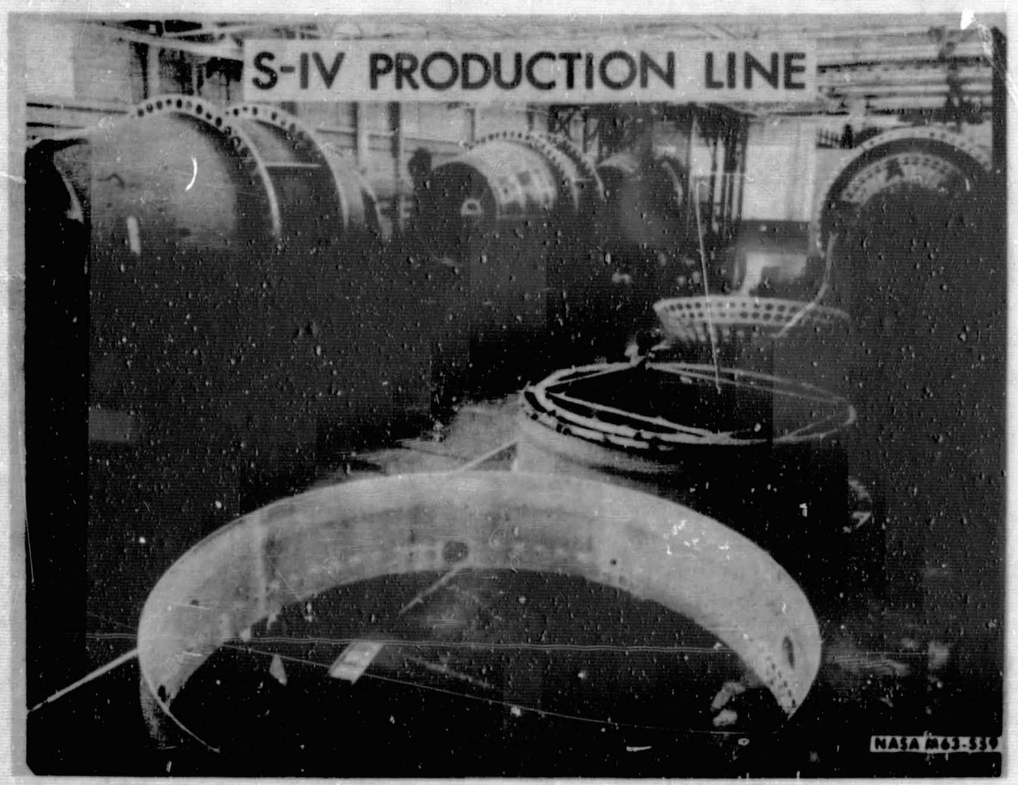

FIGURE 51

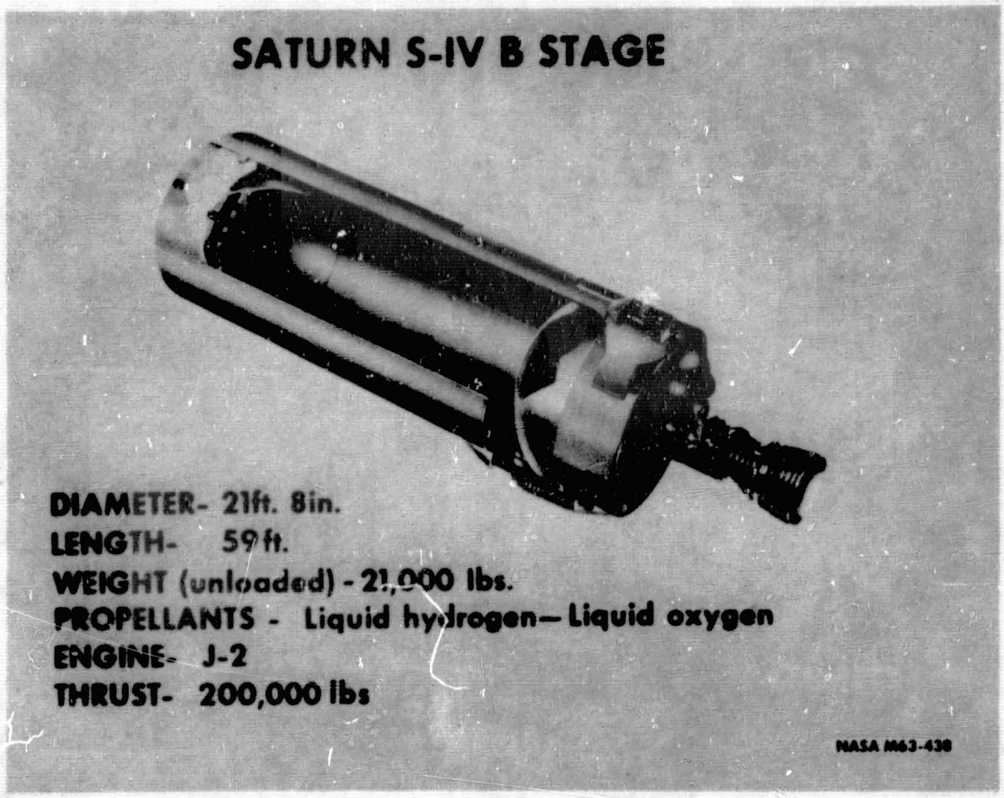

FIGURE 52

From earlier discussions of these vehicles, it will be recalled that this S–IV B stage is modified to provide the third stage of the Saturn V, the vehicle which will send the Apollo spacecraft on its lunar mission.

The Saturn I–B, with its increased orbital payload capability, will be developed through a four-flight test program which will begin in 1965, and will be ready for its first manned mission in the Apollo program in 1966.

The vehicle flight-test program is needed primarily for development of the S–IV B second stage, since the first stage will already be a well-tested vehicle from the Saturn I program.

As mentioned earlier, the Saturn I and Saturn I–B play supporting roles. The largest and most powerful launch vehicle is the Saturn V, since its role is to launch the lunar expedition spacecraft into a trajectory that will carry it to the vicinity of the Moon.

To do this, we must accelerate 45 tons of equipment and men to a velocity of 25,000 miles an hour. The Saturn V will be almost 300 feet high and 33 feet in maximum diameter. It is the largest known launch vehicle being designed and built. It will be ready for its first flight test early in 1966 and qualified for initial manned flights in 1967.

We would now like to describe the Saturn V in a little more depth by commenting briefly on each of the launch vehicle's three stages.

This slide (fig. 53) shows the first stage, the S–IC, which weighs 140 tons empty and over 2,300 tons when fueled. It is being designed at Marshall Space Flight Center, through cooperative efforts between Marshall and the Boeing Co.

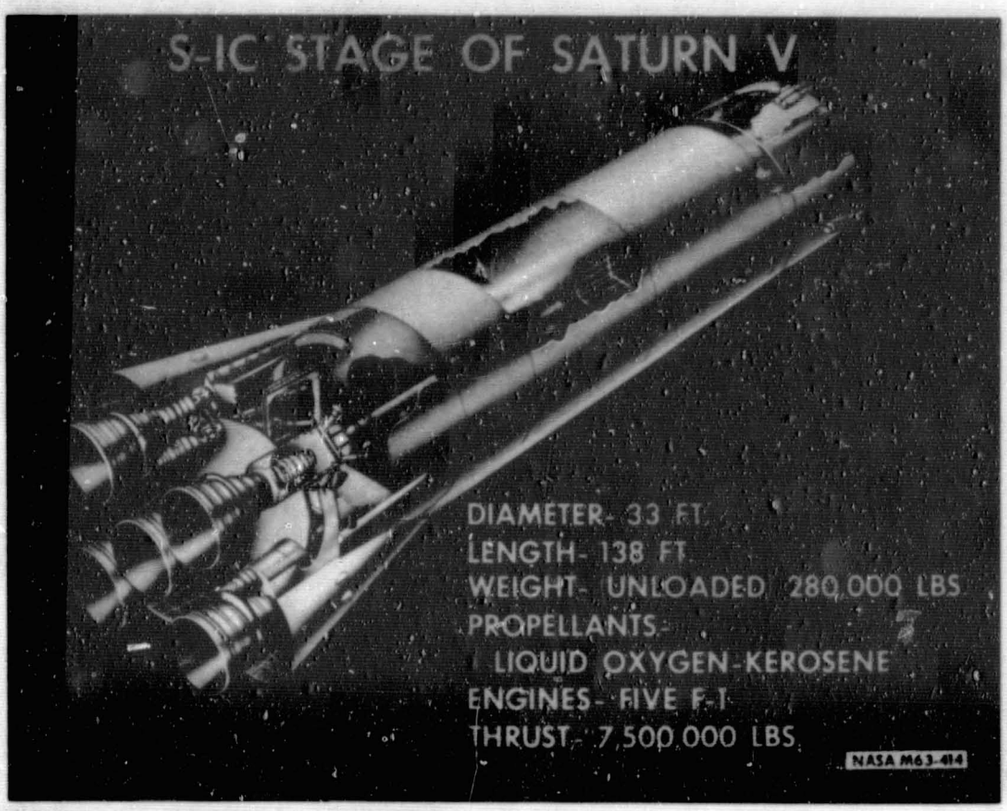

FIGURE 53

Boeing has already delivered some of the structural elements of the first ground-test stage. Here (fig. 54) we see a 40-foot boring mill which is a rather unusual tool.

The mill is a very special and precise tool. It has a long history of changing ownership between Government and industry.

Most of the stages will be assembled by Boeing in that company's portion of the Michoud plant. In this next slide (fig. 55) we see construction in progress on a vertical assembly area for S–IC work at the Michoud plant.

Fiscal year 1964 will see completion of one of the ground-test stages, fabrication and assembly of other ground stages, and initiation of work on early flight stages.

An enormous test stand for the S–IC is now under construction at Marshall. Here (fig. 56) we see that the work is underway. As you know, the Mississippi Test Facility will not be available for use until 1965. And I might digress here to say we are hard pressed to have that Mississippi Test Facility available so that we can do an S–II full scale test there in October of 1965.

At Santa Susana where the contractor—North American—has some test stands, we cannot fully load this stage with fuel because of safety restrictions. Right now we are limited to 25 seconds burning time. We hope to get that extended to 100 seconds. The problem has to do with the equivalent TNT explosion that you might get from this hydrogen fuel mixed with liquid oxygen. We can test in boilerplate because that tankage cannot rupture.

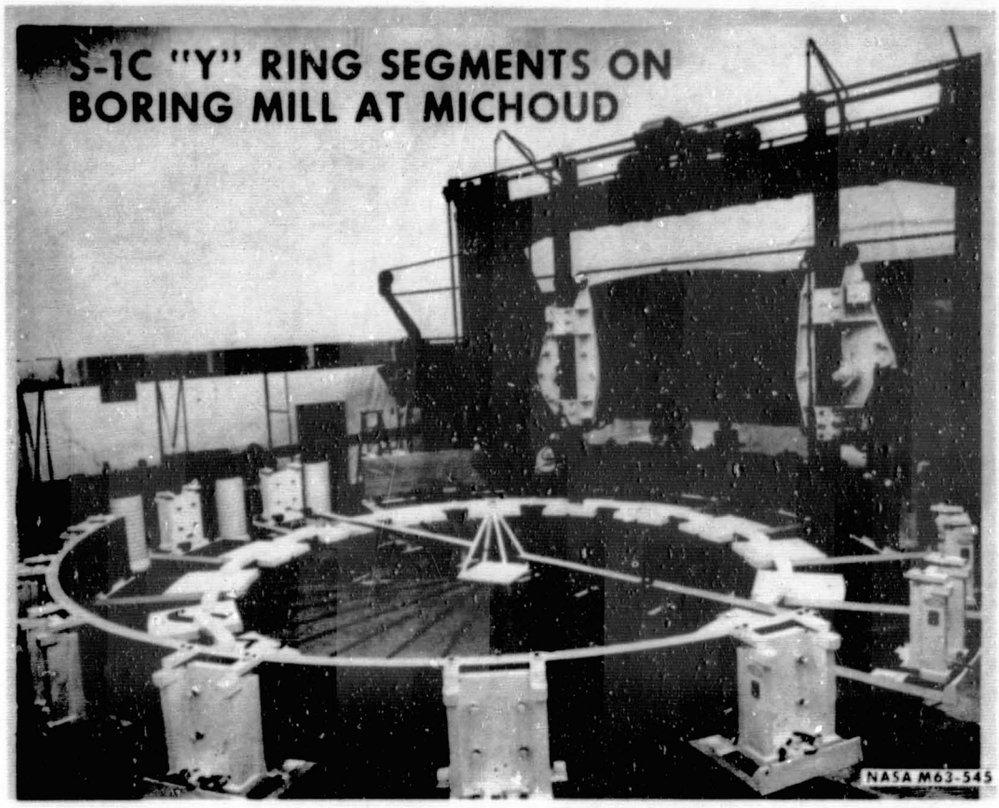

FIGURE 54

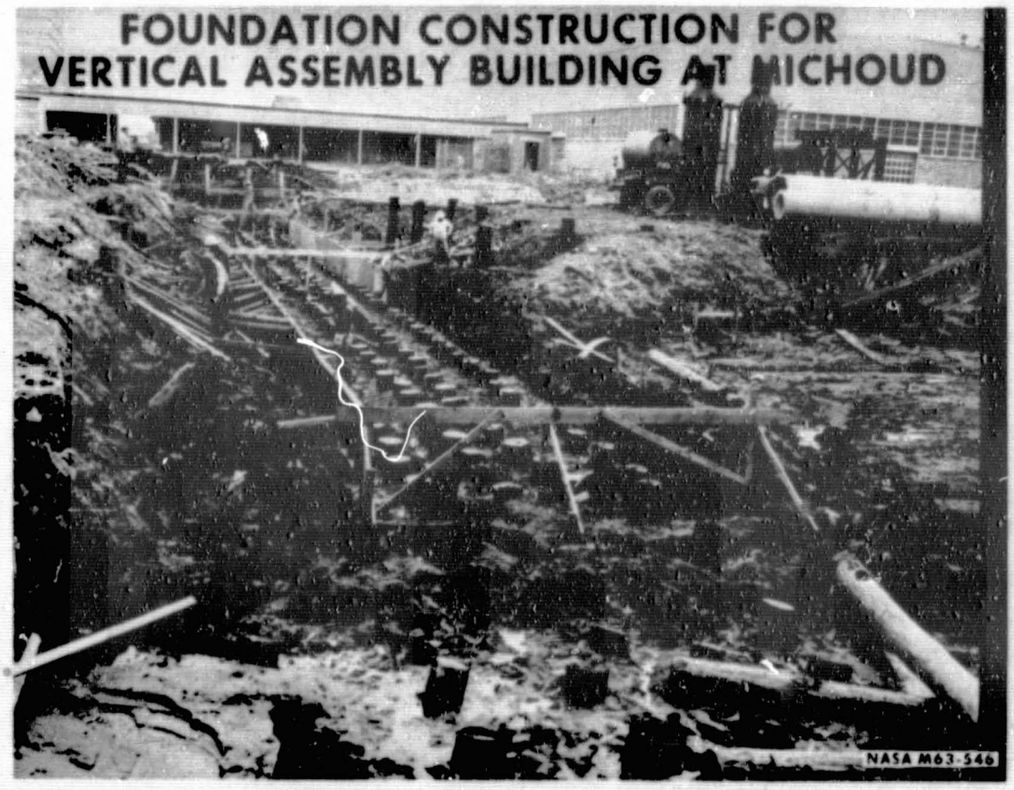

FIGURE 55

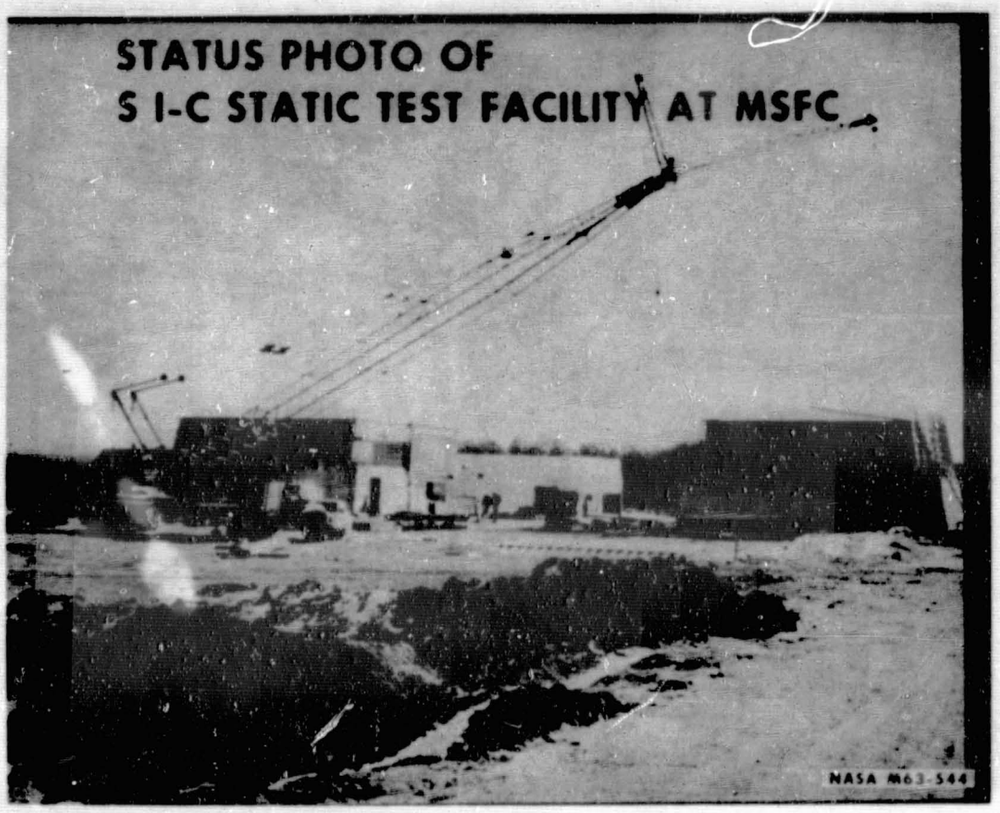

FIGURE 56

However, since the full firing of the S–II is some 400-odd seconds we cannot do a full test of that until we get this Mississippi Test Facility going.

The problem is not so critical for the first stage because we are building a static test stand at Huntsville.

The third stage is being tested by Douglas at Sacramento.

Mr. DADDARIO. Mr. Holmes, is the test restriction at the North American location the result of the type of test stand facilities? In what way is the Michoud plant an improvement, and what are the differences in the test facilities? What are the reasons why there must be the two locations?

Mr. HOLMES. North American uses Santa Susana up in the mountains, for testing their engines and they are using it for testing this stage.

The difference between Santa Susana and the Mississippi Test Facility for static firing involves the relative area, boundaries, and distances.

If one assumes a TNT equivalent of some 60 percent, which is the number presently being assumed for these propellants, one would have an explosion hazard in excess of what would be reasonable under the limiting factors of the Santa Susana site.

Mr. DADDARIO. You are talking about geography?

Mr. HOLMES. Yes. At the Mississippi Test Facility, where we have much more area, and also a buffer zone, designed so that an explosion would be contained therein.

Mr. DADDARIO. All right, fire.

Mr. HOLMES. The test stand at Marshall will be completed by early 1964. Four massive concrete footings and interconnecting wall foundations are in place. They extend 35 feet below grade. The lower section of the superstructure will extend 240 feet above grade level and will support a structure of steel extending approximately 180 feet above this point.

All of this structure will permit ground testing of the S–IC stage before it is committed to flight. During this static test firing all five of the F–1 engines will burn simultaneously, each producing 1½ million pounds of thrust.

In 1964, we plan the first ground firing of the five F–1 engines that power the S–IC—a significant event since a thrust of 7,500,000 pounds will be produced.

S–IC stages produced at the Michoud plant will be tested on stands similar to the one described above (fig. 57), but located at the Mississippi Test Facility, on the East Pearl River and 40 miles from Michoud.

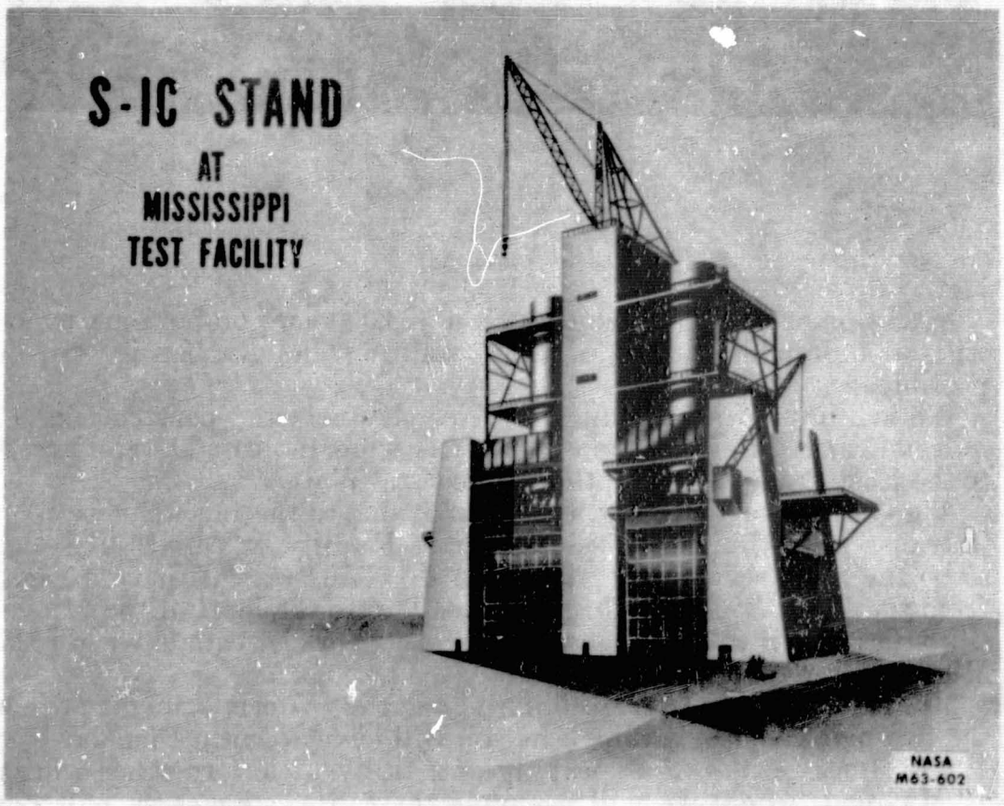

FIGURE 57

I think when the committee sees the F–1 engine fire you will be as impressed as I was. When five of these are going at once it is going to be quite a noise and quite a blast.

The testing operations of the Mississippi Test Facility take place on a 13,500-acre Government-owned central site (fig. 58).

FIGURE 58

NASA is obtaining easements on a 128,000-acre buffer zone which will be uninhabited, but in which farming and lumbering will be possible.

We are improving 15 miles of river channels and constructing 15 miles of canals, 15 feet deep and 200 feet wide, to provide water access to the East Pearl River and the Intracoastal Waterway.

A good part of that length of canal is due to the fact that we plan to transport within the Mississippi Test Facility by canal. It seems to be the most economical way to do it. Thus we will have a canal from the Pearl River, go through a lock up to the level of the Mississippi Test Facility and then through a network of canals within the Mississippi Facility.

Mr. DADDARIO. You are talking about the materials involved, not the full movement of a vehicle as you will have down in Florida.

Mr. HOLMES. Yes, I'm speaking of a full vehicle. In other words, at Michoud, where we will assemble these first stages, we will put them on a barge, take them up the Pearl River, stand them up on these test stands where they are held down, and fire them. Once they are tested out we'll put them back on the barge, take them down the Pearl River across the gulf to Florida.

Mr. DADDARIO. Thank you.

Mr. HOLMES. Land acquisition, site preparation, utility installations, and test-stand design are in progress at Mississippi Test Facility, which should be ready for use in 1965.

Construction will begin later this year for test stands and various support facilities for the S–IC and the S–II stages.

Next (fig. 59) we see the second stage, the S–II, which is being developed by North American at its Downey plant in California.

With a full load of liquid oxygen and liquid hydrogen propellants, this stage will weigh over a million pounds.

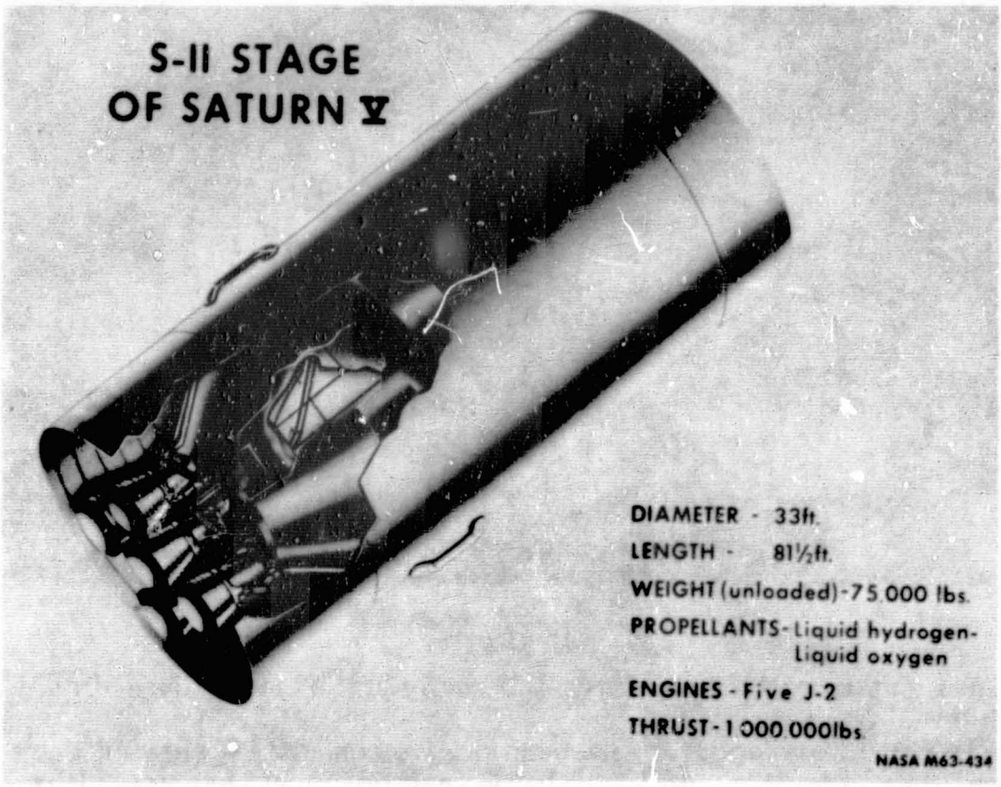

FIGURE 59

The next slide (fig. 60) shows that an assembly plant is under construction at Seal Beach so that the 82-foot-long S–II stages can be shipped directly by water from California to the test stands at Mississippi Test Facility.

All of these stages have to be shipped by water. The upper stages, the S–II and the S–IVB will be manufactured in California and shipped by water. As I mentioned before, the first stage, the even larger one, will be built at Michoud.

Mr. GURNEY. Mr. Holmes, since you are going to fire these things at Cape Canaveral and have direct firing facilities there, why is there a duplication in Mississippi, or is it a duplication?

Mr. HOLMES. It is not really a duplication in that a static test stand is different from a launch tower.

The launch tower is an umbilical tower, where you have hold-down facilities and then you release the vehicle and let it go into flight.

On the static test stand you wish to clamp it down and hold it for the entire firing. You have a great deal more instrumentation than you have on the launching facility because you want to measure and

FIGURE 60

check out flaws—temperatures and so forth. They really are quite different facilities.

In order to simplify transportation, we considered whether there would be a possibility of doing that type of testing at the Cape. However, it appeared it would so interfere with this busy flight operations center. That it would not be the wise thing to do.

Initial testing, using heavy-walled tankage, will be performed on test stands now under construction at North American's Santa Susana facility. This slide (fig. 61) shows general construction activity at the Santa Susana site.

It may indicate the rugged country that Santa Susana is in.

As pointed out previously, flight stages will stop at Mississippi Test Facility for acceptance testing on their way to Merritt Island. Fiscal year 1964 will see initiation of static and structural testing and progress on the fabrication of other ground test stages and early flight stages.

The third or S–IVB stage of Saturn V sees dual use in the manned flight program. It is the second stage of the Saturn I–B and also the escape stage of the Saturn V. It uses a single J–2 engine. It will be manufactured at the new Douglas plant at Huntington Beach, Calif., and tested at a Sacramento complex.

Then the stage will be shipped by sea transport through the Panama Canal direct to Cape Canaveral. This slide (fig. 62) illustrates how these launch vehicle stages are carried by barge.

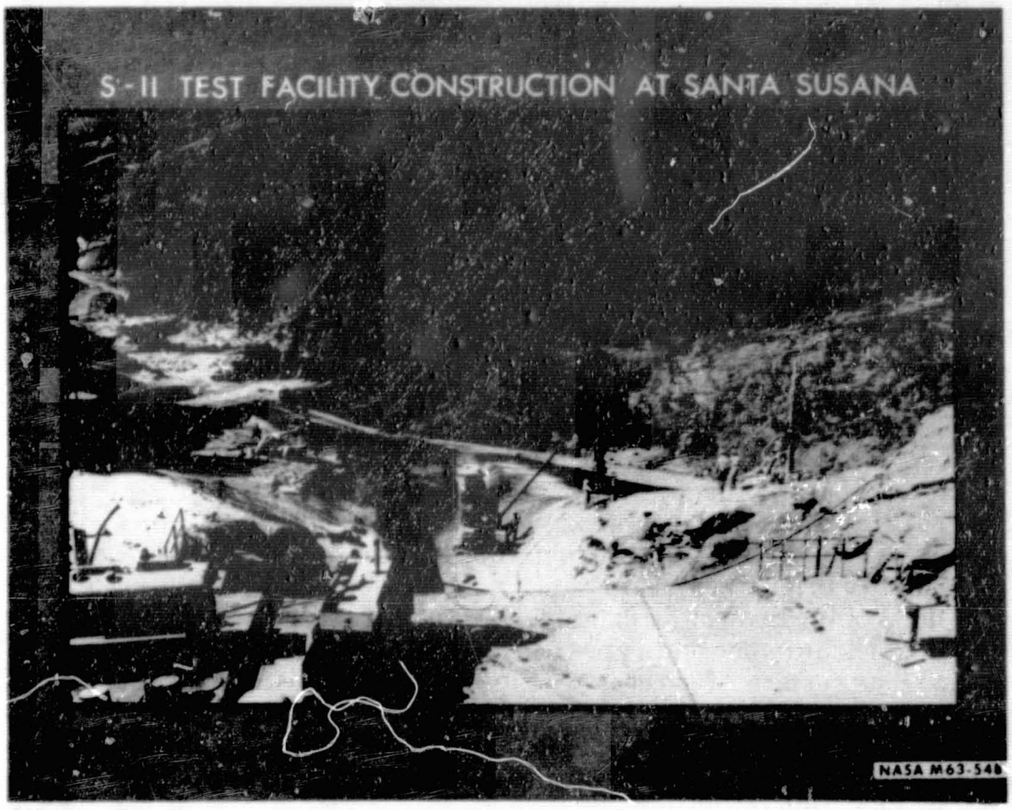

FIGURE 61

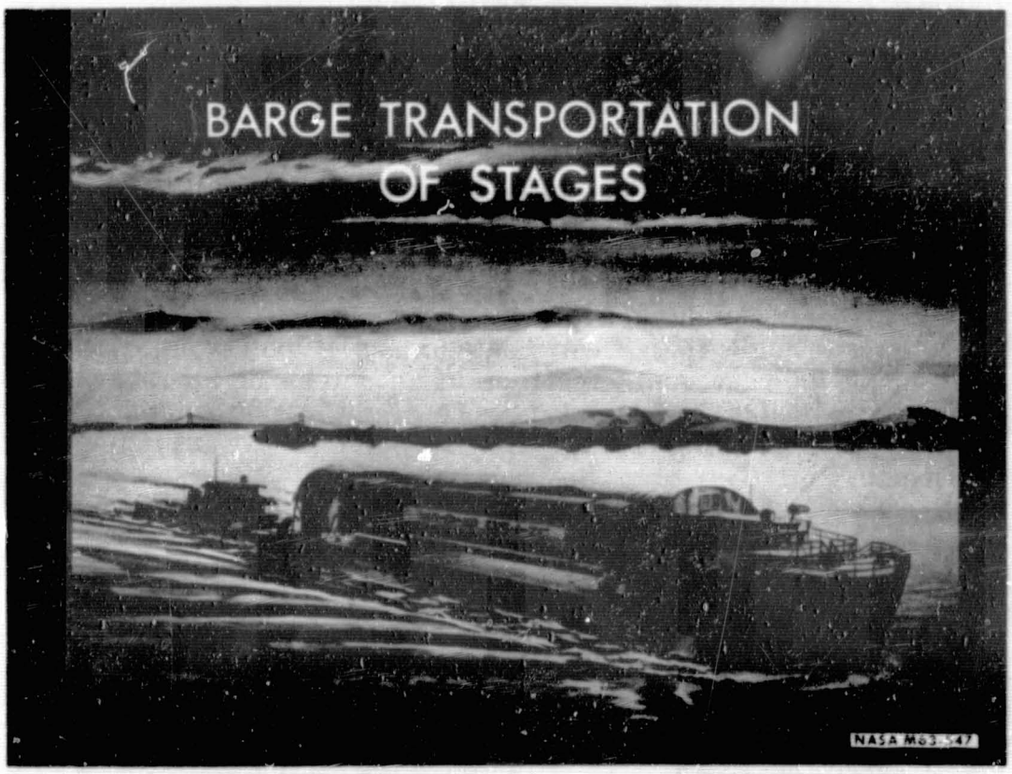

FIGURE 62

That really shows an S–I stage, I believe, on a barge being pushed by a pusher tug.

Mr. DADDARIO. You are not talking about a special barge; these are barges presently available?

Mr. HOLMES. We do have a special barge for the S–I stage. But the others are not special barges. We have a ship that the Navy has agreed to furnish—an LSD—which will do the transporting from the coast around through the Panama Canal. Then we will be contracting with a barge contractor to do the movement between Michoud, the Mississippi Test Facility, and Cape Canaveral.

Now turning to integration and checkout, I believe it would be worth while to spend some time discussing this because it is a less tangible area, but it is an area where programs often fall down.

One may effectively produce equipment and send it to the field, but if the interconnections in the system have been neglected, there are great delays and schedule slippages and so forth.

Therefore, we are emphasizing this part of the program.

Let us look at our integration and checkout activity which we discussed only briefly last year.

The Apollo project is extremely complex, both technically and in terms of the number ond types of contractors involved.

To be as certain of success as is humanly possible, we must establish a system (methods and procedures) to insure that we achieve compatibility of all of the system elements.

As a simple example, we must know that every plug will mate with its proper socket, and not with an incorrect socket. In other words, not only should it mate with the socket that it is intended to mate with, but it must be keyed so that it cannot be plugged into another one beside it which it is not intended to mate with.

We have defined this activity as integration. Success of the mission is equally dependent on the achievement of a higher order of reliability than heretofore obtained. We must have a realistic assessment of where we stand relative to the confidence goals required to commit a crew to the lunar mission.

A reliability assessment effort has been started to fulfill this need.

Prior to launch, assurance is needed that all elements of the system will operate properly and that all parts are indeed ready for the mission. Demonstration of a high degree of confidence is one of the primary roles of the checkout systems.

We have brought these three related areas—integration, reliability assessment, and checkout—together in an across-the-board program managed by the Office of Manned Space Flight in Washington.

Mr. FULTON of Pennsylvania. On that point, I have a question, Mr. Chairman.

You say you have started to fulfill this need, but that does not put much flesh on the record. Would you tell us how you are carrying that out?

Mr. DADDARIO. Do you want to go into that now?

M HOLMES. I do have another section on it. This is the introductory portion. Why don't I give that section of the testimony and see if that answers the question.

Mr. FULTON of Pennsylvania. All right. I thought you were moving to another subject.

Mr. HOLMES. We can illustrate the integration process by the next slide (fig. 63). Shown here are the first level or major system interfaces which are created both by technical considerations and by the organizational and geographical grouping of the elements we have had to bring to bear on this complex program. The red lines on the slide indicate the interfaces between the launch vehicle, spacecraft, and the ground equipment systems. These are the interfaces that are of direct concern to our program office in Washington, and it illustrates the need for at some place a central program office, and as I mentioned yesterday, our office also serves as a headquarters operation.

To assure that the proper interfaces exist between electrical signals or hydraulic signals or mechanical signals that would go across those red lines requires people looking at it and looking at it in detail and continuously.

We have established effective intercenter coordination panels to identify interface problems and resolve them. These panels consist of working-level engineers from each of the three centers primarily concerned with our program, the Office of Manned Space Flight, and our contractors, as necessary. To better understand the workings of these people, it might be well to cite an example or two of their work. There is an emergency detection system in Apollo which will save the crew in the event of a failure in the launch vehicle.

In other words, it would detect an incipient failure and energize the equipment to carry them away.

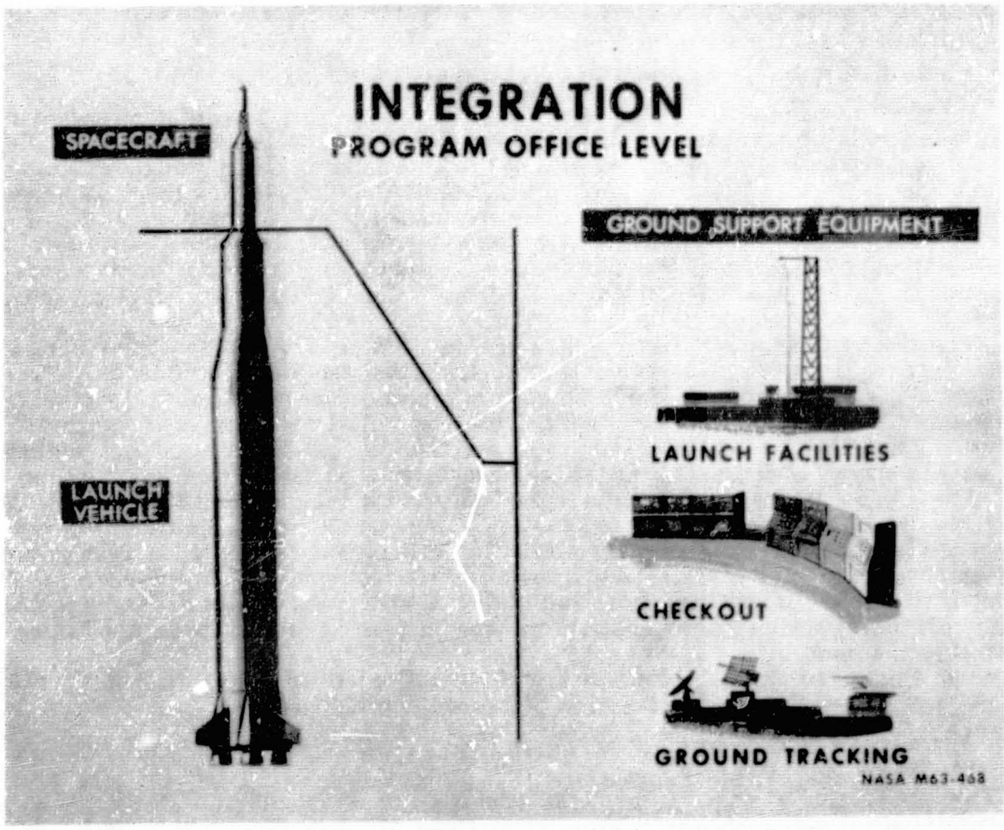

FIGURE 63

The design of this system is intimately tied into the detailed design of the launch vehicle, the spacecraft, and the capabilities of the crew under stress conditions. A joint intercenter panel is now coordinating the design of an effective and compatible system to carry out this important function.

To cite another case, the structural and aerodynamic problems of design of the whole space vehicle are equally interrelated. The length and weight of the final spacecraft to be boosted greatly affect the design of the launch vehicle. For the launch vehicle or booster, the allowable stresses to be handled are directly influenced by the spacecraft configuration. Intensive and continuous study and evaluation of the design of this spacecraft-to-launch-vehicle interface are monitored by an integration panel.

That is still another form of integration, rather than these signal flows. The spacecraft and launch vehicle have to be treated dynamically as one so that it doesn't break apart, for instance, under the thrust of high velocity wind jets going through the atmosphere.

Mr. DADDARIO. How many people are on the integration panel? You say it is monitored by an integration panel. Are you talking about a committee of some kind?

Mr. HOLMES. Yes. There are various panels at the working level which are made up of representatives from each of the centers and usually include someone from the program office.

This particular panel would have as many as a dozen people on it.

Each one would be a working engineer. They meet together to make sure that they are coordinated in the interfaces between the elements they are working on.

(The following information has been supplied for the record:)

Integration panels have been established to assure full coordination between all the levels of management that have assigned responsibility for the Apollo Saturn program. During the meetings working engineers discuss interrelated problems in terms of source, impact, and solution. The centers have responsibility for carrying out the decisions that are reached.

At present there are six integration panels: Launch Operations Coordination, Mechanical Integration, Electrical Systems Integration, On-board Instrumentation and Communication, and Crew Safety. Other panels, including ad hoc, will be formed as required.

The Flight Mechanics, Dynamics, and Control Panel, which was used as an illustration, points out the type of coordination that has been established. This particular panel is composed of 11 members representing the Manned Spacecraft Center and the Marshall Space Flight Center. Dr. R. F. Hoelker of the Marshall Space Flight Center and Mr. Calvin A. Perrine, Jr., of the Manned Spacecraft Center serve as cochairmen. OMSF representatives participate in the meetings.

The Flight Mechanics, Dynamics, and Control Panel meets to identify and resolve technical problems related to the dynamics and control of the composite space vehicle. To cite a few examples, this group evaluates and resolves problems in the areas of space vehicle dynamics and loads and guidance and control interfaces between the spacecraft and launch vehicle. As appropriate, the panel often refers problems to the contractors who in turn conduct studies and report on their findings.

The Flight Mechanics, Dynamics, and Control Panel illustrates the importance that we are placing on coordination of interface problems.

Mr. DADDARIO. Who chooses them?

Mr. HOLMES. Who chooses them?

Mr. DADDARIO. Yes.

Mr. HOLMES. The Centers choose their membership, and my program office chooses its membership and looks over the whole panel membership.

A standardized and controlled interface drawing system is being established which defines the electrical system interconnections between the launch vehicle and the spacecraft, and within each of them. This effort will help to eliminate last-minute incompatibilities at the launch site where, for the first time, the spacecraft and launch vehicle will be physically mated to each other.

From the point of view of sheer numbers, a perhaps more difficult problem is the more detailed series of interfaces that exist within the elements being developed by each of the Centers principally concerned with our program. On the next slide (fig. 64), the red lines indicate

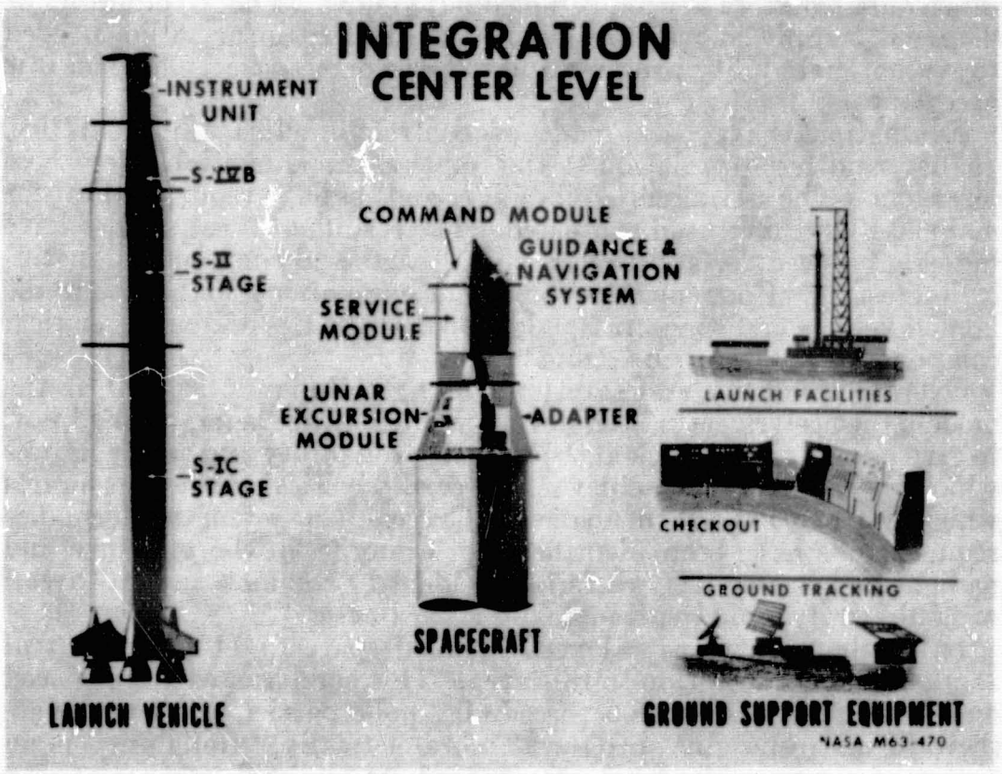

FIGURE 64

only some of these major interfaces within each Center, for the launch vehicle, the spacecraft, and the ground facilities. Each of these interfaces must be carefully designed, documented, and tested thoroughly for operating capability.

Again, we are pushing the technical decision making down to the lowest practicable working level, delegating to either the Center technical specialists or to the major contractors the responsibility for most of these interface decisions.

In other words, Marshall is responsible for seeing that the three stages of the Saturn V do mate and go together. Houston is responsible for seeing that the interfaces of the spacecraft go together. Houston has delegated that overall responsibility to a contractor, North American. In the launch vehicle, Marshall has for the S–I, Saturn I, and Saturn I–B, given that responsibility of working with them to Chrysler, and probably will give to another contractor the integration

for the overall Saturn V. We are not at that point in time. Marshall is still doing that themselves.

Reliability then, turning from integration, in the reliability area, we are in the process of instituting methods and procedures by which we can continually evaluate the reliability, quality, and test efforts of all participants in the program.

A comprehensive system of reporting on component and part failures is being established to provide information required to select components that have good histories of reliability and to weed out those that cannot be trusted. Test results and data, originating with vendors, subcontractors, prime contractors, and Centers are to be collected into a data bank. They are being collected now. This pyramiding of data will supply management with the detailed information needed to evaluate reliability progress and to take corrective action when it is necessary.

Evaluations have been made of contractor efforts in reliability, quality, and test in relation to the total resources available for these contracts. The stringent reliability and safety requirements for manned flight have been evaluated. The results of these studies have indicated a need for additional critical parts and components qualification testing. Consequently, to provide engineering confidence in the launch vehicle and spacecraft, additional quantities of specific critical components will be procured and tested.

Overall reliability and safety modeling techniques, as well as the models themselves, have been developed. They are being applied now to give us a first quick look at the probable reliability and safety figures which we can expect to achieve. Especially critical subsystem figures which we can expect to achieve. Critical subsystem performance requirements have been identified, for example, in the guidance and navigation systems. If we failed to identify the most critical areas, we could easily build inadequate flight hardware.

It is believed a more balanced manned space flight program will result from our attention to this area. This emphasis we have placed on reliability assessment has forced all Apollo participants to evaluate their formal reliability programs more critically. Reliability is an aspect of a project that has sometimes been slighted because of cost and schedule considerations. Extremely high standards of reliability are essential to the success of our manned space flight program.

Mr. RIEHLMAN. Mr. Chairman, before he goes away from reliability and checkout, in your statement you referred to checking on these contractors and trying to find those who are not reliable and weed them out. Now, I don't care to have the names of any contractors exposed, but have you found some contractors who have not been reliable?

Mr. HOLMES. I was referring, Mr. Riehlman, to the parts.

Mr. RIEHLMAN. Well, I would feel that contractors would certainly be tied in with whatever parts you buy that are not reliable.

Mr. HOLMES. Yes. We have not to my knowledge found any significant number of contractors, as such, that are not reliable. Sometime a vendor's products doesn't come up to the reliability standards that we feel we need, whereas it may be perfectly all right for some other applications.

Mr. RIEHLMAN. But they do not fulfill the requirements and standards that are needed for the work that you have for them to accomplish and perform?

Mr. HOLMES. Yes, I think that is certainly a correct statement, sir. I don't mean to be sanguine about this reliability. It is a very difficult area. We have had people now for a number of years all over the country, talking about reliability. They have met in countless reliability symposia, and a lot of what they say is true and valid. But the meat and potatoes in reliability lies in picking the best component. Our philosophy involves not cutting costs for components, or parts, or reliability. We are spending that money and we think, overall, that is most economical.

It is also vital to design in such a way that you really have a reliable operation, whether the design be for electronics circuits or mechnical or hydraulic applications. Then you must concentrate on testing, testing, testing, and testing. This must be done in the environment in which you expect to operate. Then—and these are not necessarily in any sequence of importance; they are all important—the tests must be analyzed. You must decide on best designs and components and must use redundant equipment when you don't achieve enough evidence of statistical reliability—mean time to parts failure—to assure success. That is the kind of approach we are trying to take. It is a practical approach that you or I or anyone would take to build a vehicle to take me somewhere and back.

Mr. GURNEY. Mr. Chairman.

Mr. DADDARIO. Mr. Gurney.

Mr. GURNEY. Pursuing that a little further, Mr. Holmes, I know there is a feeling by many of the people doing this work that there is an overemphasis on checking. In other words, they feel quite concerned about the fact that too many technical people's energies are being absorbed in the business of checking. Would you care to comment on that?

Mr. HOLMES. Yes, I would. I have had a lot of experience in this area, particularly in checkout. It has been my experience that usually you can effectively design hardware for a checkout system at about 10 percent of the original development cost for that system. Usually this expenditure pays off again and again and again. Now, turning again to this particular system. Here we have something more expensive and more critical than anything I have worked on. Indeed more critical, I think than most people have dealt with. Here we will have not only human life involved, but we will have a vehicle that will cost considerably more than a hundred million dollars at launch. We will also have our national prestige involved. I personally think we are not doing too much checking. We are approaching this on an overall integrated checkout approach, which I am going to describe for you here, and I think it is worth every dime spent on it.

Mr. GURNEY. I think perhaps I misdirected the question. I was not directing the question to the necessity of having a checkout program, but the duplication of the checkout procedure. In other words, checking by the Government over the people that are checking out is what I am talking about, and directed really again not to the checkout phase of it but to the whole effort.

Let me give you a little example which may sound absurd, and yet, it does illustrate the point.

I know that contractors at Cape Canaveral have to keep payroll records at the cape. They also keep duplicate payroll records at their home offices, wherever they may be. The Government people check the payroll records at the cape, and then they go out and check the payroll records at the home offices. Now this, to me, is an absurd duplication not only of effort on the part of the contractors but on the part of the Government. This is not directed exactly to your checkout of a phase of the missile, but you see the point that I am making.

Mr. HOLMES. Yes, I do. I see the point that you are making very well, and if that is occurring I think it is absurd.

Mr. GURNEY. This is occurring. This is a concrete example.

Mr. HOLMES. I agree. I could say this: As we grow in strength in NASA we will have in Government probably an unparalleled technical competence for managing programs of this kind. Unless we are careful, and unless we discipline ourselves, we then can go too far in trying to do jobs that should be delegated to industry. Our Management Council has concerned itself with this problem on many occasions. How do you discipline your people so that they check far enough to assure that the Government has the best, and still do not take over responsibilities that a contractor should have. As you know, there is a balance involved. For example, my subordinates say "if that old goat would leave me alone I would get along fine." It goes right down the chain, and the contractors say it about the Government employees. I hope I have answered your question. We are concerned to find the proper balance. We must build our competence without duplicating what is being done (and can competently be done) by American industry. I am very sincere in this, since I personally believe that the backbone and strength of this country in its competence lies in American industry.

Mr. RIEHLMAN. Not to belabor this portion of your testimony, Mr. Holmes, but I do have one more question. In your checkout bank where you find out that there are components that are not reliable and have failed to carry out the responsible portion of the program effectively, doesn't that show up the contractor that has produced this equipment?

Mr. HOLMES. Yes, sir; it will. It will tend to. We are conducting this program, as I said, with an integrated checkout approach. The checkout equipment being developed and designed by the contractors in their plants will be compatible with the overall checkout equipment we will use at the cape. I am hopeful that this approach will minimize the problem you are discussing. However, there will be cases, and in some subcontractors we have found it to date, where a good job wasn't done. Then we had to take some action.

Mr. RIEHLMAN. Well, this is the point, has any action been taken to correct this situation in cases where you have found it out?

Mr. HOLMES. Yes. At the cape complex, only within the last few weeks, we were completely dissatisfied with what a contractor was doing. This was on work on Complex 37. It involved vacuum lines from a cryogenic storage facility with which we had had considerable experience. We tried to show the contractor what we had done earlier; we tried to show him what he could do. We let him do it. He,

nevertheless, went his own way, and didn't do well, and we finally wound up terminating him.

Mr. DADDARIO. In your answer to Mr. Gurney's question, you indicated the importance of keeping things in proper balance insofar as the technical management of this program is concerned. Also, you previously said that at Houston, for example, in your integration phase you had brought in North American, and you were thinking of bringing in Chrysler at Marshall. In reference to that, would you explain to us how you choose the contractor involved? Is there the possible opportunity for competitive bidding, or is this just a choice where you tap some company on the shoulder to do it? I am compelled to go into this question somewhat at length because it seems to me that when a company gets itself involved as Chrysler has at Marshall, it retains the position year after year, and this inhibits the possibility of other companies participating.

Could you go into this a bit, and also, in going into it, would you give us some information as to the length of the contracts, and what the size of it might be in proportion to the overall project.

Mr. HOLMES. Yes. I will not speak now of our overall support contract in this integration, checkout, and reliability area which is the General Electric Co. In general, there is a natural selection as to who should be the integrating contractor. In these cases I've been discussing earlier it was natural. North American was awarded the command and service modules on competitive bid. At that time we recognized that the command module is the control center, the cabin of the spacecraft. The service module is another major element. North American, therefore, was the logical contractor to integrate that spacecraft. Further we hadn't then let the contract for the Bug. We didn't know whether we were going to need the Bug or a lunar landing stage.

In the case of large launch vehicles the most difficult interfaces are with the first stage. The first stage is not only the largest, but it is the first stage, and has the biggest interface both mechanically and generally, electrically, with the ground environment as the first stage and it supports the other stages. So it is a natural thing to use the first stage contractor as the integrating contractor.

As I said, we haven't yet made this decision for Saturn V, but the same reasoning will probably apply. Now, as far as the part of your question, concerning Chrysler: It is true that Chrysler had worked with Marshall in their earlier Army programs on the Redstone program, but they won a competitive bid for the S-1 stage. With regard to the duration of contracts, they generally run through the development and through the delivery of a certain number of spacecraft or stages. Usually the number is around 10 or 12. It is unlikely, however, that at that point in time it would be economical to change unless a contractor weren't performing well. Specifically, the contract with North American goes through a first orbital flight of Apollo in 1965 and includes 9 airframe spacecraft and 15 boilerplate spacecraft. Does that answer your question, Mr. Chairman?

Mr. DADDARIO. Yes, it does, in part, Mr. Holmes. Who makes the choice? Does General Electric play a part as a result of its management operation?

Mr. HOLMES. General Electric has not played a part in the choice of these contractors to do this integration. They have played a part

in assisting us in doing this overall integration, and particularly on those interfaces not assigned to a Center; that is, the interfaces between centers, or between spacecraft and boosters.

Mr. DADDARIO. Well, if they do have a management responsibility, are they capable of carrying it out if they don't play a part? I can understand how difficult it might be.

Mr. HOLMES. In contractor selection?

Mr. DADDARIO. Yes, insofar as it affects the overall program for which they have a great deal of management responsibility.

Mr. HOLMES. Well, as far as the contracts I have discussed, General Electric was not yet in a position to help, nor did we need their participation. Now, this won't be true in other subordinate contracts. There will be contractors to help us in assessments; there will be people to help us do data processing. There General Electric could assist. The places where they wouldn't assist would be places where they might have some interest—where they might want to bid themselves. There we would rule them out, as we have in the past, if because of their job they had some kind of competitive advantage.

Mr. DADDARIO. There is no such conflict, however, in these instances, in the decision that they should not participate in the determination of who should be the contractor involved?

Mr. HOLMES. No, sir; no such conflict.

Mr. GURNEY. Mr. Chairman, a question.

Mr. DADDARIO. Mr. Gurney.

Mr. GURNEY. Let me pursue that a bit further. All of us are certainly anxious for the program to get on, and you are most anxious for it also. Obviously, too, in a program of this magnitude there are going to be areas that the job is not done as it should be done. Suppose, for example, that I, as a Congressman from the Cape Canaveral area, get a legitimate complaint about some phase of the program that people there think is not being handled correctly. To whom would I go to in your organization to turn this complaint over so that corrective action might be taken? Let's take a specific example. Suppose you were constructing a building, or some phase of the program which was not a prime contractor phase, as Mr. Daddario pointed out, that might involve the expenditure of some $50,000, and there was a complaint that this was not let on competitive contract. To whom would I point that out, because you or your people, I am sure, would want to know about it?

Mr. HOLMES. Well, Mr. Gurney, sitting on this subcommittee as you do and being so intimately informed on the program, I would very much appreciate it if you brought it directly to my attention. Of course, you are also free to turn elsewhere if you wish. Don't think the sun will set on this day before I find out about the double-checking of payrolls you mentioned.

Mr. GURNEY. Thank you.

Mr. HOLMES. May I continue?

Mr. DADDARIO. Mr. Fulton?

Mr. FULTON of Pennsylvania. I would like to repeat the question that I asked before on reliability. This reminds me a good bit at this stage of where we were in World War II when we were substantially increasing plane production. I was one of those on the aircraft scheduling unit as a Navy representative when the planes were being sched-

uled for the Army Air Force, the British, and the Navy. The question of reliability comes up not only in the large parts but also in the smaller daily use components. I have previously suggested that there should be some sort of system of guarantee of merchantability, or guarantee of merchantability for the particular use for which these components are put. This should be supplemented with a system whereby a small bond is put up, that the component will function reliably under the circumstances stated in your specifications.

That has not been adopted, but it certainly seems to me to be an adequate solution. If it becomes public knowledge that a corporation has several of these small bonds forfeited, they will be forced by public opinion as well as by you people to come up with products of higher reliability.

When the United States has a post office built, we require a bond from the contractor, and I can't see why on ordinary off-the-shelf items that are now being used daily in the space field you do not adopt similar procedures. I am distinguishing this from procedures that might be in reference to research and development materials and, of course, would exclude that type of contract.

When I was at Cape Canaveral on the original Mariner shot, a question had come up as to a delay caused by a simple fuse. There was some doubt as to whether or not the fuse had been broken and someone had simply pushed it back into place again. It was discovered when the countdown began and there was some vibration and some temperature problems indicating that the vehicle wasn't operating correctly. It is the old story of the kingdom being lost for the want of a horseshoe nail. Some of us on this committee have seen that happen in various instances. In this particular case, when the fuse was taken out, unfortunately whoever took it out put it on a velvet pad and mixed it with other fuses so that at the time you could not identify which was the fuse which was taken out and this became quite a problem and caused further delay. So there is a real question in the procedures for handling ordinary items.

Now, I feel that the industry has developed to the point where standards must be set on ordinary items, and there must be the requirement of living up to these standards.

As you know, I have spoken of the ordinary supply items that have gone wrong on the Glenn flight. Maybe we should have a guarantee or a warranty that a particular product of this type will not malfunction in the last hour of the countdown. I think something like that is reasonable, and I think you should consider it.

My other point is this: In the armed services as well as in the AID, that is the State Department instrument for international development, and now also in the Agriculture Department there has been set up a separate inspection system. A similar inspection system might be set up for you people but the question is, Would it be simply adding another level of inspection more than you need?

On the other hand, to me, if you have an independent inspection system as distinguished from a testing system, they could evaluate as between the methods on various programs and see where the weak lines are. The way you have the system set now, the people who are doing the contracting, the people who are doing the administering, and likewise the advisory people, are all in the same pyramid of management.

My question then is, Should you have an independent inspection system in NASA?

Mr. HOLMES. Did you want me to answer that?

Mr. FULTON of Pennsylvania. Yes.

Mr. HOLMES. It is a very good question, and a very pertinent question. It is one which we have spent many hours considering and which we are considering today. I guess the last discussion I had on it was day before yesterday.

The Bell System back in the early 1920's sort of pioneered this sort of thing. I suppose there were other companies involved too, but as you know, Bell set up a separate quality organization which didn't report even to the work managers. It reported back to headquarters and was a completely separate organization. Its job essentially was to take samples off the line and test them. This was probably good to separate the responsibility for checkout from those responsible for hammering the job out. But then if you look at our problem, it is somewhat different. Some of our contractors already have such separate organizations. Many of them do in fact. Now, should we supervise not only from an overall management standpoint, but also establish another separate inspection operation? Does this lead to the very thing you put your finger on—the layering of organizations. As I said, this is a management problem which we are concerned with and discussing at this very time.

Mr. FULTON of Pennsylvania. I have brought this up for several years and haven't pressed it because I felt that you should develop your systems and then we should have a later judgment on it. I would like to have your judgment on that later for the record if you will.

Mr. HOLMES. Yes, sir. Thank you.

(The information requested is as follows:)

Many of the objectives that you may have in mind in suggesting an independent inspection system are being met by current procedures. For instance, the testimony of Mr. Siebert and Mr. Bracket before this subcommittee on March 25, 1963, highlights NASA's procedures for quality assurance. In addition, we are placing major emphasis on effective integration, reliability, and checkout in our manned space flight program. A detailed discussion of this vital function is contained in numerous portions of the testimony. As you know, NASA draws on the experience of the Department of Defense in auditing. The manned space flight scheduling system, which is described at length in the testimony, assists us in assessing not only status but also cost and manpower. As I have emphasized many times in my appearance before this committee, we are keenly aware of the necessity for reliability, quality assurance, and cost consciousness. We are taking every step to achieve these goals.

Mr. FULTON of Pennsylvania. Could I just finish on one other point and that is this: You have the problem of handling the reliability of literally hundreds of thousands of small components, and likewise you have the problem of handling the mechanical adjustment of these hundreds of thousands of components so that they are emulated in a particular small system. For example, you might have a transponder that you were going to place on a particular booster. Do you have a followup such as we needed on Mariner I, where there had been at least 100 to 300 runs through of the programing and then somebody at the contractor level forgot to put a hyphen in. How do you follow up on that kind of reliability? You cannot have some Government official looking over everyone's shoulder. In this case, but

for the loss of a hyphen, there was $12 to $14 million direct cost and probably $4 to $6 million indirect cost of taxpayers' money completely lost, as well as the fact that we had the public prestige of the United States at stake in a race with the Soviets on the first interplanetary mission.

How do we do that? What is your system recommendation of coming up with that kind of reliability to avoid this in the future?

I compliment you thoroughly on Mariner II. That actually makes the United States the first astronaut people. The moon to me is subordinate at this point. I believe you would agree with me as to the Mariner shots. When you felt you were slipping with the Centaur we said put the Atlas on. Go ahead.

Mr. HOLMES. Since Mr. Low had a lot to do with the simulation and other aspects of Project Mercury which, I think, is directly applicable, I would like him to comment.

Mr. Low. Well, I think in Project Mercury we developed the kinds of techniques that you are addressing yourself to. Here for the first time we have had to take a missile which was not designed for manned flight and adapt it for flight. There are two things we did there.

Insofar as the components, the pieces of hardware were concerned, we took special care with each piece and component. We handled the program so that each component could be traced back to the factory where it was made. We also made sure that the people who were making the piece knew they were working on a component for manned flight. Now, as to the second part of your question. I think the important point here is that every phase of a Mercury mission, including every conceivable emergency, was simulated over and over again hundreds of times before the flight took place. Thus in Mercury I think we would have discovered a computer programing error of the kind you mentioned long before the mission.

Let me give you a typical example here. In 1961 over 180 days were spent at Cape Canaveral going through flight simulations. In these simulations the entire worldwide tracking network, the launch guidance system at the cape, simulated spacecraft systems, and simulated booster systems all participated. I believe we would have caught any incorrect programing in the simulations.

We are now trying to apply exactly these same techniques to the Gemini and Apollo programs.

Mr. DADDARIO. You may proceed, Mr. Holmes, please.

Mr. HOLMES. Thank you, Mr. Chairman.

In the area of checkout, for each of the phases of the mission—takeoff, inflight, lunar landing and lunar takeoff—it is necessary to verify the readiness of all of the needed system elements to properly perform. In order to develop high confidence in our readiness to take the next step in a mission, we must carefully check out each piece, part, unit, subsystem, stage, spacecraft module, space vehicle, and ground facility as shown in this slide (fig. 65). Checkout data required for the operation launch decisions will be fed into the Launch Control Center from the spacecraft, the launch vehicle, and the launch facilities. During the early phases, the spacecraft checkout will be performed from the spacecraft operations and checkout building. The Mission Control Center in Houston, which will control the mis-

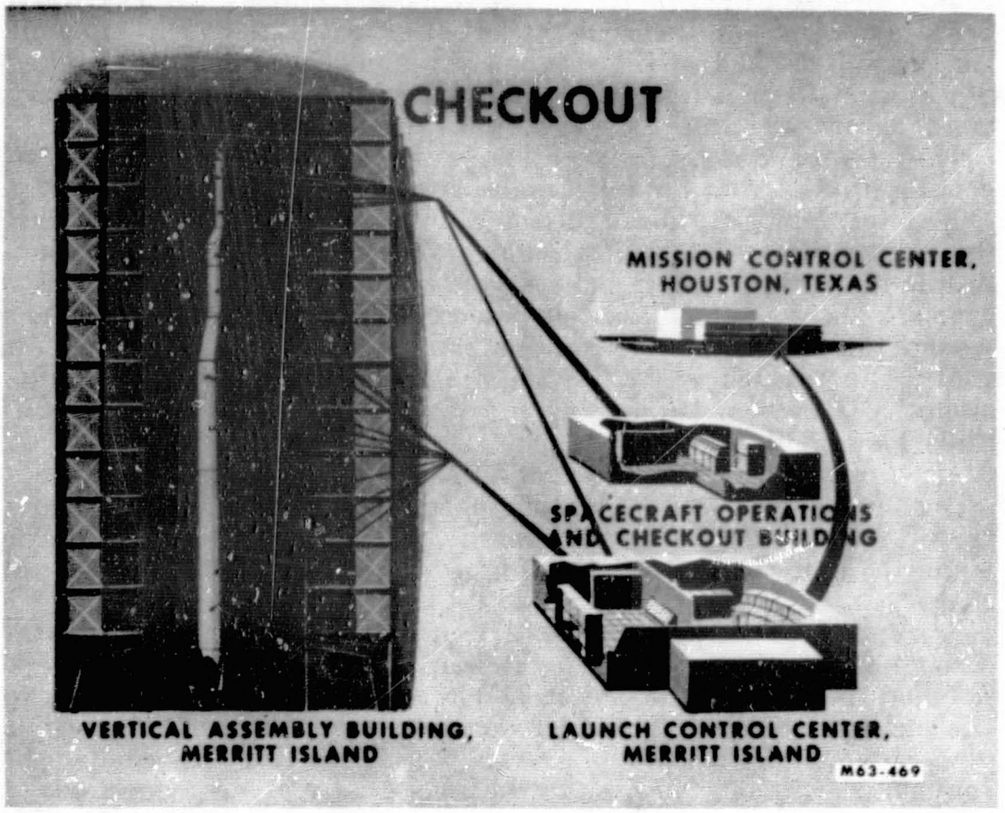

FIGURE 65

sion during flight, will also receive checkout information during the prelaunch and launch phase.

Such a checkout system is under development for Project Apollo. Its design has origins in the missile systems and electronic systems checkout experience and in the experience gained from the space exploration missions. It combines the semiautomatic, preprogramed, repeatable test concepts of the operational weapon system with the careful, detailed, almost personal techniques that NASA has employed in such programs as Mercury.

In others words, it is largely digital. We use transducers or sensing devices that change the analog information, such as a temperature change, to a digital code. Then you can transmit that information over hard line wire or radio signals over great distances.

In other words, you can process this digital information coming from an analog device, in one computer at a factory test setup, and still another computer at the cape, and still expect to get the same answer.

There are many advantages to going into these digital techniques I believe.

However, the most comprehensive and exacting preflight testing of a space vehicle at the launch site can never serve as a substitute for a good design, reliable fabrication and assembly techniques, tight quality control, and thorough preshipment testing by the equipment manufacturer.

For Apollo, the integrated launch control and checkout system at the Merritt Island launch area will be used to verify and validate the readiness of properly designed and manufactured flight hardware and launch facilities.

On this next slide (fig. 66), we can see that the equipment for the integrated launch control and checkout system is located at the vertical assembly building area, in the Launch Control Center, at the launcher-umbilical tower, and at the spacecraft operations and checkout building.

The required verification of flight readiness will be based on computer-controlled preprogramed final testing. However, it will be cor-

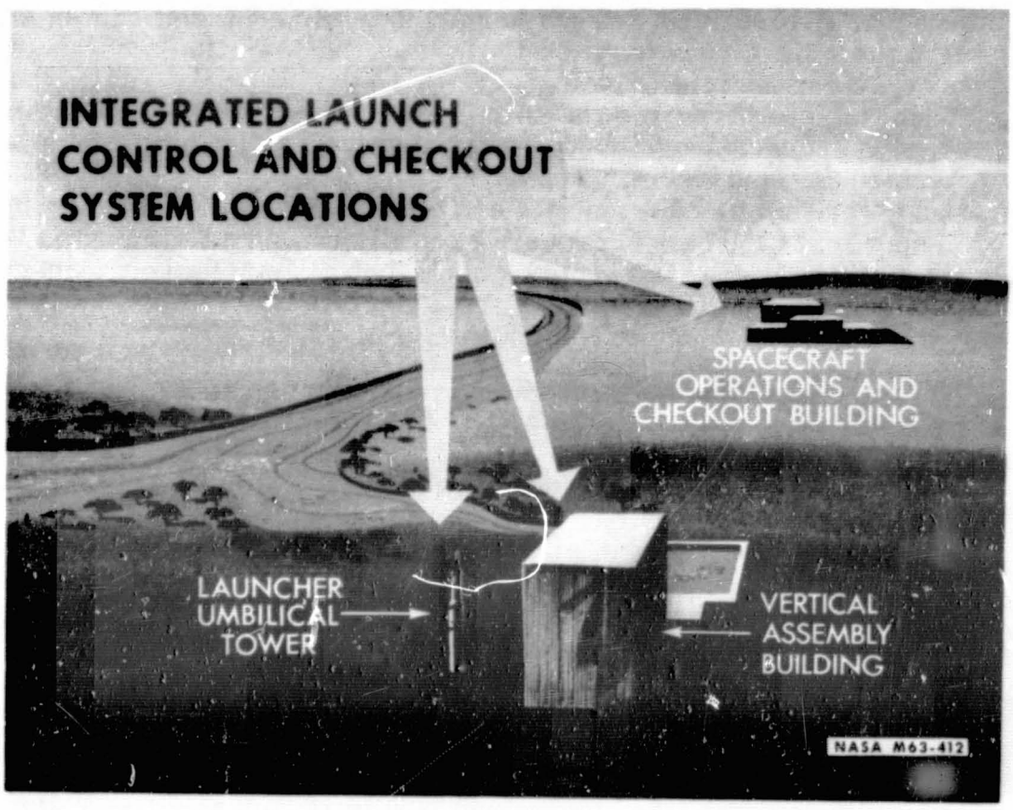

FIGURE 66

relating prelaunch test results with the long history of previously obtained and consistent test data.

Also, the in-flight checkout and the lunar takeoff checkout testing will be made compatible with the factory, static test, and preflight testing programs.

A general specification for the integrated launch control and checkout system has been generated. Also the major subsystems—those associated with the launch vehicle, spacecraft, and launch facilities—have been functionally established. This has been accomplished through a cooperative effort. The three centers particularly concerned with manned space flight, coordinated by the Office of Manned Space Flight, work as a team which we call the system checkout design review board.

They take into account all of the design requirements of all the participating organizations. Also, in support, each NASA center has established strong technical groups whose prime responsibility is developing their portion of the final integrated launch control and checkout system.

Preliminary design of each portion of this checkout system is well underway at each center by both NASA and contractor support personnel. They are now generating detailed design specifications, working directly with the flight hardware designers.

An experimental prototype of the launch vehicle checkout system is now in operation at Marshall Space Flight Center, and is being used to check out a prototype launch vehicle instrument unit. With this experimental prototype, we are acquiring equipment and computer programing experience required to develop the operational checkout systems to be used at the launch site.

A similar prototype for the spacecraft checkout system is now in process of being set up to provide a comparable capability for the spacecraft checkout design groups.

Computer design requirements and selections for each subsystem are being made. These efforts are carefully evaluated for compatibility with the overall integrated launch control and checkout system requirements.

SUPPORT CONTRACTOR

We have asked the General Electric Co. to support NASA in all three of these across-the-board areas—integration, checkout, and reliability assessment.

General Electric's response has resulted in the formation of a separate Apollo support department to provide engineering services, design assistance, development, manufacturing, installation and maintenance support to NASA's field Centers and the Office of Manned Space Flight program office.

The needed buildup of the General Electric design engineering support effort is now well underway at the Manned Spacecraft Center, Marshall Space Flight Center, and Launch Operations Center to allow for close detailed technical direction by NASA during the critical early phases of the program.

Beginning with a relatively modest staff to support across-the-board tasks at its department headquarters at Daytona Beach, Fla., General Electric will gradually increase this portion of its effort as the engineering center of gravity shifts from the concept and design phases to the detailed equipment design and production phase, as in the checkout area.

As the reliability and quality data begin to build up, the General Electric central data effort will also grow.

Integration support effort by General Electric will continue at the NASA Centers and at the General Electric department headquarters to provide assistance to NASA throughout the life of the program.

LAUNCH OPERATIONS

As the size of the space vehicle increases, the time required for checkout at the launch area increases in proportion. Until now, final checkout has been accomplished on the launch pad. A large vehicle

stays on the pad for weeks and sometimes months before it is ready to be launched. For a vehicle of the size and power of the Saturn V, more advanced launch concepts are required.

Complex 34: The launch facilities at Cape Canaveral for the Saturn I and the Saturn I–B are of a conventional type. That means assembled on the pad and launched from that pad.

An example is Complex 34, placed under construction in 1959, which has now been used for three launchings. Here (fig. 67) we see a recent aerial photograph.

Complex 34 consists of a launch pad, a blockhouse, a service tower, fueling facilities, and instrumentation.

FIGURE 67

In many respects, Complex 34 resembles the Atlas facilities used for the launching of the Mercury astronauts. The chief difference is in the size.

The gantry stands 310 feet high and contains 2,900 tons of steel. Its blockhouse has walls 12 feet thick, and a steel door 2 feet thick, which weighs 23 tons. Its fuel and liquid oxygen facilities can pump three-quarters of a million pounds of fluid into the Saturn tanks in an hour. The foundation of its launch pedestal is reinforced by 3,770 cubic yards of concrete and 580 tons of steel. Its construction includes 100 million pounds of concrete.

At Complex 34, assembly, checkout, servicing, and launch take place at the pad. This complex will be employed again for the forthcoming fourth launch of the Saturn I. During fiscal year 1964, modifications

will enable it to accommodate the Saturn I–B and the Apollo spacecraft. The work is scheduled for completion in 1965.

Complex 37: A second conventional Saturn launch facility, even larger than complex 34, is nearing completion and will be employed beginning with the fifth Saturn I flight this summer.

In other words, SA–5 will go off of one of the launch pads in Complex 37.

The second facility, Complex 37, was placed under construction in 1960. Here (fig. 68) we see an aerial photograph. Complex 37 has two launch pads, 1,200 feet apart, serviced by the large mobile structure in the center.

FIGURE 68

The service structure weighs 3,500 tons and is as tall as a 37-story building.

The two fixed launch and umbilical towers at the pads are each 268 feet tall, about as tall as the Capitol.

Pad B, shown at the left on the slide, will be employed for the Saturn I beginning with the two-stage fifth flight this summer.

Pad A will be employed for the Saturn I–B, following installation of special instrumentation and equipment to be accomplished during fiscal year 1964. As in the case of launch Complex 34, the evolution of Saturn I and Saturn I–B has required that modifications be made to this launch complex as vehicle configurations have changed during the test program.

When it is complete, Complex 37 will be able to accommodate Apollo spacecraft and the Saturn I–B as well as the Saturn I vehicle. In

summary, the Saturn I's and the Saturn I–B's will be launched from the single pad of 34 or the dual pals of 37. If the firing rate of I–B should increase enough in later years which it may well, not just for the manned program but for others, then we may seriously consider accommodating it in our vertical assembly buildings which we can do within the present planning.

Merritt Island Launch Area: During the long period of time a space vehicle is being checked out the pad is available only for that particular vehicle. Thus the frequency of launchings is limited by, among other factors, the number of pads we construct. Work proceeds under very difficult conditions, in that large-scale facilities for making the changes and adjustments frequently required as the result of the checkout process are not available in the immediate area of the launch pad.

In addition, the vehicle is exposed during this checkout time to salt spray and weather.

For the Saturn V, as we mentioned earlier, we are using an entirely new concept in launch facilities, in which the rocket and spacecraft are assembled in a large building more than 3 miles from the launch pad.

We have a model of that vertical assembly building, that large building, here, for you to look at if you like.

The Saturn V launch facility, designated Complex 39, is in the Merritt Island area to the north of Cape Canaveral. As also noted earlier, NASA will manage and serve as the host agency of this new Merritt Island launch area under the January 1963 agreement between NASA and the Department of Defense.

FIGURE 69

96-504 O—63—pt. 2a——8

Here (fig. 69) we see an artist's conception of an overall view of the Complex 39 model. The vertical assembly building at the lower left will be one of the largest structures on Earth. For a closer look, let us go back to a slide we saw earlier (fig. 10, p. 154).

You see there the vertical assembly building housing the vehicle in a controlled environment. The total internal volume won't be controlled but all of the area around the vehicle will be.

According to present plans, the high-bay area will be 524 feet tall, about as tall as the Washington Monument.

It will be almost as wide and deep as it is tall—418 feet wide and 513 feet deep. Its total volume will be about 128 million cubic feet. As a matter of comparison, the Merchandise Mart in Chicago has a volume of 56 million cubic feet. The largest office building in the world is the Pentagon, with a total volume of slightly more than 77 million cubic feet.

The low-bay area, housing shops and an aisle to carry the vehicle stages and spacecraft modules to the assembly bays, will have an inside height of 190 feet.

We could stand the Saturn I vertically inside the low-bay area, which appears as a minor portion of the building on this slide, if that area were equipped for such a task.

The launch vehicle stage will arrive by barge. It will roll off the barge and directly into the transfer aisle in the low-bay area. The big S–IC stage will go directly to the assembly bay, where it will be erected vertically.

The other stages and the spacecraft modules will undergo some checkout and preparation in the shops of the low-bay area before they are taken to the vertical assembly bays and hoisted into place.

In other words, this building will allow us to check out each of these stages and finally to assemble them all, to mate them and check them out completely assembled and in a controlled location.

Vertical assembly will take place on a mobile launcher, on which a tower for umbilical connections will be mounted. The tower will be about 425 feet tall. The platform, 25 feet tall, and resting on 21-foot-high supports will be 160 feet long and 135 feet wide, considerably larger than a standard baseball diamond; in other words the flat part of that crawler that is going to carry these vehicles will be larger than a baseball diamond.

I am not boasting about this size. In fact, I would like to be able to tell you it will be a lot smaller. I am just trying to indicate the magnitude of the facilities required to handle launch vehicles of this size.

Mr. DADDARIO. Are you correcting these figures or has there been a change in the program enlarging the size?

Mr. HOLMES. In this particular case these were figures anticipated and put down before we started working in detail with the contractor.

The study efforts with the contractor have produced these revised figures. They do not represent changes because we have not started to fabricate the detailed design yet. But they are changes in the sense of study changes.

Mr. CASEY. What was the contract price for the crawler?

Mr. HOLMES. The bid—we have not negotiated the contract yet—the bid was about $9 million. This was a CPIF bid for development and fabrication of two crawlers.

Mr. DADDARIO. Your original estimate on that was about $10 million, wasn't it?

Mr. HOLMES. Yes, sir. We had several bids.

On this next slide (fig. 71), we see an artist's conception of how the platform, the space vehicle, and the umbilical tower will move along a specially constructed roadway, more than 3 miles to the pad, transported by a tractor crawler, of a type used in strip mining. The speed limit for this crawler vehicle is 1 mile an hour. We

FIGURE 71

expect to begin test runs of the crawler at Merritt Island by late next year.

Once again I would refer you to the models here. I think you can get a lot more from them by spending a few minutes of your time than I can give in many more minutes worth of words.

Mr. FULTON of Pennsylvania. I think we should again have the concurrence as to why you chose the crawler method, put that in as between the railroad and the barge costs and the stability.

Mr. HOLMES. We would be glad to put that in the record, Mr. Fulton.

(The information requested is as follows:)

In selecting the basis of mobility at launch Complex 39, extensive consideration was given to three modes—barge, rail, and crawler. The barge problems were many—namely, stability, propulsion and steering control in the restricted waterways, and pad design. In order to place the flame deflector under a barge-

borne launcher umbilical tower (LUT), the deflector base must be placed some 50 feet below water level or the LUT must be raised the same amount. It is virtually impossible to create a flame diverting structure below the water level because of the high-water table in the Merritt Island area. Lifting the LUT requires a jacking system or an enormous 50-foot-high lock system with gates 135 feet wide. There is a high risk involved in lifting the 12 million pound load 50 feet and holding this weight, which would then total 17.5 million pounds, during the initial lift-off environment. The barge concept was eliminated for these reasons. The rail system and the crawler concept are somewhat comparable. The rail system provides a solution to the steering and positioning problems at the pad and at the vertical assembly building. Solutions to these problems are more difficult, but not impossible, with the crawlers. However, the turning radius of the track system was such that changes in direction at the vertical assembly building and en route to the various pads would have to be handled by right angle turns, with elaborate jacking systems to allow rotation and retracking of the wheel trucks. The crawlers, which will be based on a similar concept used in strip-mining operations, have a relatively short turning radius of 500 mean feet and lend themselves to conventional roadway and steering techniques. Since a large surface of the crawlers will be in contact with the roadbed, in contrast to the essentially point contact of a railroad wheel, the crawler roadway requires less exacting and less expensive footings and subbase than those that would have been required for an adequate rail system.

Mr. FULTON of Pennsylvania. Likewise would you put in the record again the difference in launch time that is being saved and likewise the difference in cost between having the ordinary Complex 34 and Complex 37 methods?

Mr. HOLMES. Yes; we will be glad to do that.

(The information requested is as follows:)

At the inception of the Apollo program, extensive studies were conducted regarding the relative advantages of fixed versus mobile launch facilities. The studies indicated that cost of mobile versus fixed launch facilities were comparable for a launch rate of 12 to 18 vehicles per year. Beyond that point, mobile launch is definitely more economical.

However, of equal importance to cost are the many other advantages inherent in the mobile concept, which will be developed at launch Complex 39. The space vehicles will be checked out in a controlled environment protected from salt water, erosion, rain, and hurricane winds. Instead of tying up a complete launch facility for several months while checkout problems are solved, normal pad stay time will be less than 2 weeks. The mobile facilities are versatile and lend themselves to launch of Saturn I–B and Saturn V, as well as nuclear upper stages. An important factor which permits adaptation of the mobile concept is the use of automatic and digital equipment. Much of the present checkout and launch equipment is composed of analog computers whose readings are affected by the voltage drops encountered over long distances. This has contributed to the development of expensive reinforced concrete blockhouses adjacent to the launch pads. With digital computers, variable voltage is not a factor, and useful data can be received over long distances. This makes it possible to check out and launch the space vehicle with one set of equipment adjacent to the vertical assembly building and permits maximum common use of expensive ground equipment outside the hazard area. By centralizing the checkout operations and associated shops in the vertical assembly building, the most efficient use of personnel will be achieved.

As a result of these studies, NASA decided to adopt the mobile concept in order to accommodate an anticipated launch rate and to provide the necessary operational flexibility.

Mr. FULTON of Pennsylvania. Would you put one final thing in the record, too? Some people are still urging that this be done by sea launch rather than by land launch on this Merritt Island complex. Would you put in the record what your feelings are as between those two systems?

Mr. HOLMES. Yes, we would be glad to do that.

I think some of those people ought to fly over Merritt Island and they might change their minds and say this is sea-launched. I meant no offense, Mr. Gurney.

(The information requested is as follows:)

At the time, three launch techniques were possible: sea launch, off-shore launch, and land launch. Considerable study effort is required before the sea launch technique can be developed and put into operation. The concept involves high developmental costs, long developmental time, and, initially, high operational costs, which include an extensive system of supporting ships and probable industrial port facilities.

The length of time required to develop the sea-launch technique makes it inappropriate for Project Apollo. In addition, its unique advantage—mobility of launch point—is not a requirement for the Apollo program. NASA is, however, following with great interest the sea-launch studies that are underway in the Navy Department and industry.

At the inception of Project Apollo, the Department of Defense and NASA conducted a comprehensive study to determine the most suitable launch site for Apollo missions. The study compared the merits of a land-based site and an off-shore site. The results of the analysis favored the current launch complex 39 site on Merritt Island for substantial reasons. Compared with the off-shore concept, the land-based site offered lower costs for construction, development, maintenance, and operation. Launch from a land point also entailed less construction time and presented greater operational flexibility. Another deciding factor was that a land-based point would be less effected by adverse weather conditions than an off-shore site.

Mr. FULTON of Pennsylvania. Mr. Chairman, one final point on the structure.

Why is there one structure instead of a number of smaller structures needed for the particular boosters that are being worked on?

Mr. HOLMES. Would you ask that again, sir?

Mr. FULTON of Pennsylvania. I was wondering why you have one structure instead of smaller structures that just enclose the particular vehicle?

Mr. HOLMES. In the vertical assembly building?

Mr. FULTON of Pennsylvania. Yes, in the vertical assembly building.

Obviously when you have these areas around the edge of the building, you have a large cubic content that is a center area. It is actually not a work area, it might be an assembly. I think we need the reason for the structure of the building.

Mr. HOLMES. Yes, we can submit that for the record.

We did analyze several different approaches, and this approach, with an overall shell housing, appeared to be the most economical.

Mr. FULTON of Pennsylvania. I think we should have the justification for the building at this point in the record, if you will, on the various modes.

Mr. HOLMES. Yes, sir.

(The information requested is as follows:)

We conducted detailed studies of the unique facilities problems associated with vertical assembly of vehicles away from the pad. For example, we studied whether or not we should provide an enclosure for the vehicle alone, leaving the launcher umbilical tower exposed to the weather conditions. We decided that both the vehicle and tower should be sheltered to protect them against adverse weather and to prevent work delays because of weather conditions. By enclosing the vehicle and the tower, we assure ease of access between the two.

Our studies also lead to the conclusion that a back-to-back design for the assembly bays would allow for a common service aisle and flexible use of

costly instrumentation and equipment. One example is the 250-ton overhead crane, which lifts the stages into a vertical position. There was greater overall economy in building one large facility instead of small, independent units. The current concept for the Launch Complex 39 vertical assembly building provides ease of access, optimum use of equipment, weather protection, and economy in construction.

The dimensions of the vertical assembly building are generally determined by the height of the lifting hook and the area of the launcher umbilical tower platform on which the vehicles are assembled. The size is also determined by weight and wind stresses, since the crane's hook must be supported 456 feet above the floor of the building and the structure must withstand winds up to 125 knots an hour. Although structural considerations require a considerable amount of space between and around the bays, we plan to take full advantage of this space for necessary supporting functions and storage. According to our current plans, 16 levels between the bays and 10 levels around the bays will be used for supporting shops, laboratories, and offices. In addition, the space must accommodate the machinery and platforms of the nine pairs of retractable work platforms which each bay requires. We are continuing our studies to assure optimum utilization of the enclosed volume of the vertical assembly building.

Mr. HOLMES. Now, before the space vehicle is ready for launch, there is one step in the assembly and checkout procedure that cannot be performed inside the vertical assembly building. The launch vehicle and spacecraft system includes small- and medium-sized solid-propellant rockets and pyrotechnic devices in the launch escape system, for retrograde propulsion on return from earth orbit, and for stage separation.

For reasons of safety, these devices must be installed out of doors. Launch Complex 39 will include a mobile arming tower, which will be parked about a mile from the pad. After the mobile launcher is on the pad, the crawler-transporter will carry the arming tower to an adjacent position for attachment of rockets and ordnance items and to facilitate additional servicing that may be required at this stage.

The final step in readying for launch is to pump liquid fuels into the tanks, first the storable fuels, and then liquid oxygen and liquid hydrogen. Here (fig. 72) we see the vehicle at the pad, where fueling takes place.

The funds in the current fiscal year provide for incremental funding of the design and construction of the vertical assembly building, the crawler roadway, one launch pad, two launcher and umbilical tower structures, and steel for a third.

With fiscal year 1964 funds, we shall design and construct flight crew quarters, a launch control center, related ground support equipment, and facilities within the vertical assembly building.

We shall build a second launch pad and prepare the site and support facilities for a third pad. The arming tower will be constructed, and service systems for kerosene, liquid oxygen, liquid hydrogen, and other propellants will be completed.

The target date for making one assembly bay ready for operation is the summer of 1965. The facilities to be constructed with fiscal year 1964 funds are scheduled for completion in mid-1966.

FIGURE 72

ASTRONAUT SELECTION AND TRAINING

Up to this point in our report, we have assembled the hardware for the flight to the moon. We have analyzed the system and selected the mode of flight. We have developed the spacecraft and its life-support equipment.

We have constructed launch vehicles of sufficient power to conduct both preliminary flights and the actual mission. We have built the facilities required for launching space vehicles. We have made certain that the components are reliable that they fit together properly, and are in operating condition. One additional element is required. We must select and train the men who will fly these spacecraft.

Until last September, the U.S. pool for current flight missions consisted of the seven Mercury astronauts. At that time, we selected nine additional pilots and announced that Deke Slayton, disqualified from Mercury flight missions for physical reasons, had been appointed coordinator of astronaut activities.

The selection process began last April with an invitation for volunteers. We announced a set of qualifications similar to those established at the time the original seven astronauts were selected in 1959, but which opened the door for civilian pilots.

The new standards allowed candidates to be a little taller than the Mercury astronauts—maximum height of 6 feet instead of 5 feet 11 inches—but reduced the maximum age from 40 to 35 at the time

of selection. The lower age limit was established because of the long-range nature of the present manned-space-flight program.

As previously, we required experience as a jet test pilot, preferably still active. This experience might be gained through military service, aircraft industries, NASA, or graduation from a military test pilot school.

We required a degree in physical science, biological science, or engineering. We required U.S. citizenship.

Finally, we required a recommendation from the applicant's organization.

More than 200 applications were received. On reviewing the applications, we found that 63 met the basic requirements. The 63 were asked to provide additional detailed information on their academic background, flight experience, and career history, and to undergo a medical examination. This next screening reduced the number to 32.

During July and August, the 32 men reported to the Manned Spacecraft Center, where they were given extensive medical examinations by NASA space medicine specialists, aided by members of the staff of the Air Force School of Aviation Medicine in San Antonio, Tex.

One was dropped during these examinations because he was found to be too tall. The remaining 31 applicants returned to the Manned Spacecraft Center in Houston for 4 days of examinations and interviews. During the next few weeks, we carefully reviewed and evaluated the results of these tests and interviews. Finally, we selected nine.

This slide (fig. 73) shows the present 16 pilots—Coordinator Slayton at the top, the other six Mercury astronauts in the second row, and the new men below.

FIGURE 73

The new group consists of two civilians and seven military officers—four from the Air Force and three from the Navy. The military men are detailed to NASA as are the seven officers in the Mercury team, which includes three from the Navy, three from the Air Force, and one from the Marine Corps.

The new pilots have an average of about 2,800 hours of flight time, 1,900 of it in jets. This compares with the Mercury VII's average flight experience of more than 3,500 hours, 1,700 in jets. At the time of selection, the new group had an average age of 32½, compared with 34½ for the Mercury team.

The new pilots were born in seven of the United States—two in Ohio, two in Texas, and one in California, Indiana, Pennsylvania, Illinois, and Oklahoma. The Project Mercury astronauts were born in Colorado, Oklahoma, Ohio, New Jersey, Indiana, New Hampshire, and Wisconsin.

These nine men and the original Mercury astronauts will provide flight crews for Project Gemini, Project Apollo, and future space missions. In the late stages of the Apollo spacecraft development, we plan to select a third group of flight test personnel to join the current pilots.

In selecting this third group, we will take into consideration the recommendations made in the Space Science Board's summer study report, that one crew member of each Apollo lunar mission should have scientific abilities and scientific training maximized consistent with his required contribution to spacecraft operations.

The third group and the present pilots will be combined to form a pool from which Apollo flight crews will be chosen.

Training: The training program for Projects Gemini and Apollo will be very similar to that developed in Project Mercury. However, it will be even more extensive. In the Mercury training, the astronauts studied in the classroom, trained on simulated flights, and worked with actual flight hardware. The simulation training was extensive. The astronauts worked on procedures in a fixed device. They were exposed to disorientation and worked on spacecraft orientation control in mobile devices. They were exposed briefly to zero gravity for short periods in aircraft flights. They were exposed to high gravity in a centrifuge.

In Projects Gemini and Apollo, the flight crews must be trained to carry out a number of tasks in addition to those in Project Mercury. They must navigate, correct flight trajectories, and make controlled landings, through the Earth's atmosphere and on the airless surface of the Moon.

They must conduct checkout and launch, in Earth orbit, in orbit about the Moon, and on the Moon's surface, aided only by the instruments aboard the spacecraft and the information obtained by radio from the Earth. They will have to learn the details of spacecraft, launch vehicles, and ground facilities far more complex than was the case in Project Mercury.

In the next slide (fig. 74), we see some aspects of the training that has been in progress for the new pilot candidates. In this early phase of the training, they have been made familiar with the Mercury spacecraft, launch vehicle, and operational techniques.

They have been briefed on the spacecraft and launch vehicles of Projects Gemini and Apollo. Early this year, the training entered

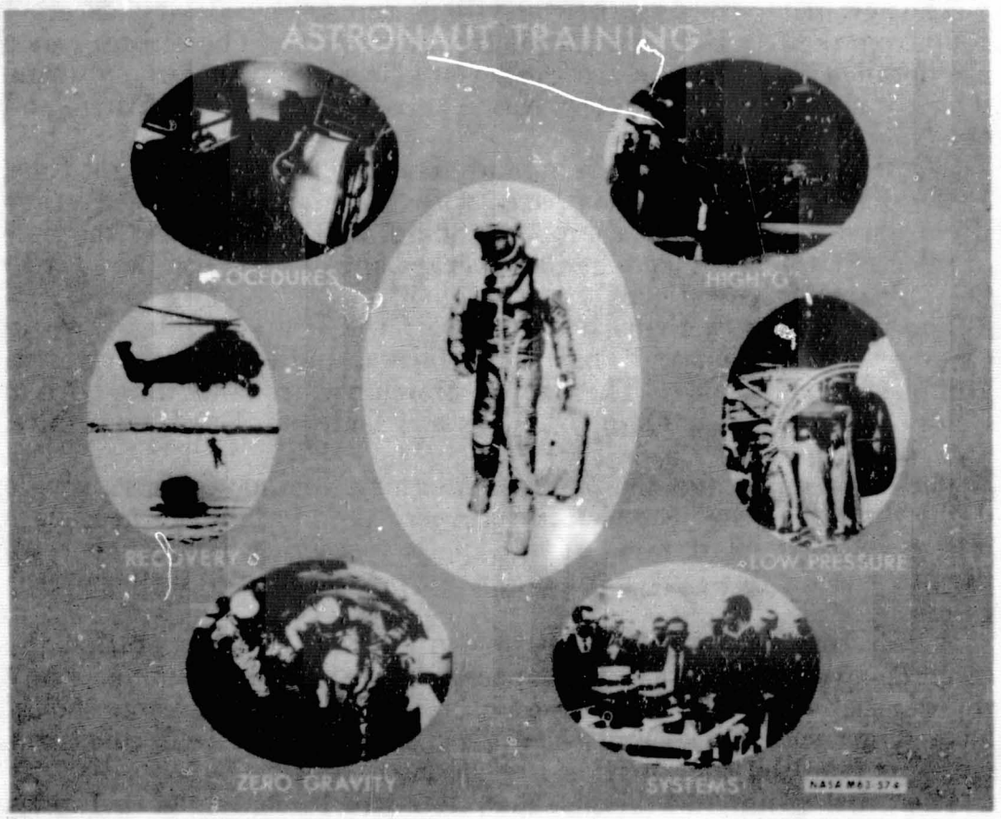

FIGURE 74

a new phase in which all pilots were assigned to specific tasks in the establishment of design and operational concepts for the Gemini and Apollo program.

The classroom training places special emphasis on space navigation, computer theory, flight mechanics, astronomy, physics of the upper atmosphere and space, bioastronautics, advanced propulsion systems, aerodynamics, guidance and control, space communications, meteorology, and study of the Moon.

In the later phases of training for Projects Gemini and Apollo, the astronauts will work with many types of simulators being developed and will establish detailed flight operational procedures.

The early phases of the training for Projects Gemini and Apollo last fall were intended primarily for the new pilots.

However, the Mercury astronauts trained with them as much as possible. Since January, only Astronauts Cooper and Shepard have remained with Project Mercury. All of the others are assigned to the advanced programs. On completion of Mercury flights, of course, the entire group of pilots will be together.

FLIGHT OPERATIONS

In Project Mercury, we were faced for the first time with the requirement for control of a manned vehicle in space in real time, that is, on an immediate-action basis.

For Mercury, we established a worldwide network of tracking and telemetry stations, which were linked by a vast communications net-

work to the Mercury Control Center at Cape Canaveral, as shown at the upper left of this slide (fig. 75).

Through the use of the Mercury network, our operations and mission directors at Cape Canaveral were able to make immediate decisions based on information received from the opposite ends of the Earth, by way of the Goddard Space Flight Center at Greenbelt, Md.

Through these decisions, it was possible to successfully complete missions that otherwise might have ended in failure. And I think you are all quite familiar with that.

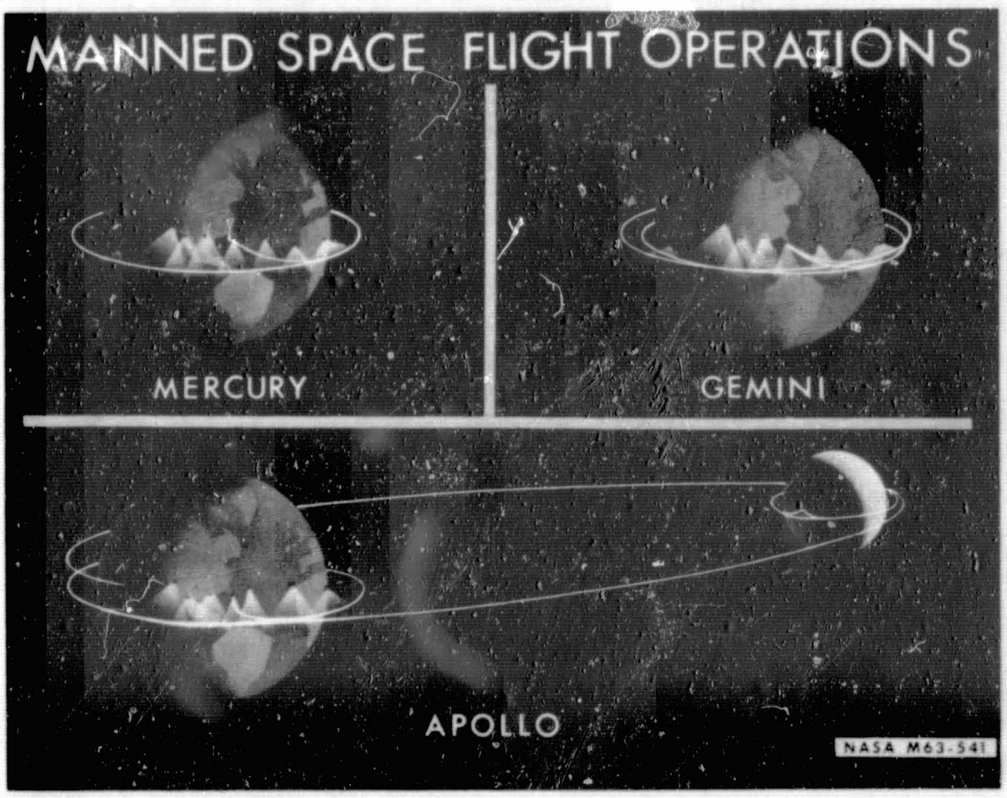

FIGURE 75

The flight of the chimpanzee Enos and those of Astronauts Glenn, Carpenter, and Schirra repeatedly demonstrated the value of this tracking network and control center.

At the upper right, we see that the Gemini flight operations will be more complex than those in Mercury, since the Gemini spacecraft will be able to maneuver in space. The Mercury spacecraft was confined to a fixed orbit.

Gemini of course will be confined to a fixed orbit except after having rendezvoused with the Agena, it will have limited control.

Apollo operations, shown at the lower portion of the slide, will be even more difficult. The Apollo spacecraft will fly not only into Earth orbit but to the distance of the Moon, almost a quarter of a million miles from the surface of the Earth.

Astronauts at the controls of the Apollo spacecraft will be able to maneuver and to make midcourse corrections of considerable magni-

tude. Thus the tracking network and a control center will have to be able to follow a spacecraft that is not tied to a fixed path, predictable by the laws of orbital mechanics.

In Gemini and in portions of the Apollo mission, two parts of the spacecraft will have to be tracked simultaneously.

In Gemini, these two parts will be the manned spacecraft and the target vehicle. In Apollo, they will be the Command and Service Module combination and the Lunar Excursion Module.

Thus it will be necessary to expand the capability of the worldwide tracking network to carry out operations for Gemini and Apollo. Although the existing Mercury network will be used for Project Gemini, we shall have to add equipment at selected stations to provide for the control of a maneuvering spacecraft and to facilitate receiving data from two separate craft.

On this slide (fig. 76) we see that for Apollo, we shall combine the present Mercury network, as augmented for Gemini, with stations of the Deep-Space Network, such as those employed for the Ranger, Surveyor, and Mariner programs, and directed by the jet propulsion laboratory at Pasadena, Calif. Mr. Buckley, who is director of our Office of Tracking Data Acquisition, will discuss these tracking plans in greater detail in his presentation.

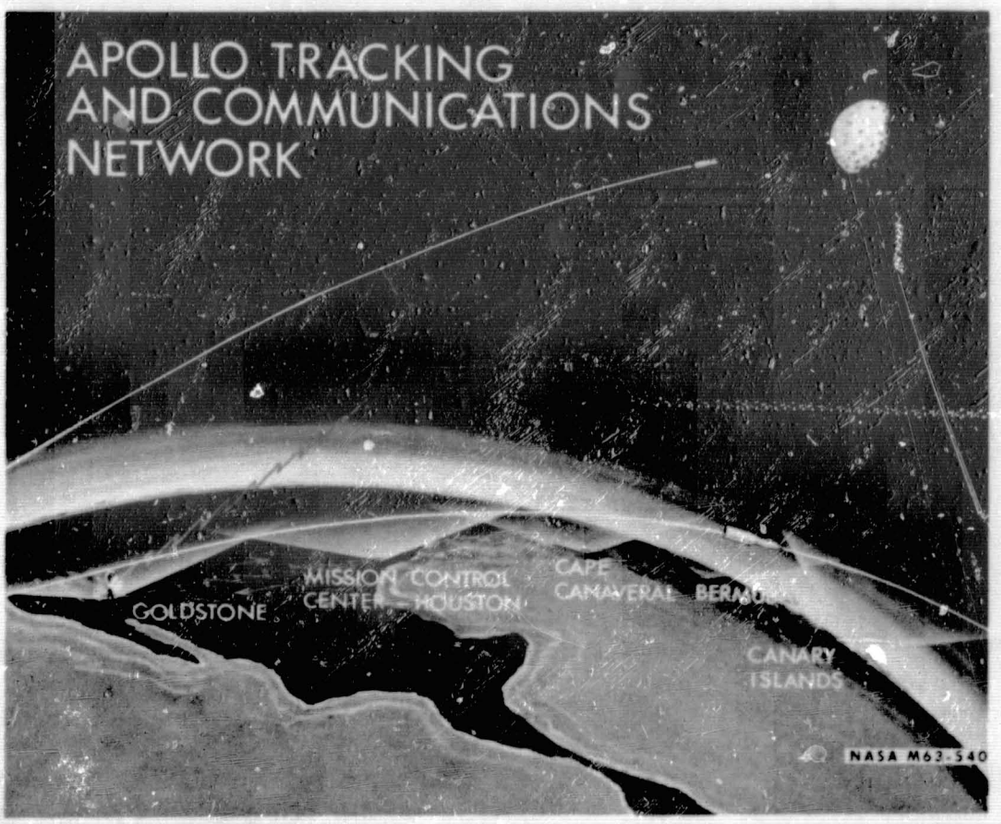

FIGURE 76

MISSION DIRECTOR'S ROLE

In Gemini and Apollo missions, the mission director—this is Walt Whitman in the case of Mercury flights—will be confronted with de-

cisions far more complex than those that were required in Project Mercury.

The mission director must be in a position to make immediate decisions on whether to continue the mission or to terminate it in the event of any abnormal situation. If the mission must be terminated, he must decide the best time to recall the spacecraft so that it can fly back toward Earth and reenter the atmosphere at the proper angle to avoid catastrophically high heating rates. There will be many factors affecting these decisions. The mission director and his staff must keep track of the quantity of fuel, food, water, power, and oxygen remaining, compared with that required, as well as the detailed status and functioning of hundreds of components in the various systems and subsystems.

MISSION CONTROL CENTER

Because of the almost infinite number of variables and contingencies during an operation, a control center far more elaborate than the Mercury control center at Cape Canaveral is required for Project Apollo. Such a control center is now under construction at the manned spacecraft center in Houston, Tex., as our primary Earth station for the control of manned space flight operations.

This slide (fig. 77) is a photograph of the model. The mission control center is scheduled to go into operation in mid-1964, in time for flight simulations for Project Gemini rendezvous missions. Until that time, manned space flight missions will be controlled from the Mercury control center. After that time control will be at Houston.

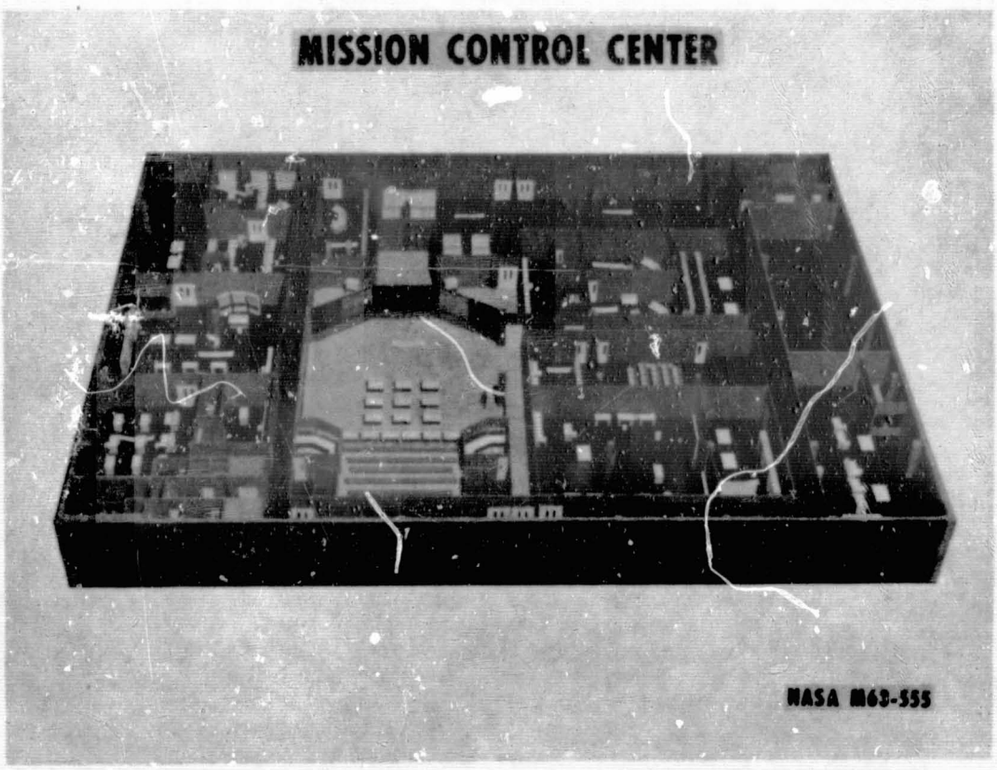

FIGURE 77

This three-story wing, 200 feet square, will house a computer complex and a communications center on the first floor, and identical mission operations control rooms on the second and third floors.

While one control room is in use, the second control room can be employed for training for a subsequent mission.

Each room will contain the necessary equipment for extensive closed-loop simulation exercises, for training and systems checkout.

Tracking stations around the world will transmit to the communications center the data to be processed and fed into the computers. The computers will contain preplanned alternative courses of action for use in any of the vast number of contingency situations.

During an operation, the information from the computers will be displayed in the selected mission operations control room. An artist's conception of the room is shown on this slide (fig. 78).

The operations director, the mission director, and the flight controllers—fewer than 20 persons—will be in the room, but 250 or more persons will provide technical and administrative support in adjacent rooms.

The support will include recovery control, recovery communications, meteorology, trajectory calculations, communications, simulation equipment, and the monitoring of life support and vehicle systems.

Mr. DADDARIO. Mr. Holmes, in reference to this Mission Control Center, without going into too much detail, this committee looked into the proposal submitted in last year's budget request for a separate Apollo Mission Control Center and a Gemini Control Center.

FIGURE 78

We went into some detail as to why these should not be combined.

We were convinced that they could not be. We appropriated the funds for both and then this year we are being advised that they are being combined and yet the extra amounts of moneys involved have been diverted in other directions.

The reason I ask this question is: Are we going to be constantly confronted with budget requests that are so changeable that the moneys which we were advised very strongly would be spent in one way are spent in another way, and the Congress is merely advised of that fact but has no control whatsoever over those funds?

I think something that Mr. Fulton said a little while ago is extremely important in this consideration. The American taxpayer is willing to pay for this, but I think that over the course of time, if there is a constant reshuffling and readjustment of programs when we are told one story and then something else is actually done, that this great confidence of the public might in some way be affected.

I just wonder if we might expect some improvement in these programs and in the program for the expenditure of funds as we go along.

Mr. HOLMES. Yes; I think you can as the program becomes more definitized.

The particular example that you give had to do, I believe, with the checkout facilities at the cape for Gemini and for Apollo.

Actually the reason I am particularly embarrassed is that your comments and the comments of this committee stimulated us to see if we really were right in our initial decision that these had to be separate because of the timing.

Later when we changed the Gemini schedule somewhat because of our funding problems, it became possible to change our timing requirements.

Now I am embarrassed that when you gentlemen have made a suggestion that has helped us, we should not just go ahead and make the change you suggested without discussing it with you; particularly when the action perturbs the budget. We apologize for this.

Actually, however, I think we are doing what was suggested by this committee. It has worked out and will save funds.

Mr. DADDARIO. If I might interrupt right there I think an important part of this is the fact that as we were looking into the budget requests last year, if we had known at that time that you did not require both centers, we actually would not have authorized as much funds, and we would have been better able to carry out our responsibilities. The thing that bothers me is not that you have made a change which you feel is a necessary one, but that there was such strong argument against combining the centers in the first instance. This compelled us to appropriate funds which perhaps we should not have appropriated.

Mr. HOLMES. I really feel at that point in time you acted wisely in appropriating the money. We were then very hard pressed on Gemini's schedule. If we had been able to retain August 1964 as the suborbital Gemini launch date which we were planning when you were debating this, it would have been impossible to do this combining we have now done. So at the time I believe your action was certainly correct. What bothers me is that when the facts changed later it wasn't brought back and thoroughly discussed in an open fashion.

Mr. DADDARIO. Well, if we were correct in doing it then, Mr. Holmes, it comes down to the point where you need much more flexibility in the appropriation of funds than seems to be indicated by the budget requests. If there are changes of this kind, and if places are found for the moneys to be used before we have a chance to really appropriate for a specific purpose, and if we must come to the conclusion that this is certainly being done in a responsible way, then there does need to be a certain amount of money in the budget which you can divert for your own purposes during the course of the year as the programs adjust themselves to reality.

Mr. HOLMES. I really believe that that is absolutely correct. It is essential to have flexibility, particularly in the early years of a development program of this type, where one cannot predict—and I think I stated this last year—just what the program will be. Now, I hope this year is going to be better, and the next year still better as far as limiting changes is concerned.

Mr. DADDARIO. As the programs become definitized, then you do think that there will be less reprograming?

Mr. HOLMES. Yes, I do.

Mr. DADDARIO. Then Congress can expect that we will not be having as many of these letters of information being transferred to us where the funds are being diverted and over which we have really no control other than being advised.

Mr. HOLMES. I think there will be less, yes.

Mr. DADDARIO. Mr. Fulton.

Mr. FULTON of Pennsylvania. I feel that is a good point. I think we should point out in justification of the reprograming during fiscal year 1963 that we did look ahead with the committee as well as with you, Mr. Holmes, to the fact that there might be a change in the Nova approach, and likewise there might also be a change because you were not quite sure of the earth orbital rendezvous techniques. In those two instances reprograming was required, but we rather expected it might come. Isn't that the case?

Mr. HOLMES. Yes, sir, that is the case.

Mr. FULTON of Pennsylvania. So that it was an unusual decision, but on that basic decision we could see ahead to a firm point later in time than the authorizing and appropriating process; is that not correct?

Mr. HOLMES. Yes, Mr. Fulton, it is correct.

Mr. FULTON of Pennsylvania. You made a comment a few minutes ago of the slippage on this manned-space-flight program. In order that the record will be clear, I believe you will recall that Congressman Teague, the chairman of the Manned Space Flight Subcommittee, as well as I as the ranking member on the Republican side, had sat with you and said that as far as this committee was concerned we would urge the committee to give you adequate money even if it came to a supplemental appropriation so that there would not be the slippage of the manned-space-flight program. Isn't that correct?

Mr. HOLMES. Yes, sir, that is correct.

Mr. FULTON of Pennsylvania. The decision then was made at a level of authority other than this committee because we were going to get you the funds and likewise it was a budgetary decision that was made—if I can be allowed to say it—at a different level than the

manned-space-flight program that you are directing yourself, wasn't it?

Mr. HOLMES. Yes, I think in order to properly present why I don't call it a slippage and why the administrators of NASA do not want to call it a slippage, I must say these words: I think everything you have said is correct, Mr. Fulton. I believe that the NASA position is that the program schedule was not fully definitized and couldn't be until the mission mode was firm. Until then exact times and costs could not be fixed. The mode decision was not reached until July 1962. As we proceeded to establish a firm schedule structure, we had a program with which the funds were not exactly compatible. Hence we definitized a later schedule. I think that is a little different from a slippage. But everything else that you have said, to the best of my knowledge, is correct.

Mr. FULTON of Pennsylvania. I would not want to call it a slippage either, so that it is just a difference in schedule based on budgetary reasons. What would have been the difference in the program calendar had you gotten the extra funds?

Mr. HOLMES. In Gemini I suspect the average was around 4 months. The suborbital flight was five or six. In Apollo it was about 4 or 5 months.

Mr. FULTON of Pennsylvania. So that when this committee recommends a certain amount of funds that are necessary for the program according to the calendar that you have set up to acquire the preeminence in space, as well as an efficient approach to these programs, there is no doubt that the funds will be needed. When the funds are cut appreciably, it does hold you back substantially. Would you agree with that?

Mr. HOLMES. Yes, sir, I would agree with it. I think today we are more able to realistically predict our needs. I could tell you more clearly, for instance, that if we don't get these dollars we are going to slip this much. I think I could say to the Congress with honesty that since we don't have any duplicated hardware, we have no alternative except to slip schedules when insufficient funds are available.

With regard to the NASA position as to a supplemental, I should say that we are not going as fast as we could go. We are not going as fast as military programs have moved which I have been accustomed to running.

On the other hand, we are not going at a leisurely rate. I think it is a good rate, a sound rate. I think we have a sound engineering program. It is a matter of judgment as to the optimum rate for the country; judgment of people at a higher level than I. I am perfectly satisfied as a program manager to work under their decisions, and try to do the best I can with what my superiors and the Congress are willing to give us.

Mr. FULTON of Pennsylvania. Well, in justification of NASA and its leadership, I believe that the budgetary decision on the supplemental appropriation was made on a higher level than NASA.

Mr. DADDARIO. I would just like to make one point. I think Mr. Fulton has very nicely set out what the various possibilities have been and how it has turned out properly, that funds have been reprogramed in the schedule as you have gone along. I think the fact still remains though, that if we had been advised last year that

there was the possibility of Nova being put off a bit, that we would most likely not have authorized those funds. Therefore the program would have had to receive a supplemental appropriation. I am sure that this would be the procedure which the committee and the Congress would prefer.

I point this out only on the basis of looking ahead and calling attention to the fact that the public is aware of these things too. The public certainly will be much more convinced of the need for supporting the program if we can remain as definitely committed as possible to what we are told. Of course, there may be where there is nothing that can be done about it. If we were at that time actually told the right story when we were advised that Nova was necessary, and for which reason we appropriated the vast sums of money involved, then to my mind there is a question about the whole Nova program.

Mr. RIEHLMAN. Mr. Chairman, before you leave that point, I want on the record my position in respect to this. We discussed that pretty thoroughly in this committee and I was never of the opinion that my friend from Pennsylvania expressed that there was going to be a possible change in the Nova program. If there had been any idea in my mind, I certainly would have voted the same as Mr. Daddario said, to cut the funds out.

We were convinced from the testimony that this was essential and that it was a program that was going to be continued. For that reason I supported it. I know that we discussed this just the other day. I interrogated the witnesses last year very carefully to find out if it was an essential and necessary program to be followed, or whether there was a possibility that there would be a change, and we would go into the lunar rendezvous project.

Mr. FULTON of Pennsylvania. Could I just comment on that. I don't think there is much difference really between us, because it was a question of the preplanning of the Nova program which was emphasized and for which we gave the funds. Of course, we cut the construction out and the program planning for installations of Nova in last year's budget. I did feel at the time that it was necessary to go into the question of whether Nova should be built and whether or not you should have a direct descent method. I feel that it was wise that we spent the funds for this kind of preinvestigation procedure.

On the other hand, I feel that when it became evident that a decision had been made on the lunar orbital rendezvous procedure that we should then, of course, reprogram and use the money for the correct purposes. Now that is not a case of our disagreeing among ourselves on the committee nor with, shall I say, Mr. Holmes. I don't think we disagreed. It is just a difference of emphasis.

Mr. HOLMES. May I speak, Mr. Chairman?

Mr. DADDARIO. Yes, of course.

Mr. HOLMES. I may not have made it as clear as I should have during my testimony last year. I tried to indicate that we had not definitized the mission by which we would go to the moon but were using, as a primary assumption earth orbital rendezvous, and as a backup assumption direct ascent with Nova. Thus, although we needed the funds requested, we couldn't be precisely sure how we were going to use them. I had thought that, as rapidly as we knew, we kept the committee informed. I refer you to my letter of July 18,

which was addressed to the committee (at least to Mr. Teague and Mr. Fulton) and which the Administrator of NASA and Dr. Seamans reviewed.

We tried to spell out just exactly what we meant there, for example, I said in that letter that even after delaying the Nova development as a corollary to the lunar orbit rendezvous decision, we would face deficits in excess of $200 million. So as early as we knew it, I tried to give the committee the full information.

On the other hand, it is a complex thing, this balancing one versus the other, and I can see how misunderstandings might have resulted. I certainly bear the responsibility for that.

Mr. DADDARIO. We are not asking you to bear the responsibility, Mr. Holmes. We are very well satisfied with the strength and direction that you have brought to this entire program and I personally feel that you have been extremely valuable and helpful in presenting to us a very clear picture of the program. But I do think that the constant change and constant utilization of funds in the manner as that occurred last year can mitigate against the future success in obtaining the moneys needed for this program over a sustained period, and it certainly will be over the course of the next decade.

Mr. HOLMES. Yes, sir.

THE MISSION

Now that we have described the hardware, the trained men, and the operational techniques required, let us examine the details of the first trip to the moon and back. The journey will begin at complex 39 of the U.S. spaceport at Merritt Island, Fla.

Earlier, we saw how the space vehicle will be checked out in the vertical assembly building and carried to the pad on the crawler, where solid-fuel rockets and pyrotechnic devices will be installed, and liquid propellants will be pumped into the tanks.

The three astronauts will climb into their spacesuits and ride to the launch pad in a specially equipped van. An elevator will carry them to the level of the command module, about 320 feet above the base of the Saturn V launch vehicle.

They will climb into their positions, and the final minutes and seconds of the countdown will tick away.

At ignition, the five F–1 engines of the S–IC first stage will flame into life, generating 7½ million pounds of thrust. The holddown arm will release the 6-million pound vehicle and it will lift off as shown on this slide (fig. 79).

As it does, the astronauts will begin to feel heavier. The vehicle will rise on an arching path over the ocean. The rocket engines will consume fuel and oxygen from the first-stage tanks at the rate of 15 tons a second.

By the time they are empty, 2½ minutes later, the vehicle will weigh only a quarter as much as previously.

Steadily increasing acceleration will place increasing force on the astronauts, and they will be pushed back into their couches, feeling apparent gravity that rises to about 4½ times what they experience on earth.

When the fuel is consumed, the engines will cut off and the first stage will separate, as shown in the next slide (fig. 80).

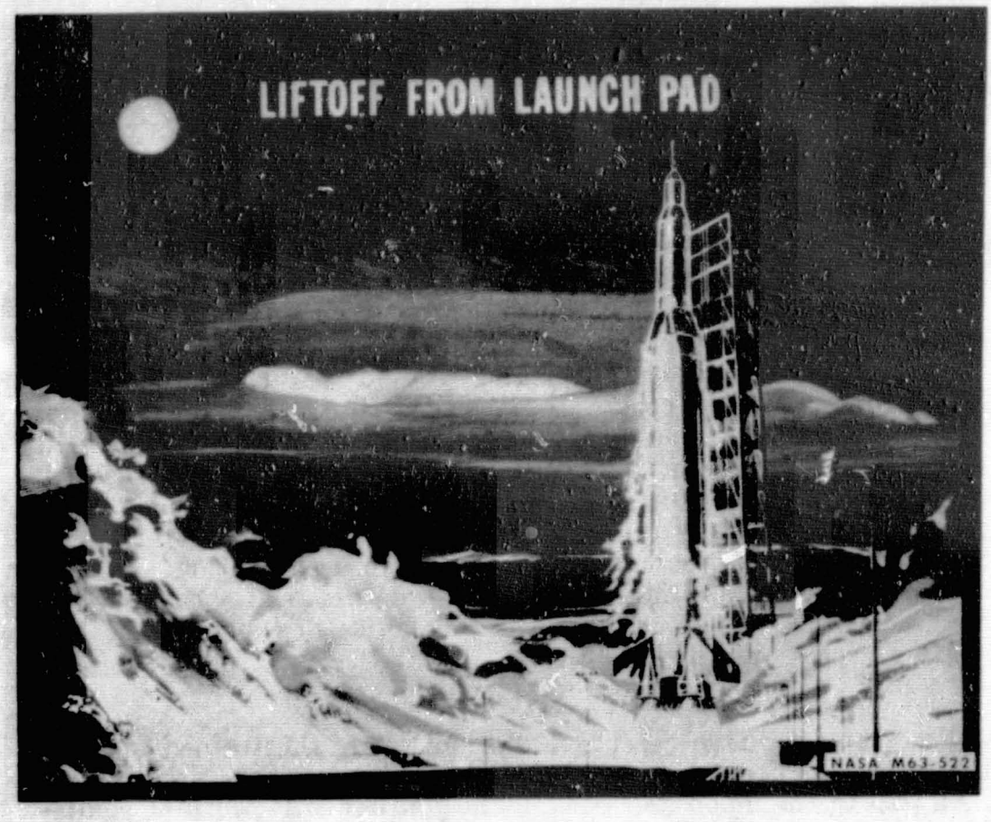

FIGURE 79

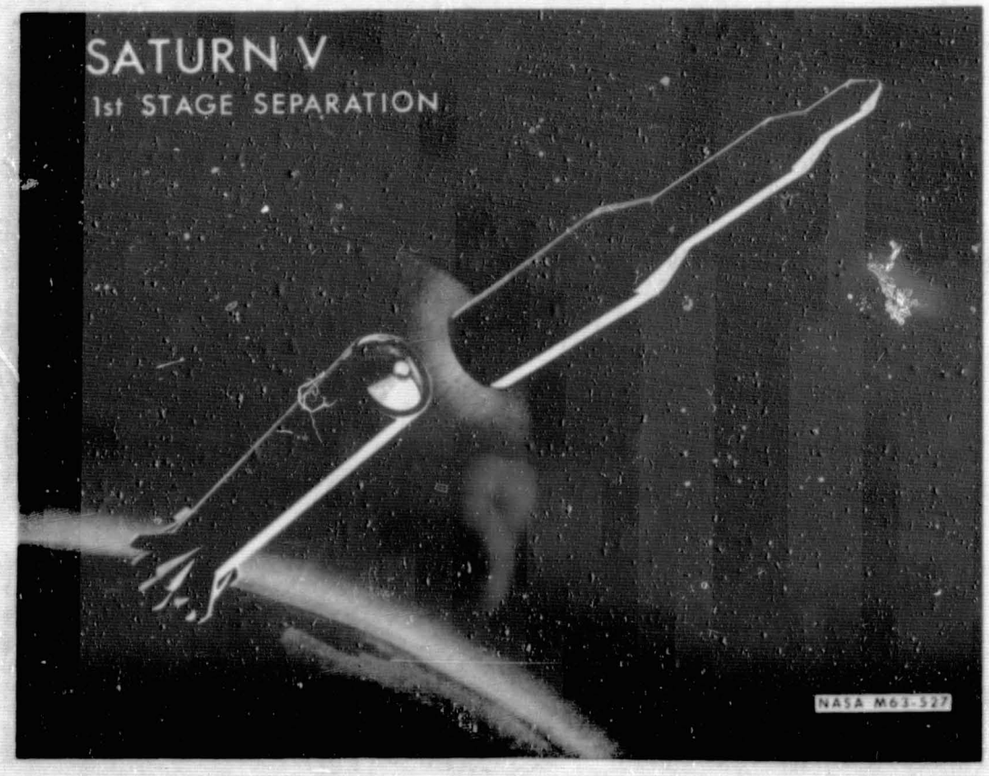

FIGURE 80

Now the S–II second stage will ignite. Its five J–2 engines will provide a million pounds of thrust. On this slide, it will be noted that a rocket flame looks different in a vacuum from the way it appears on earth.

At the beginning of second-stage burning, the astronauts will experience for the first time on this trip an acceleration of less than 1 g; they will feel apparent weight of about two-thirds normal. Again, however, fuel will be consumed rapidly and the vehicle will become lighter.

The "g" forces will increase gradually to a little over twice normal earth gravity when the second-stage tanks become empty, about 6½ minutes later. Then the second stage will be separated and will fall away as shown on this slide (fig. 81).

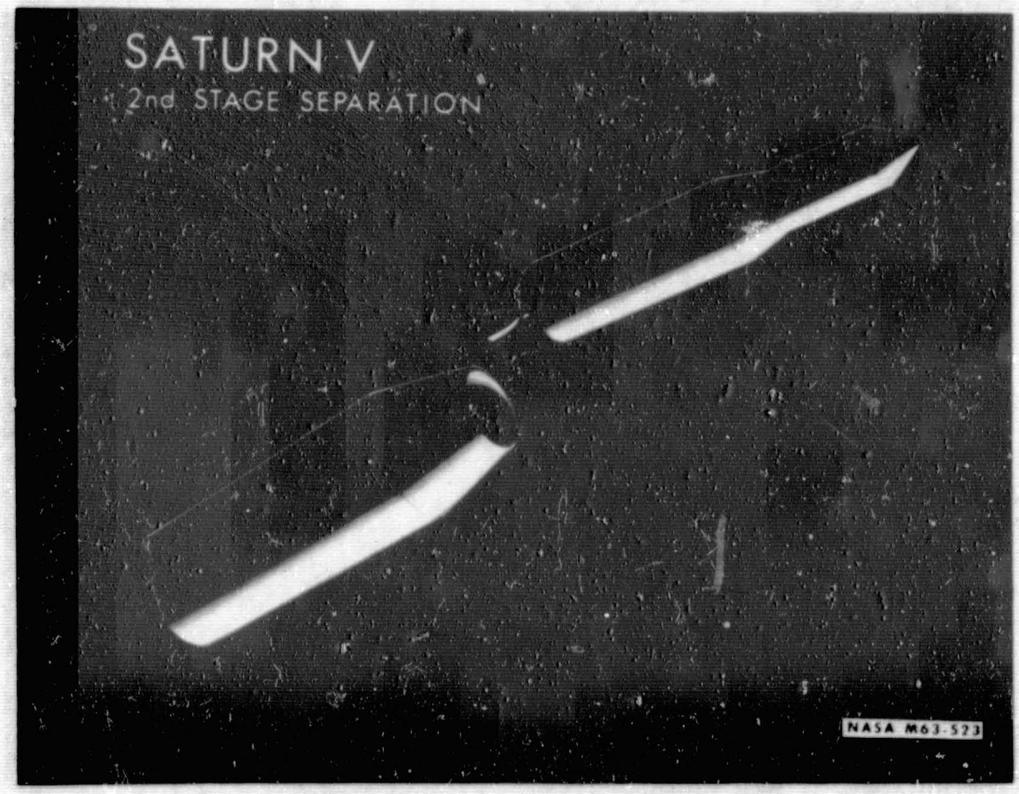

FIGURE 81

Next, the S–IVB third stage will ignite. Its single J–2 engine will provide 200,000 pounds of thrust, which will cause the astronauts to feel a weight of about two-thirds normal. The third stage will burn part of its fuel, for about 2¾ minutes, until the spacecraft and the Saturn stage are in orbit about the earth. Then the engine will be shut down.

When the vehicle is in earth orbit, the Mission Control Center at Houston will exercise direct control of the mission. The spacecraft and the S–IVB stage will be checked out as shown on this slide (fig. 82) by the astronauts and, through telemetry, by the Mission Control Center at Houston.

FIGURE 82

The vehicle will circle the earth 1½ times in this parking orbit during checkout. Precise measurements of the orbit, calculated with the aid of large computers at Houston, will be fed into the spacecraft guidance computer.

If all systems are functioning properly, the S–IVB stage will be ignited again as shown on this slide (fig. 83) at a moment precisely determined by the guidance system, and the astronauts will again experience apparent gravity, a small fraction less than 1 g.

After a little over 5 minutes, the spacecraft will reach a speed about 25,000 miles an hour, enough to overcome the earth's gravitational attraction, and it will be on a trajectory that will carry it toward the Moon; g forces will increase only slightly while the third stage is burning.

The next slide (fig. 84) shows a series of events that will occur after the S–IVB third stage shuts down, and the astronauts are again experiencing zero gravity.

First, at the lower left, the adapter surrounding the lunar excursion module will be separated. Next, the command and service modules will separate, leaving the bug attached to the third stage. Using the service module propulsion system, the astronauts will turn the command and service modules around and dock, nose to nose, with the bug.

Finally, when the structural connection has been accomplished, the S–IVB Saturn stage will be separated. In the upper right, we can see the configuration of the spacecraft for the remainder of the flight

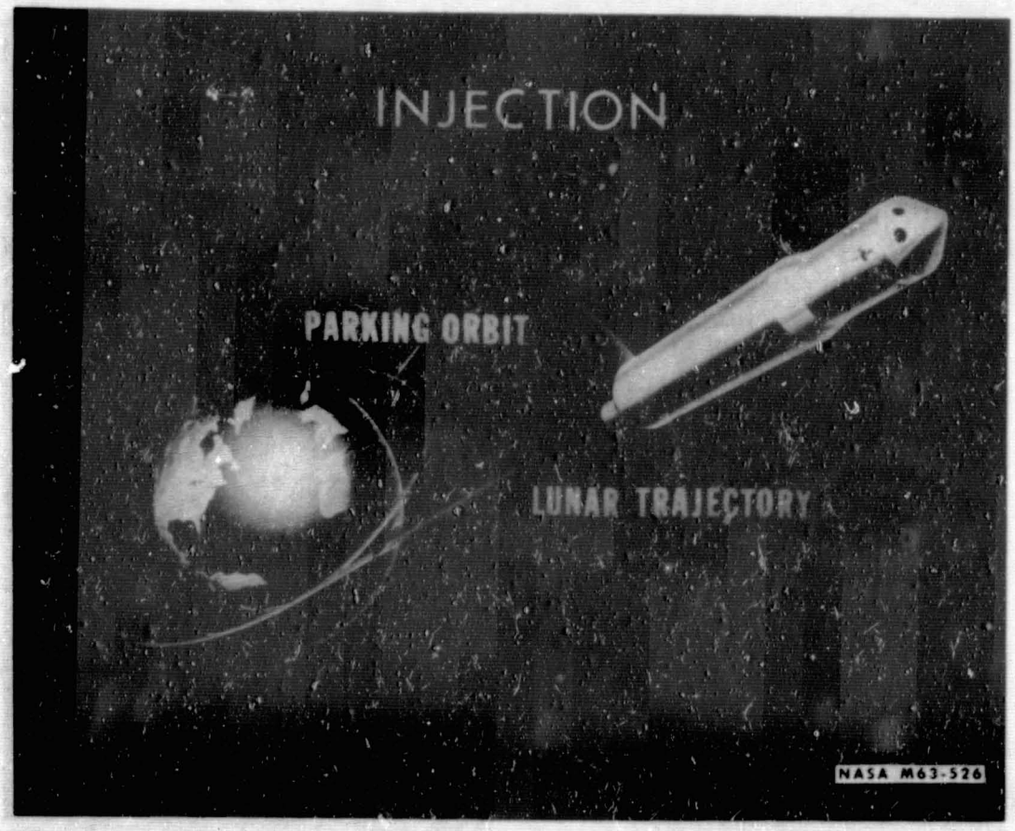

FIGURE 83

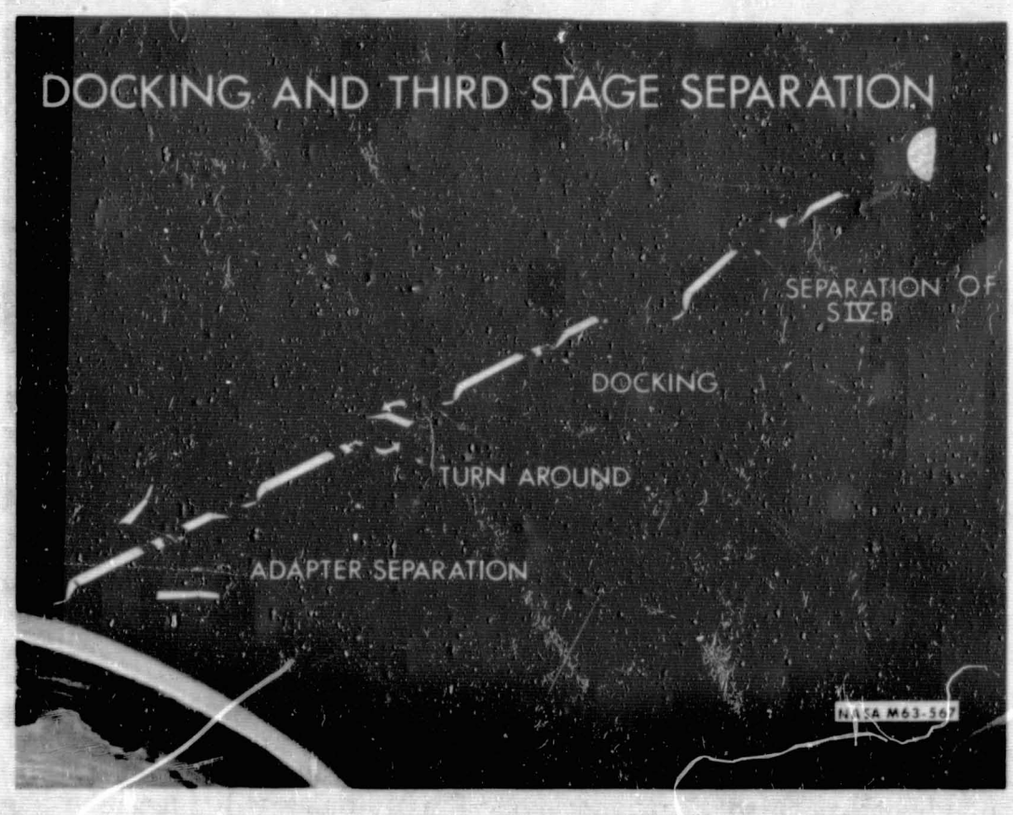

FIGURE 84

to the neighborhood of the Moon, which will take about 72 hours from the time of departure from earth orbit.

During the early phases of the flight, the astronauts will take star sights and the on-board guidance system and the ground tracking system will measure deviation from the desired flight path. They will make any necessary midcourse corrections by firing the 22,000 pound thrust engine in the service module.

When this engine is being fired, they will feel apparent gravity of about one-quarter normal. On arrival at the vicinity of the moon, they will use orientation controls to turn around and ignite the service module again, to burn for about 6 minutes, and slow the spacecraft enough to place it in an orbit about 100 miles above the Moon's surface, as shown on this slide (.85).

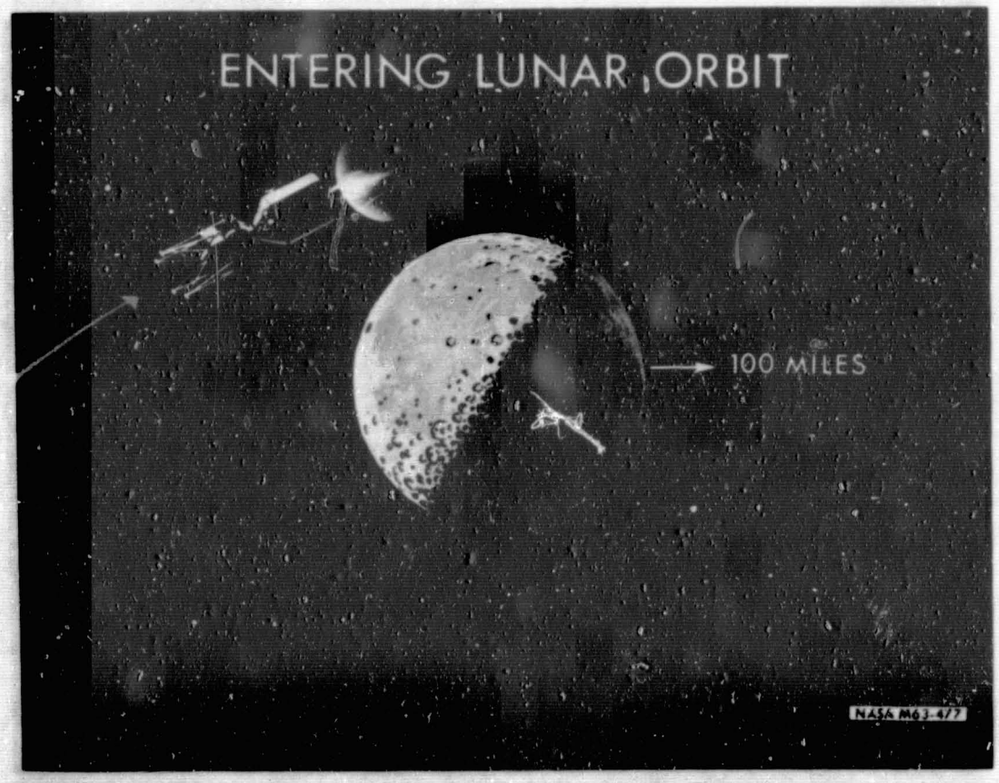

FIGURE 85

At this time, all elements of the spacecraft will again be checked out. If they are functioning properly, the decision will be made to continue the mission.

Two of the astronauts will climb through the hatch from the command module into the lunar excursion module as shown on this slide (fig. 86). At this time, all elements of the spacecraft will again be checked out. If they are functioning properly, the decision will be made to continue the mission.

Next, the engine of the LEM landing stage will be ignited to provide about 8,800 pounds of thrust for about a half-minute.

During this time, the astronauts will experience apparent gravity of about one-third Earth normal. This impulse will place the bug

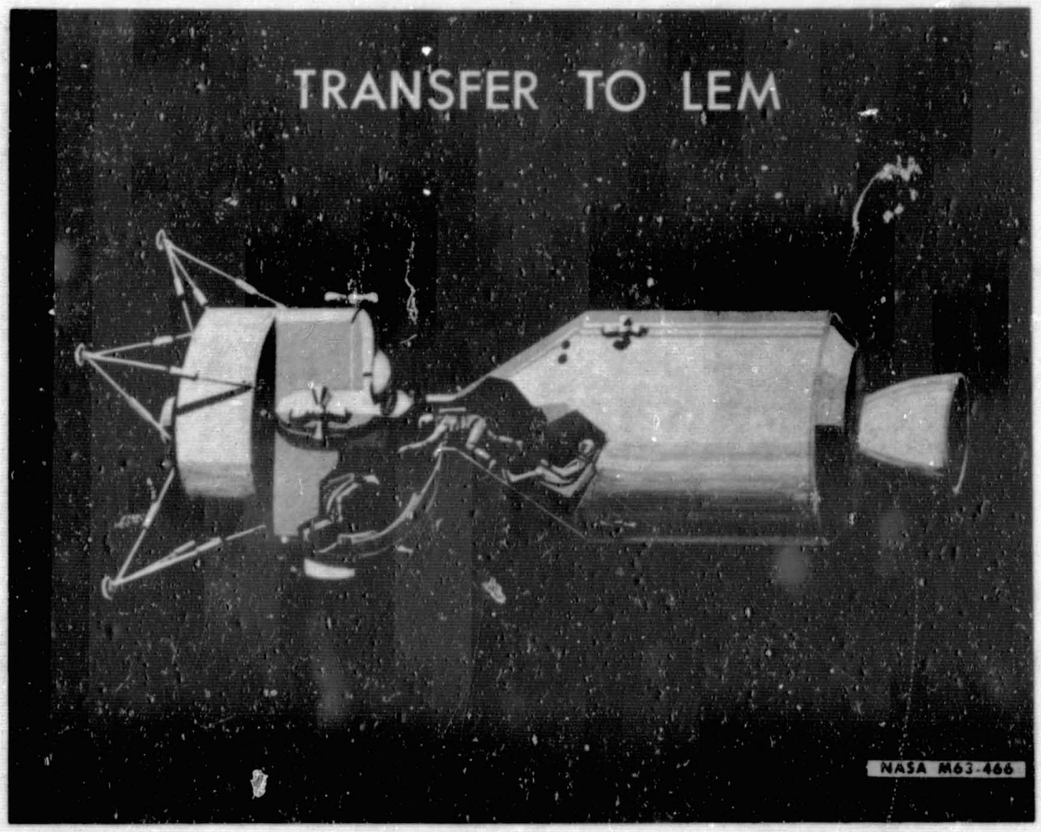

FIGURE 86

in an approach orbit that has the same time period of revolution as that of the command module, shown on this slide (fig. 87).

The approach orbit will be in the shape of an ellipse that dips down to an altitude of about 10 miles above the landing site. From this lower altitude, the explorers can directly observe the conditions at the site.

If for any reason they decide not to attempt the landing, the equality of orbital periods assures a rendezvous of the bug and the mother spacecraft every 2 hours.

When the lunar excursion module reaches the 10-mile minimum altitude of its approach orbit, it will be traveling at a speed of about 4,000 miles an hour with respect to the moon's surface. At this time, the landing-stage engine will be ignited again; to provide about 8,800 pounds of thrust to slow the bug to a halt and to allow it to descend toward the surface.

This rocket engine will have the capability of being throttled down considerably, perhaps as low as 1,100 pounds of thrust.

As the spacecraft slows and falls toward the moon, as shown in the next slide (fig. 88), the engine will be throttled down gradually until the craft reaches a hovering position about 300 feet above the surface, where it will remain for a short period.

As the vehicle hovers, the astronauts will feel the moon's gravitational attraction, about one-sixth that of earth.

FIGURE 87

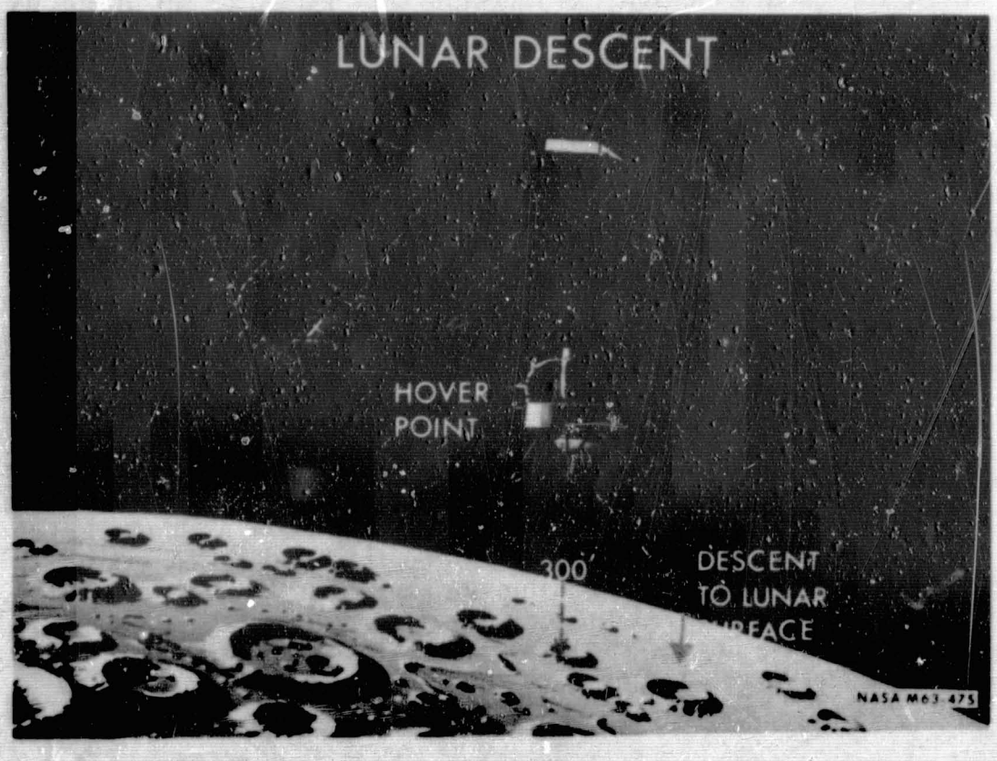

FIGURE 88

Windows will provide the astronauts with a clear view of the lunar surface as we see on this slide (fig. 89), so they can select the exact point at which to touch down. They will be able to maneuver their craft horizontally as much as 1,000 feet until it is above the desired landing point.

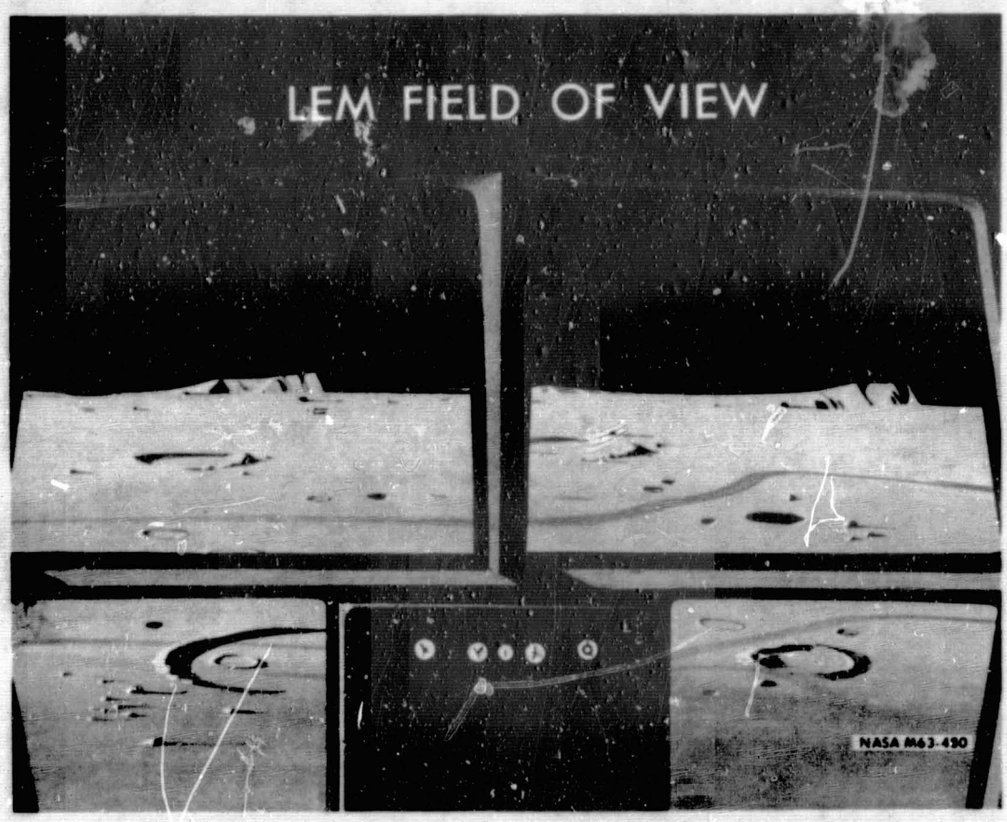

FIGURE 89

The craft will then descend slowly to the surface and touch down at a speed of less than 7 miles an hour (fig. 90).

During the touchdown maneuver, the command module will always be within line of sight of the LEM. At any point up to and including the hover maneuver, the astronauts can, if necessary, ascend and get back to a rendezvous with the command module during the first orbit. At touchdown, the command module will be nearly directly overhead.

While on the moon, the two explorers will first check out the LEM in preparation for the return flight.

After that, as shown on this slide (fig. 91), one of the two astronauts will leave the LEM and explore the lunar surface in the immediate vicinity of the landing site.

He will take detailed notes on the conditions he observes. He will collect and prepare samples for return to earth, and photograph the surrounding area. He may emplace experiments that can continue to function after the crew has left the moon. After 4 hours, the two explorers will change positions and the other astronaut will continue the exploration.

FIGURE 90

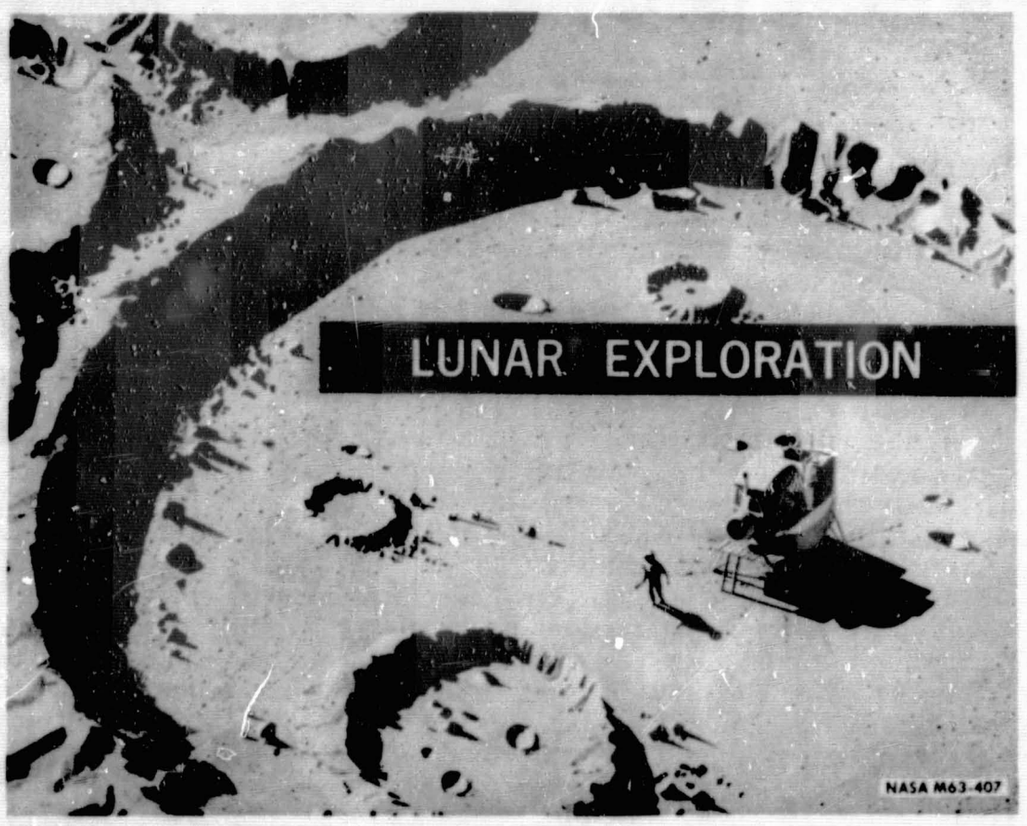

FIGURE 91

On the first mission, the total length of stay will be about 24 hours.

After completing the initial exploration and a night's sleep, the two explorers will begin the countdown for launch from the moon, which will take place when the command module is in line of sight over the horizon.

The return stage of the LEM will separate and lift off from the landing stage as can be seen on this slide (fig. 92).

Its 3,000 pound thrust engine will burn for about 6 minutes and the astronauts will experience one-third G acceleration until the craft reaches orbital speed of about 4,000 miles an hour, at an altitude of 10 miles.

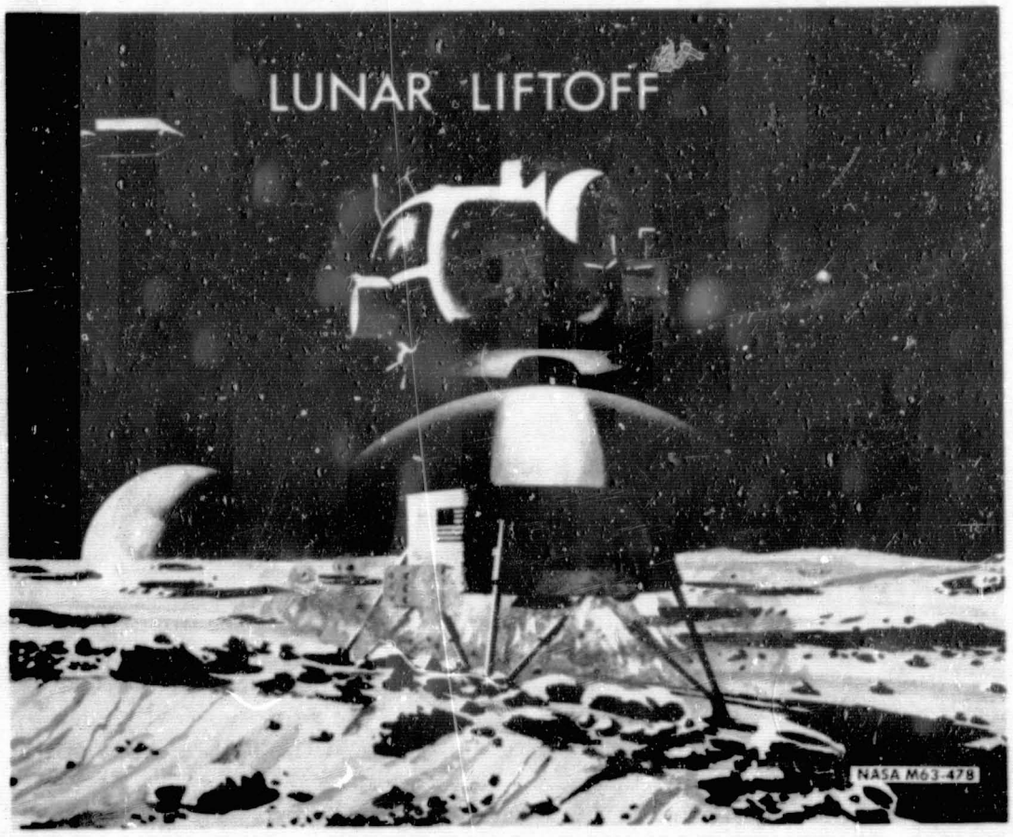

FIGURE 92

During powered flight and the coast phase that follows, radars aboard both the command module and the bug will track each other. The LEM engine, a short time after the initial powered phase of its flight, will make any major course corrections needed to assure the rendezvous.

About an hour later, after both spacecraft have coasted halfway around the moon, they will be quite close together and the relative difference in their speeds will be about 70 miles an hour, as shown at the left of this slide (fig. 93). When they are about 5 miles apart, LEM guidance system will command its engine to bring the two craft closer.

When the distance has been reduced to a few hundred feet, the two astronauts in the LEM will take over control and complete the docking maneuver at the right.

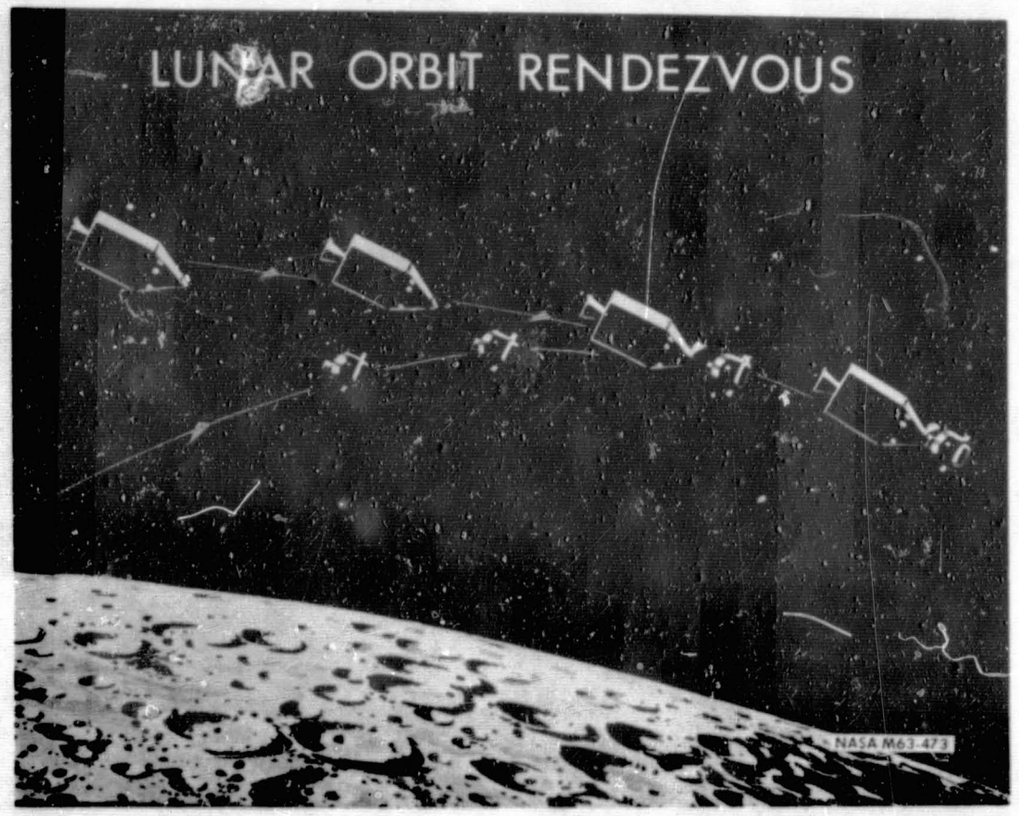

FIGURE 93

This maneuver is clearly essential to the success of the mission. Consequently, we are providing a capability within the command and service modules for the third astronaut to perform the rendezvous even if the bug should become incapacitated during the latter stages of the ascent maneuver.

Thus the crew can still be rescued and the mission can be successfully completed.

Once the explorers have climbed back aboard the command module, the bug will be detached and left in lunar orbit.

The service module engine will be ignited and will generate its 22,000 pounds of thrust for about 2½ minutes as shown on the next slide (fig. 94). This will provide the additional velocity of 2,000 miles an hour that will speed the spacecraft on the homeward journey.

As the service module fuel is consumed, the acceleration will increase to about 1 G. During return the service module engine will be employed to make course corrections as required.

After the final flight path adjustments have been completed to assure hitting the 40-mile reentry corridor as shown on this slide (fig. 95), the service module will be discarded, and the command module will be oriented for reentry.

During reentry (fig. 96), the offset center of gravity of the command module will provide a lift-to-drag ratio of approximately 0.5.

This will permit maneuvering the command module through part of its descent through the atmosphere.

FIGURE 94

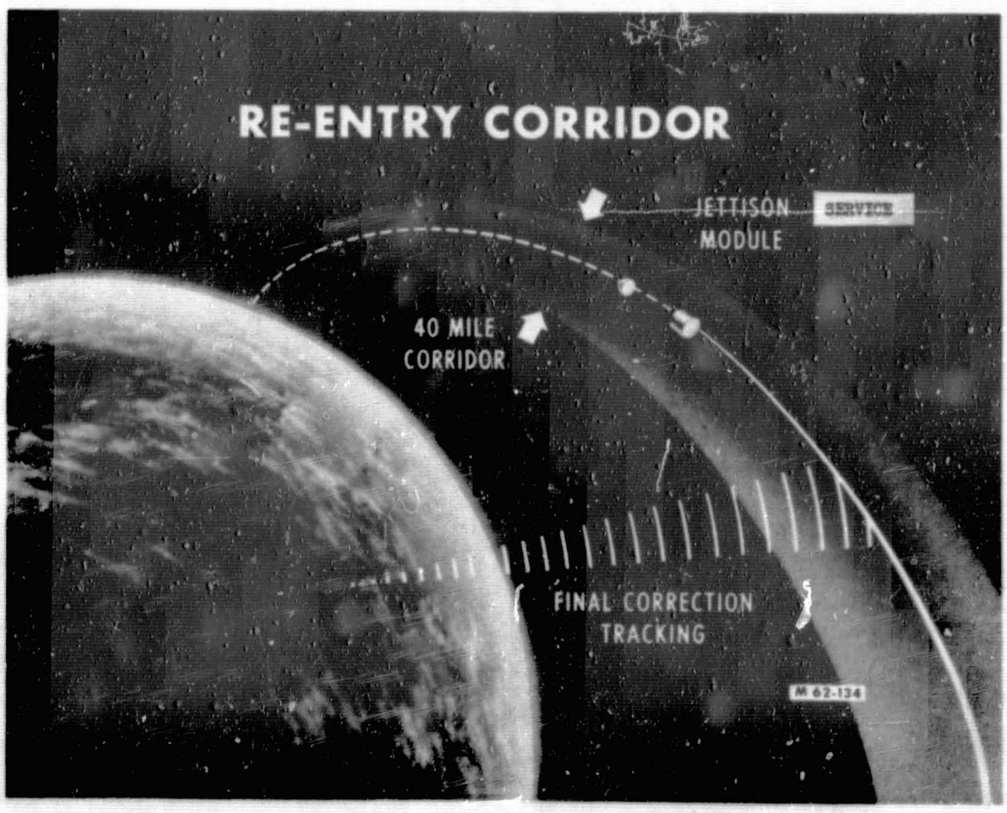

FIGURE 95

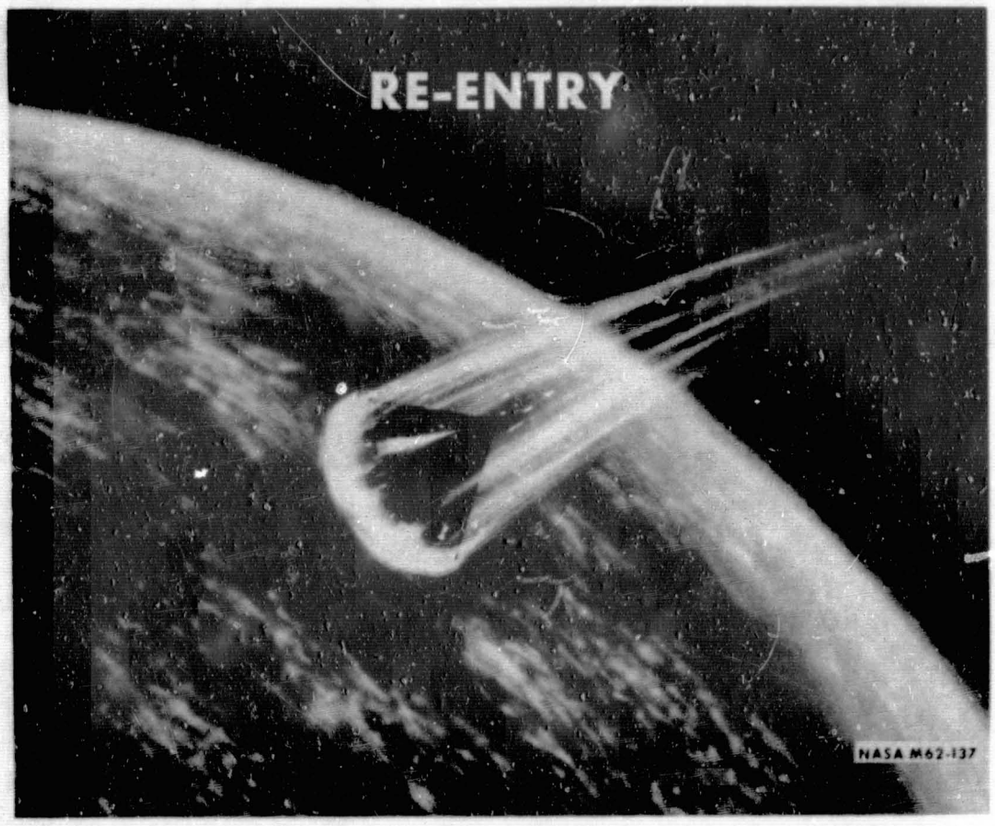

FIGURE 96

Once the main aerodynamic deceleration has taken place, and the command module has been slowed to below the speed of sound, three parachutes will be deployed (fig. 97) and the command module will float gently to rest on the earth's surface (fig. 98).

Mr. DADDARIO. We have gone beyond the 12 o'clock period, Mr. Holmes.

May I ask what would be best for you, from the standpoint of coming back for a little while this afternoon. If you are tied up, we can take the balance of your testimony at a later date.

Mr. HOLMES. I can come back this afternoon. I would be most happy to come back. I have only 5 or 10 minutes of testimony, and then I would be ready for discussion.

Mr. DADDARIO. Fine.

Could we proceed at 1:30?

Mr. HOLMES. Yes, Mr. Chairman.

Mr. DADDARIO. The committee will adjourn until 1:30 p.m., this afternoon.

(Whereupon, at 12:10 p.m., the subcommittee adjourned to reconvene at 1:30 p.m., the same day.)

FIGURE 97

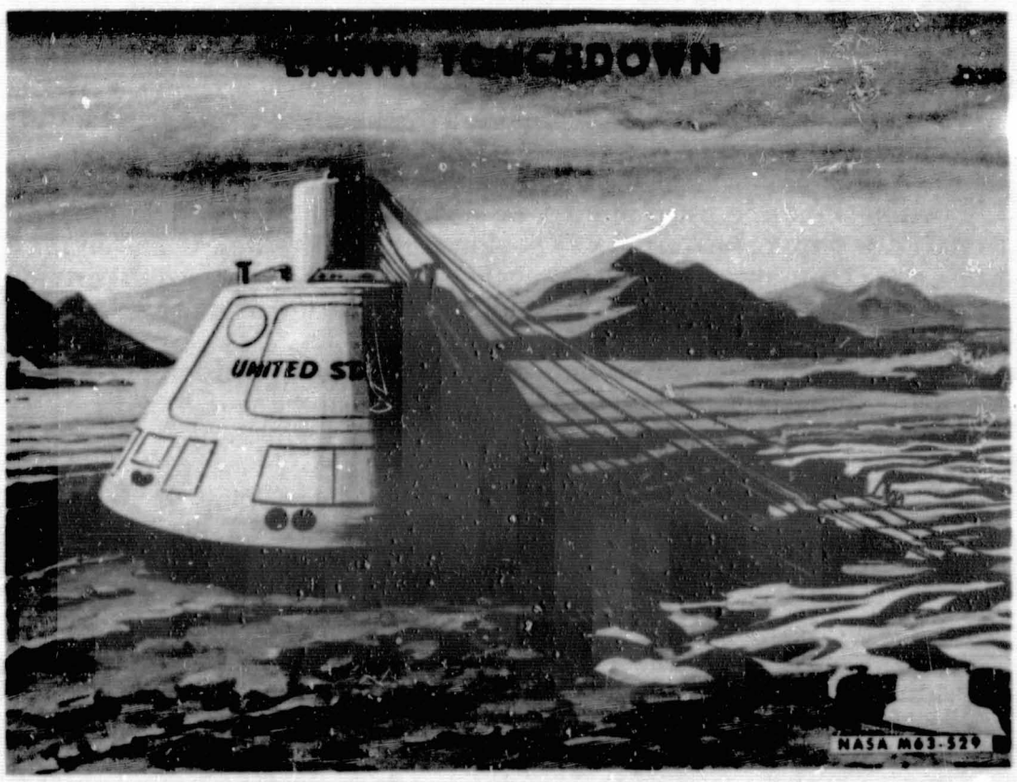

FIGURE 98

AFTERNOON SESSION

Mr. DADDARIO. The meeting will come to order.

Would you proceed, please, Mr. Holmes.

Mr. HOLMES. Yes, Mr. Chairman.

Mr. Chairman, members of the committee, we have reached the point in the testimony I believe on page 84, Advanced Planning.

As Dr. Seamans stated in his testimony, NASA is continually conducting studies of possible future missions throughout all NASA program areas.

In manned space flight, we believe that exploration of the Moon is not the end but the beginning.

The Office of Manned Space Flight is carrying out planning and studies looking to the time when the Nation will have available the capacity to undertake more advanced programs. Key considerations in this planning involve programs that provide direct support of the manned lunar landing program and extend the possible scope of lunar missions, manned Earth-orbital space stations, and manned planetary missions.

We have included in the testimony some of the systems which we have and which we feel have early application, and we feel it is proper to review them here, thinking that you would be interested in them.

During fiscal year 1964, we shall place primary emphasis on studies of programs that directly support Project Apollo. These plans center on the lunar logistic system, which is intended to provide support for Apollo missions by placing suitable auxiliary, unmanned payloads on the Moon's surface. During the current fiscal year, we have studied both appropriate vehicle configurations and possible payloads.

We find that payloads can be landed directly on the Moon's surface from either a Saturn I–B or a Saturn V launch vehicle. It turns out you can soft land about 15,000 pounds from a Saturn I–B on the Moon.

We have looked into the possible use of the lunar excursion module landing stage to carry cargo to the Moon's surface during either unmanned or lunar orbital Apollo missions.

Possible lunar logistic system payloads under study include additional life support equipment, shelters, roving vehicles, power supplies, and communications equipment that would be required to provide stay times on the Moon in excess of the 2 to 4 days provided by the lunar excursion module.

It appears that for any extended exploration of the Moon one would have to have a logistic system, something to put a cache of supplies and materials on the Moon, in addition to what you could carry with the astronauts in the lunar excursion module.

For example, if one analyzes the time the astronauts might have for lunar exploration during a 24-hour stay on the Moon, you arrive at about 6 hours.

One of the most attractive lunar logistics systems which we are studying involves using this lunar exploratory model. This part [gesturing] would be the truck, and the upper part would be redesigned for payload.

Now in that way you could put around 7,000 pounds soft landed on the lunar surface.

This is one thing we are looking into, and it might be an economical way to go.

The other thing we are studying is a soft landing stage on top of the Saturn V. Through this we could put 30,000 pounds on the lunar surface.

Another area of particular interest is a manned space station.

Another possible future project of considerable interest is the manned Earth-orbiting station. Studies over the last 2 years have demonstrated that such a station is technically feasible today. The major objectives of such a station would be the evaluation of the physiological effects of zero gravity on man over very prolonged periods, the conduct of scientific experiments requiring the presence of man in space, and the development of engineering subsystems and techniques in the space environment.

Proposals for such stations vary widely. At the lower end of this range are proposals to extend the Apollo spacecraft stay time up to 100 days. At the high end of the range is the elaborate station, in which rotation provides artificial gravity. Such a rotating station might support a large crew for indefinite periods of time.

Our approach in our studies in this indicates that literally Apollo itself could be a manned station for short duration—you probably could extend it up to a month or two—and the next step from that would be a large cylindrical station that you might launch on a Saturn vehicle which could stay up many months and perhaps house anywhere from three to four men.

I think this Nation will want to study and learn of the environment about us at an early point in the future. To do this we would probably stay up there over extended periods.

As far as the immediate requirement of manned space flight, we would very much like to have a man in an environment of zero gravity for say 90 days so that we could study the effects.

Mr. GURNEY. A question, Mr. Chairman.

Mr. DADDARIO. Yes.

Mr. GURNEY. Realizing our budgetary limitations, if NASA had the money now, I assume from your statement that you would go ahead with this project at once; is that right?

Mr. HOLMES. We would go ahead with studies at once. After the studies were completed in perhaps another year, we would go ahead with actual hardware programs. I think that we probably will be proposing that. I think that we must consider not only the requirements I have mentioned for scientific information, but also the international, political significance of having several people continuously in orbit around the world.

Mr. FULTON of Pennsylvania. What activities would you have on a space station?

Mr. HOLMES. First and foremost, Mr. Fulton, we would be measuring these people to see whether there was any degradation in their actions over a period of time from weightlessness. We can't find this out any other way.

The other things that one would like to do are astronomical experiments, of measurement of meteoroid density, meteoroid dust density, temperature variations, photographs of the Earth, and so forth. The scientific community has numerous experiments they would like to see performed.

One of the more expensive aspects of a space station is the resupply problems; that is, to go up and resupply it and then transfer crews.

Most of our current studies suggests the use of the Gemini vehicle for the supply vehicle. In relative costs, it is an inexpensive vehicle compared to our large vehicles.

Mr. FULTON of Pennsylvania. I would be particularly interested in the medical and the life science aspects. For example, if with a heart patient you could relieve the patient's heart of all the weight forcing the blood through the arteries and veins, you would immediately have quite a breakthrough, so that a tired heart or tired blood would be immediately relieved.

I am looking forward to the time when you will start putting people up who are not these perfect physical specimens.

In closing I would like to point out to you that I saw a clipping yesterday of the UPI from Russia, which said they are planning to put a woman in space and have such a program, in order to beat us in that field.

Maybe the United States better wake up and take this thing of women in space seriously. When you spoke of having three or four men in space, maybe you can have some women, too, on a space platform; couldn't you?

Mr. HOLMES. Yes, sir, I think you could.

I think we all love the ladies and I am sure they would probably be a rather welcome addition.

Mr. FULTON of Pennsylvania. Seriously, there has been quite a lot of humor about it—the early ones, the space cadets, where is your helmet, your plastic headpiece, and all that sort of thing, but, practically, to me anybody can be in space, and it is going to be a mode of living rather than just these space probes.

With that in mind, with the women paying half the taxes, I don't see why we don't have as a national objective a woman-in-space program and at least be first in something.

Mr. DADDARIO. Would you go so far as sending four of them up at a time, Mr. Fulton?

Mr. FULTON of Pennsylvania. As I am a bachelor, I better not limit the number of women.

I would like to say just seriously that we ought to plan on a broader view of space, to look at it from many aspects. For example, on the medical end of it, we don't know on people that are cancer prone whether exposure to this slight amount of radiation might have a blocking or retarding effect on cancer development. So we have many things to do, and I hope you do go ahead with the space station.

That is all; thank you.

Mr. GURNEY. Mr. Holmes, along that same line I wanted to ask specifically whether we are now planning any vehicle which is more sophisticated than Gemini and which we could quickly recall from space or precision land. Do we have any plans along this line?

Mr. HOLMES. Within the Office of Manned Space Flight, the only more sophisticated one is Apollo itself, which you could use and probably will use in earth orbit operationally.

Apollo should have localized landing capability with parachutes within an area of perhaps 10 miles on a side. This can be achieved because of the lift-to-drag ratio of the capsule.

Other programs beyond that are being studied but they are in the Office of Advanced Research and Technology.

These are things, which I am really not qualified to talk about.

In line with Mr. Fulton's statements, in order that I can go home tonight and be let in, I would like to add that we certainly agree women have a place in space in the future.

It wasn't very long ago that we thought of jet aircraft as accommodating only strong men. Now it is pretty commonplace to see a mother and child sitting comfortably in a jet aircraft.

Mr. FULTON of Pennsylvania. That is the way I feel about space. We must get over this feeling that it is a separate place. It is simply an extension of a dimension of activities that we have been progressing in and working further out.

I would like to see an astronaut go up who has a heart condition and who would be very willing to go and see what the effect is, rather than to have an astronaut trained such as we have and then have him set fear aside. I think that we have to prove that space is safe. We have had a half a million miles of travel and not one injury, not even a hangnail, so you are doing pretty well.

Mr. HOLMES. Although much scientific and technical interest has centered on manned planetary exploration, we feel it is much too early to discuss either mission concepts or schedules for such a program. During the next fiscal year, we plan to conduct studies to enable us to discuss this problem intelligently.

Before we make firm recommendations, we want to supply ourselves with detailed information on the magnitude of the problem and the characteristics of both the spacecraft and the launch vehicles that will be required to carry out such missions.

We are presently carrying on studies of more sophisticated launch vehicles than the Saturn V for use in such missions.

Our previous experience does tell us that the launch vehicle is the longest leadtime element of any large system, and the large rocket engine is the longest leadtime unit of the launch vehicle. We have asked the Air Force to work on the demonstration of a large solid propellent rocket. We have had a NASA contractor, Aerojet General Corp., at work for a year on the development of the M–1 liquid hydrogen-liquid oxygen engine.

In addition, Dr. Bisplinghoff's Office of Advanced Research and Technology is investigating more advanced forms of propulsion that might become available by the time we are ready to begin the development of a new launch vehicle.

We use the name NOVA to describe the launch vehicle that would follow the Saturn V. Studies of a number of possible NOVA configurations are now in progress, and further studies will take place during the fiscal year beginning July 1.

We must give careful consideration to these possible future programs, not only from engineering considerations but also from those of national policy. Until now, this Nation has taken on almost every task in space that was feasible. As soon as the rocket power became available, we launched small satellites and space probes. The Mercury astronauts were launched into space the very first day we thought it safe. The same will be true in our lunar exploration program.

Soon, however, we shall have available rocket power and advanced propulsion systems, spacecraft technology, facilities, and operational techniques that will allow us to go in many directions in space.

Preliminary examination of scheduling considerations indicates that flight to Mars may be feasible during the 1970's. However, the cost in money, time, and manpower would far exceed that of Project Apollo. Should we do it?

We are discussing these areas from the standpoint of technological feasibility. It is not intended that such statements should be interpreted as a recommendation for a course of action. Such future programs would involve the commitment of significant amounts of funds and manpower. The decision to proceed would, of course, be made at the highest levels of the Government.

CONCLUSION

In conclusion, let us recapitulate what has been stated in this extended report of the status of the U.S. manned space flight program.

We have found that there are excellent reasons why the United States should devote resources, manpower, and money to an endeavor to achieve national preeminence in space. We have made the organizational arrangements needed to achieve our national goals, or at least we so believe. The manned space flight program consists of three projects, Mercury, Gemini, and Apollo, in which we are proceeding step by step to develop broad capabilities in manned space flight. Our efforts to carry out this program are broken down into several major areas, which have been covered in this statement.

We have discussed systems engineering, which provides program-wide technical analysis, determines broad specifications and conceptual designs, identifies alternative contingencies within a program as it progresses, provides overall reliability and system test plans, prepares a long-range plan, and assists in the establishment of project development plans for future manned space flight projects.

We have recounted progress in spacecraft development, flight missions, and space medicine. We have reported what has been learned from Project Mercury, the status of Project Gemini, and the results to date in the research and development of the spacecraft to be employed in Project Apollo. We have discussed the medical considerations in each of these programs.

We have described the three powerful launch vehicles of the Saturn series—the Saturn I, the Saturn I–B, and the Saturn V—which will provide the lifting power required in Project Apollo and with which we intend to make the United States preeminent in this area.

We have shown how we are taking steps in our integration and checkout effort to make certain that the elements of this complex program fit together, to assure overall reliability and safety, and to establish that everything is in working order when it is time to begin a mission.

We have discussed the facilities in being and under construction which will enable the United States to carry out launch operations with great flexibility from the spaceport at Merritt Island, Fla.

We have reported on the selection and training of astronauts, in which we are seeing to it that the men who will take part in the flight phase of this great enterprise are properly prepared for their work.

We have described the techniques of flight operations control, in which we are providing a maximum of Earth-based support to en-

able our astronauts to find their way to their destination and return safely.

Having discussed all elements of the mission, we have examined the details of a trip to the Moon and back, reporting the events that must occur at each step along the way.

Finally, we have seen that studies of possible future manned space flight programs are in progress.

Thank you very much for the opportunity to appear before the subcommittee.

Mr. DADDARIO. Mr. Holmes, we appreciate the fact that you have been before the committee and also that you agreed to come here this afternoon.

Mr. YEAGER. I had one question, Mr. Holmes.

In regard to your advanced planning—you spoke about it on page 84—is there any particular item for this in the budget, or is this drawn from your general R. & D. funds when you feel it is necessary?

Mr. HOLMES. In 1963 I guess it is all in our systems engineering. Is that right?

Mr. LILLY. It is in systems engineering for 1964.

Mr. HOLMES. How about 1963?

Mr. LILLY. For 1963 also.

Mr. HOLMES. It is under our systems engineering budget.

Mr. YEAGER. Is there a fixed amount?

Mr. HOLMES. For 1964 on we show a systems engineering level of about $60 million a year. That includes Bellcomm, our inhouse work, and studies, two-thirds of which would be carried out through contracts through the centers.

Mr. YEAGER. If you had a fairly substantial fund for advanced planning which would include advanced design, is it conceivable that you might be able to come before the committee with designs further along or more crystallized, which would then result in less reprograming, or do you feel that you have sufficient funds for that now?

Mr. HOLMES. I think particularly in the construction of facilities area with more funds earmarked for advanced design, we would be able to do two things.

One, I think we would be able to save time and probably money in the long run. At least our friends in the Corps of Engineers tell us this.

Secondly, we would be able to define for the committee to a much greater extent what we want to build, so that you could judge whether or not you felt the Congress should authorize the funds.

Futher, our thoughts would be more crystallized, so that there would be less reprograming later.

I think it would be most helpful, Mr. Yeager, if we had more advance design funds. Do you agree with that, Mr. Lilly?

Mr. LILLY. Yes, that is correct.

Mr. YEAGER. Do you feel that would be helpful in R. & D., too, that you could design things as far as possible in regard to systems and concepts and that type of thing, rather than construction?

Mr. HOLMES. I think it is important for us to have the system engineers' funds to cover the several things I mentioned. We must have the specification for the ongoing program, and we must look to the future so we are not caught napping.

Indeed, we should have started the systems engineering for Apollo at least a year or possible 2 years ahead of when we did. It would have made it a lot easier for us today.

Mr. YEAGER. In a sense this is a money-saving way of handling it.

Mr. HOLMES. I believe so, Mr. Yeager, yes.

Mr. DADDARIO. Mr. Patten.

Mr. PATTEN. No questions.

Mr. DADDARIO. Mr. Fulton.

Mr. FULTON of Pennsylvania. How has the arrangement with the U.S. Corps of Engineers been working out for the construction of facilities?

Mr. HOLMES. It has been working out very well, Mr. Fulton.

They carry a very major portion of the burden of getting the construction of facilities accomplished. We give them our technical requirements and then they, as you know, contract both for the A. & E. and for the construction. They also monitor the performance of those contractors.

Mr. FULTON of Pennsylvania. I would like to put in the record with the chairman's permission the estimates, and how the construction of facilities actually has conformed to these prior estimates.

Mr. HOLMES. Yes, we can do that.

Mr. FULTON of Pennsylvania. It would mean just the major facilities.

Mr. HOLMES. The major facilities.

Mr. FULTON of Pennsylvania. Then on the construction of facilities, I would like the timetable you originally set up for programing and how closely you are conforming to that timetable, to see what your efficiency is on meeting your plans.

Mr. HOLMES. Yes, sir, we would be glad to submit that.

(The material referred to is as follows:)

The following table illustrates the cost and time comparison between budget estimate and current working schedule. Key facilities are represented.

Project location and title	Cost comparison		Timetable for completion (design and construction)		Remarks
	Budget estimate	Current working estimate	Budget submission	Current schedule	
LAUNCH OPERATIONS CENTER					
Apollo mission support facilities:			*Months*	*Months*	
Operation and checkout building.	$14,413,000	$13,142,300	21	27	Original estimates did not contemplate the 4 months' requirement for surcharge (soil compaction). Current working estimate is based on actual bid prices.
Supply, shipping, and receiving building.	596,000	868,934	10	12	Criteria not available at the time the budget estimate was prepared. Current working estimate based on 100 percent design.
Protechnic test weights and balance facility.	1,753,000	1,753,000	12	15	
Modifications to Titan II launch complex.	2,400,000	2,700,000	18	16	The increased cost of the project was based on preliminary design completed subsequent to the budget submittal.
Advance Saturn/Nova supporting facility: Central telephone office.	3,250,000	2,958,000	13	15	The current working estimate is based on actual bid prices for building construction.

Project location and title	Cost comparison		Timetable for completion (design and construction)		Remarks
	Budget estimate	Current working estimate	Budget submission	Current schedule	
MANNED SPACECRAFT CENTER			*Months*	*Months*	
Flight acceleration facility	10,630,000	10,630,000	22	25	Current schedule based on 30 percent design completion.
Thermochemical test facility	6,000,000	6,000,000	24	22	Do.
Manned spacecraft facilities.					
Project management building.	4,278,520	4,801,104	23	25	The current working estimate is based on actual bid prices.
Central data building	1,331,240	998,100	22	24	The current working estimate is based on actual bid prices. This structure is included in the MSC fiscal year 1962 Construction of Facilities program and is currently under construction.
MARSHALL SPACE FLIGHT CENTER					
Engineering and administration building.	2,500,000	2,500,000	18	16	Current working estimate is based on actual bid prices.
Addition to computation division building.	1,255,000	1,249,500	18	18	Current cost is based on preliminary design.
MICHOUD PLANT					
Hydrostatic test and cleaning facility.	3,000,000	3,000,000	21	20	Current working estimate is based on actual bid prices.
Vertical assembly facility	3,000,000	3,000,000	21	20	Do.
MISSISSIPPI TEST FACILITY					
Utility installation and support facilities:					
Maintenance and supply facilities.	500,000	1,430,000	20	18	Criteria and detailed Construction of Facilities schedules were not available at the time the budget estimate was prepared. Current working estimates and time table are based on 100-percent complete criteria and detailed Construction of Facilities schedules.
Navigational lock (foundations only).	500,000	1,500,000	14	12	
VARIOUS LOCATIONS					
Facilities for F-1 engine program	$25,000,000	$26,952,000	31	29	
Modification to Mercury Control Center.	843,300	872,000	17	16	The current working estimate is based on actual bid prices for building construction. This modification is a part of the $5,000,000 item identified in the fiscal year 1963 budget submission under project entitled "Manned Space Flight Control Centers." This facility was originally scheduled to control the entire Gemini program. The present plan, however, will utilize this center for monitoring only the earth orbital missions. The Integrated Mission Control Center, being constructed at Houston, Tex., will be used to control succeeding development phases.

Mr. FULTON of Pennsylvania. I would like to have some comment on the method of moving toward free competitive bidding on off-the-shelf and over-the-counter regular recurring items in the space field. I would like to see us get to the point where we can get away from this choice of contractors and get one best who is then best qualified in that field forever. Have a grouping of contractors who feel that when they put the work in on the study and the design that they then have an investment that they might get something out of.

I do hear complaints from companies that they did all the work and design, and were called in, but that they did not then get the contract after putting quite a bit of expense and work into the project.

Do you have any method of avoiding that advanced contractor expense which 9 times out of 10 is going to simply be an expense and a loss to them? Do you have anyway to meet such a situation?

Mr. HOLMES. No; I don't think we do have a complete solution which allows for a competitive bidding system.

We have tried, conscientiously, to notify contractors when we thought it would take an exceedingly good proposal on their part to win the job. Now this is a difficult thing to do with a capable contractor. But sometimes it must be done because of a particular contract that contractor might have. For example, the General Electric Co. was so advised with regard to the integrated mission control center at Houston.

Mr. FULTON of Pennsylvania. Well, take as a specific example the Goldstone project which is the deep space radar dish that will cost about $15 million. I realize that there is a research and development angle to that dish, but there likewise is quite a lot of straight construction work, fabrication and other regular day-to-day contracting involved in this particular project.

When it comes down to four companies or groups of companies that are all competent in the field, then it would seem to me it would be wise to say, gentlemen, put your bids in, they are opened at a certain time, these are the specifications.

My criticism would be that it still is making a choice of contractor through the personal leaning of the particular contracting officer or contracting officer groups. This personal leaning is often through past history or through connections or friendships.

In order to get the least cost to the taxpayer, it seems to me that when you eliminate the research and development items, that you then have these people who are competent in the field submit proposals for the lowest bid.

I feel that it is not wise to eliminate people of competency simply by a variable choice without reason.

On one case in the low-vacuum test facility, I asked why a company that had done over $50 million worth of business in the low-vacuum field or high-vacuum field, was eliminated and not even allowed to make a bid on it; the answer was they did not show enough imagination in their proposal.

So, of course, I said, "Well, what kind of imagination?" and I have a letter from Mr. Dembling saying that you have changed your practice in the vacuum field installation so that it is now on public bid. I hope you will do that in these other fields.

Can we assure the House of Representatives and the American taxpayers that you will set up procedures that will broaden the base

of public bidding on these off-the-shelf, over-the-counter items of regular use in the space field?

Mr. HOLMES. Yes, Mr. Fulton, we can assure you of that. I think we can assure you—and I will speak for NASA now rather than just my office—that we will go to advertised, fixed-price bidding, wherever we feel it is possible and to the advantage of the Government. One must, of course, be able to specify what is to be done clearly enough so that you can tell whether the product delivered is really that which the specification called for.

Mr. FULTON of Pennsylvania. Do you have adequate in-house capabilities and personnel for definitive specifications? It seems to me that in a good many cases you are trying to save money but are putting out for bid what is more general ideas, with the basic design not really reduced to paper, let alone any particular specifications.

Mr. HOLMES. Well, it is my personal belief that we have in house, in NASA, more competence than any other Government agency does——

Mr. FULTON of Pennsylvania. Shouldn't you have more; that is really the question.

Mr. HOLMES. For putting out engineering type specifications.

Mr. FULTON of Pennsylvania. Should you have more personnel and facilities of that type?

Mr. HOLMES. Maybe I should clarify. We have a great many competent people in NASA. But I really think the limitation, Mr. Fulton, is that it is not possible for any group of people to define these early development tasks to the detail necessary to get a fixed-price quotation.

I think if one looks at the specifications that we put out for Apollo, or for the integrated mission control center, you would find that they were tremendously detailed and yet still they were not to the point where it was to the advantage of the Government to take a fixed price quotation.

Mr. FULTON of Pennsylvania. Do you need to break down your bidding from the project level to the individual programing level within the project? Do you need to come down out of picking somebody to do a tremendous overall project where then the subs and the sub-subs have any competitive bidding, or rather take over the project management yourself in-house and keep control of it with adequate personnel.

Mr. HOLMES. Well, I believe that we are going about as far as we should in exercising in-house control. As I mentioned this morning, I think a prime contractor should select his subcontractors within certain ground rules designed to assure cost and technical competition where possible, et cetera.

Mr. FULTON of Pennsylvania. Does the prime contractor put out these proposals on public bid for subcontracts?

Mr. HOLMES. There are some cases where we feel that it is to the advantage of the Government to go ahead with a subcontractor that was proposed by the prime contractor without competition, but competition is generally highly desirable.

Mr. FULTON of Pennsylvania. How far down in the series of contractors, subcontractors, do you go?

Mr. HOLMES. Beg pardon.

Mr. FULTON of Pennsylvania. How far down in the series of prime contractors, subcontractors, and sub-subcontractors do you go to see that the Government is getting its money's worth through public bid or even through competition?

Mr. HOLMES. I am going to ask Mr. Bothmer, my executive assistant, who is more qualified than I am, to speak on this, if I may.

Would you like to comment, Mr. Bothmer?

Mr. BOTHMER. Yes. Mr. Fulton, I don't think that the prime contractors have a public bidding system in the sense that we have in the Government; that is, an open advertised procurement system. They do have competitive procurements and are required to do so in many cases under our regulations concerning approval of subcontracts.

In NASA and other Government departments such as the Defense Department, regulations are issued to require prime contractors to follow certain procurement practices. For instance, we have small business subcontracting programs; we have administrative contracting procedures which require approval by the Government over subcontracting procedures; we assure that primes do obtain competition where they reasonably can through the approval of subcontract awards.

Mr. FULTON of Pennsylvania. How far down in the contracting procedure do you monitor the contract? For example, the prime contractor, the major subcontractors, the sub-subs, where do you stop?

Mr. BOTHMER. This depends, of course, upon the dollar value of the contracts involved. On large prime contracts we might well have provisions, for example, that would require the prime contractor to comply with certain procurement procedures, and in turn require his major subcontractors to follow the same rules. For example, large primes are required to specify certain small business programs, and this sort of thing, which their subs must follow.

Mr. FULTON of Pennsylvania. Do you have within the structure of NASA, on your organization setup, a firm organization to inspect and monitor these contracts on the spot as they proceed?

What kind of inspection procedure do you have of that type?

Mr. BOTHMER. We have, for example, working with some of the major NASA prime contractors on the west coast, the Western Operations Office which——

Mr. FULTON of Pennsylvania. I have been there.

Mr. BOTHMER. Which is in this contract administration business and does monitor the kind of things I am talking about.

Mr. FULTON of Pennsylvania. But they have very little personnel there.

Mr. BOTHMER. That is true, and on a great many of our major contracts we have in the past in NASA relied on the Defense Department to carry on this sort of activity for us.

We are gradually building within NASA an in-house capability to do more of this on our own.

Mr. FULTON of Pennsylvania. That is the process I am getting at.

I don't want to take the committee's time. Will you please put in the record how you have previously done it, how you are changing it, and what you expect to come to?

Mr. BOTHMER. Yes, we will be glad to do that.

I think also you are having Mr. Siepert and Mr. Brackett before the subcommittee tomorrow. They are certainly well qualified to discuss this subject further.

(The information requested is as follows:)

NASA's existing policies and procedures on procurements are derived from the Armed Services Procurement Regulations (ASPR). NASA's Procurement Regulations establish definite policies and procedures for evaluating contractor purchasing practices and subcontract management. For example, the contractor's purchasing methods, pricing policies, and adherence to statutory clauses are examined carefully.

A "subcontract" clause is prescribed in NASA contracts that are price redeterminable, incentive, or cost type. According to the terms of this clause, the contracting officer must review and approve all subcontracts that are of a cost-plus-fixed-fee nature, exceed $25,000 or 5 percent of the contract price, or provide for industrial facilities. The contracting officer must also give his written consent on subcontracts that call for special tooling over $1,000 or are based on time and material or labor-hour. NASA's Director of Procurement and Supply reviews and approves contracts above a certain dollar level and related modifications to verify that the subcontract provisions are followed.

The NASA Procurement Regulations establish guidelines for implementation of the subcontract provisions. These policies apply both to NASA contracting officers and to Department of Defense contracting officers who are acting on NASA's behalf.

NASA devotes continuing effort to proper review of project costs. The provisions of section XV of the Armed Services Procurement Regulations, "Contract Cost Principles and Procedures," are incorporated into contracts. These comprehensive principles serve as a contractual basis for the determination and allowability of cost related to negotiation and administration of cost-reimbursement contracts. All contracts of this type are subject to a detailed audit.

NASA follows a comprehensive program for quality assurance. Three quality publications, NPC 200–1, 200–2, and 200–3, represent the cooperative efforts of all NASA installations and establish mechanisms for achieving the highest degree of reliability in space program procurements from research and development through space operations. NPC 200–1, entitled "Quality Assurance Provisions for Inspection Agencies," is designed to utilize the services of existing Government inspection agencies, under the technical direction of the responsible NASA installation. Minimum requirements for the performance of quality assurance functions by an inspection agency are described. NASA installations retain and cannot delegate overall responsibility for the quality of hardware and services procured.

NPC 200–2, entitled "Quality Program Provisions for Space System Contractors," establishes requirements that ensure high quality in space systems, major subsystems, and complex assemblies involving design and development. The third publication, NPC 200–3, govern the inspection system for suppliers of materials, parts, components, and services that are used in space systems.

These policies require prime and subcontractors to maintain a quality assurance program more stringent than traditional standards. In addition, the guidelines enable NASA management to evaluate contractor performance on current work and provide a judgment factor for considering future awards to that contractor. In some instances the scope and importance of the work justify the establishment of a resident NASA office at the contractor's plant. Examples are North American's Downey, Calif., plant, Pratt & Whitney's West Palm Beach plant, and the Boeing and Chrysler operation at the Michoud plant.

NASA's inspection system is part of a quality assurance program to achieve high reliability of hardware in space operations. The agency performing inspection at the plant is required to submit a written quality assurance and inspection plan providing for quality verification at all stages, including receiving, qualification, in process, end item, shipping, and storage. This plan includes a flow chart of planned agency operations, a list of processes and procedures involved, and numbers and skills of personnel. The inspection agency is required to submit monthly summary reports. Similar requirements are placed upon system contractors and suppliers of parts and materials, based on NPC 200–2 and 200–3, which contain detailed requirements for planning, reporting and feedback, as well as controls over purchases assembly, testing, and processes. NASA has also initiated use of inspection stamps to identify both the level of quality and verifying officer.

Each NASA center involved in the manned space flight program has a centrally directed quality assurance organization that responds to program needs. The functions and procedures are aimed at achieving the highest degree of confidence in mission success and flight safety.

In addition, NASA is preparing process control documents which are specifically designed to satisfy the high standards for work on existing space programs. These documents will specify NASA-wide requirements, including those for certification of Government and contractor personnel.

The success of the NASA quality concept requires adequate numbers of technically competent and trained personnel to represent our centers in contractors' plants and to perform inhouse quality functions. Both professionals, such as aerospace engineers, and nonprofessionals are involved. At NASA's request, the Civil Service Commission has defined and approved a new classification series, called "Space System Quality Control and Inspection" (GS–1955–0). A NASA-wide reliability and quality assurance training program is also being developed. The program, directed by the headquarters office of reliability and quality assurance, will include training in the application of quality publications and concepts of space vehicle performance. At present training is available in automatic checkout techniques, radiography, cleaning control and fluid analysis, high-pressure fittings, and component testing (electrical, electronic, and mechanical). These courses are directed at Government quality assurance personnel, both from NASA and other agencies. In addition, a soldering course provides training for instructors and examiners in industry.

Mr. FULTON of Pennsylvania. While we are on this, the General Accounting Office has no scientists, nor do they have any engineering talent as such. How do they monitor what you are doing in NASA, because they just look into the administration and the accounting.

Mr. BOTHMER. If you mean how do they monitor the procurement policy aspects of what we are doing, that is one thing, Mr. Fulton, but if you're talking about technical matters, that's something else. I am not sure I understand the question.

Mr. FULTON of Pennsylvania. What is the interface between your agency and the General Accounting Office?

Mr. BOTHMER. I think the General Accounting Office uses its audit services to look into our contracts to see whether they have been properly awarded and administered. The GAO is interested in seeing that the pricing policies, for example, have been followed as they should have been.

As far as the technical aspects of the procurement——

Mr. FULTON of Pennsylvania. That is it, there is no technical judgment, or research judgment, or engineering judgment on their findings, is there?

Mr. BOTHMER. They do not to the best of my knowledge, have any capacity for this sort of thing, no.

Mr. FULTON of Pennsylvania. So there is no outside monitoring of NASA on that basis?

Mr. BOTHMER. Not on a technical basis from the General Accounting Office; no, sir.

Mr. DADDARIO. Mr. Gurney.

Mr. GURNEY. One question was brought up this morning. I suppose it is a basic premise that we have lagged behind the Russians in manned space flight because they had a great start on us on large boosters.

If that is the case, are we running into danger of another lag by not going ahead with the Nova program or something like it, or to put it another way, how soon should we go ahead with a booster like Nova?

Mr. HOLMES. Well, with respect to the first part of your question

on Russia, to our knowledge they have launched over and over again a booster capable of putting perhaps 15,000 pounds into orbit.

They have used it in various ways. Sometimes with 10,000 pounds, sometimes to put up as much as 15,000 pounds for the Lunik third stage.

Our Saturn I will put 22,000 pounds into Earth orbit; our Saturn I–B, 32,000 pounds into Earth orbit, and our Saturn V, 240,000 pounds into Earth orbit.

The Russians will have to show a capability to launch much higher weights if they expect to retain their lead, and if they expect to go to the Moon, other than through very complex rendezvous techniques.

As far as when we should go ahead with the Nova, I think we should now be studying what the latest state of the art is and studying different approaches, including the use of solids, different kinds of engines, and different kinds of fuels. We are doing this.

I think we should go ahead with development of engines (such as we are with the M–1) which take so many years to develop. Then at such time as we develop a program for a launch vehicle for planetary flight, we will be able to proceed. I don't think we should be spending major amounts of dollars on its unless we want to speed up the date that we had anticipated to go into planetary flight.

Mr. GURNEY. If the Russians landed on the Moon in 1965 or 1966, would this make any difference in your program, or are we probing something here that we shouldn't?

Mr. HOLMES. If they launched a much larger booster tomorrow, I would revise my testimony tomorrow.

I don't mean that to be flip at all, but it is very difficult to get information on what they are doing. I think it wouldn't be just going to the Moon. I mean if they launched much larger boosters I think that we would review that.

I don't think personally that it would perturb very much our ongoing lunar program unless the Nation decided that we should proceed at a faster rate recognizing the waste that you get with very fast rate programs.

As far as changing the step-by-step development, or pushing aside the Saturn V for a different booster in the lunar program, I think we would not do that. That is my present thinking.

Mr. GURNEY. You might review whether it was more important to go to the Moon or else start more work on interplanetary missions; is that right?

Mr. HOLMES. One might, I suppose. It is somewhat unrealistic to say we aren't affected by what some other nation does—but I think it is highly unlikely that the Russians will demonstrate a capability such as to perturb our program in the near future anyway.

That is a difficult statement to make. I would like to have a lot more knowledge. It is a bit like running a contest in which all the signals are revealed on one side, while they are all kept secret on the other.

Mr. DADDARIO. Mr. Fulton.

Mr. FULTON of Pennsylvania. What are you doing in conjunction with the Department of Agriculture or any other agency to see about maybe raising food on the Moon rather than transporting it at a very high cost per pound?

Mr. HOLMES. I don't believe we are doing anything with the Department of Agriculture in that respect.

We are doing advanced studies on closed ecological systems in order to maximize the use of any weight we do carry to the Moon.

I think that most of the scientific community feels there would be very little chance of actually raising food on the Moon.

Mr. PATTEN. They had better plant something they can gather in a hurry.

Mr. HOLMES. Yes, sir. There is very little atmosphere and fairly sterile soil. We are having scientists and physicists study it.

Mr. FULTON of Pennsylvania. It is not as ridiculous as it might sound. If you put on the under side of plastic some of this bacteria that increases up to 12 times a day in weight, through some application of oxygen, possibly you might come up with some sort of system whereby you had your waste materials fed over a plastic and might even come up—if the three dimensional tomato would explode—you might come up with a two dimensional tomato.

Mr. HOLMES. I guess that is right. I think in the closed ecological systems, the kind of thing you are talking about growth of bacteria, or reuse of waste we are doing quite a lot of work in our research centers.

Mr. FULTON of Pennsylvania. So we are trying to keep open-minded in developing new systems and not just the ordinary food inhalation that we do here.

Mr. HOLMES. Very much so, yes, sir.

Mr. FULTON of Pennsylvania. The other problem is this, and I have often wondered about it, what might be called the child's approach to the problem of boosters. When we are using a booster, we are raising everything vertically along with all of the weight, and, of course, the greatest amount of weight is at the beginning. It is like a pyramid, so we have to get bigger and higher rockets, and more propellant must be lifted the first few feet.

We have had experiments with sleds that will generate speeds up to 300 or 400 miles an hour on the earth's surface. Why don't we look at having sleds operating on an inclined plane up a mountain.

When we set the booster off on its pad, it goes up so far vertically and then does a gravity turn so that you vector it more into a horizontal position, a directional position. Why wouldn't it be possible to have a lot of this tremendous amount of fuel we are talking about on Nova by running it up a 16,000-foot mountain? How much fuel do you have to have to get that high in proportion to your total Nova? It is a tremendous amount.

Another thing is you could use the sled again. The third is that it could be varied directionally so that when you inject it into orbit, you are already on a gravity turn that is more nearly in conformity with the vector that you want.

Mr. HOLMES. We have looked at these techniques. We have received mail from many people as to balances and spring loads, and counterbalances to the weight of the rocket. We have had suggestions on such schemes as sliding down mountains. I think it is quite logical for these things to come to mind. However, if you really sit down and look at them, you find that the energies released by these cryogenic engines are so great that the footpounds that you can get from sliding down a hill, or anything, are just negligible.

In the Delta V you would get——

Mr. FULTON of Pennsylvania. I am not talking of a U-turn or anything like that.

Suppose you could start your NOVA up at 16,000 feet.

Mr. HOLMES. It wouldn't help a great deal.

Mr. FULTON of Pennsylvania. And with a velocity of a certain amount, how much fuel would that save you?

As you know, I have always had great doubts on the Nova. I think the Nova with present fuels is just ridiculous, unless you get high energy fuel.

Mr. HOLMES. I think it would save you very little fuel. You would start at 16,000 feet, but the gravity would be essentially the same. It is true the atmosphere would be more rare, but not a great deal, and you would start at a velocity of zero. You would still have to increase from zero to 18,000 miles an hour.

Mr. FULTON of Pennsylvania. Not with my sled. I would have your Nova going 400 miles an hour.

Mr. HOLMES. Then your sled is sliding down the hill and then I have to get a——

Mr. FULTON of Pennsylvania. I am not coming down the hill, I am pushing the sled up the hill.

Mr. HOLMES. Well, it is going to take you as much energy to get the Delta V on that sled with a rocket on it as it will take us to launch it from the pad. But I would be glad to sit down with pencil and paper with you. You would probably outwit me, but still we would probably have a good time.

Mr. FULTON of Pennsylvania. Thank you very much.

Mr. DADDARIO. Mr. Holmes, you have just touched on medical considerations here and without going into any detail, just a general opinion, are you satisfied that since the discussions have taken place as to coordination of activities with the other agencies of the Government, that progress has been made in this direction and that we are carefully avoiding duplication, and we are carefully using our best medical talents in this area of space?

Mr. HOLMES. Yes, Mr. Chairman, I am.

I think that you personally have contributed a great deal to that with your interest in it over the years. During fiscal year 1963, Dr. Roadman of my office met with the Department of Defense and outlined a detailed program concerning the way one program should support the other.

This is continuing now, and it will continue in future years. So I think there is very close relationship there.

I would like to point out that the last nine astronauts, the new astronauts, had essentially their total medical evaluations done by Brooks Air Force Base in San Antonio.

Further, Brooks is doing much other work which is of assistance to us.

I think in general we are much closer together than we were, and I think it is to the advantage of the country that we are.

Mr. DADDARIO. Well, we will be having before this committee the men in charge of that program, but I did want your personal opinion.

We want to thank you for your appearance before this committee today. I hope that if there are questions which come up, as I am

sure there will be, that we will have you here again to help us reach a solution.

Mr. FULTON of Pennsylvania. I want to thank you, too, and I might say parenthetically that you ought to have a couple of hashmarks on your biography for your appearances before the committee. They have been good.

Mr. HOLMES. Thank you very much.

Mr. DADDARIO. This committee will adjourn to meet at the call of the Chair.

(Whereupon, at 2:31 p.m., the committee adjourned to meet at the call of the Chair.)

1964 NASA AUTHORIZATION

MONDAY, MARCH 18, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON MANNED SPACE FLIGHT,
Washington, D.C.

The subcommittee met at 10 a.m., the Hon. Olin E. Teague (chairman of the subcommittee) presiding.

Mr. TEAGUE. The meeting will come to order.

Do you have people with you, Dr. von Braun?

Dr. VON BRAUN. I have an aide, to help me with the slides.

Mr. TEAGUE. Doctor, you may proceed.

STATEMENT OF DR. WERNHER VON BRAUN, DIRECTOR, GEORGE C. MARSHALL SPACE FLIGHT CENTER, NATIONAL AERONUATICS AND SPACE ADMINISTRATION

Dr. VON BRAUN. Mr. Chairman, I have brought a prepared statement. May I read it?

Mr. TEAGUE. Yes, sir. Go right ahead. We will include your biographical sketch at this point.

(The biographical sketch of Dr. Wernher von Braun is as follows:)

DR. WERNHER VON BRAUN, DIRECTOR, GEORGE C. MARSHALL SPACE FLIGHT CENTER

Dr. Wernher von Braun is the Director of the George C. Marshall Space Flight Center of the National Aeronautics and Space Administration, Huntsville, Ala.

The Marshall Center is in charge of developing the National Aeronautics and Space Administration's larger space vehicles and conducting related research. The Saturn space vehicles are being developed to carry out this country's goal of placing men on the Moon and returning them safely to the Earth within this decade.

Employing about 7,000 persons, the Marshall Center is capable of conducting all phases in the research and development of a large space rocket—from conception of the idea, through design, development, fabrication, and assembly of hardware, and testing.

Among the Center's current programs are the Saturn I, Saturn IB, Saturn V, and Nova heavy space vehicles.

The Marshall Space Flight Center also provided and launched five modified Redstone rockets for the Mercury man-in-space program of NASA. The Redstone booster successfully placed a chimpanzee, Ham, and two astronauts, Alan B. Shepard, and Virgil I. "Gus" Grissom, in suborbital flights.

The Saturn I has been test flown successfully three times.

Dr. von Braun was born in Wirsitz, Germany, on March 23, 1912.

He was awarded a bachelor's degree at the age of 20 by the University of Berlin. Two years later, in 1934, he received his doctorate in physics at the same institution.

In 1930 he joined a group of inventors who constituted the German Society for Space Travel. In 1932 he was employed by the Ordnance Department of the

German Government. From 1932 until 1937 he was chief of a small rocket development station near Berlin. The liquid-fueled rockets, identified as A–1, A–2, and A–3, forerunners of the V–2, were developed there.

He became technical director of the Peenemuende Rocket Center in 1937. The V–2 was developed there. In the closing months of World War II he led more than 100 of his fellow scientists to the West and surrendered to the Allied Powers.

Dr. von Braun came to the United States in September 1945, under contract to the U.S. Army. He directed high-altitude firings of captured V–2 rockets at White Sands Missile Range, N. Mex. Later he became project director of a guided missile development unit at Ft. Bliss, Tex., which employed some 120 of his Peenemuende colleagues. In 1950 the entire group was transferred to Huntsville, Ala., where the Army centered its rocketry activity.

Dr. von Braun and about 80 of his associates and their families received American citizenship in Huntsville on April 15, 1955.

The Army Ballistic Missile Agency development team which Dr. von Braun headed was transferred to the National Aeronautics and Space Administration in 1960 at the direction of the President. The group was made responsible for developing and launching NASA's large space vehicles.

At the Huntsville installation, Dr. von Braun directed the development of the 200-mile Redstone rocket, which was America's first large ballistic rocket. Later the Von Braun group developed the Jupiter IRBM. The Pershing rocket development program was also directed by Dr. von Braun.

Special versions of the Redstone, the Jupiter C, and the Juno II were used by the Von Braun team in launching the free world's first satellites of the Earth and Sun, Explorer I and Pioneer IV, and in the first successful space flight and recovery of animal life.

Dr. von Braun has received many professional and scholastic honors for his leading role in rocketry and space research activity. In 1959 he was presented the Distinguished Federal Civilian Service Award by the President of the United States.

Dr. VON BRAUN. Mr. Chairman and members of the subcommittee, I appreciate the opportunity to discuss with you the status and plans for the Saturn launch vehicles. In my discussion, I will also cover present status of the F–1 engine development program.

Status and plans for the Saturn vehicles cover a good deal of ground. We have, to begin with, development programs for five stages, two instrument units, and four major engines. There is also the required complex of ground test, manufacturing, and launch facilities, together with appropriate ground support equipment.

We must also consider the various interfaces involved: Stage-to-stage, spacecraft to vehicle, and vehicle to facilities. And that very large interface of Government to industry, which is critical in getting these complex and demanding programs to work as parts of a coordinated whole.

The managerial requirements of these programs are fully as arduous as the scientific and technological requirements.

As managers, we have to spend the taxpayers' money as carefully and intelligently as possible, and get the most out of what we spend. To do this, we keep ourselves keyed up to a high level of technical competence. We must remain in a position where we can establish standards and evaluate proposals. And we must retain and nurture the ability to act effectively, in all aspects of exceedingly technical programs, to stop trouble before it starts.

This is bench-oriented philosophy; the position of strength from which management leads in new programs where we are working up the technology as we go along.

With this preface, let me turn, now, to the development programs for the Saturn I, IB, and V. About 2 weeks ago Brainerd Holmes

gave you an overall view of these programs as they are integrated into the total manned flight effort. From this account I would like to step off into a more detailed review of the launch vehicle programs and where we are today.

SATURN-CLASS LAUNCH VEHICLES

There are three Saturn vehicles being developed to support the Apollo phases of the manned flight programs (fig. 99). Saturn I, now in flight testing, is to be a two-stage vehicle capable of placing about 11 tons into Earth orbit. The vehicle will place two of the three Apollo modules into orbit for flight testing and spacecraft qualification.

There is a block I and block II shown on the left-hand side of this chart.

The Saturn IB is an intermediate step between the present Saturn I and the Saturn V, and draws a stage from each of these programs. By combining the flight-tested Saturn I first stage with an advanced upper stage from the Saturn V, we will secure a vehicle with a payload capability of about 16 tons. The vehicle will launch the complete Apollo spacecraft into low Earth orbit for qualification of the lunar excursion module and the development of spacecraft orbital maneuvers.

The final Saturn vehicle is the three-stage Saturn V, being developed to support the manned lunar mission, including both circumlunar flights and manned lunar landings. The Saturn V will have an Earth orbital capability of about 120 tons, and it will be able to accelerate 45 tons into an Earth-lunar trajectory.

This summary is indicative of the role played by each vehicle in supporting development of the Apollo spacecraft system. Of equal importance are the technological advances secured during these development programs which lead to the rapid definition and development of the Saturn V vehicle system and associated equipment. The technological enrichment occurs at virtually every level of vehicle development; from propulsion systems and the application of liquid hydrogen technology, through vehicle structures, guidance and instrumentation, and propellant tank manufacturing methods, to ground and flight test philosophies.

SATURN I

Development of the first of the Saturn heavy launch vehicles began in 1958. This vehicle, Saturn I, is now undergoing flight tests, with 10 launches scheduled during the development program. The first four vehicles use live first stages, only, with inert upper stages. The remaining six vehicles will be composed of live first and second stages (fig. 100). By 1965, we expect to have an operational Saturn I with the capability of orbiting about 11 tons of payload. With this capability, we can place two of the three Apollo modules into a low-Earth orbit to begin qualification of these modules and crew training. These two modules are the command module and a partially fueled service module. We expect to begin this training program in 1965, with the first manned flight. During prior flights, we will have flown unmanned but instrumented modules to add confidence and reliability for manned flights.

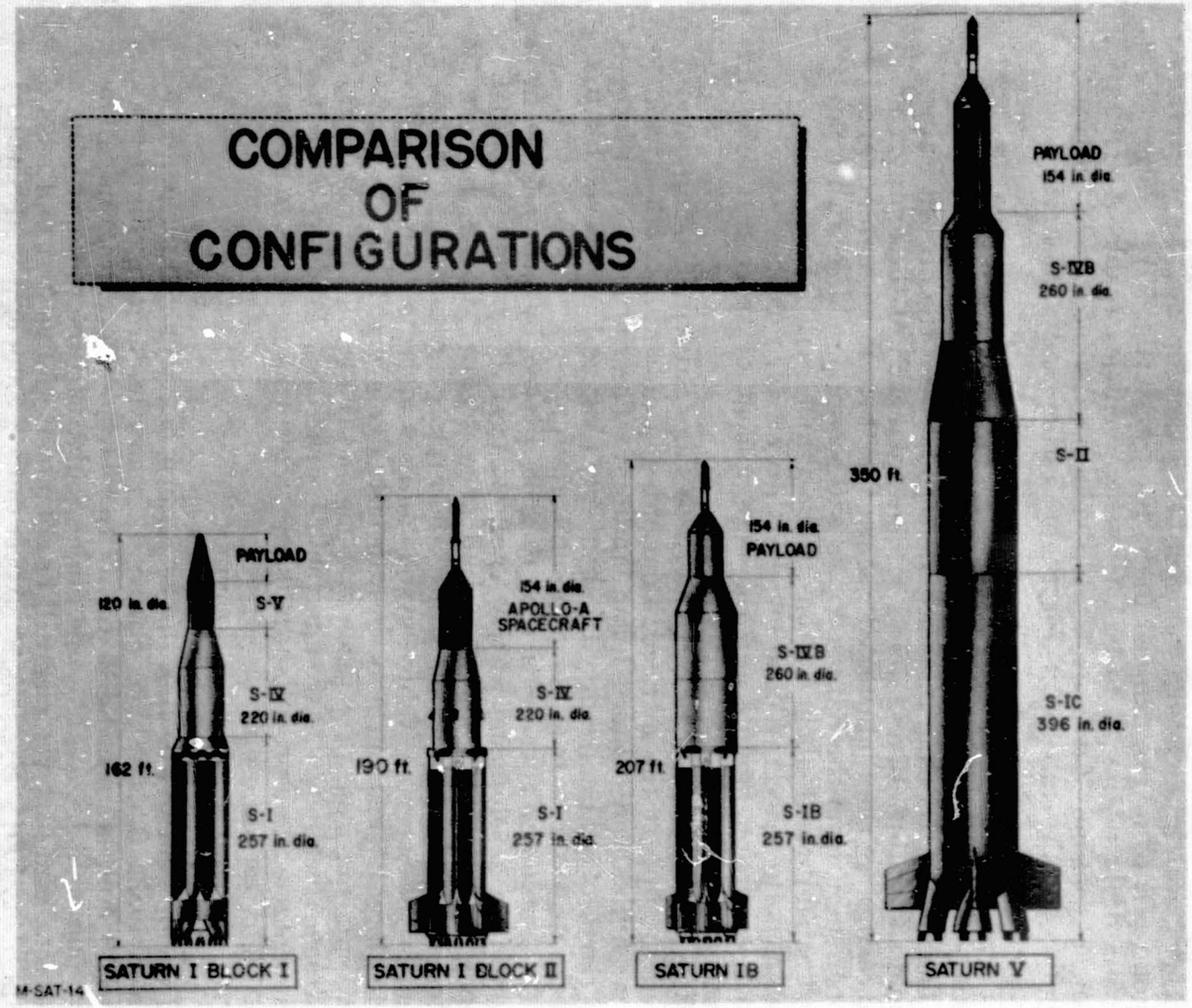
COMPARISON
OF
CONFIGURATIONS
PAYLOAD
120 in. dia.
S-V
S-IV
220 in. dia.
162 ft.
S-I
257 in. dia.
SATURN I BLOCK I
154 in. dia.
APOLLO-A
SPACECRAFT
S-IV
220 in. dia.
190 ft.
S-I
257 in. dia.
SATURN I BLOCK II
154 in. dia.
PAYLOAD
S-IVB
260 in. dia.
207 ft.
S-IB
257 in. dia.
SATURN IB
PAYLOAD
154 in. dia.
S-IVB
260 in. dia.
S-II
350 ft.
S-IC
396 in. dia.
SATURN V
M-SAT-14

FIGURE 99

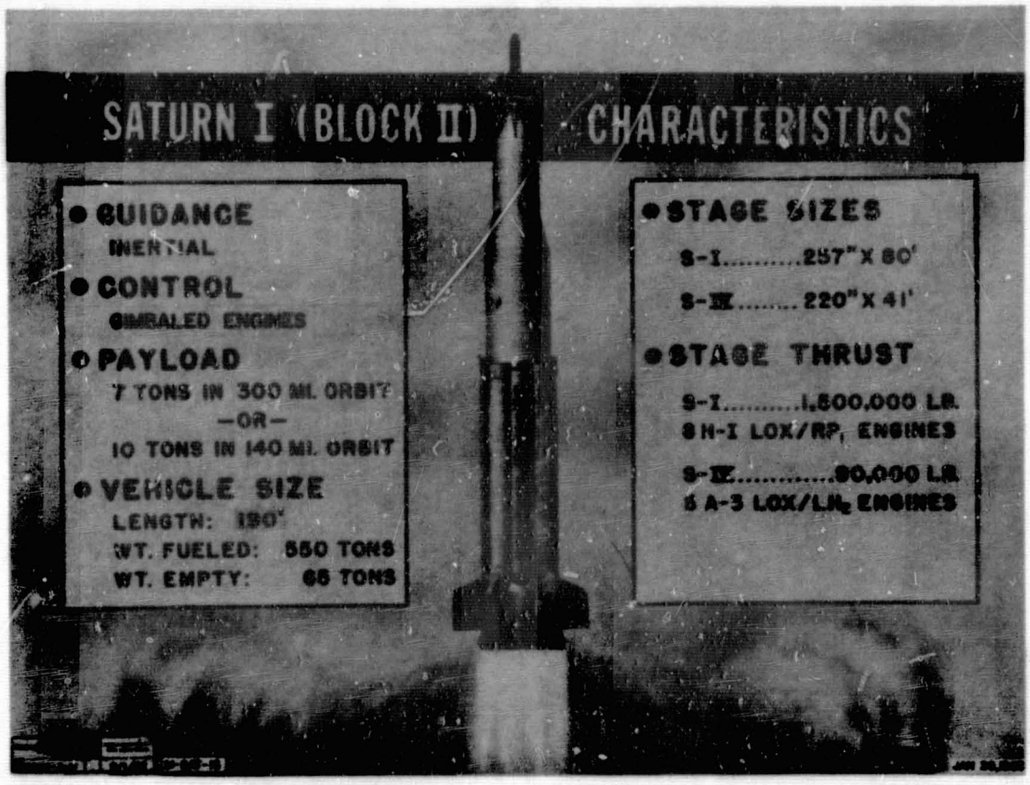

FIGURE 100.—Saturn I (block II) characteristics.

SATURN I FIRST STAGE

Eight of the ten R. & D. first stages are being built by the Marshall Space Flight Center at Huntsville, Ala. Chrysler Corp. Space Division is building the remaining stages at the Government-owned Michoud plant in New Orleans.

In February, NASA Headquarters approved negotiations to modify the contract awarded Chrysler Corp. in July 1962 for the manufacture of the Marshall-developed Saturn I boosters. The modified contract will call for a total of 20 boosters; 8 S–I and 12 S–IB (the Saturn IB first stage). Delivery is to be made between 1964 and 1967.

The two-stage Saturn I flight booster is approximately 21.5 feet in diameter and 80 feet in length (fig. 101). It is powered by eight H–1 engines burning LOX/kerosene propellants. The engines, produced at Rocketdyne's Neosho, Mo., plant, were rated at 165,000 pounds thrust for the first four test flights. The engines have been tested satisfactorily at the design thrust level of 188,000 pounds and will be used for the SA–5 and subsequent flight boosters. A thrust of 1.5 million pounds is delivered by the combined eight engines. Vehicles tanks have been lengthened to accommodate 850,000 pounds of propellant, 100,000 pounds more than that of the earlier booster. Guidance, control, and related instrumentation have been relocated to an instrument unit forward of the second stage, and fins added to augment the dynamic stability of the man-rated vehicle.

The first of these modified Saturn I boosters, S–I–5, has been assembled at Marshall, and the final static firing qualification tests are to be

FIGURE 101.—Saturn I booster.

completed this month. During the tests, a total of 1.5 million pounds of thrust was developed. This will then be the first flight booster to fly with full-rated stage thrust. The booster will be delivered to the cape in June of this year.

Also at Marshall, assembly of the first stages for Saturn I vehicles SA–6, SA–7, and SA–9 continues on schedule (fig. 102).

At the Michoud plant, the first Chrysler-built booster for vehicle SA–8 is in production (fig. 103). Clustering of the tanks is expected to begin on schedule in May. Fabrication of the second Chrysler-built booster is also on schedule with clustering of the tanks to begin in August. Fabrication of the first Saturn I booster (S–I–111) for manned flights is to begin at Michoud this April. Pictured here is the thrust structure for the first Chrysler-produced stage at Michoud.

SATURN I SECOND STAGE

The second stages for Saturn I, called the S–IV, are being built by the Douglas Aircraft Corp., Santa Monica, Calif. (fig. 104). The contract with Douglas, approved in July 1960, covered procurement of four test stages and nine flight stages. A proposal is now being prepared for procurement and launch support of three additional flight stages.

The S–IV is 220 inches in diameter and 41 feet long. Six RL10A–3 engines, developing a total thrust of 90,000 pounds, power the stage. The LOX and liquid-hydrogen burning engine will be flight tested for the first time on the SA–5 vehicle. The RL10A–3 preliminary flight

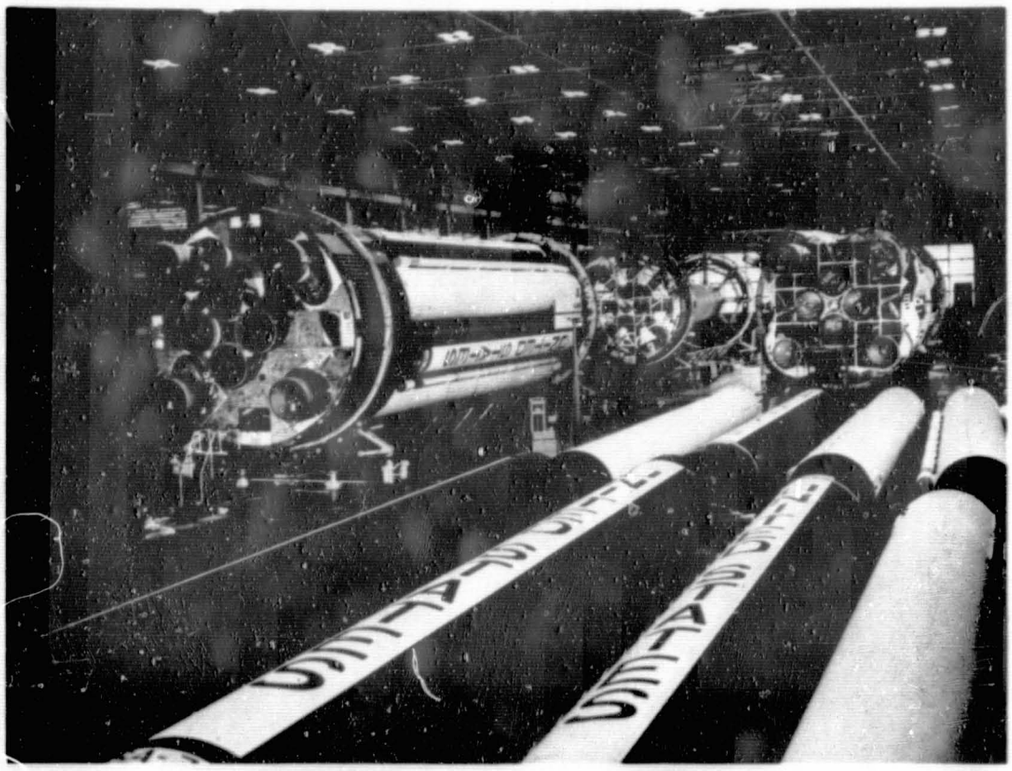

FIGURE 102.—S-I stages in assembly at Marshall Space Flight Center.

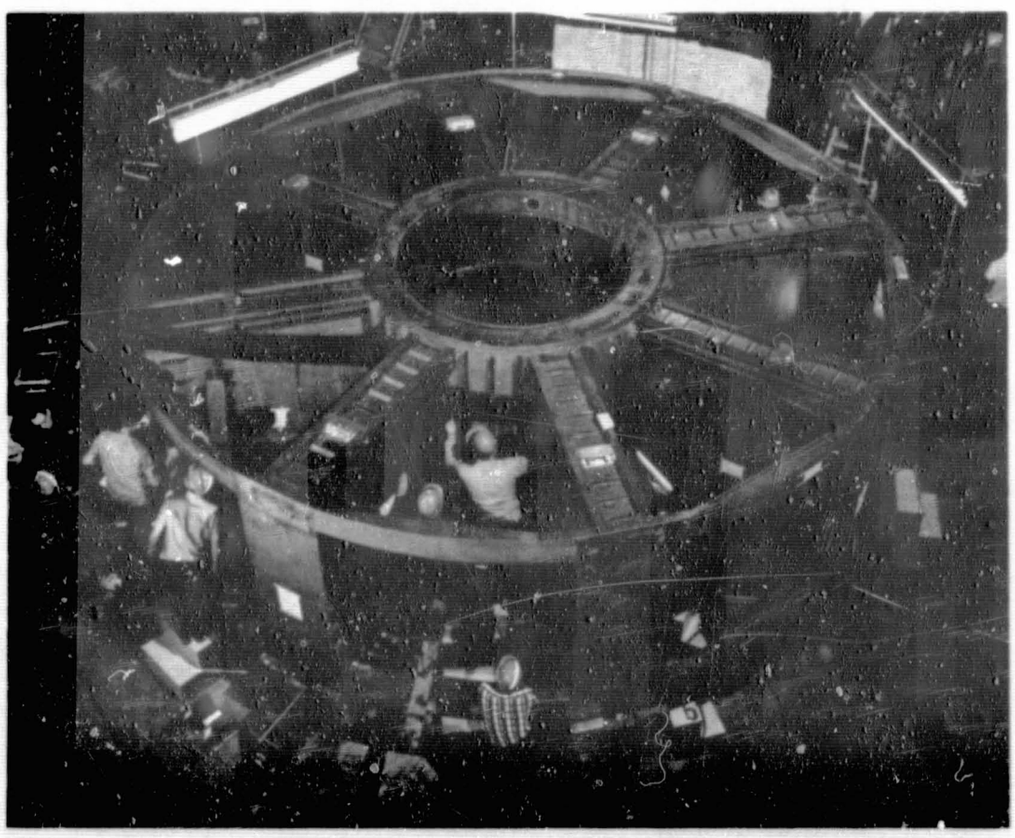

FIGURE 103.—Thrust structure for first Chrysler-produced stage.

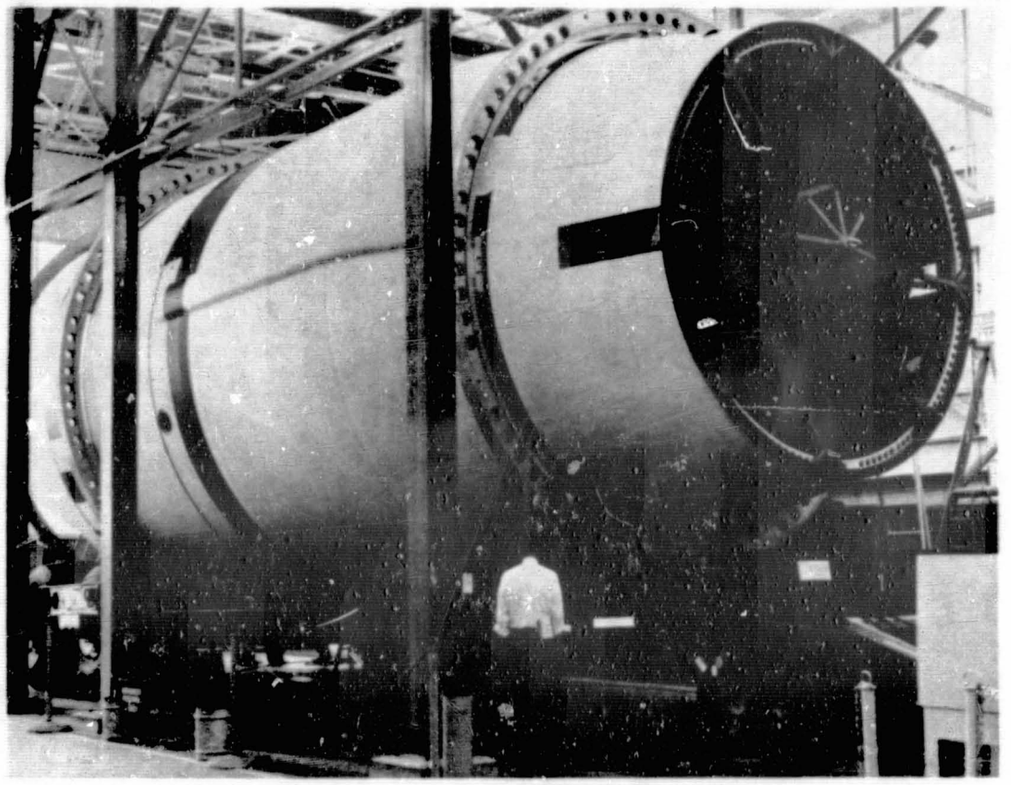

FIGURE 104.—Saturn I second stage.

rating tests were completed in mid-1962. The engine will complete qualification testing by the end of the year. Pratt & Whitney produces the engine in East Hartford, Conn., and tests them at their West Palm Beach, Fla., plant.

The first live S–IV stage will be flight tested on SA–5. Assembly of this stage has been hampered by late delivery of parts. However, steps have been taken to correct the deficiencies; and we do not expect to have parts shortages for subsequent vehicles.

Fabrication of second stages for the remaining R. & D. vehicles is on schedule at Douglas. Shown here (fig. 105) is the 1–4 production line at the Douglas plant. In late December, the contractor began parts fabrication of the S–IV stage for the first man-rated, operational Saturn I (SA–111). Work is continuing on schedule.

SATURN I TEST VEHICLES

The ground test programs comprise a particularly critical phase of stage and vehicle development. Ground test is our best chance to evaluate designs before they become flight hardware. It is here that we develop necessary handling techniques and secure masses of data on stage operational characteristics prior to actual flight. On the ground, we can stop and start at will. We can reinstrument and reevaluate. None of this is practical after the stage is lighted. It goes, then. There is no recall.

So, for a flight program with a minimum number of surprises, we have an intensive and detailed ground test program. This has been

FIGURE 105.—S–IV production at Douglas.

our approach in the S–I stage development. Test and test and test. It is more effective—and a lot cheaper—to ground test than to second guess a flight that did not work out the way it should have.

Now, in the test programs for the S–IV stage, at Sacramento, Marshall, and the cape, you can see a great deal of this test philosophy in action.

Since last August, we have been testing an S–IV battleship vehicle at the Douglas Sacramento test facility (fig. 106). "Battleship" refers to the thick walls of the propellant tankage which are considerably heavier than a flight stage. The battleship vehicle is the focal point for propulsion system testing. The first series of S–IV battleship tests were completed in November last year. During these tests, the six liquid-hydrogen engines were repeatedly fired. These tests also served to qualify the static test stand, which is a complex piece of equipment with unique design features. Because the S–IV engines will operate in a near vacuum, the stand simulates stage operational altitude: The first firing with operational flight-type engines was successfully completed this January with a full duration of 468 seconds. These battleship tests will continue through April.

Tests of the S–IV all-systems vehicle will also be conducted at Sacramento. The all-systems is a ground test stage equipped with flight-type, flight-weight systems. The tests will verify results of the battleship test program, and allow extensive engineering evaluation of the flight configuration performance. The all-systems vehicle was completed at Douglas last December and has since been erected at Sacramento. Testing will begin later this month.

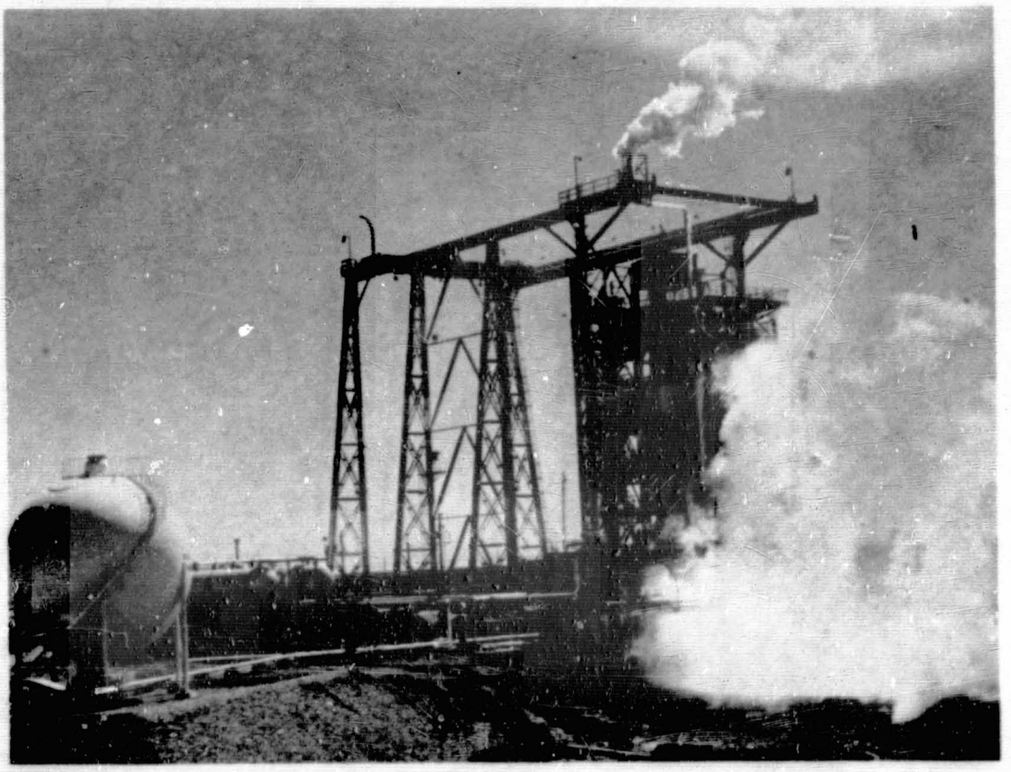

FIGURE 106.—S–IV battleship vehicle test at Sacramento test facility.

Other S–IV stage ground test programs are proceeding as scheduled. In late November, Marshall received an S–IV test vehicle (fig. 107) that is now being used in early dynamics testing of the two-stage Saturn I vehicle design. By midyear, we expect to begin dynamics testing of the two-stage vehicle with Apollo boilerplate modules. The S–IV dynamics vehicle was the first of the stages to be shipped from the Douglas California facility (fig. 108). A second ground-test stage was shipped in early December from Douglas to Cape Canaveral to check out propellant systems at Launch Complex 37B. This is in preparation for the first two-stage flight later this year.

SATURN I INSTRUMENT UNIT

The Saturn I vehicle instrument unit is being developed in-house at Marshall, with guidance, control, and related instrumentation being built by industry (fig. 109). The unit is a nonpropulsive, cylindrical structure located above the S–IV stage. This unit, 154 inches in diameter, houses the vehicle guidance and control systems, telemetering and measuring equipment, and associated electrical systems. We are progressing satisfactorily in the assembly and inspection of instrument units for the SA–5, SA–6, and SA–7 vehicles. Fabrication and assembly of major guidance components and instrumentation are being performed by Bendix, Sperry, and IBM.

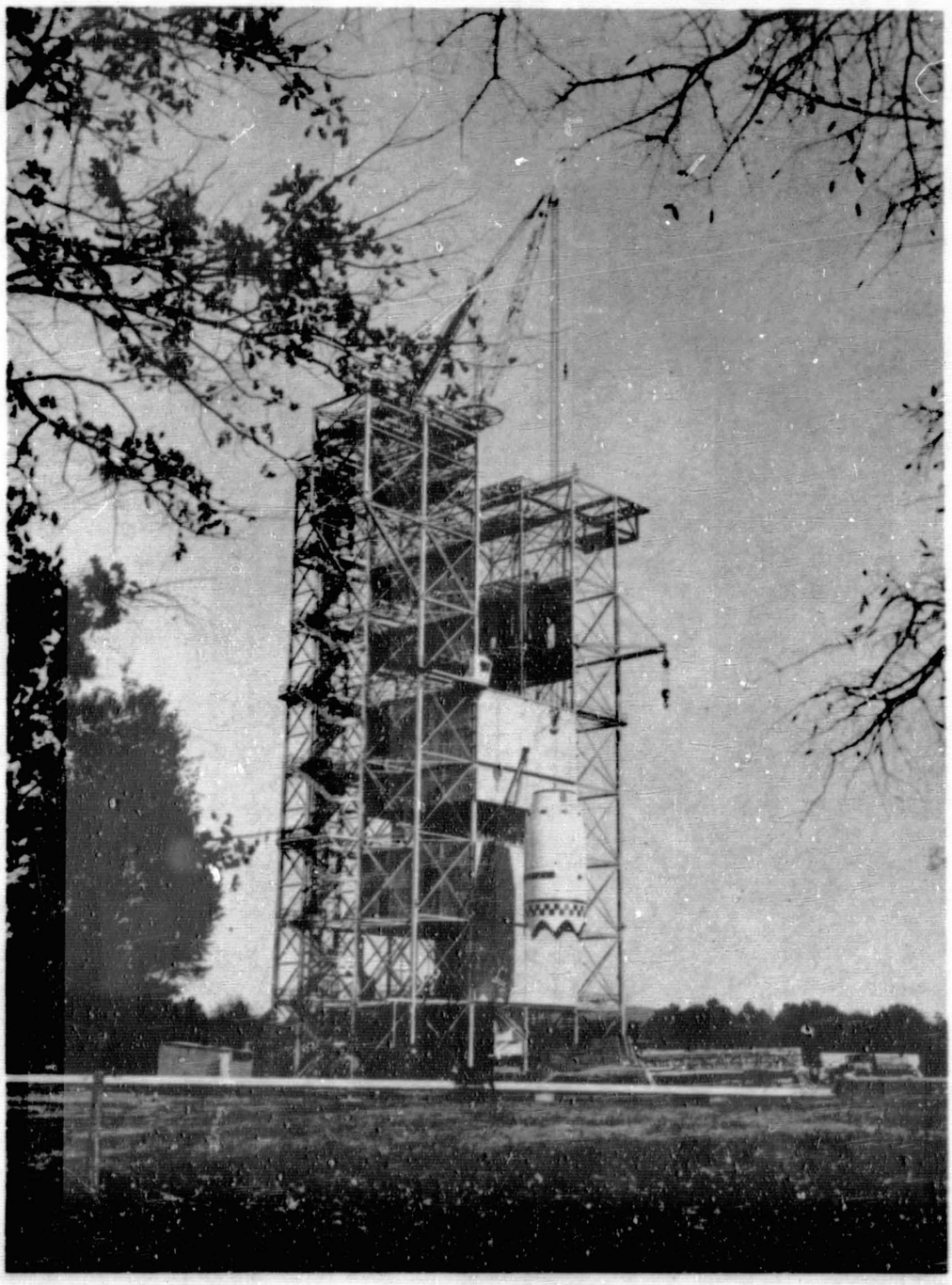

FIGURE 107.—Hoisting S–IV dynamics vehicle in Marshall dynamic test tower.

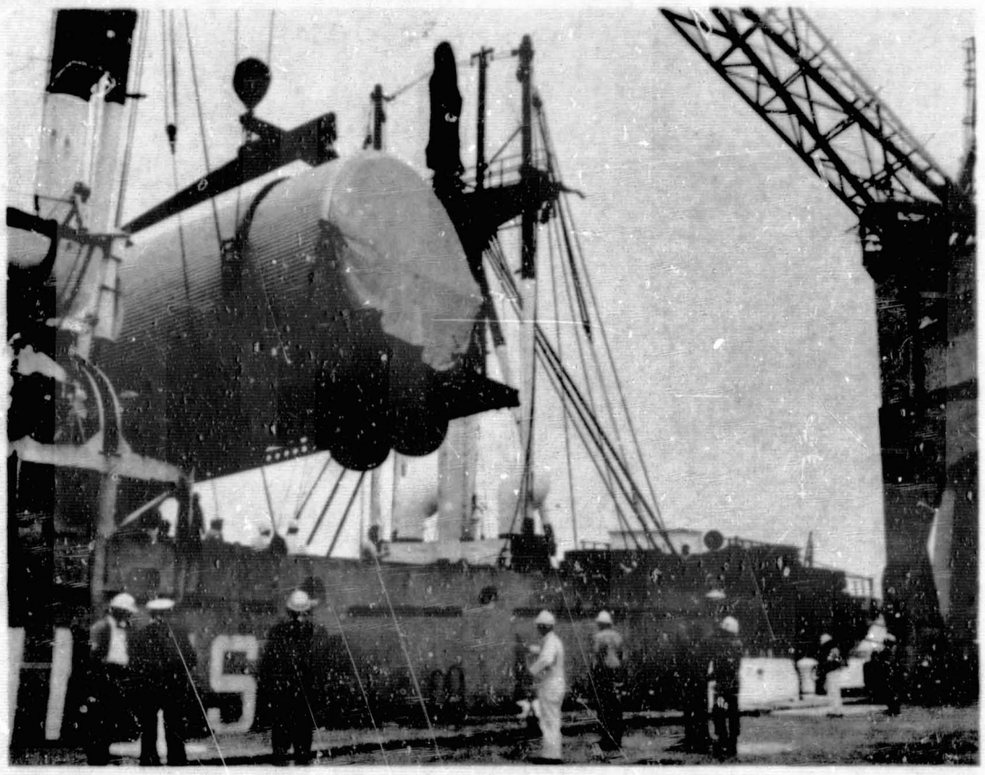

FIGURE 108.—Receipt of S–IV test vehicle at AMR.

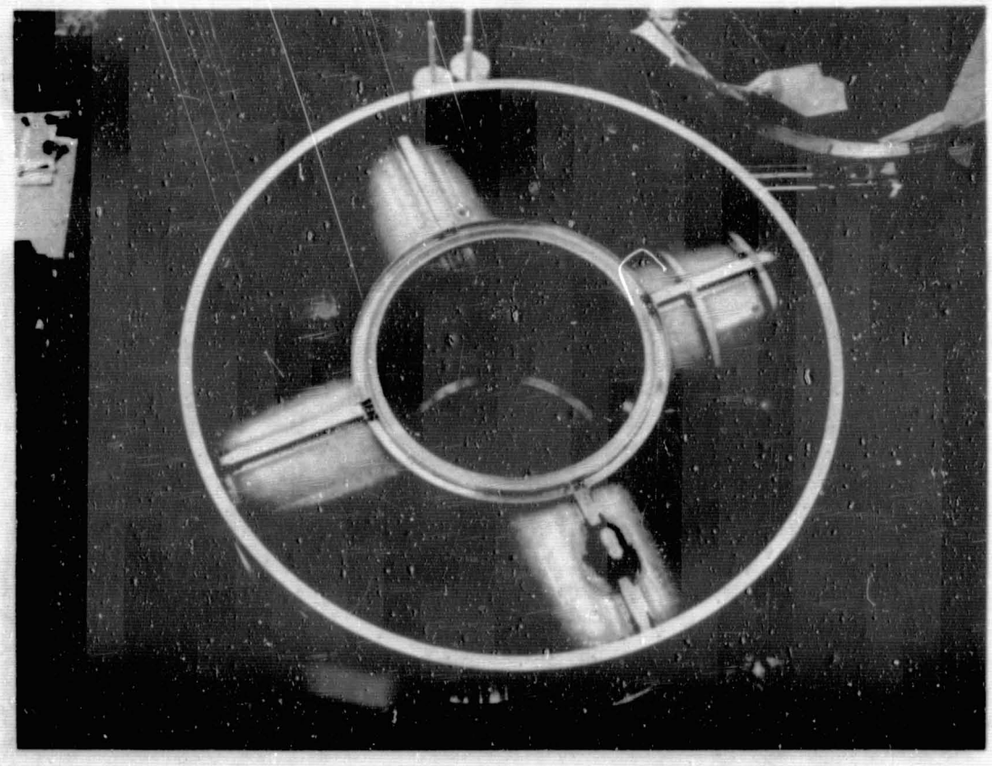

FIGURE 109.—Saturn I instrument unit during fabrication.

SATURN I LAUNCH PLANS AND MISSIONS

Three R. & D. Saturn I vehicles of our early design have been successfully launched from Cape Canaveral. The fourth vehicle was shipped from Marshall in January, and is now on the pad undergoing checkout for launch. The primary missions of these vehicles are to test the propulsion system, to verify the aerodynamic structural design of the first stage, and to insure that the interrelating components and subsystems operate properly in the true flight environment. Some of the secondary missions are a test of first stage retro-rockets, a test of heat-shield insulation, and early inboard engine cutoff.

Launch of the SA–5, first of the two-stage vehicles, is scheduled for this fall. Primary flight misisons are test of the redesigned man-rated booster, described earlier, test of the live second stage, performance of the instrument unit, and interaction of all components and subsystems during flight.

With the launch of SA–6, in the last quarter of this year, we will flight test an early Apollo spacecraft configuration for the first time. The SA–8 and SA–9 (fig. 110) vehicles will carry an additional experiment, a micrometeroid detection satellite. The satellite will collect information concerning the hazards of penetration by micrometeroids during space flight. The data will be used for the design of manned spacecraft systems. A contract was awarded to Fairchild Stratos Corp., Hagerstown, Md., in February to build three of these satellites, one as backup. The satellites are to be available for launch next year.

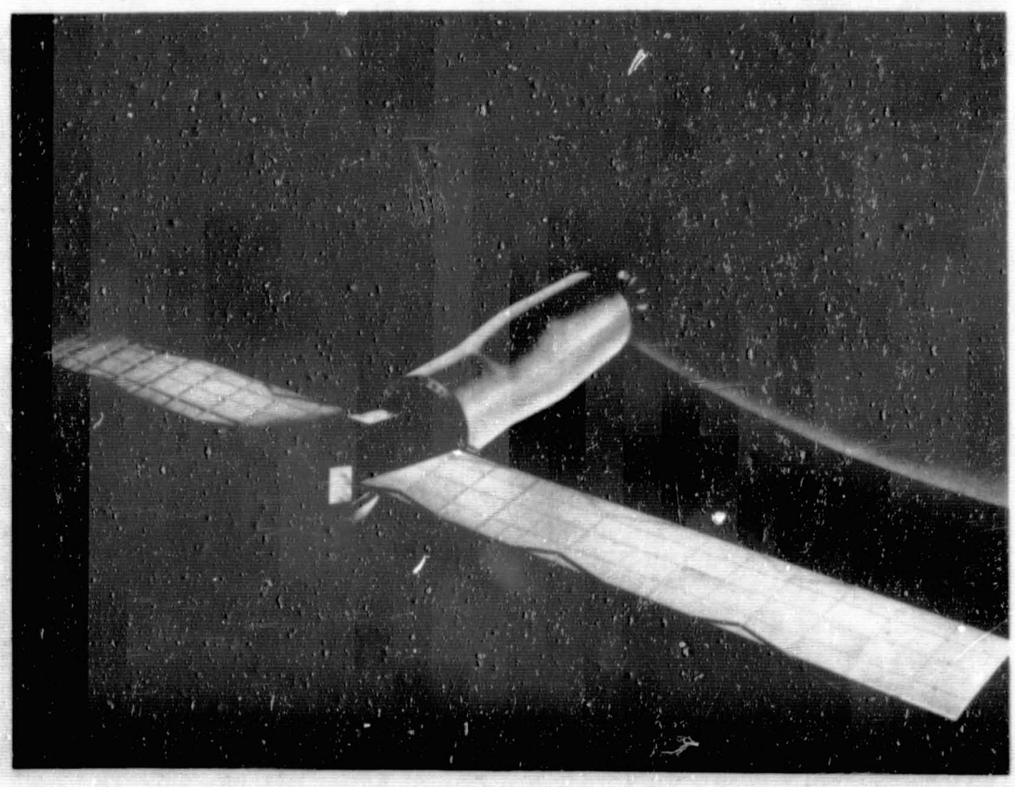

FIGURE 110.—Micrometeoroid satellite mission for Saturn I vehicles SA–8/SA–9.

SATURN I FACILITIES

The Michoud plant at New Orleans, La., was selected in late 1961 as the manufacturing site for the Saturn I, IB, and Saturn V first stages. Renovation and modification have been underway for about a year and a half.

Shown here (fig. 111) is the Chrysler area, which comprises about 40 percent of the present plant. Major tooling for fabrication of S–I stage assemblies has been installed. Fabrication work is proceeding on the first stages for both the SA–8 and SA–10 flight vehicles. All 70-inch and the 105-inch propellent tanks for the S–I–8 have been received from the vendor and work is proceeding, on schedule, toward

FIGURE 111.—Chrysler area of Michoud operations.

start of clustering in May. Buildup of the Chrysler fabrication and assembly areas will continue, concurrent with facility design which is proceeding on schedule. Complete activation is scheduled by the end of the year.

I shall cover the Boeing Michoud activities during the Saturn V portion of my discussion.

Activation of the computer facility, located at Slidell, La., is progressing satisfactory. This facility, situated about midway between the Michoud plant and the Mississippi test operations, will support the engineering computations required at both places. By the end of March the facility will be operational.

Construction of contractor facilities for production and test of the S–IV stage at Sacramento and Santa Monica was begun shortly after award of the contract in 1960 (fig. 112). All Sacramento S–IV facilities are now operational.

Development flights of Saturn I vehicles will be divided between Launch Complex 34 and 37–B. Following flight of the fourth Saturn I vehicle, final modifications will be completed at Launch Complex 34 for two-stage Saturn I launches. The modified facility will be operationally ready in the last quarter of this year.

The first two-stage Saturn I launches will be prformed at Launch Complex 37–B, located north of the present launch complex (fig. 113).

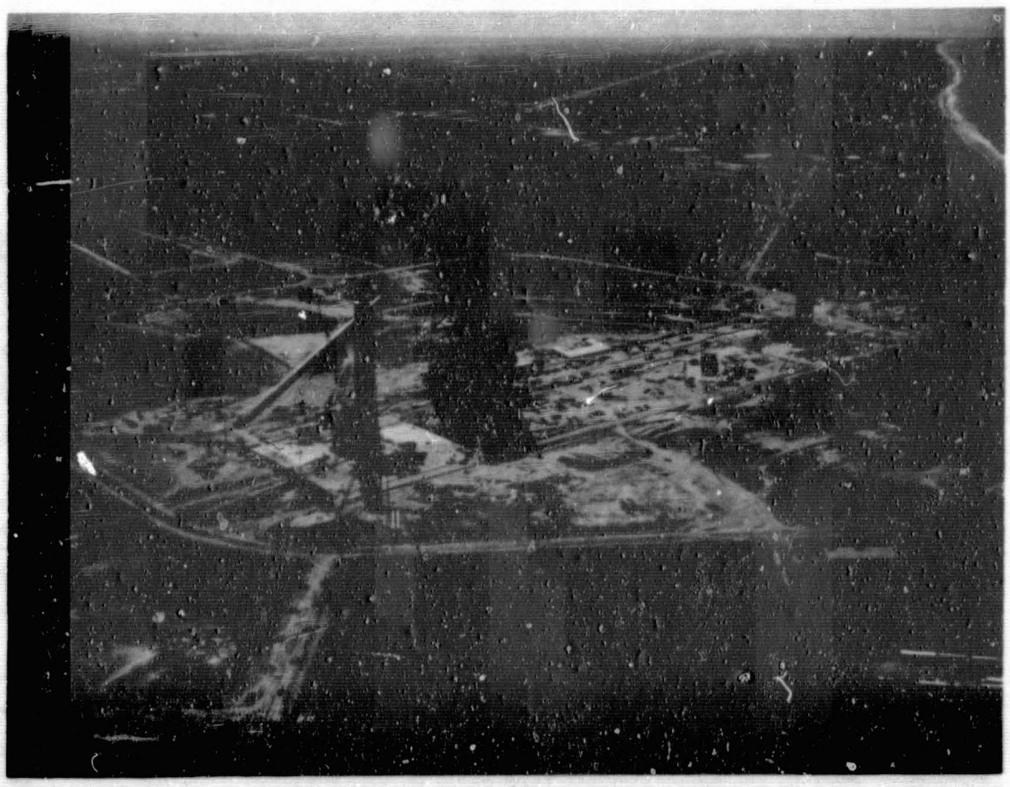

FIGURE 112.—Sacramento test facility.

Construction is on schedule. All elements of the facility needed to support the fifth flight vehicle are scheduled for availability in June.

SATURN IB

As I mentioned earlier, the Saturn I will be able to place about 11 tons of payload into low Earth orbit. For Apollo application, the payload would comprise a command module and a partially fueled service module. However a vehicle of increased capability is required to place the complete Apollo, including a partially fueled lunar excursion module, into Earth orbit.

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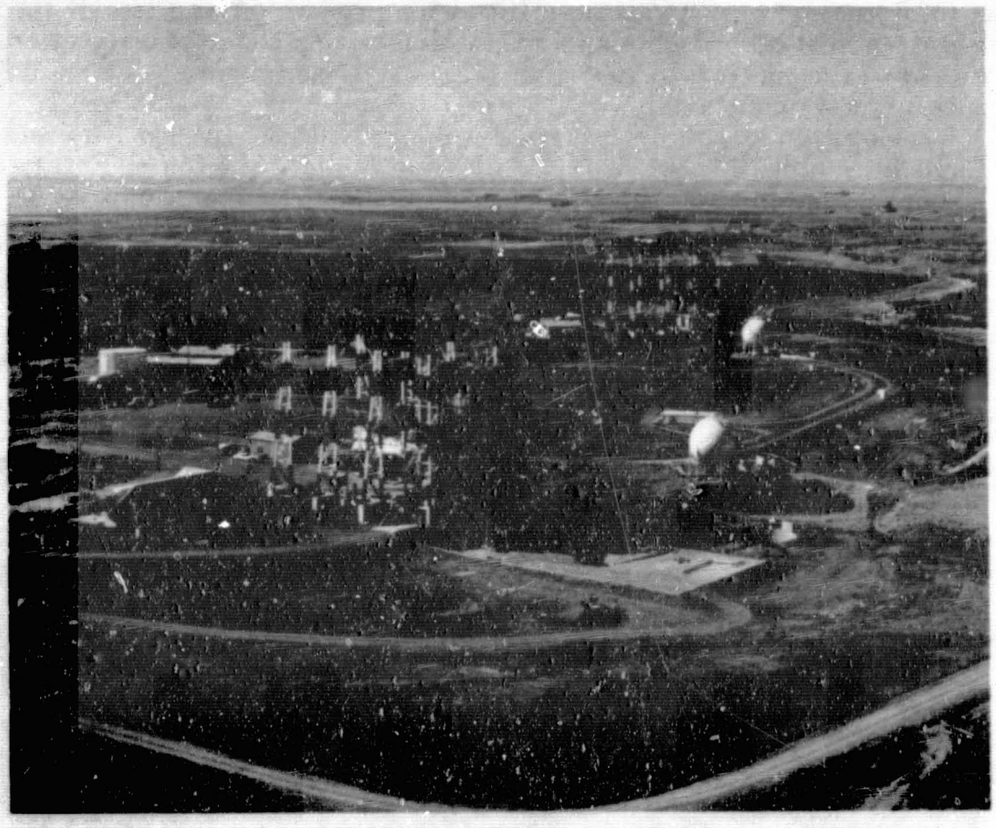

FIGURE 113.—Launch complex 37A/37B.

To support these flight missions, we are developing the Saturn IB, a two-stage, liquid-propellant launch vehicle system (fig. 114). The Saturn IB is a natural fallout of stages from both the Saturn I and V for potential high-payload applications. Essentially the vehicle will be a Saturn I with a new second stage. That second stage, identified as the S–IVB, will also be used, with slight modifications, as the third stage of the Saturn V. Vehicle guidance will be all inertial, using components qualified during Saturn I flights, and including an instrument unit similar to that to be used in the Saturn V.

Development costs for both stages and the instrument unit are primarily carried by the Saturn I and V programs. By applying the results of development programs already begun, we can secure, at minimum development cost, a vehicle capable of supporting advanced Apollo Earth-orbital missions almost a year prior to availability of the Saturn V.

A series of 12 launches of the Saturn IB are planned. The first four flights will be vehicle development tests, beginning in 1965 and ending in 1966. All development flights will use live first and second stages. The four development flights will carry unmanned developmental Apollo spacecraft modules. However, the flights are primarily concerned with qualification of the S–IVB stage, instrument unit, and overall vehicle.

Beginning in 1966 eight operational manned flights will be performed. All three Apollo modules will be launched into Earth orbit,

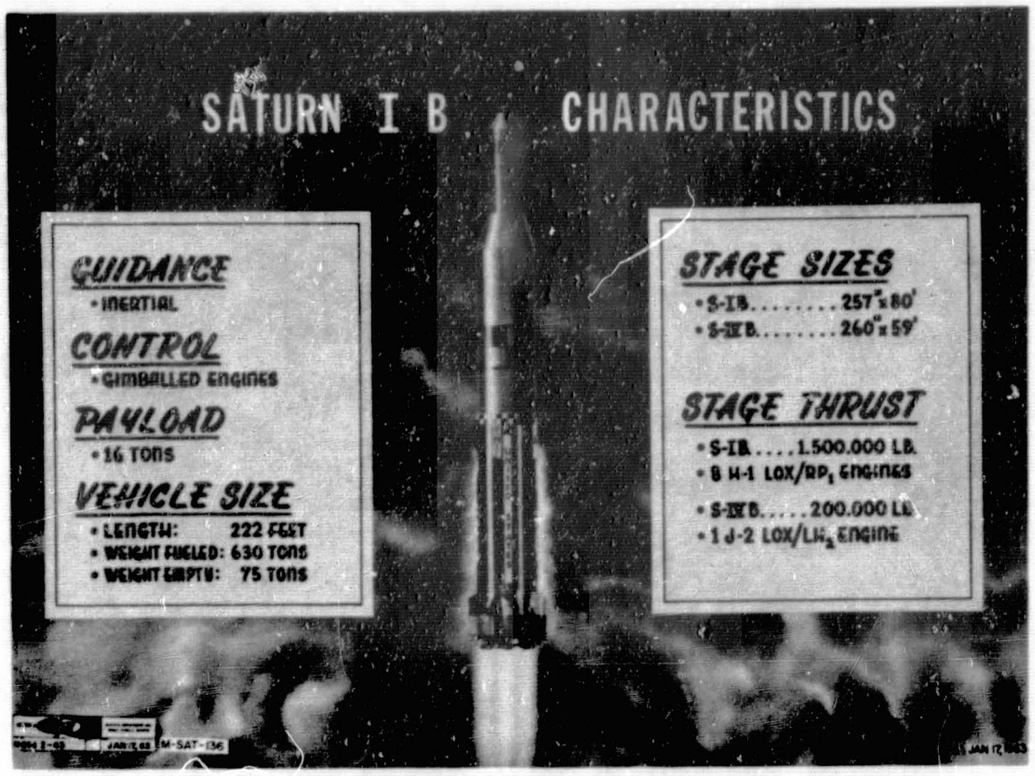

FIGURE 114.--Saturn IB characteristics.

with a partial fuel supply in the service and lunar excursion modules. During these flights the spacecraft crew will develop operational methods for deployment and docking of the lunar excursion module, and will further define spacecraft orbital maneuver techniques. By the conclusion of the operation Saturn IB flights, we will have fully tested, in Earth orbit, a large portion of the system required for the lunar mission.

SATURN IB FIRST STAGE

The first stage, the S–IB (fig. 115), is similar to the Saturn I first stage. Increased vehicle payload requirements made a slight weight reduction necessary, and it has been found desirable to incorporate a few other design features, based on our Saturn I flight experience. The stage will weigh about 16,000 pounds less. The propellant containers and the tail section assembly are being resized. Interstage requirements between the S–IB and the S–IVB have been defined and, last month, design of the interstage shroud was selected. Chrysler, contractor for the stage, was authorized last year to begin design effort. The required redesign is scheduled for completion by mid-1964.

SATURN IB SECOND STAGE

The S–IVB stage (fig. 116) is under development by the Douglas Aircraft Corp., and is being designed for use with the Saturn IB and V vehicles. The stage will measure almost 22 feet in diameter and 59 feet high. Liquid oxygen and liquid hydrogen are used as propellants, and the stage draws heavily on the liquid hydrogen stage experi-

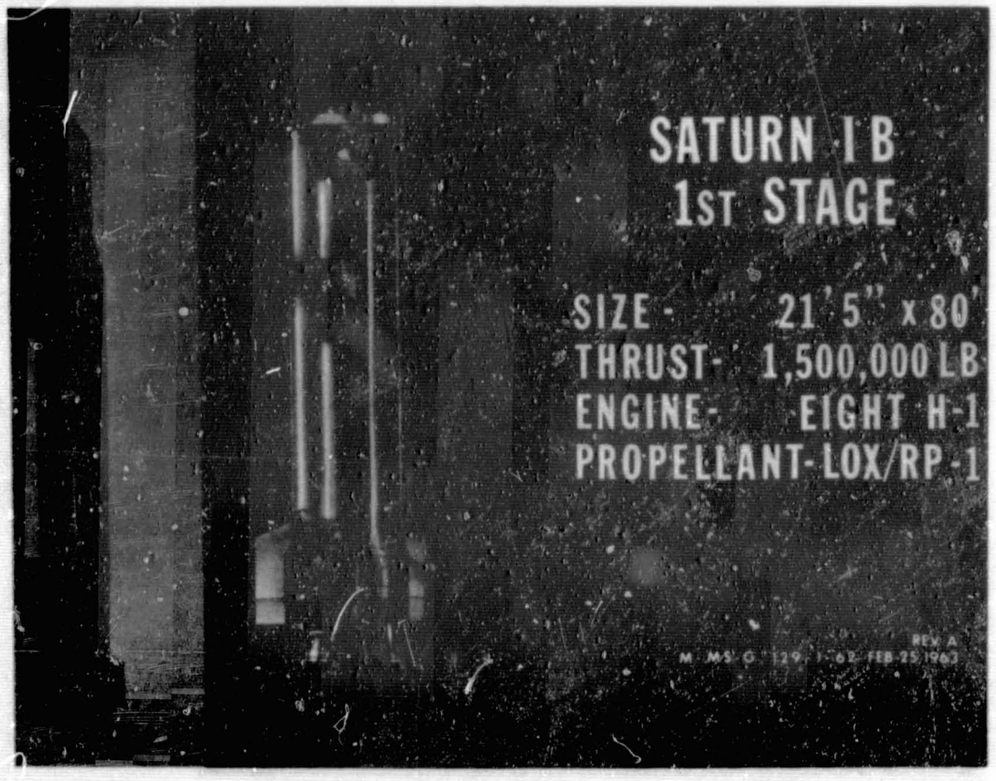

FIGURE 115.—Saturn IB first stage.

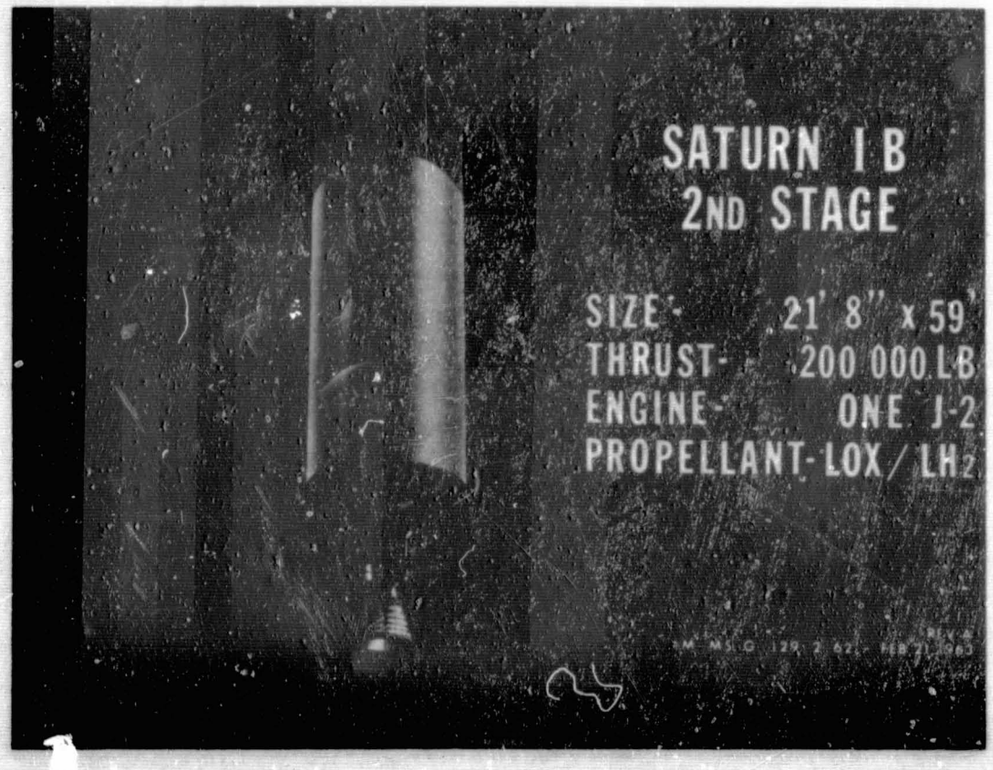

FIGURE 116.—Saturn IB second stage.

ence gained by Douglas during the S–IV development program. A single J–2 engine will provide 200,000 pounds of thrust under vacuum conditions. The J–2 will also be used on the S–II, the second stage of the Saturn V.

The J–2 engine has been under development by Rocketdyne for slightly over 30 months. The first long-duration, full-thrust firing, was performed in October last year. Preliminary flight rating tests will begin in the third quarter of this year. Engine qualification tests are to begin in about 2 years.

Stage design is proceeding on schedule. Fabrication of major tooling is already underway, with completion expected late this year. Vendors have been selected for development of the two basic attitude-control engines required for auxiliary stage propulsion.

Fabrication of parts began last December for the S–IVB battleship stage. This will be used at the Sacramento test facility to prove out the stage propulsion system and test site facilities for propellant handling and loading. Battleship testing is to begin during the first quarter of next year. Design of other ground test and flight stages is continuing on schedule.

SATURN IB INSTRUMENT UNIT

The instrument unit, under Marshall development, is located immediately behind the spacecraft. It will a cylinder 36 inches high and 260 inches wide, and will contain vehicle guidance and control instrumentation, instrumentation for telemetry and tracking purposes, and associated power and electronic systems. Bendix and IBM are developing, now, guidance components with designs to be completed by the fourth quarter this year. Flights of the vehicle stable platform are already being performed on Saturn I flights. The instrument unit is being funded from the Saturn V development effort.

SATURN IB FACILITIES

The facilities construction is proceeding on schedule. At the Douglas Sacramento test facility, a new test complex is being constructed for ground test of S–IVB Battleship and flight stages under simulated operational flight conditions (fig. 117). Site preparation was completed early this year. Construction contracts are to be awarded this month. Three test positions will be built at SACTO for Battleship, all systems, and flight vehicle acceptance. Development of design criteria for this latter facility is to begin next month, with construction to be completed late in 1964. Construction of the Douglas Huntington Beach facility began early this year. The facility will be used for S–IVB final assembly and checkout, and will be ready to begin operations in October of this year.

Development flights of the Saturn IB will be launched from the Atlantic Missile Range, using launch complexes 37–A and 37–B. Construction of Launch Complex 37–A, scheduled for completion early in May, is slightly ahead of schedule. The service structure, which will service both the A and B complex, will be completed about the end of this quarter. The Launch Complex 37–B will be used for both the Saturn I and IB launches.

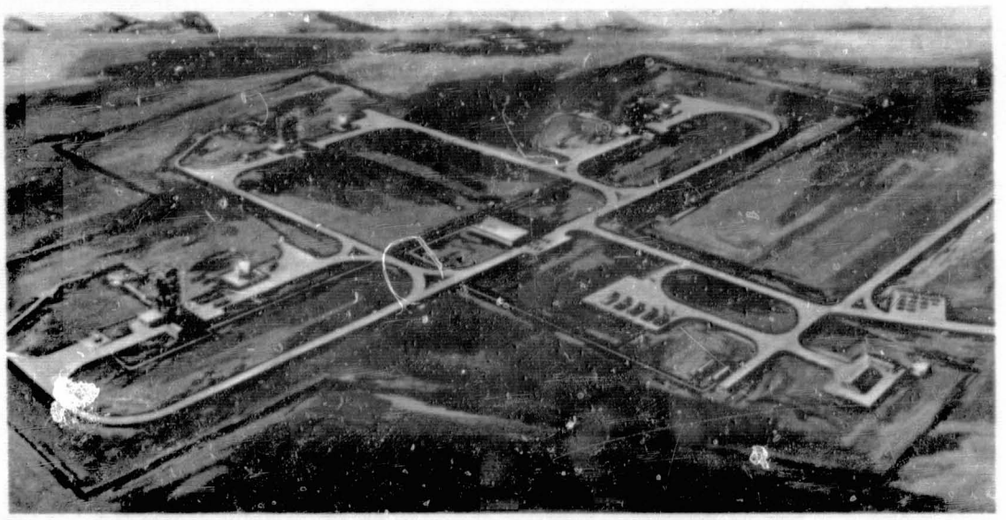

FIGURE 117.—S–IVB static test facilities at Sacramento test facility.

SATURN V

To place the Apollo spacecraft into an Earth-lunar trajectory, we require a vehicle of far greater performance and technical sophistication than is provided by the Saturn IB. To escape from the Earth's gravitational field, the spacecraft must be accelerated to an escape velocity of 25,000 miles per hour (fig. 118).

To support this flight mission, we have begun development of the three-stage Saturn V. Here you see the Saturn V, a liquid-propelled vehicle capable of orbiting about 120 tons or escaping 45 tons toward the Moon. It will be inertially guided by components carried in an instrument unit mounted above the third stage. Vehicle development was approved in January 1962, with the mission of supporting manned circumlunar flights and manned lunar landings.

Within 5 years from development approval, the first Saturn V R. & D. flight vehicle will be launched from launch complex 39 at Cape Canaveral. The vehicle will consist of a live first stage, two inert upper stages, and an unmanned developmental spacecraft. The flight will test the first-stage propulsion system, and the vehicle structure and control system.

The next two vehicles are scheduled to be launched during the same year. The second flight will use a live second stage. The flight mission will include S–IC/S–II separation, test of the second-stage propulsion system and performance, as well as another test of the first stage. The third flight vehicle will carry three live stages. The spacecraft carried by this vehicle will be subjected to the complete launch exit environments. Spacecraft experiments, such as high-speed reentry, will begin with the fourth launch.

The first manned flight with the Saturn V will occur with the seventh launch, presently scheduled for 1967.

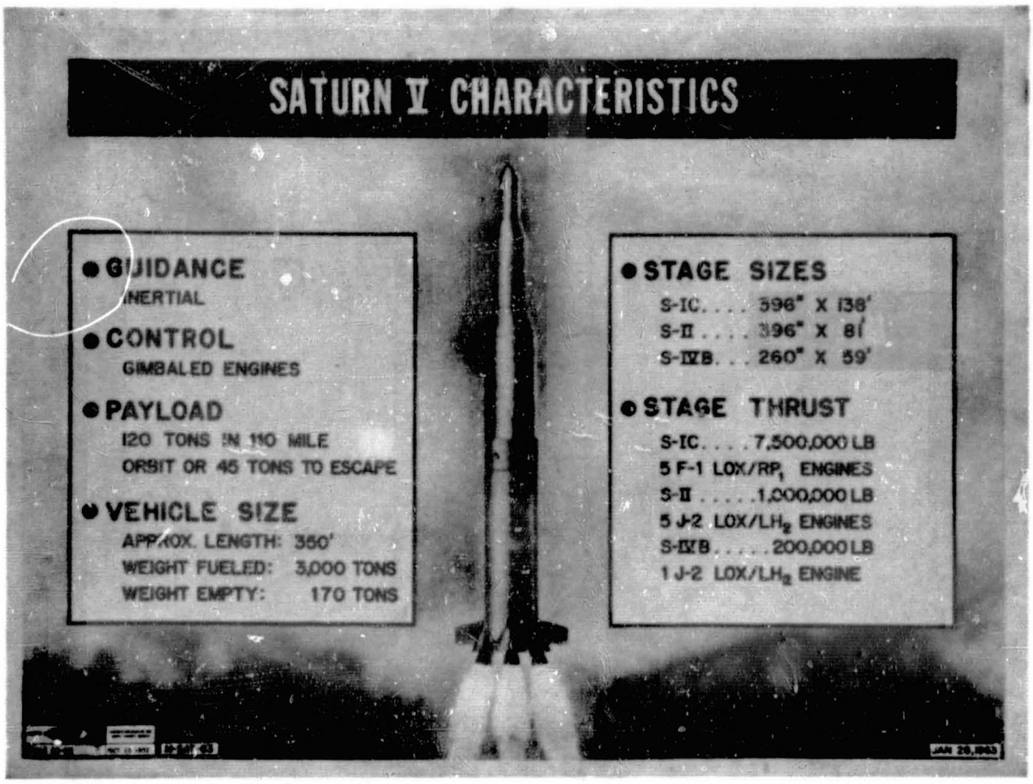

FIGURE 118.—Saturn V characteristics.

SATURN V FIRST STAGE

This slide illustrates the S–IC stage (fig. 119). It is 33 feet in diameter and 138 feet long. The initial thrust for the 6-million pound Saturn V will be generated by five Rocketdyne F–1 engines burning LOX and kerosene. The combined thrust of these engines is 7.5 million pounds at sea level.

Stage design work is being done in a combined effort by Marshall and Boeing personnel. Tooling fabrication and some component design is being performed by Boeing at their facility in Wichita. Three of the ground test stages and the first flight stage will be assembled at Marshall. The other 10 stages called for in the contract, which was signed about 2 weeks ago, will be produced by Boeing at the Michoud plant in New Orleans, La. This phasing will allow the fastest possible stage development and production, coupled with optimum transfer of experience gained by Marshall in vehicle development.

Preliminary stage design and layout were completed late last year. Engineering design for production is on schedule, and engineering tests are being performed now.

We started the S–IC tooling buildup at Marshall late last year, and it is progressing satisfactorily (fig. 120). Here you see one of the bulkhead tools installed at Marshall. The tools and fixtures were fabricated by Boeing at their Wichita, Kans., plant.

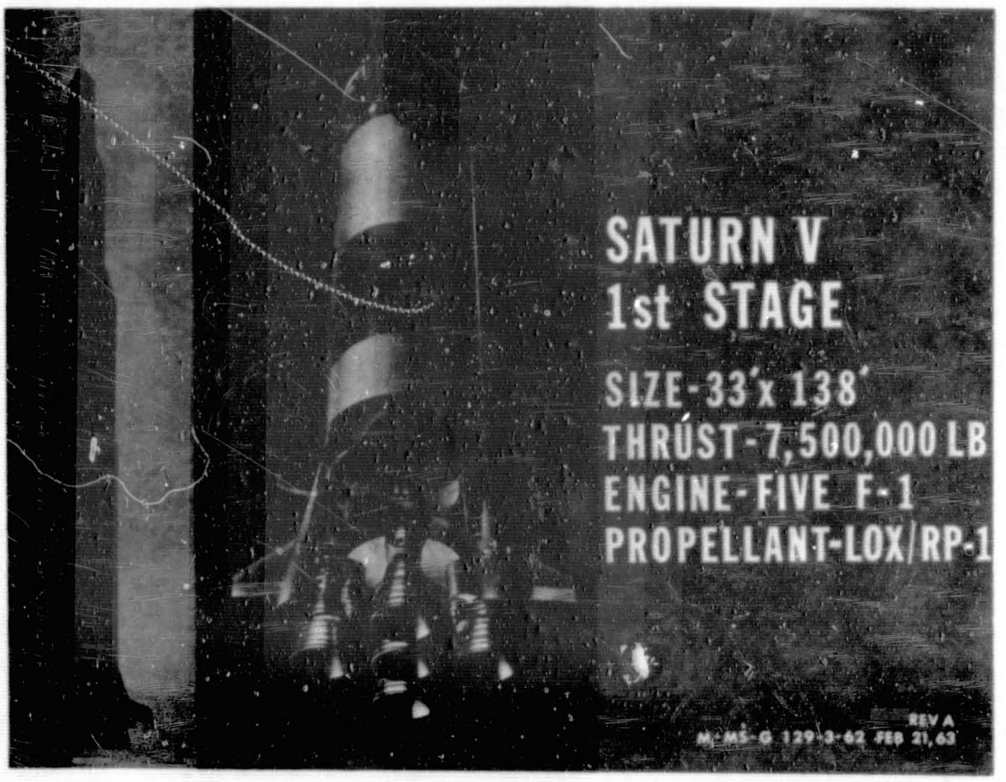

FIGURE 119.—Saturn V first stage.

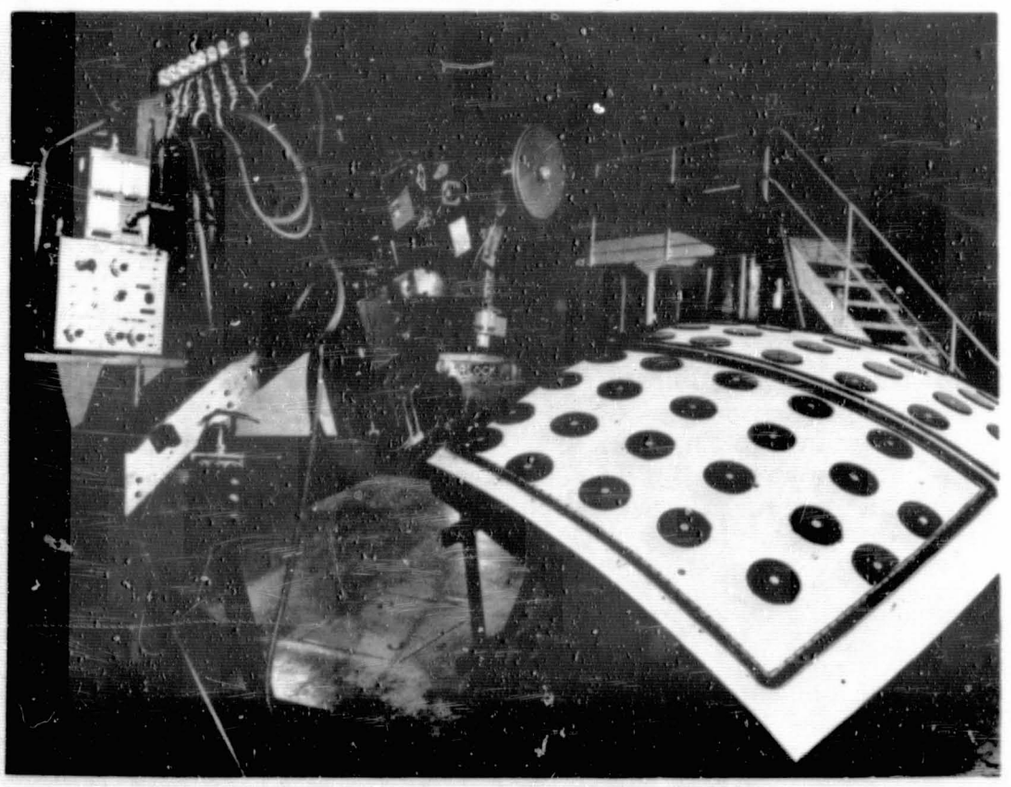

FIGURE 120.—Saturn V first stage gore segment weld and trim fixture at Marshall.

Last month, Boeing began fabricating fuel tank segments at Wichita. These segments will be shipped to Marshall for use in early buildup of a ground test stage.

At the Michoud plant in New Orleans (fig. 121), production buildup is continuing. This 40-foot boring mill has already been used by Boeing to fabricate th efirst Y-ring, a 2-ton structural element of stage tankage. The Y-ring has been received by Marshall, and we will use it to qualify some of our tooling.

The first Boeing-produced stage, a ground test vehicle, is scheduled to roll out the Michoud doors in late spring 1965.

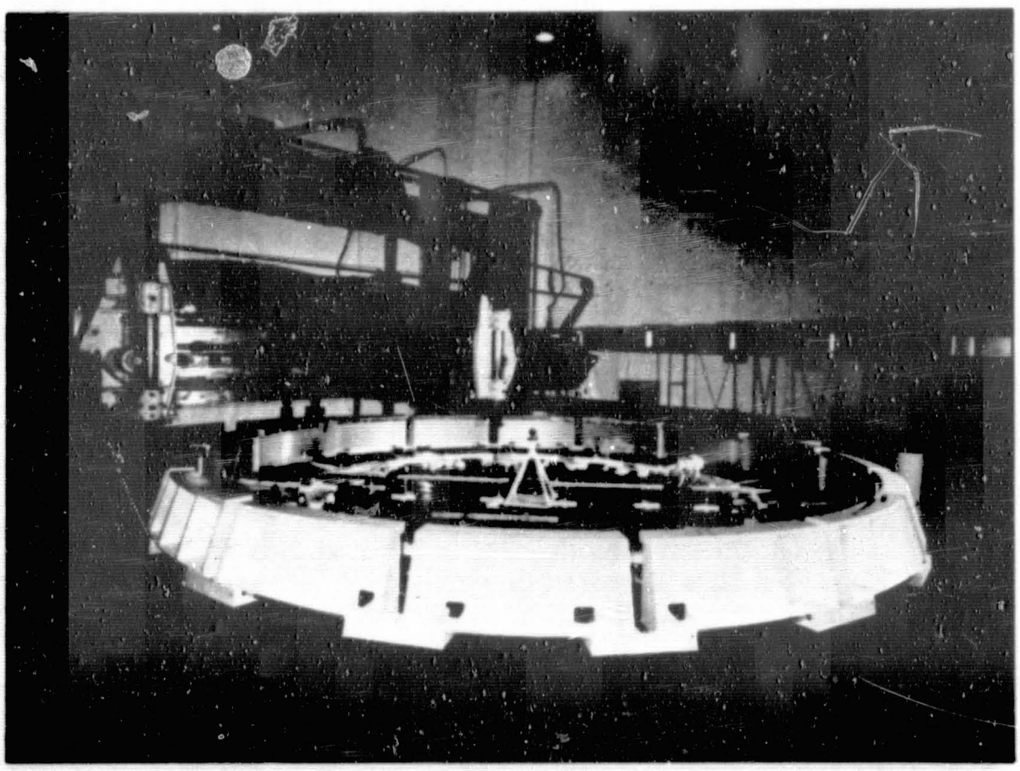

FIGURE 121.—Boring mill at Michoud.

SATURN V SECOND STAGE

The Saturn V second stage (fig. 122) called the SII, is shown here. It is 33 feet in diameter and 81 feet long. The stage is powered by five Rocketdyne J–2 engines producing a combined thrust of 1 million pounds under vacuum conditions.

The design, production, and test of this stage is being performed by the Space and Information Systems Division of North American Aviation, Inc., Downey, Calif. A preliminary S–II contract was awarded to the Space and Information Division in September 1961. On October 12, 1962, NASA approved the S–II stage definitive contract, which calls for five ground test stages and nine live flight stages. Delivery of the first live flight stage is scheduled for April 1966.

At the present time, engineering design is on schedule. Space and Information Division completed the preliminary stage criteria and layout last summer. Engineering testing, mostly with models, is progressing satisfactorily.

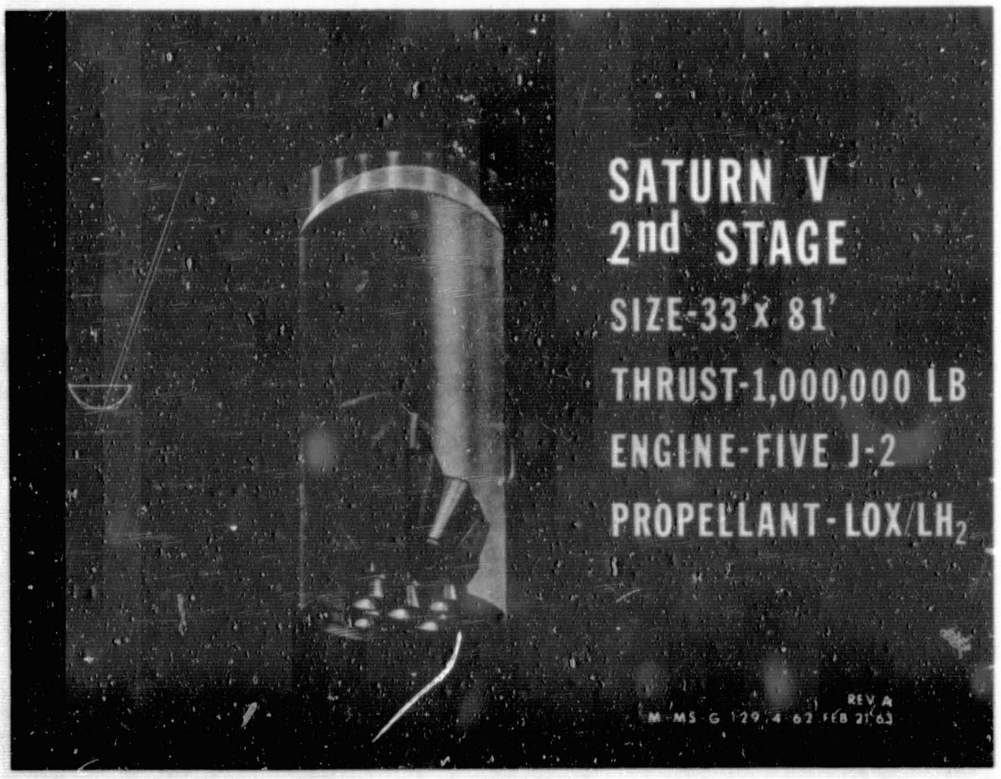

FIGURE 122.—Saturn V second stage.

One of the engineering models being used by Space and Information Division, NAA, is shown in this slide (fig. 123). It is a full-scale

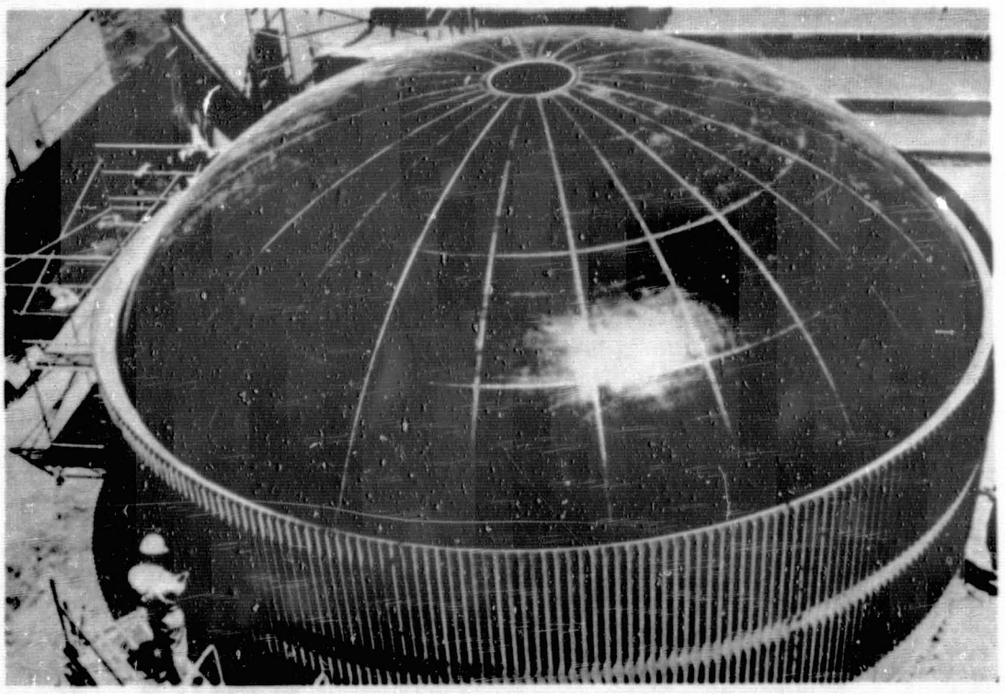

FIGURE 123.—Saturn V second stage bulkhead and mockup skirt assembly.

bulkhead mockup. Among other things, it is being used to determine a satisfactory method for the bulkhead fabrication.

Stage tooling is being produced by the North American Los Angeles Division and is being installed in the Government-owned Seal Beach assembly facility.

Space and Information Division has begun the fabrication of S–II Battleship stage components and should begin live ground firing tests in mid-1964. Fabrication of the all-systems stage will start in mid-1963. It will be placed in the all-systems test stand at Santa Susana, Calif., during the first quarter of 1965.

SATURN V THIRD STAGE

I have already described the Saturn V third (fig. 124), or S–IVB, stage. So I will limit my mention of it very briefly here.

The contract for the design, production, and test of the Saturn S–IVB stage was awarded to the Douglas Aircraft Co. last August. The contract which is now being modified will require a total of 5 ground test stages and 10 flight stages for the Saturn V and 4 flight stages for the Saturn IB.

The instrument unit for the Saturn V will be carried directly above the S–IVB. As I mentioned earlier, the unit is being designed and built by Marshall for both the Saturn IB and the Saturn V. Design and engineering for the unit is on schedule. It will be completed late in 1963 and will be followed by a test program beginning in early 1964.

FIGURE 124.—Saturn V third stage.

SATURN V FACILITIES

At Marshall, construction and modification of the Saturn V facilities is proceeding satisfactorily (fig. 125). Here you see an artist's concept of one of the facilities under construction at Marshall, the S–IC static test stand. The stand foundation, which extends about 35 feet below ground surface, was completed last December. Construction of the 420-foot high superstructure started immediately after foundation completion. By August 1964, the first S–IC static firing will be performed in this stand.

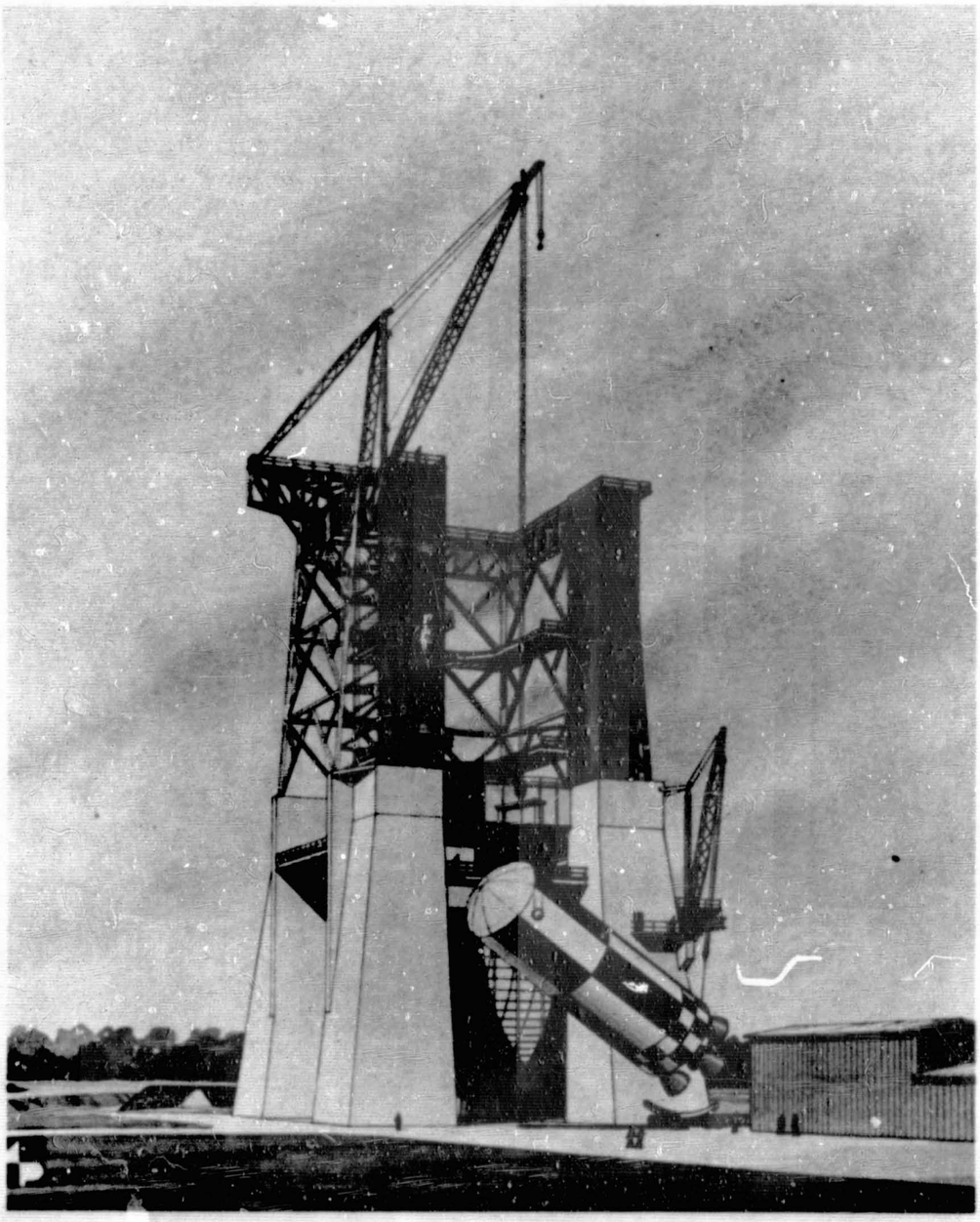

FIGURE 125.—Saturn V first stage static test facility.

Here is another test facility to be built at Marshall (fig. 126), the Saturn V dynamic test stand. In this stand, beginning in April 1965, we will test a complete three-stage Saturn V vehicle for response to simulated flight environment, including vibration levels, body bending modes, and other dynamic criteria. Design of this stand was completed a few weeks ago and the construction contract has just been awarded. It will be completed by mid-1964.

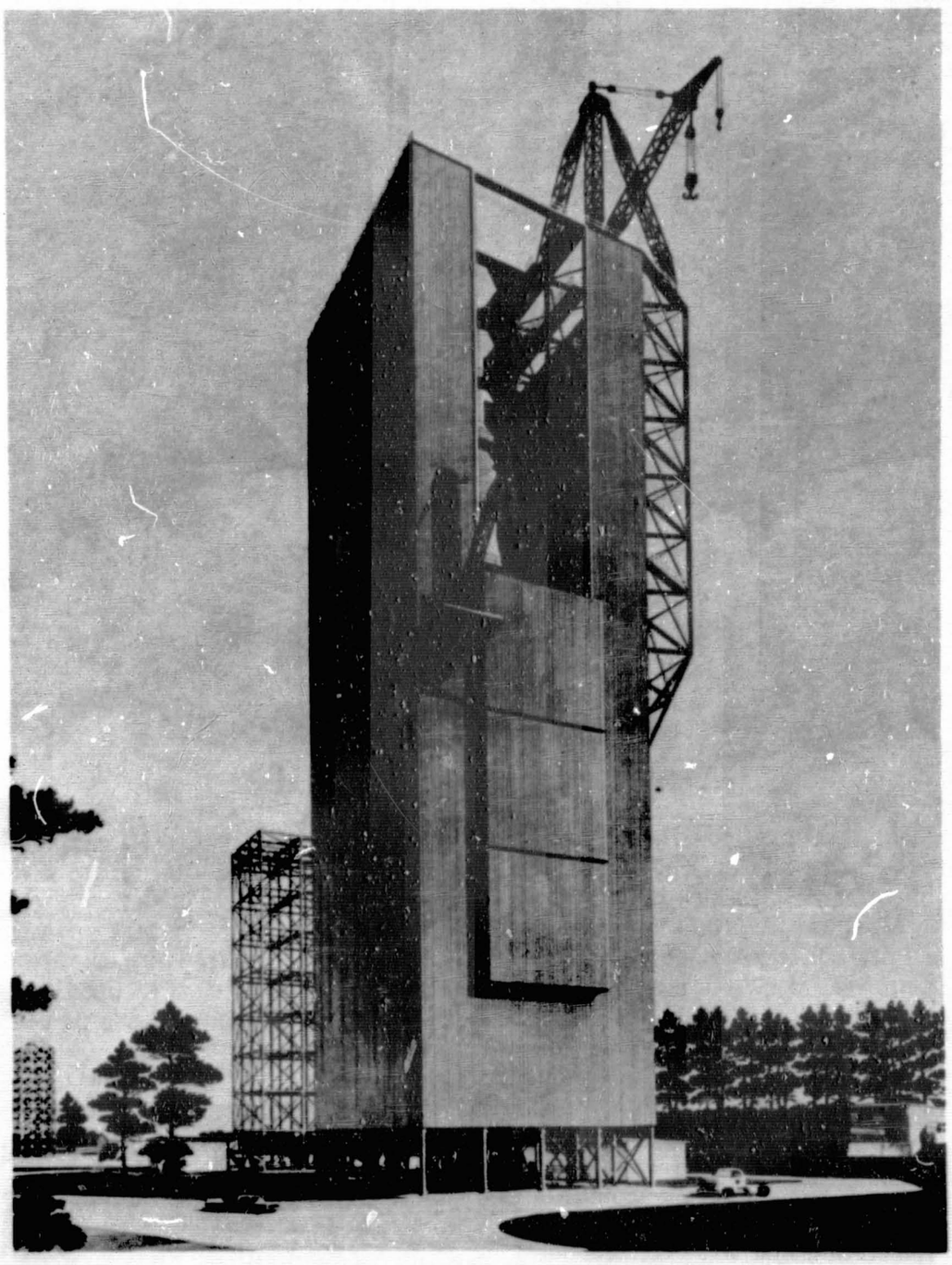

FIGURE 126.—Saturn V dynamic test tower.

Construction and modification at our Michoud plant (fig. 127) are proceeding on schedule. By early 1964, the S–IC portion of the plant should be completely activated. Tooling is now being procured.

The major construction effort at Michoud is the vertical assembly building, shown on the righthand side of the slide. This structure, over 200 feet high, will, when finished in November of this year, be used to assemble and hydrostatically test S–IC stages.

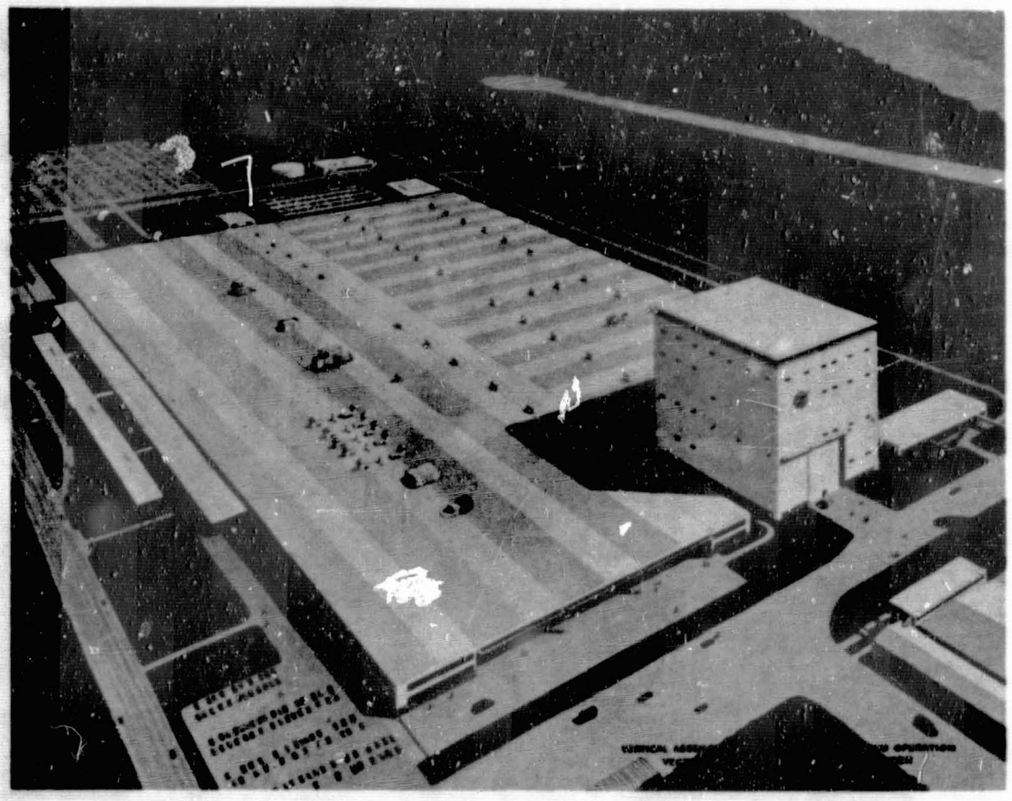

FIGURE 127.—MSFC Michoud plant.

The stages produced at Michoud will be static tested at the Mississippi Test Operations, about 39 miles east of Michoud (fig. 128), and the S–II stage will later be acceptance tested at this site.

Most of the 13,500 acres, which the Government is acquiring outright, has been obtained. Easements are being secured on the surrounding 128,000-acre buffer zone. This outer area can be used for farming or grazing, but will not be open to habitation because of the high-level noise and vibrations caused by the firings.

Design criteria for the test facility were completed just a few days ago. We are on schedule, and have reached the point where the people in this area will begin to see dirt being moved and buildings being constructed.

Construction is on schedule at other Saturn facilities. The S–II bulkhead fabrication building at the Seal Beach assembly and test facility is nearing completion (fig. 129). Last month, NAA's Space and Information Division began installing the first fabrication tooling

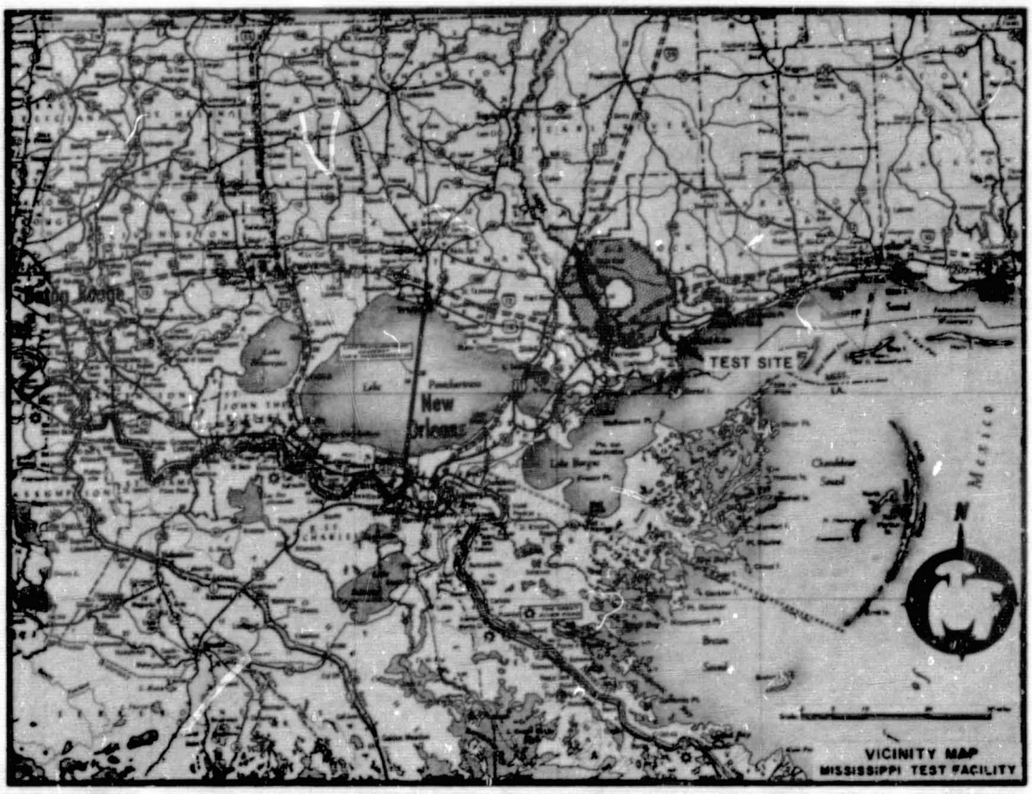

FIGURE 128.—MTF and Michoud facilities vicinity plan.

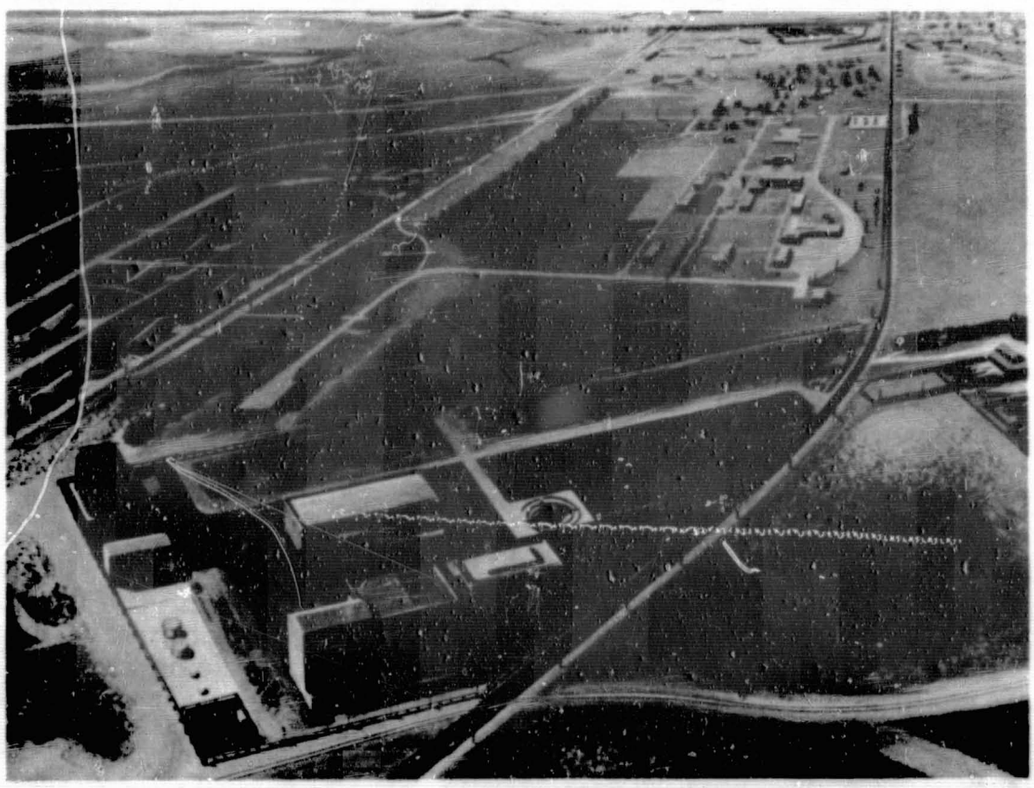

FIGURE 129.—Seal Beach facility.

in this building. Construction at Seal Beach started early last September. Work on the other buildings shown in the slide is well underway, and the facility should be activated early in 1964. To summarize briefly, the S–II high-energy forming production facility at El Toro, Calif., has been completed. Construction at the Santa Susana static test area is also on schedule, and the facility should be completely activated by November 1963.

At Cape Canaveral (fig. 130), site preparation for the Saturn V Launch Complex 39 is progressing satisfactorily. The ground is being cleared and design criteria for the vertical assembly building were completed last December. Drawings and specifications should be completed by next August.

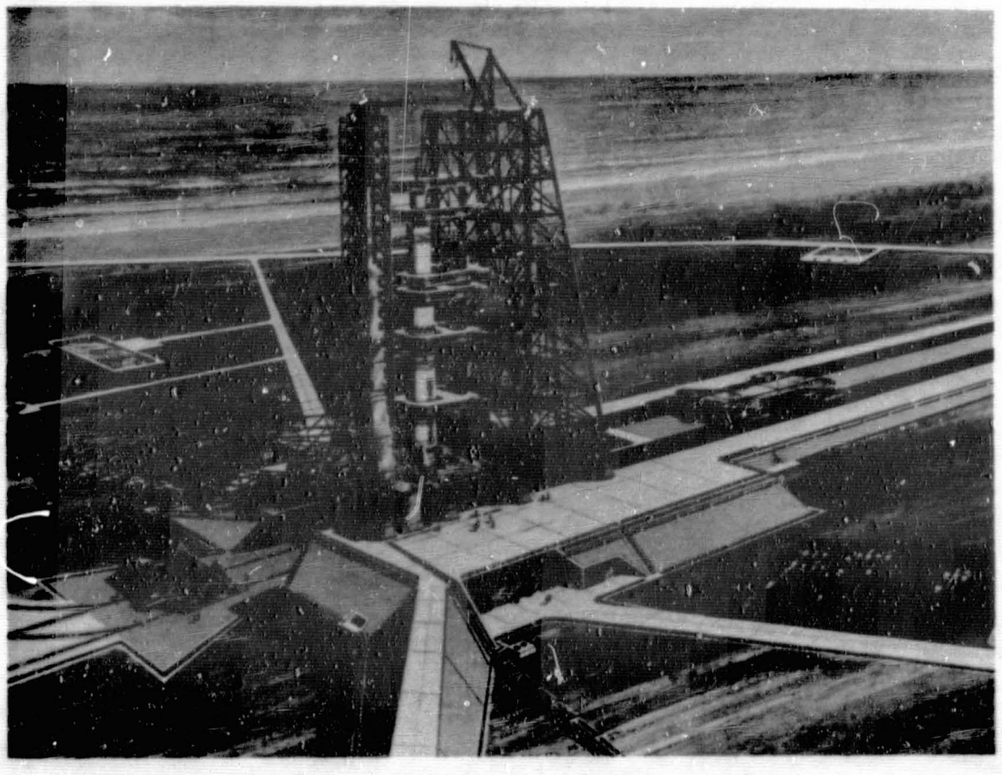

FIGURE 130.—Servicing Saturn V at launch complex 39.

This concludes my summary review on the status and plans for the Saturn programs. I would now like to address myself specifically to the status and plans for the F–1 engine prokram (fig. 131).

F–1 ENGINE: DESCRIPTION

The F–1 engine is the largest liquid propellant engine in the free world. A single engine produces 1½ million pounds of thrust. To obtain this level of thrust, 3 tons of kerosene fuel and liquid oxygen are pumped into the thrust chamber every second, using a turbopump on the engine which develops 60,000 horsepower. The engine is 13 feet across at the exit and stands 18 feet high. It weighs 10 tons.

We have used in this engine the same basic design principles as were used in prior liquid rocket engines, such as the Redstone, Thor,

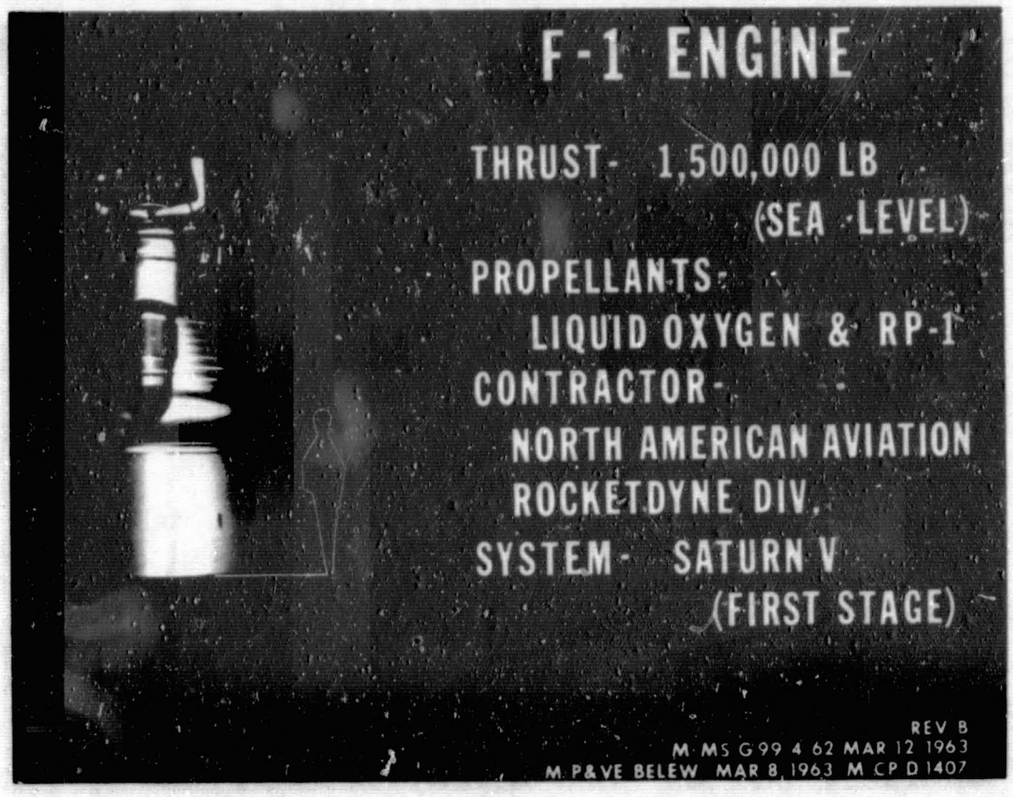

FIGURE 131.—F–1 engine.

Jupiter, and Saturn I. The propellants used are also the same as on those engines. At the same time, however, we have found it possible to make improvements and simplifications based on our prior experience.

PROGRAM HISTORY

The initial studies for the F–1 engine were performed in 1958. They showed that an engine of this size would be feasible to design and build. The contract for development was signed with the Rocketdyne Division of North American Aviation in January of 1959. Shortly after establishment of the Marshall Space Flight Center as a part of NASA, the technical management responsibility was transferred from NASA headquarters to the center.

Since that time, a number of research and development engines have been built and a total of 266 test firings have been made. In the early part of the program engine systems testing was aimed at determining the interaction of components during the critical start transition phase of operation. Consequently, most tests were of short duration.

FACILITIES

Concurrent with the engine development program, work was pursued on the design and construction of the largest engine test facilities in the country. These test stands are located in the Mohave Desert in California, at Edwards Air Force Base.

Because of the size of the stands, a major development effort was necessary to obtain the test equipment for use on these stands. For example, the valves in the propellant lines supplying the engine weigh 6 tons each. No experience or test equipment was available on the design and flow tests of such valves, and much of the development had to be done as part of our program. We now have in operation three engine test positions and a special test stand for testing of the thrust chamber. When delivery of production engines begins, next year, we will require additional test positions for checkout and calibration firings, and for that purpose, three new test stands are now under construction. Additional manufacturing space is being provided at the contractor's home plant to enable him to make and deliver the quantities of F–1's which our plans require.

PROGRAM STATUS

The F–1 engine development program has an impressive list of accomplishments. A year after the contract was signed full-scale components were undergoing tests, and in 27 months complete engine systems testing had begun. Full thrust and full duration tests have become routine. The engine has been gimbaled during hot firing. We expect successful completion of the preliminary flight rating tests this year.

By the end of this year F–1 engines will be delivered to MSFC and will be committed to ground testing for the booster stage of the Saturn V. Delivery of production engines for the early development flights of the Saturn V will begin early next year; development of the engine will continue through this entire period and beyond to increase the reliability to meet the requirements for manned flight.

The development program for this engine is going through the same characteristic technical phases which were experienced on other (Redstone, Jupiter and Saturn I) engine development programs. The areas which have required particular emphasis thus far have been subject to straightforward engineering solutions. Let me illustrate with three examples.

Early in the program, we found that to build the large thrust chamber, new manufacturing techniques had to be found. The large number of tubes which make up the chamber are held together by brazed metal, and it proved difficult to obtain the uniformity and quality which was needed. The manufacturing experts at Marshall worked closely with the contractor to develop a brazing process which has eliminated the need for expensive and time-consuming handbrazing of these chambers.

As a second example, about a year ago a series of malfunctions occurred on the turbopump test stand where the pump was being tested as a component to measure and improve its performance. An analysis was made which included not only the basic turbopump, but also the test stand and the procedures used in performing the tests. The cause of these malfunctions was found to be the formation of gas bubbles in the facility pipes which supply liquid oxygen to the pump. After some changes were made in the supply lines and the operating procedures were modified, testing was successfully resumed.

My third example is what is commonly known as the combustion instability phenomenon. When design of the F–1 was begun in 1959,

combustion instability was known to be a potential problem. Accordingly, early in the program tests of various injectors for the thrust chamber were conducted, and a design was selected which had not experienced unstable combusion. For about a year, from mid-1961 to mid-1962, engine tests were conducted without this phenomenon occurring. Then, on June 28 of last year we were testing development engine No. 008 on the test stands in California. A test run which was scheduled for the full 2½ minutes running time was interrupted after 106 seconds of satisfactory performance by a rupture of a valve casting. The rupture was traced to combustion instability. Since this occurrence, several cases of combustion instability have taken place.

This phenomenon is not unique to the F–1, but has occurred in the development of most liquid rocket engines. Under certain conditions, vibrations can start which grow to such magnitude that rupture and internal erosion may occur. In some cases, we have found that vibrations in the propellant feed system influence the thrust chamber oscillations.

We are presently concentrating on combustion instability and are making progress. With the contractor at Rocketdyne, we have made an exhaustive survey of all test data having a bearing on the problem. Additional injectors have been built. This hardware is now in testing. Effort has been made to isolate those oscillations which take place in the propellant feed lines, and progress here is encouraging.

To summarize, the F–1 engine development over the last 4 years has made satisfactory progress. The engine start and ignition problems which caused us so much trouble on the engines for the S–IV stage have been nonexistent on the F–1, and the engine shows an almost perfect record of starts and shutdowns. The individual components, such as valves, gas generator, and turbopump, have progressed satisfactorily.

The many tests have indicated that we will have a sound engine available when we need to begin our first stage flight tests. The maturity of the engine at this time is such that with the emphasis we are now putting on the remaining development tasks, we shall meet the requirements of the Saturn-Apollo program.

CONCLUSION

Mr. Chairman, in this statement we have covered the status, launch plans, and flight missions of the three Saturn vehicles—Saturn I, Saturn IB, and Saturn V—which will perform vital roles in meeting the objectives of Project Apollo.

We have discussed the current status of the stages, instrument units and engines that comprise each of these vehicles, including contractor and Government effort, facilities, test programs, and production schedules.

We have described the current status of the F–1 engine program.

We have seen that we are progressing satisfactorily in all areas of our programs, and that, despite the magnitude and technical complexities of the task, we are still on schedule to meet the established objectives of the National Space program.

Thank you for the opportunity to appear before the subcommittee.

Mr. TEAGUE. Thank you, Dr. von Braun.

That was a very clear report. Every phase is progressing satisfactorily.

We have the chairman of our full committee here this morning. Mr. Chairman, would you like to ask some questions?

The CHAIRMAN. I would again like to welcome Dr. von Braun. It is a pleasure to have him come here and bring us these words of encouragement. We are very happy to get this detailed report.

You said using the turbopump on the engine will develop 60,000 horsepower. I wondered why we didn't have that in terms of thrust, but you are talking about the internal pumps in the engine, weren't you?

Dr. VON BRAUN. The pumps feed the fuel and liquid oxygen into the thrust chamber.

The CHAIRMAN. That is a pretty good sized pump.

Dr. VON BRAUN. Yes, sir.

The CHAIRMAN. Thank you very much, Doctor.

Dr. VON BRAUN. Thank you, Mr. Chairman.

Mr. TEAGUE. We have our hard-working majority leader here this morning, Mr. Albert. Any questions?

Mr. ALBERT. No. I would like to concur in what Mr. Miller said. It is a pleasure to have you here, Dr. von Braun.

Dr. VON BRAUN. Thank you, Mr. Albert.

Mr. TEAGUE. Questions by the committee? Mr. Fulton?

Mr. FULTON of Pennsylvania. A question keeps coming up as to the rate of progress on manned space flight programs. In conformity with the statement of the President that landing men on the Moon in this decade is a national goal, my question is: How would you describe the rate of progress of the program? Is it a crash program where funding and expenses become secondary?

My next question is: Is it done at the most efficient rate? We are in a race with the Soviets to be first on the Moon, while at the same time we want to have our scientific research and development be most outstanding and foremost in the world.

I also have concern that we are not offering enough contracts at public bid. Every contractor should have the right to submit a proposal for a low bid on contracts in the space field. Such competitive bidding would first give the lowest cost to the U.S. taxpayers who are financing this program, but it would also give a broader base of technological competence and knowledge within the space field.

That brings up the point that we might be relying too much on a certain group of large contractors. They select their own subcontractors and sub-subcontractors without proper checking on the part of NASA to see that we are getting the lowest cost for items that do not specifically involve research and development. NASA does not have the machinery to follow the subcontracts through to make sure that we are getting the lowest cost for the taxpayer as well as effectively using our scientific resources.

Would you just comment briefly on those questions?

Dr. VON BRAUN. I will be glad to. To answer your first question about the adequacy of our funding level, sir: I would say the program, as presently pursued, requires the occasional cutting of corners. If we had more funds in the program we would undoubtedly be able to provide more depth, particularly in the area of reliability testing.

We could procure more hardware that we would not commit to flight testing, but to ground testing. With the funding level that we have at the moment we are not able to do this to the fullest desirable extent.

Mr. FULTON of Pennsylvania. So you do not then describe your own planning and programing as a "crash program" as we customarily think of the term?

Dr. VON BRAUN. I would say, sir, with more funding we could probably increase the confidence factor of the program. Since we cannot now do reliability testing to the fullest extent possible, we are running a higher risk with respect to the success of the program.

Mr. FULTON of Pennsylvania. A crash program means that you are going so fast there is almost a devil-may-care attitude on costs.

Dr. VON BRAUN. Oh, no; definitely not.

Mr. FULTON of Pennsylvania. You can assure us that there is no crash program on everything under your jurisdiction, on the manned space flight program?

Dr. VON BRAUN. Absolutely. There is no crash program.

As far as the orderliness of the program is concerned, I am not aware of any elements in this program that have not been completely analyzed in advance on paper. Now, as to the adequacy of our approach, we have not added any alternate methods or alternate hardware to the program; that is, wherever there is a high-risk element, we are just taking a gamble.

Mr. FULTON of Pennsylvania. Could you comment on the possibility of more contracts being let out at public competitive bid?

Dr. VON BRAUN. Yes, sir. In this area the directives the centers have received from NASA headquarters are very clear. We are directed to go on competitive fixed-price bids wherever possible.

Mr. FULTON of Pennsylvania. When did those directives come out?

Dr. VON BRAUN. They have been valid ever since I have been connected with NASA, sir. The only problem is that there are some highly technical areas where we are running into rather serious difficulties, in abiding by this directive. Maybe I could illustrate. For example, many facilities that we are building in support of our manned spaceflight program are not standard buildings like shops or administration buildings, but are, in a way, critical parts of the research and development program itself. And, just like the research program itself, or the development program itself, these supporting facilities are subject to unpredictable developments. New requirements arise in this area constantly which require either awkward reprograming actions or design changes in the facility itself.

For example, in the case of our launch complex 37, at Canaveral, we went out on a fixed-price bid, at first, but in due time so many development changes crept into this program that it is no longer very meaningful to even refer to the original cost proposal. All these changes were the direct result of R. & D. inputs into the construction program. I can illustrate some of these things in a little more detail, for example——

Mr. FULTON of Pennsylvania. Rather than take the committee's time to go into the example, with the chairman's permission, could we have that in the record later?

Dr. VON BRAUN. Yes.

Mr. TEAGUE. Without objection, it will be placed in the record.

(The information requested is as follows:)

I would first like to state that I believe it is possible that more contracts can be let on this basis and we are exploring every avenue to make this possible. It is the policy of NASA, including the center I represent, to use public competitive bidding where it is in the best interest of the Government. We will continue to work hard toward this end.

In carrying out this policy there are certain areas of procurement such as construction of facilities and procurement of supplies where contracts are let almost exclusively on a competitive fixed-price basis. Where this is not possible every effort is made to obtain competition. We are, however, faced with problems on certain research and development procurements because the number of firms qualified to serve the best interest of the Government in this highly specialized field is very limited. The development of large systems such as the Saturn V is an unprecedented undertaking. It requires the best resources the country has to offer if we are to be successful. It requires the best companies possessing large numbers of highly skilled personnel with a high ratio of scientists and engineers to other skills. In most cases it requires extensive and complex modern facilities. In view of these requirements we have had to select the most qualified companies available. In searching for the most qualified company it develops that they are frequently qualified because of experience and facilities gained through having previously assumed large systems responsibility for NASA or the Department of Defense. Let me cite an example:

In the rocket engine field the Government, through the Department of Defense and NASA, has expended hundreds of millions of dollars in the construction of large facilities for the development and testing of these engines. As you have suggested, it would be highly desirable to bring additional talent into this field. To do so would require the expenditure of additional millions of dollars on new facilities to provide the new contractor with equivalent capabilities. In view of the highly specialized nature of the work and the lack of a market for the product, the contractors are reluctant to provide company funding for such facilities. It has therefore been necessary for the Government to provide such facilities. Through this process a number of companies have gained the position of offering the best potential for new engine development programs. Also through this process NASA has saved large sums of money by using existing Government-financed facilities for engine development, production, and testing. We are deeply concerned about this problem and are doing our utmost to bring in new companies in areas where they have the capability to give the Government the best job, both technically and financially.

A similar situation exists in the field of systems management. The systems we are talking about are the large launch vehicle systems which are of unprecedented magnitude and complexity and require enormous systems capability. Such major systems requirements are not found to the same extent and kind in most industrial enterprises. Over the years the Government has invested large sums of money in projects such as the B–52 program. This has resulted in the development of large systems management capabilities by a relatively few large companies. In the development of large systems such as Saturn V this capability is extremely important to the efficiency, the reliability, and hence, the success of the project. While we are well aware there a number of excellent companies in the country that would like to develop this capability, we are unable to justify the expenditure of large sums of Government money to develop new sources when there are qualified companies available.

In spite of the limited availability of qualified companies as cited above, we nevertheless obtain competition to the maximum extent. Each case is handled on its individual merits and a careful and very thorough selection process is employed.

In summary, we will continue to develop additional sources and distribute the work as broadly as possible consistent with preserving the Government's best interest and the taxpayer's dollars.

Mr. FULTON of Pennsylvania. Suppose there were a 5- or 10-percent cut on this $5.7 billion overall program; what effect would that have on the activities under your jurisdiction, as to time, money, and efficiency of procurement?

Dr. VON BRAUN. Sir, I can only speak about the portion of the program I am engaged in myself, the launch vehicles of the manned

space flight program, particularly the Saturns for Apollo, but here I can state that our program can most definitely not stand a 10-percent cut without very serious effects on the schedules.

In fact, I am convinced that it would become very questionable whether the President's statement (that we will put a man on the Moon in this decade and bring him back alive) could be met, with such a cut in the funding of the launch vehicle program.

Mr. TEAGUE. What funding level will the $5.7 billion budget give you?

Dr. VON BRAUN. For research and development plus construction of facilities we had about $1.2 billion in fiscal year 1963, and we expect about $1.8 in fiscal 1964. Much of that higher 1964 figure is simply due to the fact we are now activating facilities built with previous money.

Mr. TEAGUE. I don't believe I am getting my point over. If Congress passes the $5.7 billion, what level of funding will it give you? When you come back next year, will you tell us you had to cut more corners, or didn't have to cut as many?

Dr. VON BRAUN. For fiscal year 1964 we are expecting $1.8 billion as our part of the $5.7, which would permit us to continue approximately under the same conditions that we had in 1963.

Mr. WAGGONNER. No acceleration or deceleration?

Dr. VON BRAUN. That is correct.

Mr. FULTON of Pennsylvania. You spoke of a 10-percent cut. What effect would a 5-percent cut have?

Dr. VON BRAUN. It would lead to a slippage in the program, sir.

Mr. FULTON of Pennsylvania. How much of a slippage? I think you should make your comments on each of these two alternatives at some length in the record, so we have them carefully set out.

Dr. VON BRAUN. Under the assumption the 5 or 10 percent would be passed on to the 1.8 in Marshall?

Mr. FULTON of Pennsylvania. Yes, prorated.

(The information requested is as follows:)

Before addressing the question directly it is necessary to describe our position in general.

First, I want to reiterate what I said in my testimony, that our program is already experiencing financial difficulties. We started fiscal year 1963 with approximately a 10 percent funding shortage, which required complete reevaluation of our program and a number of major adjustments. For example, on the Saturn V program we were forced to slip the schedule approximately 5 months. We were able to avoid additional slippage by delaying the Boeing buildup at Michoud. To do this we had to absorb more work at MSFC.

In spite of our economy measures we still have a $30.9 million shortage in the fiscal year 1963 program, which can only be overcome by postponing essential buys. This could result in further slippage of the Saturn V program. If we must assume a pro rata share of a 10 percent cut this would mean approximately an additional $160 million shortage. This certainly would result in a serious program slippage.

In considering the impact of such cuts I would like to point out that the schedule we are attempting to meet in the Saturn V program is a "success schedule." This is a schedule capable of exploiting success. It is a target-type schedule to provide maximum challenge. It assumes no major unforeseen problems. Naturally, this schedule is much tighter than our Saturn I schedule has been up to this point. In short, we are trying to accomplish the greatly expanded and more complex Saturn V program in less time than we have taken with Saturn I. We recognize that this is a staggering undertaking which may contain unforeseen problems of major proportions.

Next, I would like to say that we have also assumed early man-rating of these vehicles. In contrast, Mercury was flown first by a Redstone which had already performed successfully in more than 50 flight tests; then on an Atlas which also had a large number of test flights before.

What I am pointing out is that we can't just arbitrarily change schedules when the funding changes. In considering a serious funding shortage, we must look at entire programs for sources of funds. We must examine all the technical aspects and weigh impacts of various possible changes. This requires serious engineering investigations to come up with definitive answers. Of course, since we have been through such an exercise for fiscal year 1963, we have in general terms established our priority sequence.

In view of the magnitude, newness, and cost of Saturn V we have arranged our schedules to derive maximum technology input from Saturn I and Saturn IB. We would have to give this approach even greater consideration in any rearrangement of schedules. This means we attempt to hold the Saturn I on schedule, slip Saturn IB a small amount, and apply most of the cut directly in the Saturn V program. This would also permit MSC to get on with its early testing program for the spacecraft on Saturn I and Saturn IB. We also must keep the engine program moving along because it includes long leadtime development requirements with many uncertainties.

This is an orderly approach but one that could result in more delays. For by postponing the Saturn V, we postpone the program with the largest amount of uncertainty, and hence delay the time when we may learn of serious problem areas to be solved.

The same impact would affect MSC. Although we still provide early Saturn I and IB tests for them, we would delay the time they can fly their complete systems on Saturn V; hence they would not gain needed knowledge as early as desirable.

Theoretically, a 5 percent cut alone would delay our schedule approximately 3 months; a 10 percent cut approximately 6 months. However, when we add the 5 or 10 percent cut to our present shortage, consider the inefficiency accrued in accelerating and decelerating the effort, and consider possible future technological problems, we are realistically looking at a slippage of unpredictable length.

Mr. TEAGUE. Mr. Daddario.

Mr. DADDARIO. With reference to the F–1 engine, you referred to the construction of the additional injectors. Apparently this is causing some kind of problem. I wonder if you see a solution, and if not, what effect might it have on this whole F–1 development program?

Dr. VON BRAUN. I am very confident by the time we need the F–1 engine and are ready to put it into the tail end of the first stage of Saturn V, that problem will be well under control.

Mr. DADDARIO. What caused you concern as you went along? Since it has been part of the overall planning, and apparently in the beginning you had confidence in it, yet the engine has constantly developed problem after problem? What now makes it so certain, when as I understood the testimony in the first instance, you did not consider that this would be any problem at all?

Dr. VON BRAUN. The reason we have this combustion instability problem in the F–1 engine is mainly due to the fact that the dimensions are much larger than anything we had experience with. The diameter of the injector plate is greater, also the flow of propellants through every square inch of injector surface is substantially larger than with previous engines. All investigations and diagnoses of injector plates that have been damaged during tests clearly indicate that there is an oscillating pressure wave traveling across the injector plate which changes the pressures on the combustion side, and conversely, also, back into the feed side of the injector. The two fundamental means of eliminating rough combustion are to interrupt the flame front on the combustion side by zoning (by breaking it into several zones), and at the same time by providing baffling on the feed side.

We are very confident this will give us the desired effect, because this cure was very effective with older type engines, also.

Mr. TEAGUE. Dr. von Braun, we will hear later today from Mr. Hoffman, but in the two firings last week, was the new injector in one of those firings?

Dr. VON BRAUN. I don't know.

Mr. Hoffman?

Mr. TEAGUE. Did I understand you to say at Edwards Air Force Base there were different injectors in the two firings?

Mr. HOFFMAN. Yes. The first firing was with an injector having upstream modifications which is an improvement. The second one that you saw was a modification of the first, again with upstream modifications. That, too, was satisfactory. I will cover that a bit more in my testimony.

Mr. TEAGUE. Mr. Riehlman?

Mr. RIEHLMAN. At the present time, Doctor, we hear considerable testimony in our committee about the reprograming activities of NASA, perhaps due to lack of flexibility in their budget. Would you comment on whether or not you have flexibility enough to carry out your program? And also, I would like to have that applied to the research and development program as well as the construction of facilities.

Dr. VON BRAUN. I would say we have enough flexibility in the research and development part of the program. In fact, NASA gets one block of money, essentially, in the R. & D. category, and that gives both the centers and also NASA Headquarters sufficient flexibility to roll with the punch.

In the construction of facilities area things are not so good. I don't think there is any need of greater flexibility in C and F funding of standard buildings, such as administration buildings, shop buildings, any kind of routine buildings. But we have a great number of special facilities, as the pictures here showed, of highly technical facilities in direct support of the research and development work. Even a minor change in such a facility, which is an intimately interwoven part of the research and development program, calls for reprograming operations which are very cumbersome and awkward—whereas in the R. & D. funded portion of the program proper we can implement all changes quite freely.

Maybe I can cite one example here at this point.

Mr. RIEHLMAN. I would appreciate it if you would.

Dr. VON BRAUN. When we invited North American Aviation, Space and Information Systems Division, to make a proposal on the S–II stage, the second stage of the Saturn V, their proposal provided that all the static testing of this stage would be carried out at their static test facility in Santa Susana, Calif. Shortly afterwards the Arthur Little Co. of Boston published some new test results on the so-called TNT equivalent of explosions of liquid hydrogen and liquid oxygen mixtures (the purpose of these tests was to determine what equivalent TNT effect we must expect if such an accidental explosion occurred). The new figures were substantially higher than previously estimated. As a result of these findings, the Air Force Safety Board ruled that a full duration test of the S–II stage at Santa Susana could not be carried out for safety reasons.

As a result, the need for construction of a test stand for the S–II stage at the new NASA Mississippi Test Facility arose. But under the law we are permitted to finance facilities at the company-owned Santa Susana complex under the R. & D. This whole facility was planned to be built under R. & D. This can't be done at the Government-owned Mississippi complex. There it had to be funded out of C of F. Therefore, we had to introduce a brand new C of F item into the list. As you know, Mr. Webb has a limited degree of flexibility in this area. The exact authority he has—I think he can reprogram 5 percent of his R. & D. funds into C of F, and authorize $30 million across NASA for not previously authorized facilities.

But this relatively small reserve out of a multibillion-dollar program is very rapidly used up, considering the tremendous percentage of the total these facilities cost. As a result, in the case of this S–II test stand, we got involved in about 6 months of reprograming and replanning of the whole thing, and this time is irrevocably lost.

Mr. RIEHLMAN. Of course, that would have an adverse effect upon your program.

Dr. VON BRAUN. Yes, it will.

Mr. RIEHLMAN. If you had broader authority, do you feel you could bring about greater efficiency and economy in the operation?

Dr. VON BRAUN. Yes, sir. I think the ideal solution from our point of view would be if all facilities that are directly related to research and development, not standard buildings, but test stands and that kind of thing, could be appropriated in the R. & D. category, rather than C of F. As long as this can't be done, I think we will always have this difficulty.

The CHAIRMAN. Would the gentleman yield?

Mr. RIEHLMAN. Certainly.

The CHAIRMAN. In this particular instance, this was brought about by finding by the Air Force Safety Board that could not have been anticipated by NASA prior to that time, and was way beyond NASA's control?

Dr. VON BRAUN. Yes, sir. That is correct.

The CHAIRMAN. NASA had to abide by this, because the Santa Susana operations belong to the Air Force?

Dr. VON BRAUN. That is right.

The CHAIRMAN. So there are things that come from the outside into a program as delicate as this that can completely upset it unless you have flexibility.

Dr. VON BRAUN. Yes, sir.

Mr. RIEHLMAN. If Dr. von Braun has other areas or illustrations to give our committee, to justify broadening this authority, or if he feels it is necessary to bring about greater efficiency and economy and greater ability to act more expeditiously, it would be well to have it.

Dr. VON BRAUN. The F–1 combustion instability problem, for example. We decided to activate two new facilities in Huntsville to come to the help of Rocketdyne on F–1 turbopump testing and on F–1 injector plate testing.

Here, too, we cannot act as fast as we wanted to for lack of C of F money. We are trying to do what we can with R. & D. money, but

here again it would certainly help a great deal if we had a ruling across the board that all these facilities in direct support of research and development could be funded out of R. & D.

Mr. TEAGUE. Mr. Gurney.

Mr. GURNEY. On this cost, take the F–1 injector, for example. That is one of the most expensive parts of the program in both manufacturing and test firing. Do you have, for example, now, a specific number of engines that you plan to purchase during this whole program? Do you have a specific number you intend to purchase this next fiscal year?

Dr. VON BRAUN. Yes, sir.

Mr. GURNEY. Do you have a specific number you intend to test this next year?

Dr. VON BRAUN. Yes, sir.

Mr. GURNEY. How many?

Dr. VON BRAUN. We have developed a precise procurement plan geared to the static test program and also the flight program. The lead times required both for delivery of the engines themselves and also for the assembly period of the entire stage (which, of course, must be placed between engine delivery and launch date)—all this has been carefully calculated. I shall be glad to furnish you the exact figures. It is quite a sizable plan.

Mr. GURNEY. I would be curious if you could furnish those for the record.

Dr. VON BRAUN. Yes, sir.

(The information requested is as follows:)

Question. Do you have a specific number of F–1 engines you intend to purchase this next fiscal year?

Answer. We plan to order 12 complete engines and long lead hardware for 19 additional engines for the Saturn V in fiscal year 1964.

The funds required in any given period are computed on the basis of the delivery schedule, and the lead times inherent in each major subsystem such as turbopump, injector, thrust chamber tubes, etc. Initial funding must be in the contract 17 months prior to engine delivery.

Question. Do you have a specific number of F–1 engines you intend to test this next year?

Answer. Engine testing in fiscal year 1964 at Edwards Air Force Base will include tests on all 14 of the engines which will be delivered in fiscal year 1964, plus tests conducted on engines delivered in fiscal year 1963. Additionally, two of the propulsion system test engines will be tested at Huntsville in fiscal year 1964.

Question. Do you have, for example, now, a specific number of engines that you plan to purchase during this whole program?

Answer. The number of engines we plan to purchase is divided into three categories as follows:

(1) Development program—These engines are purchased under the F–1 development program, and are used by Rocketdyne to evolve the final design and high reliability required.

(2) Propulsion system test program—These engines are purchased by the Saturn V program, and are tested both by Rocketdyne and by Marshall Space Flight Center. These engines are used for:

(*a*) Verification of engine design requirements.

(*b*) Development of vehicle associated components.

(*c*) Development and testing of a complete stage.

(3) Flight Engines—These engines are purchased by the Saturn V program, and will power both the development flight vehicles and the later manned vehicles.

Total planned F–1 engine deliveries are:

	Through fiscal year 1962	Fiscal year 1963	Fiscal year 1964	Fiscal year 1965 and subsequent	Total
Development program	8	4	[1] 12	10	34
Propulsion system test program	----------	----------	9	7	16
Flight engines, including spares [1]	----------	----------	1	89	90
Total	8	4	22	106	140

[1] Flight test engine totals are based on a 15-vehicle program. Actual number of vehicles which will be in the program is dependent on total mission requirements and flight results.

Mr. TEAGUE. Mr. Fulton?

Mr. FULTON of Pennsylvania. The question has come up on the reprograming of funds for the manned space flight programs; would you put in the record later the fact that the transferability authority was necessary, and your comment as to whether it was rightly or wrongly used? And lastly, whether it did drain from research and development programs for the practical use of engineering in manned space flight?

(The information requested is as follows:)

The facilities requirements for the manned lunar mission are normally provided under the construction of facilities appropriation. Under current legislation, the Administrator of NASA has authority to use funds provided under the research and development appropriation for construction of a major facility on contractor property, and may transfer up to 3 percent of the research and development appropriation to the construction of facilities appropriation. In both instances, the Administrator must make findings and determinations, and must notify appropriate committees of Congress.

In the past 12 months, the Marshall Space Fight Center has submitted 35 reprograming actions requiring notification of the committees. Eighteen of these involved the transfer of funds between the R.D. & O. appropriation and the construction of facilities appropriation. In my opinion, these actions were absolutely necessary if we are to meet the goal of putting a man on the moon in this decade. These actions were required because of changes in the development program that occurred after submission of the budgets.

Decisions which vitally affected our facility requirements included the decision to build the Saturn V, NASA's decision to use the lunar orbit rendezvous mode, and the decision to eliminate a direct flight Nova mode as a back up for rendezvous techniques. In order to implement these decisions, it has been necessary to eliminate facilities previously programed in budget submissions, build new ones not budgeted, modify existing facilities, and redesign facilities already under construction.

While an increase in transfer authority would provide some of the needed flexibility, it does not, in my opinion, recognize the inseparability of the research and development effort and the "tools" to accomplish it. Over 58 percent of the facilities budgeted and planned for the manned lunar program are directly and intimately tied to the developmental effort. Under the present appropriation structure, we are forced to predict research and development requirements for facilities, in quite some detail, 3 to 5 years in advance of the need for the facility. This, of course, is a practical impossibility, except for conventional items of construction, such as office buildings and other institutional-type facilities.

In view of the urgency of the attainment of the Nation's objectives in space, it is my conviction that the Administrator of NASA should be given legislative authority to use research and development funds for research and development facilities, with no more restrictions than are currently placed on other resources needed in the total effort.

Mr. FULTON of Pennsylvania. You had spoken of a proposal to build 12, I believe, Saturn IB boosters. Likewise, you plan to build eight Saturn V boosters. The question naturally arises, from the

taxpayers' point of view, why do you need so many? We didn't have that many for Mercury.

Dr. VON BRAUN. In the case of the Saturn 1–B, these flights are needed to wring out the lunar orbit rendezvous technique tests in Earth orbits.

Mr. FULTON of Pennsylvania. That will be the 12 for that particular purpose?

Dr. VON BRAUN. Yes. We need the first four to certificate the launch vehicle itself before we dare put a man in it. The subsequent flight tests with the 1–B involve all those complicated orbital maneuvers, like swinging the lunar excursion module around and dock it to the command module, and so forth.

Mr. FULTON of Pennsylvania. What backup do you have in the three separate divisions?

Dr. VON BRAUN. I would say if everything worked very well and there are no setbacks, no launches aborted, no mishaps during the rendezvous exercises, it may well be that all Earth-orbit tests in support of the lunar orbit rendezvous mode may be completed with two-thirds or three-quarters of the total planned. But I think it would be unrealistic to assume that a certain amount of backup hardware was not necessary.

Mr. FULTON of Pennsylvania. Have you taken steps to avoid the situation that occurred in Mercury where boosters appeared at Cape Canaveral for checkup and revision with 500 change orders pasted on the side of the booster? What is the situation on that now?

Dr. VON BRAUN. I do not believe that I could honestly promise that this situation has or can be remedied altogether.

In fact, due to the fact that, for the time being at least, all these large stages must be shipped by water to Canaveral, they are tied up for up to 3 weeks in transit; and whenever a black box is missing in a stage at shipment date, the temptation will always be very great to say, "We will fly the black box to Canaveral and put it in there rather than hold shipment of the stage until the box is available."

Some of these things make up those Canaveral engineering change orders. Sometimes more is involved, sometimes less. But I do not believe it could be completely avoided. It is a very undesirable procedure, but I don't think it could be completely avoided.

Mr. FULTON of Pennsylvania. I have been a severe critic of the manned space flight program on the basis of the five off-the-shelf-type items that went wrong within the last hour before the Glenn flight. Hatches and valves stuck, the electric power went out at the Bermuda tracking station that was to put the capsule into orbit, the hatch door had a bolt break on it as it was being fastened, and there were temperature troubles as well.

Of course, the experiment that NASA made while Glenn was in orbit when they tested out the inverter equipment for the first time at that temperature was a rather remarkable success under the circumstances.

However, are we preparing so we will get adequate reliability of component parts, so we can now say that we have a group of competent contractors in the space industry who do not cause us a $12 million direct loss, with a $8 to $10 million indirect loss?

For example, on Mariner I, there was the leaving out of a minus sign, and also the trouble with a fuse where someone took it out and

put it among 10 or 15 other fuses so that no one could tell which fuse had been taken out.

I think in justice to the American taxpayer, when you see an amount of money equal to a total college or foundation grant over the years is gone in the twinkle of an eye through that kind of failure of procedure and reliability, we on this committee must stop it.

Are you trying to do it?

Dr. VON BRAUN. NASA inaugurated about a year ago a new set of quality control procedures. They have been even adopted by the Air Force in many areas. These procedures are very much more stringent than what was customary in the aircraft industry. There is 100-percent vendor inspection, for example. There is also so-called inprocess inspection where you do not just inspect the final product, but also the procedures during manufacture; for example, before a tube is sealed and buried in some plastic foam, where it would be no longer accessible, the tube and its wiring leads will be inspected.

I believe these NASA standards—I am referring to the NASA quality assurance procedures, 200–1, 200–2, 200–3, in particular, which are, in my opinion, a very good step in the right direction.

As I said, they have even been accepted by the Air Force now as guidelines for some of their own products.

There is one problem closely connected with quality controls and that is the recurring problem of, shall we say, free competition among all kinds of vendors, versus dependence on a limited list of qualified vendors. Whenever a vendor comes up with something new, a transistor, a valve, or some mechanical device, we subject this device to an extensive environmental test program, and finally say that the part is now qualified.

This qualification is, of course, only valid to the extent that this particular vendor is involved. When another vendor comes out with a value that is to meet the same specifications, it doesn't necessarily mean that his product will also qualify.

As a result it will be necessary to requalify every single product from another vendor before you accept it. In this area there are sometimes genuine conflicts between the desire of either getting in more competition, or getting in more suppliers, and the desire to tighten up and use qualified vendor parts only.

Mr. CASEY. Mr. Chairman.

Mr. TEAGUE. Mr. Casey.

Mr. CASEY. Did I understand you to say a while ago, Doctor, that you could use more funding in testing and finding out some of the problems in the F–1 engine? Did I understand you to make that statement?

Dr. VON BRAUN. I spoke about the F–1 in conjunction with the difficulty of reprograming money into facilities construction.

Mr. CASEY. Do you have adequate funds in this proposed budget now?

Dr. VON BRAUN. In this case we have not asked for additional funds. We asked in this case for permission to use some research and development money for some facilities construction work.

Mr. CASEY. But, in the proposed budget we are holding hearings on now, do you have adequate funds for your contemplated necessary test checkouts to find these problems?

Dr. VON BRAUN. I am confident if the fiscal year 1964 budget, as suggested, goes through, we will be adequately covered for the F–1.

Mr. CASEY. You were inferring that the present budget you are operating under is inadequate?

Dr. VON BRAUN. No, sir. I was speaking of the fact that across the board the entire Saturn Apollo program is not a very rich program and we have to cut corners wherever we find them, and sometimes we are feeling a little uneasy about this.

Mr. CASEY. Even with the proposed budget before us, it is going to be a tight one. Is that what you are saying?

Dr. VON BRAUN. That is correct.

Mr. CASEY. Is it sufficient to meet the goal that has been set by the President?

Dr. VON BRAUN. I think so, yes.

Mr. CASEY. To keep us moving to achieve our ultimate goal?

Dr. VON BRAUN. Yes. It is very tight. I would have personally liked to see the supplemental in fiscal year 1963 go through, that was discussed.

Mr. CASEY. There were several others of us who would have liked to see that too.

Dr. VON BRAUN. It would have helped us a great deal.

Mr. CASEY. But in your opinion, if we authorize the proposed budget as submitted, we can keep on schedule to meet the goal announced by the President and make a manned lunar landing and return, in this decade?

Dr. VON BRAUN. Yes, sir; but there is no fat left in there. I think we are really down to lean meat in the program.

Mr. CASEY. Well, have you had any fat at any time in this program?

Dr. VON BRAUN. No, but I think a program like this ought to have a little fat.

Mr. CASEY. You think it ought to have a little fat?

Dr. VON BRAUN. It ought to have a little fat, because there are so many unpredictable things.

Mr. CASEY. In other words, this doesn't allow for many mistakes, where you might have to retrace or repeat some portion of a program?

Dr. VON BRAUN. Yes, sir.

Mr. CASEY. It is putting you on your toes to the point where you must practically accomplish your objective the first time; otherwise, you will not have the money to repeat that portion of the program, is that correct?

Dr. VON BRAUN. Precisely.

Mr. CASEY. Are you going to maintain this schedule for manned lunar landing in this decade?

Dr. VON BRAUN. Precisely. If all works well, I think we can meet it, but it wouldn't be right to expect everything to work well.

This is an unprecedented program here. There are bound to be some setbacks. It is very difficult to say how many there will be and how much they will cost, but when I say a little fat is desirable, it is in order to take care of these unforeseen setbacks.

I think right now we are really down to lean meat. We cannot afford to cut anything else out, otherwise we just can't do it even if everything works well.

Mr. CASEY. If the American public then wants to accomplish the goal that the President has set, they must be prepared to back this request that NASA has made for funds.

Dr. VON BRAUN. Yes, sir; this is my firm conviction. Yes, sir.

Mr. TEAGUE. Will you tell us a little about the budgetmaking process? What budget are you working on now? When did you have to submit the fiscal year 1964 budget to NASA headquarters in Washington?

For instance, last year when you came here, the decision had not been made at that time whether or not NASA would use Earth-orbit rendezvous, lunar-orbit rendezvous, direct ascent, or what. Are there any big changes that could be made in the next year as far as this budget is concerned, for which it would be more desirable to have a percentage of money that you could transfer from one program to another as far as R. & D. is concerned?

Dr. VON BRAUN. I don't remember offhand whether the figures as presently submitted were first prepared before or after the mode decision. But I can definitely say the program that is presently being pursued, that I discussed here a little earlier, really needs the requested funding support.

The lunar-orbit rendezvous mode introduces certain elements that didn't exist previously.

The lunar-orbit rendezvous mode introduces certain elements that have been needed had the command module been used to land on the Moon.

On the other hand, certain things could be saved. For example, in the earth-orbit rendezvous mode the development of a tanker would have been necessary. It was to be carried up by a first Saturn V to be followed up later by a manned vehicle. This tanker is no longer in the program since the earth-orbit rendezvous mode was decided against. Had the Nova mode been adopted at the time, the development of another launch vehicle would have been necessary.

Mr. TEAGUE. How long ago did your request for $1.8 billion go to NASA headquarters?

Dr. VON BRAUN. I don't exactly remember how this budget cycle works, but——

Mr. TEAGUE. Approximately. Was it last October?

Dr. VON BRAUN. I think about April or May 1962, thereabouts.

Mr. TEAGUE. Then you are now working on what you will submit this coming May for fiscal year 1965?

Dr. VON BRAUN. That is correct, yes.

Mr. TEAGUE. And this budget of yours covers Marshall, Michoud, and the Mississippi Test Facility.

Dr. VON BRAUN. Yes, sir. The budget cycle within NASA works as follows: First the centers make a submission to NASA headquarters. Usually headquarters finds the total is too much when all the requests have come in. Then headquarters decides in what areas they would reduce the overall program and they give the submissions back to the centers with new ground rules.

Mr. TEAGUE. Each center submits separate budgets?

Dr. VON BRAUN. Yes. I think there are two submissions. The first is due approximately in April. We are right now working on the first submission for the 1965 budget. We expect it back in August or Sep-

tember, if I am not mistaken, when we shall take another reading on it. This is about the leadtime involved.

Mr. TEAGUE. Do you know where in the budget the money would go, for example, that we give to Navy for recovery operation? Whose budget would that be in? Yours, or Cape Canaveral, or Houston?

Dr. VON BRAUN. If the Navy is reimbursed, it will probably come out of Mr. Holmes' manned space flight office here in Washington and be transferred direct to the Navy.

Mr. CASEY. Since you said that your budget request went to NASA headquarters, then they said it is too much, evidently you originally submitted more than $1.8 billion, is that right?

Dr. VON BRAUN. Yes, I think so. And in this particular case, as the chairman pointed out, there have been major technical decisions in the meantime also.

When we submitted the 1964 budget for the first time, this was prior to the mode decision; in the meantime, when the submission same back from headquarters, the lunar orbit rendezvous had been selected, and we had harder facts to nail our funding requirements down.

Mr. CASEY. But did you originally ask for more than $1.8 billion for your part of the program?

Dr. VON BRAUN. I would have to check. I don't remember.

Mr. CASEY I just wondered if $1.8 billion is less than you originally requested?

Dr. VON BRAUN. It may well be. But we know now better what we really need because the mode was selected in the meantime, so any differences wouldn't be too meaningful.

Mr. CASEY. That is right.

Mr. TEAGUE. Mr. Fuqua?

Mr. FUQUA. It is apparent we need this flexibility because of the technological and other unforeseen changes?

Dr. VON BRAUN. Yes, but in our "Research and Development" appropriations we have flexibility, so we can't gripe about this.

But in the construction of facilities appropriations you have to spell out both location and construction items, exactly what and where you propose to build. To know a year and a half in advance what special test facility you will need in a program as unprecedented, dynamic and unpredictable as this one is downright an impossibility.

This rigidity in our construction of facility submissions is really the main reason for these many reprograming actions that are necessary. I think if we had fewer items to reprogram it would also facilitate things.

For example, if instead of having 20 different items of construction approved for Huntsville, we had only one consolidated Huntsville construction budget and could reprogram at Marshall within that budget, it would greatly facilitate things. I think, though, the best answer is really that funds for these technical facilities in direct support of research and development tasks be appropriated in the R. & D. category.

Anything short of that would probably keep that problem permanently with us.

Mr. TEAGUE. Mr. Waggonner?

Mr. WAGGONNER. To pursue a little further what Mr. Casey asked you a minute ago, I think you said in answer to one of Mr. Fulton's

questions that if you had more money you would spend that additional money in further ground testing, buying more hardware for ground testing; isn't that what you really meant to say there?

Dr. VON BRAUN. Precisely.

Mr. WAGGONNER. If you could get more money, it would be needed, and you would gain more reliability by additional ground testing?

Dr. VON BRAUN. Yes, sir. Let me say a few words about our financial operating plan. Our monetary needs in R. & D. are usually made up of two elements. One element is just running operating expenses. It is made up by what it costs to develop things. You have, say, a stage on a static test stand that must be fired up repeatedly, and you have to pay operating expenses for salaries, fuel, instrumentation evaluation and so forth.

The other element is what goes into the long-range hardware procurement plan. We have to buy long leadtime items. Just to cite an example: In order to be able to fly our first Saturn I–B at a given date, we must give Douglas contract authority to go ahead with the manufacture of the second stage. There may be 24 months leadtime involved. We have to commit substantial sums of money years ahead of the launch date.

Mr. WAGGONNER. You would like to be able to do more testing and evaluating at Marshall in order to gain reliability, rather than having errors show up after the manufacturer starts testing?

Dr. VON BRAUN. Right. But as we count our dollars, we find every dollar is needed to do either just the basic ground testing, or to buy the hardware needed in support of the flight program which is equally necessary for, say, orbital rendezvous exercises.

We would like to have money above our present funding levels to buy hardware that can be tested extensively in laboratories, so we can shake a stage structure to pieces, test valves under higher than normal pressures and other than normal temperatures, and this kind of thing; in other words, subject all the many components and subsystems of our rockets to torturous test programs.

Mr. WAGGONNER. Marshall has the development responsibility for the instrument unit for Saturn and I think you said that IBM and Bendix are responsible for the development of the guidance systems.

Relatively speaking, are there any problems with respect to the development of the instrument system as to its leadtime? Is it ahead, or is it behind the engine development?

Dr. VON BRAUN. I don't believe the guidance system is really a major problem area. We are in very good shape there.

Mr. WAGGONNER. Are there any problems in the instrumentation and its development?

Dr. VON BRAUN. There are a few left, but no really critical problems.

Mr. WAGGONNER. In this area we are nearly able to apply and use what we learned in Mercury?

Dr. VON BRAUN. Yes.

Mr. WAGGONNER. We have had some slippage in the Nova program. What are you going to do in fiscal year 1964 toward the development of Nova at Marshall?

Dr. VON BRAUN. To us at Marshall Nova looks as follows: Before the mode decision was made, we had one particular configuration of Nova as a possible contender for the job of putting a man on the Moon

in this decade. This particular Nova called for eight F–1 engines in the first stage and two M–1s in the second stage, and was very clearly defined. When the decision was made to use the Saturn V and the lunar orbit rendezvous mode instead, this particular Nova configuration was no longer of interest.

We decided not to build it, and that was it.

The Nova program as a whole, of course, also lost priority because the national commitment with respect to the lunar landing was henceforth based on the use of Saturn V. As a result, one could say that the Nova project as a whole went on the back burner.

It is pretty obvious that in our present situation one would not want to initiate a full-fledged Nova program for several years from now. On the other hand when we shall have enough money to go into high gear with Nova we would not want to base it on a concept that we developed in 1962.

We won't be able to do very much right now about an active Nova development (I mean really in high gear, to the tune of one billion dollars a year or more). But whenever we shall want to go ahead with it in, say, 1968 we would want to base it on a 1968 concept of Nova, and not a 1962 concept.

That is what we are presently working on: to develop a concept for Nova that we would like to see going into high gear in about 1968.

Now you cannot advance the plateau of engineering without spending some money. Even to lay the groundwork for an advanced Nova concept costs some money, not billions, but maybe $100 million a year. This money is needed to do some basic pioneering work in critical fields. So in 1968, if we are finally ready to go with Nova, we will know more about advanced engines, advanced structures, recovery techniques and that kind of thing.

We are presently trying to identify areas where limited amounts of money ought to be spent during the next few years on advanced engineering for Nova.

Mr. TEAGUE. Would you tell us a little about the first two Saturn shots? I understand they had a lot of water in them. You put expensive payloads in these first vehicles because you were afraid you would lose the payload; isn't that correct?

Dr. VON BRAUN. We have one more Saturn I shot with a live first stage only, and from then on we will fly live second stages also. These are the Douglas-developed liquid hydrogen-liquid oxygen S–IV stages with six Pratt & Whitney engines. Test flying these new stages is quite a challenge in itself.

Flights Nos. 5, 6, and 7 will be just two-stage launch vehicle tests, with the main purpose being flight testing of the second stage. (Flights 6 and 7 will be equipped with boilerplate Apollo payloads.) Then come flights Nos. 9 and 8—No. 9 shall fly ahead of No. 8, for some strange arithmetic reasons. (We are building No. 9 in Huntsville while No. 8 comes out of the Chrysler line at Michoud.)

In No. 9 and possibly No. 8 we will fly a large micrometeroid satellite designed to provide badly needed statistical data on micrometeroid density of the altitude of low Earth orbits. This is felt to be a very essential piece of engineering information for the Gemini and Apollo programs. In addition, No. 9 and No. 8 will carry an Apollo boilerplate configuration in the nose.

Thus No. 9 and No. 8 will be the first to fly really useful payloads. No. 10 will be a dry run for the "real thing." It will fly an unmanned, but completely equipped Apollo spacecraft and is designed to perform an Apollo reentry mission. From No. 11 on we propose to man the Saturn I. So there is not much unused hardware left.

Mr. TEAGUE. Any other questions?

Mr. Yeager?

Mr. YEAGER. Concerning the Saturn flight No. 5, will you fly six of those before you have any manned payload?

Dr. VON BRAUN. Yes. Flights 5, 6, 7, 8, 9, and 10 will be unmanned.

Mr. YEAGER. With the big Saturn V, could you put a useful scientific payload in the earlier test shots? Would that cause you difficulty?

Dr. VON BRAUN. Sir, the problem is, when you offer 240,000 pounds of net orbital payload, the space science people may be tempted to spend $100 million developing a suitable scientific payload. But once they have it they won't want to entrust their $100 million payload to a completely unproven launch vehicle. Whoever spends that kind of money on a scientific payload is liable to say, "I would rather wait until you have demonstrated a few successful flights."

Mr. YEAGER. In connection with the questions that Mr. Waggonner asked, do you envision for the future when we get into, say, manned planetary flights, that the vehicle would be using engines that are just scaled-up versions of what we have presently, or do you think they would be entirely different types of engines?

Dr. VON BRAUN. Sir, I believe that when we go for a manned flight from the Earth to a planet we will probably switch our transportation equipment in Earth orbit.

In other words, we would want to use a different type of ship to go from the Earth orbit to Mars, than we will use to climb from Canaveral up into an orbit around the Earth.

The main contenders for the deep-space propulsion systems for manned interplanetary flight are our NERVA-type nuclear blowdown engines and nuclear-powered ion engines. Both would be boosted into Earth's orbit with chemically propelled rocket ships, and what we have in mind for this part of the job is a chemically powered Nova-type vehicle. I don't think any stage of the Nova itself will ever go to Mars, at least any for manned missions. Nova will be essentially an orbital truck to carry these deep spaceships and their propellants into their departure orbit around the Earth.

Mr. YEAGER. In connection with the Apollo project, do you believe that the present plan for a rescue mission, insofar as we have heard it presented, would be adequate? I understand this would mean putting an extra LEM on the Moon about the same time or before our people land there. Does this seem sufficient to you as a mode of rescue, or should we have a separate lunar logistics vehicle to help out?

Dr. VON BRAUN. A rescue mission in case of disaster on the surface of the Moon doesn't look too attractive from the point of view of raising the statistical chances of a successful lunar landing and return. There are more effective means to raise the confidence factor.

In other words, the "probability of success" gain you will get out of this lunar surface rescue vehicle will be quite marginal. The reason is

that many things can happen before the astronauts get to the surface of the Moon, and the mission abort and safe return capabilities for the crew during this phase of the operation are quite good. There are, of course, a few things that could go wrong on the Moon itself, but to develop a vehicle solely in order to rescue some stranded astronauts on the surface of the Moon would probably not be warranted. This opinion, incidentally, is shared by the astronauts themselves.

However, it is only too obvious that the lunar excursion module has only a limited payload. It cannot sustain the two astronauts on the surface of the moon for more than 2 or, at the utmost, 4 days.

In order to increase the scientific utility of a landing on the Moon, it is strongly felt by all of us in the manned space flight program that more payload must be furnished the landing party simply in order to enable them to do more useful scientific work.

For example, there ought to be a shelter on the Moon where the astronauts can take off their space suits and sleep. There ought to be more food and oxygen and water supply, and there ought to be a roving surface vehicle at their disposal so they are not limited to the few miles they may be able to walk on the lunar surface in their clumsy space suit.

All these requirements combined justify very strongly what we call a lunar logistics vehicle of some sort, a cargo vehicle that will carry extra payload to the surface of the Moon.

Once you have that cargo vehicle, you can possibly spin off an emergency return capability. For example, by landing a returnable upper end of the lunar excursion module on the surface of the Moon, the astronauts could use this in case their own lunar landing vehicle fails.

Mr. YEAGER. Do you believe we should have that for the first flights?

Dr. VON BRAUN. I don't think it is necessary to have it there for the first manned landing attempt. In fact, I think it would even be wrong to say we should not commit ourselves to lunar landing before we have such a vehicle sitting there on the Moon. I think this conclusion would be wrong because we would be boxing ourselves in.

But I think to really capitalize on the early manned landings on the Moon it would be very good to have a follow-on program in the form of a lunar logistics vehicle that can fly supplies to the Moon and extend the scientific capabilities of the lunar expeditions.

Mr. TEAGUE. Dr. von Braun, do we have reason to believe the Russians are going to use lunar orbit rendezvous?

Dr. VON BRAUN. I think it is in the nature of lunar rendezvous that you want to try it first in earth orbit. We are planning to do just that with Saturn I–B: to simulate the lunar orbit rendezvous techniques in an orbit around the Earth.

If the Russians were to demonstrate a rendezvous in Earth orbit tomorrow, it doesn't mean at all that they would use that technique also to land on the Moon.

Mr. TEAGUE. They are going to do the Earth rendezvous first, anyway?

Dr. VON BRAUN. They were pretty close to doing it in their recent twin flight. Apparently they did not try to change the orbits of their two spacecraft that were simultaneously in orbit. But I am convinced

that in the very near future we shall witness a Russian Earth orbit rendezvous exercise. However, I don't think it will necessarily indicate that they will use an Earth rendezvous mode when they will attempt a landing on the Moon.

Mr. TEAGUE. Is there disagreement within NASA as far as the method of going to the Moon is concerned?

Dr. VON BRAUN. None whatsoever.

Mr. TEAGUE. In Houston, we were told that the astronauts were unanimous in their belief that this was quicker, cheaper, and safer.

Dr. VON BRAUN. We believe so, too. I am aware that there have been some statements to the effect that it was a bit surprising that Marshall, after having advocated Earth orbit rendezvous, came around and recommended lunar rendezvous.

Fact is that at first we put a great deal of work into the Earth orbit rendezvous studies and found this mode entirely feasible. But later we put a lot of work into the lunar orbit rendezvous mode also, and now we are convinced that this the fastest and safest way to go. This mode selection is not a question of basic feasibility. There are many ways to go to the Moon. It is a question of time, cost, confidence factors and so forth.

There is complete agreement in the manned space flight family that lunar orbit rendezvous is the way to go.

Mr. TEAGUE. Mr. Waggonner?

Mr. WAGGONNER. Of course, launch vehicle development has progressed to the point we are able to go from Earth orbit rendezvous to lunar orbit rendezvous, and that is primarily the main consideration, isn't it?

Dr. VON BRAUN. We use the smaller Saturn I and IB vehicle, sir, to develop Apollo rendezvous techniques in Earth orbit. After we understand how to rendezvous the various Apollo modules in Earth orbit, we shall be ready to go to the Moon.

Meantime, we have to develop the big Saturn V that can carry all the equipment out to the Moon, so we can base the lunar landing operation on lunar orbit rendezvous.

Mr. TEAGUE. Are there any other questions?

Mr. YEAGER. With your permission, Mr. Chairman, I have some questions which I would like to submit and ask Dr. von Braun to answer for the record.

Mr. TEAGUE. Without objection, it will be placed in the record.

(The information referred to is as follows:)

Question 1. Will any of the Saturn I R. & D. shots carry other than vehicle test payloads? If not, why not?

Answer. The Saturn I R. & D. lanuch vehicle will carry a considerable number of secondary payloads which do not pertain to the development of the launch vehicle. These payloads have been selected to aid the overall manned lunar program wherever possible. Other scientific payloads have been selected to aid the national space program without extensive complication of the launch vehicle checkout for launch. The pertinent secondary payloads on the Saturn I are as follows:

SA–1: No secondary payloads.
SA–2: Project highwater.
SA–3: Project highwater:
Centaur dynamic pressure study.
Horizon sensor for orbital stabilization determination.

SA–4: Horizon sensor:
Radar altimeter—Development of instruments which furnish more precise determination of injection and orbit positions.
Missile tracking and measuring (MISTRAM)—development for improved range safety.
Micrometeroroid sensor test for experiment on SA–9.

NOTE.—SA–1, 2, 3, and 4 are one stage flight tests only and are nonorbital.

SA–5: Horizon sensor:
Radar altimeter.
MISTRAM.
Transmitter to provide orbital tracking information and temperature data.
Tape recorder and transmitter for human voice (voice orbital transmitter, code name "VOT").

SA–6: Apollo developmental (inert) configuration for launch environment of spacecraft:
Horizon sensor.
Radar altimeter.
MISTRAM.

SA–7: Apollo boilerplate configuration for lanuch environment of spacecraft.
A communciation satellite consisting of a heavy metal sphere from 1 to 3 meters in diameter to serve as a radar calibration standard is under study for feasibility of integration into this launch vehicle.
Horizon sensor.
Radar altimeter.
MISTRAM.

SA–8: Apollo boilerplate configuration:
Micrometeoroid satellite.
Horizon sensor.
MISTRAM.

SA–9: Apollo boilerplate configuration:
Micrometeoroid satellite.
Horizon sensor.
MISTRAM.

SA–10: Apollo—Production configuration for launch and reentry qualification:
Horizon sensor.
MISTRAM.

SA–5 through SA–10 are planned as orbital flights.

In addition to the above secondary payloads, a considerable number of components and systems of the Saturn I will be the basis for components and subsystems of the Saturn IB and Saturn V. The experience gained with these items on the Saturn I flights will enhance the development of the Saturn IB, Saturn V, and the Apollo spacecraft. Typical components and systems are:

ST–124 stabilized platform.
Control accelerometers.
Control rate gyros.
Control computer.
Guidance signal processor.
Liquid hydrogen propulsion.

Question 2. How much are the six Saturn V test launches going to cost, approximately?

Answer. The six Saturn V test launches will cost approximately $550 to $600 million. This includes all hardware cost, supporting engineering effort, launch preparation, launching (including propellants), and launch evaluation. It does not include:

Basic vehicle design, research, and development effort.
Engine research and development.
Facilities and pertaining equipment.
Tooling cost.
GSE, test equipment, etc.

Question 3. Why not use the Saturn V test launches for something besides tests of the vehicle itself?

Answer. The six Saturn V test launches represent a completely saturated developmental test program, incorporating spacecraft related experiments and total space vehicle integration and qualification, in addition to the basic launch vehicle developmental and qualification requirements. As presently planned,

each launch represents a major advance in the development of each of the space vehicle's subsystems. For example, the very first launch with only the first stage live, will carry a prototype spacecraft for the measurement of launch environmental parameters and to determine physical and flight compatibility of the launch vehicle with the spacecraft. With the second Saturn V launch (first stage and second stage live and third stage inert), the prototype spacecraft will be capable of testing the launch escape system jettisoning during second stage burn. On the third launch, with all three stages live, the prototype spacecraft will measure exit environmental parameters through all three stages of boost, and into lunar injection. On the fourth launch the command module heat shield will be qualified for full speed reentry at maximum heating rates and on the fifth launch qualification of the heat shield at full speed and maximum total heat load will be achieved. Finally, on the sixth launch, complete integration and qualification of all the Saturn V based space vehicle elements will be accomplished through lunar injection, in preparation for the first manned launch.

Bonus payloads have not been considered for the Saturn V because of the mission saturation reached within the developmental launches in combination with the flight profiles required for the essential Apollo experiments.

Question 4. What will the first manned Saturn V flight do, and what will it be expected to accomplish?

Answer. The first manned flight is intended to demonstrate the crew and total space vehicle compatibility, demonstrate the capability of a manned system to perform a 14-day mission, prove operational techniques, perform crew training, and prove the capability of the space vehicle and crew to undertake the lunar landing mission.

Question 5. Have any Centaur-type problems shown up in connection with the A–3 engine or the S–IV staging?

Answer. No.

Question 5. Do you envision any slippage on the SA–5 shot because of technical trouble with the second stage?

Answer. The S–IV–5 stage currently has part shortages and checkout problems which might cause a slippage of some weeks which probably cannot be made up any more. It is, however, very encouraging that the static testing of the battleship stage with the six clustered Pratt & Whitney engines did not reveal any critical problems might might cause further slippages. A statement whether there will be any slippage, and how much that slippage will be, can only be made after the actual S–IV stage has been statically tested at Sacramento, which will occur in late April or the beginning of May. No manufacturing difficulties are envisioned.

Several technical problems have occurred during the S–IV program which cannot directly be considered contributory to the S–IV–5 slippage.

(*a*) Helium heater and lox tank pressurization system. Difficulties occurred when the fuel tank was step-pressurized. The mixture ratio of the helium heater decreased to the point where combustion could not be sustained. This has been corrected but an ambient backup system will be incorporated on SA–5 and SA–6.

(*b*) Hydraulic actuators—a new design was required, however, the new actuators will not be installed on the S–IV–5 vehicle. Modified DAC actuators will be utilized on S–IV–5.

(*c*) Parts qualification program has proceeded slower than anticipated, therefore all parts are not qualified as yet but will be prior to SA–5 launch.

Question 7. There have been few, if any, holds on Saturn launches thus far; to what do you attribute this excellent record?

Answer. Under the Army, and later on under NASA, the guided missile and space flight group at Huntsville (now called the Marshall Space Flight Center) has developed, over a period of more than 10 years, a team of Government scientists, engineers, and industrial procurement experts whose experience is based and kept astute by an extensive in-house development and testing activity. Having successfully developed and turned over to the military services for deployment three complete guided missile systems, having also developed and launched various space vehicles, this Government team enjoys high professional respect throughout the aerospace industry. The closely knit Government-industry team concept developed by Marshall has now been brought to bear on the development of the family of Saturn vehicles. In designing, developing, fabricating, inspecting, testing, and preparing for launching "no stone was left unturned." Any potential problem—whether in the vehicle or in the ground

equipment at Huntsville, at Cape Canaveral, or at a contractor plant—was thoroughly investigated and solved.

In summary the good "holds" record on the Saturn launches and the successful accomplishment of all Saturn launches can probably be attributed to our particular management concept of a Government-contractor team, with its emphasis on keeping the Government partners of this team "bench oriented." Another vital factor is the long experience of Marshall's personnel: the personnel turnover rate at MSFC over the last 5 years has been far below the average of the aerospace industry. The personnel experience is reflected in Marshall's procedures in fields such as quality control, static testing, structural testing, guidance, electronics, hydraulics, environmental testing, launch operations, etc. These procedures are applied to total systems, subsystems, and components.

Question 8. Why do you need 4 Saturn I–B flights on top of the 10 Saturn I launches before manning the payload?

Answer. The development of a launch vehicle up to the point of reliability where a manned spacecraft can be entrusted to it takes at least four test flights of each stage according to our judgment and experience. We consider this number of flights a bare minimum and I want to direct your attention to the fact that it took the military services some 20, up to 50 or more, development test flights before they considered a guided missile ready for operational deployment. We should not overlook that the Saturn space vehicle, no matter whether we talk about the Saturn I, IB, or Saturn V, is more complicated and technically complex than any of the guided missiles developed. Although the S–IV–B stage (second stage) of the Saturn IB is of the basic design of the S–IV, it has a different engine; namely, the Rocketdyne 200,000-pound-thrust J–2 engine. This engine and its associated propulsion system will be flight tested the first time on the Saturn IB and this fact alone justifies at least four-stage development tests before it can be called man rated.

Question 9. Isn't the second stage of Saturn V dealing with so much explosive fuel as to make it susceptible to lengthy delays because of difficulty in testing?

Answer. The second stage of the Saturn V is designed for a rapid tanking and detanking rate, as are all other stages of the Saturn V. The battleship program (static test program) with special tanks will be used among other purposes for the early development of tanking and detanking procedures. It will also be used for prestatic checkout of equipment required to handle all propellants. By these tests we feel we can resolve most of the propellant handling problems so that they do not come up as problems and holds during the countdown at the launch site. Past experience shows that we have not missed a firing date due to our inability to manage large quantities of propellants. The more hazardous nature of the liquid oxygen/liquid hydrogen propellants should not cause additional delays if a proper development program on components and subsystems, and an extensive test program is conducted prior to shipment of the stages to the cape.

Question 10. Do you see any slippage in Apollo because of engine trouble or vehicle design?

Answer. Although problem areas exist, as in all R. & D. programs, no slippages are currently anticipated either in the manned flights or the early R. & D. flights do to engine problems or vehicle design.

Question 11. Is there any fundamental difference between the A–3 and the J–2 engine, or is the J–2 a more or less scaled-up version of the A–3?

Answer. NASA's RL–10 and J–2 liquid rocket engines are of the same basic family of engines in that they both use liquid hydrogen as a fuel; they are both designed to operate in the vacuum of space; and they have most of the same basic components. The J–2 engine is 10 times as heavy and has a thrust of more than a dozen RL–10's.

Along with the difference in size and development status the two engines have a difference in operation in that the energy used to force the propellants into the engine is derived in different ways. The RL–10 uses the heated fuel (which has cooled the combustion chamber) as an energy source to feed the propellants into the combusion chamber. The J–2 engine uses a separate, smaller combustion chamber to generate power which is used to pump the propellants into the main combustion chamber.

Experience in developing the smaller engine, the RL–10 was used to some degree in developing the larger J–2. Naturally all of the experience did not

apply because the larger size of the J–2 made the use of some different features necessary.

In summary the two engines are alike in their general category, but different within that category primarily because of their difference in size, weight, thrust, and operating cycle. The J–2 cannot be considered a scaled-up version of the RL–10.

Mr. TEAGUE. Thank you, Dr. von Braun. I think your report has been very encouraging. If we can get the money until next year, I think we will be in good shape. Thank you very much.

The committee will be adjourned until 1:30 at which time we will hear Mr. Samuel Hoffman, the president of Rocketdyne Division of North American Aviation.

Thank you again Doctor.

(Whereupon, at 12 noon, the subcommittee was adjourned, to reconvene at 1:30 p.m., the same day.)

AFTERNOON SESSION

Mr. TEAGUE. The meeting will come to order.

Mr. Hoffman, would you come to the front? And would you like to bring Mr. Aldrich and Mr. McNamara with you?

Mr. HOFFMAN. It won't be necessary for them to come up now. Perhaps on the questions——

Mr. TEAGUE. All right. Do you have a prepared statement?

Mr. HOFFMAN. Yes, sir; I do.

Mr. TEAGUE. All right, sir; go right ahead. We will include your biographical sketch in the record at this point.

SAMUEL K. HOFFMAN, PRESIDENT, ROCKETDYNE, A DIVISION OF NORTH AMERICAN AVIATION, INC.

S. K. Hoffman, vice president of North American Aviation, Inc., and president of the Rocketdyne Division, heads a major element of the Nation's missile and outer space research industry.

Under his leadership was the development of high-thrust liquid propellent rocket engines for the Atlas, Thor, Jupiter, and Redstone ballistic missiles, all of which are now operational with the Strategic Air Command and the U.S. Army. High-thrust, solid-propellent rocket motors also have been developed to power high-speed research sleds and provide instant launch to fighter and drome aircraft.

Current research and development activities guided by Mr. Hoffman include the development of the F–1, 1.5 million-pounds-thrust single chamber liquid propellent engine for the National Aeronautics and Space Administration, the H–1, 188,000-pounds-thrust engine to be used in clusters of 8 to develop 1.5 million pounds of takeoff thrust for the Saturn booster vehicle, and a 200,000-pounds-thrust hydrogen-fueled engine for Saturn upper-stage applications.

Rocketdyne's research and development activities are located at Canoga Park, Calif. Extensive field test laboratories are located in the nearby Santa Susana Mountains. Production of liquid propellant engines is conducted in the Neosho, Mo., plant. Solid-propellant operations are centered in the McGregor, Tex., plant.

Mr. Hoffman was born on April 15, 1902, in Williamsport, Pa. He received his B.S. degree from Pennsylvania State University in 1925 and completed work on his M.E. degree in 1945 at the same educational institution.

After graduating from Penn State, he was employed as a sales engineer until 1927 with the Reliance Electrical & Engineering Co. in Cleveland, Ohio.

From 1927 to 1928 he was a design engineer for Fairchild Aircraft Co. in Farmingdale, Long Island, N.Y. Subsequently he held design engineer positions with Lycoming Manufacturing Co. from 1928 to 1929, and with the Allison Division, General Motors Co., from 1929 to 1930.

A project engineer with Aviation Corp.'s Lycoming Division from 1930 to 1934, Hoffman became assistant chief engineer of that organization in 1934. He was promoted to chief engineer in 1936 and served in that capacity until 1945 when he left industry to return to the campus of his alma mater, Pennsylvania State University.

At Penn State, he was a professor of aeronautical engineering until 1949, the year he joined North American Aviation as chief of the aerophysics department propulsion section. (Mr. Hoffman serves as North American Aviation's representative on the Pennsylvania State University Industrial and Advisory Council.) In November of 1955 Hoffman was appointed general manager of the newly created Rocketdyne Division where he has continued since to direct research, development, and manufacture of high thrust rocket engine powerplants.

He was elected a vice president of North American Aviation, Inc., in November 1957, and was appointed president of the Rocketdyne Division in March, 1960.

Hoffman's professional associations include memberships in the American Rocket Society, the Society of Automotive Engineers, the American Society of Mechancial Engineers, the Institute of Aerospace Sciences, and the American Management Association. He has served as a national director of ARS, vice-president of SAE (aircraft engine activities), and is a fellow of both ARS and IAS.

For his leadership in the development of the first U.S. high thrust rocket engines, Hoffman has received several national honors. They include the American Rocket Society Propulsion Award (awarded by ARS) in November 1962; the Spirit of St. Louis Medal (awarded by ASME) in June 1962; the Louis W. Hill Space Transportation Award (presented by IAS) in January 1960; the Robert Goddard Memorial Award (presented by ARS) in November 1959; and the Dr. Robert H. Goddard Memorial Trophy (presented by Missiles and Rockets magazine) in May 1959.

Hoffman's contributions to missile and space activities also have been recognized twice in resolutions by the Los Angeles County Board of Supervisors and twice by the City Council of Los Angeles.

His civic activities include participation on the advisory board of San Fernando Valley State College, the board of directors of Valley Presbyterian Hospital, and the associate board of directors of the San Fernando Valley Youth Foundation.

Hoffman and his wife, Genevieve, reside in Tarzana, Calif. They are the parents of three daughters, Jean Lynn, Susan, and Louise; and one son, John.

STATEMENT OF S. K. HOFFMAN, PRESIDENT, ROCKETDYNE DIVISION OF NORTH AMERICAN AVIATION, INC; ACCOMPANIED BY JOSEPH P. McNAMARA, VICE PRESIDENT AND GENERAL MANAGER, LIQUID ROCKET DIVISION, D. E. ALDRICH, F-1 PROGRAM MANAGER

Mr. HOFFMAN. Mr. Chairman and members of the committee, it is a pleasure to appear before this committee and report on our progress in developing and producing rocket engines for the U.S. space program.

First, let me acknowledge the recent visit of Chairman Teague and members of the Manned Space Flight Subcommittee to our facilities in California. We were pleased to be able to provide this first-hand inspection of our activities, and we hope that the tour was instructive and beneficial. We hope the tour was helpful to you in your deliberations.

Mr. TEAGUE. It certainly was. Thank you.

Mr. HOFFMAN. I hope you and the other committee members will be able to come again soon.

Mr. TEAGUE. Thank you.

Mr. HOFFMAN. I would like to open my remarks with a brief résumé of our background as a designer, developer, and producer of rocket

engines. Until the advent of the Nation's space program our work in this field was in support of military missile programs. Beginning in the late 1940's our first assignment was to develop the engine for the initial Navaho missile program for the Air Force. This engine had a thrust of 75,000 pounds, and with a subsequent program change and further development became the engine for the Army's Redstone tactical ballistic missile.

A more advanced stage of the Navaho program called for a 135,000-pound thrust engine. With further development, uprating, and packaging to suit particular requirements, this engine powered the Atlas, Thor, and Jupiter ballistic missiles. The Atlas propulsion system was started in March 1954; it consists of two booster engines and a single sustainer engine producing a total of 390,000 pounds of thrust. The Thor and Jupiter programs began in November 1955, each using a single basic 150,000-pound thrust engine. The standard propellant throughout these programs has been liquid oxygen as the oxidizer and kerosene as the fuel.

These engines have provided the propulsive power for most of the missile strength of the United States since the advent of the missile era. They have also been adapted for use in nearly all of the satellite and other space launchings to date. They represent together more than than 22,000 tests for a total of more than 1 million seconds of firing time. In the development of these engines new concepts were pioneered in reliability, refining it from qualitative valuations to quantitative measurements in extensive test programs. As a result, very high reliability has been achieved in service. For instance, the Redstone engine has a 100-percent record extending over the past 72 flights, which span not only the entire operational period but also a good part of the missile research and development period. As another example, our Thor engine achieved more than 100 successive flights without a failure and it has failed only once in 3½ years.

Two of the missiles referred to have been employed for the manned space flights of the Mercury program. The Redstone was used as the booster for the suborbital flights, and the Atlas for the orbital launches. As you know, the engine performed perfectly in all five of these flights.

Obviously, where manned flight is concerned, we are never satisfied with existing reliability, and in this area we are constantly striving for improvement. The objective is, of course, 100 percent reliability.

As the Nation pushes further along in the program of space exploration, there is a need for larger thrust than the adaptations of military engines and boosters provide. Engines designed specifically to meet the needs of this space program include the H–1, F–1, and J–2, which we are developing for the Marshall Space Flight Center of the National Aeronautics and Space Administration. While these engines have previously been discussed before this committee, I will provide a brief summary of the programs, as well as the current status of development progress.

H–1 ENGINE

The H–1 engine uses liquid oxygen and kerosene as propellants and is rated at 188,000 pounds of thrust. A cluster of eight provides 1.5 million pounds of thrust for the first stage of the Saturn I and I–B.

These are two-stage vehicles for early orbital launches in the Apollo and various other programs.

The H–1 is a further development, refinement, and uprating of the Thor, Jupiter, and Atlas booster engines, making use of the technology gained in those programs and incorporating features to achieve even greater reliability.

An H–1 model is on the desk in front of you, to your chairman's left, the small engine. It has been described previously. I think I will only mention here that it has the usual thrust chamber and turbopumps. In this case the pumps are driven by a geared turbine. Perhaps the most significant advancement on this engine has been the simplicity that has been achieved. In one area, for example, a solid gas generator is used for starting. Thus, it has a simple, one-wire start-stop system, and only operates once without a new start cartridge. In other words, a small, solid propellant rocket starts the engine. H–1 is 8½ feet long, approximately 6 feet in diameter at the nozzle exit, and weighs 1,650 pounds.

Mr. TEAGUE. Did you say 8 feet or 18 feet?

Mr. HOFFMAN. Eight feet.

The H–1 contract was received in September 1958. The first engine was delivered in May 1959. Test flights began in 1961, and the first manned flight is scheduled for 1965. Production of the H–1 is underway at our plant in Neosho, Mo., and development work to refine the engine still further is continuing at our plant in Canoga Park, Calif.

As you know, the first three flights of the Saturn I first stage, using the H–1 cluster, have all been successful. This represents satisfactory flight performance of 24 out of 24 engines. Results of the flight tests are in conformity with the high reliability currently established in the engine development program.

F-1 ENGINE

The F–1 is the most powerful engine in the free world today. It develops 1.5 million pounds of thrust in a single chamber and uses liquid oxygen and kerosene as the propellants. The F–1 will be used in the Saturn V launch vehicle, which will send a manned expedition to the moon. For the Apollo lunar flight, five F–1 engines will be clustered to provide 7.5 million pounds of thrust in the Saturn first stage.

The model of the F–1 is to my extreme right. You already have a feel for the amount of propellant, 3 tons per second, necessary to give a million and a half pounds of thrust. The turbopumps are mounted on the side; both pumps are mounted on a single shaft driven by a single turbine, and as Dr. von Braun mentioned, it takes approximately 60,000 horsepower to drive the two pumps, the two pumps, of course, delivering the propellant through the injector to the thrust chamber.

The gas generator itself is a good-sized little rocket engine. The gas generator is, incidentally, the device which provides the hot gas to drive the 60,000-horsepower turbine which in turn drives the pumps.

The F–1 contract was received in January 1959. We were able to proceed immediately with tests of critical model components. During 1960, testing of prototype components, such as gas generators,

turbopumps, and thrust chambers, began. Following activation of the large test facility at Edwards Air Force Base, we conducted the first engine test, at reduced thrust, in June 1961. By spring of 1962 we had progressed to the point of testing the engine at full thrust for full duration.

Preliminary flight rating test is scheduled for completion this year. The first engine is scheduled for delivery to NASA in October of this year. Qualification and first flight is scheduled for 1966. As you can see from this skeleton time schedule, we are a little over half way through the F–1 development period.

To date the main components have been test fired a total of more than 1,300 times for a total duration of more than 33,000 seconds. The gas generator and the turbopump have each been tested for a total number of seconds equivalent to 100 flight durations.

Complete engines have been fired more than 250 times. It is significant to note that, as an indication of the basic validity of the F–1 design, the first 19 test runs of the first complete engine showed a success record of 95 percent. This is unusually high for an initial engine test.

During these early tests at reduced thrust, our objective was to establish good starting and shutdown characteristics. These and subsequent tests have demonstrated a very high reliability in these categories. The latest test series has shown over 99 percent starting reliability.

The full thrust and full duration test phase is designed to test every facet of engine operation under requirements that may be demanded of it in flight. This includes testing for performance specifications, combustion stability, mechanical operation, and structural integrity, that is, testing to establish reliability. In probing the characteristics of the engine we not only test it within its specified performance range, but also in various off-design areas. By this means we turn up weaknesses that might otherwise be difficult to discover, and in correcting them we improve the reliability of the engine for operations within its design parameters.

You will be interested to know that in devising these tests on the F–1, we are now able to establish much more demanding criteria than was the case for previous engines. In fact, it is due to our experience with other engines that we have greatly improved our techniques for measuring, identifying, and analyzing characteristics requiring additional attention.

For example, we have developed methods of inducing combustion vibration at will, in order to supply and evaluate potential corrective measures—measures that enable the engine to restore itself to stable conditions within a few milliseconds. This self-restoring capability has been achieved in several of our other engine programs. It is of paramount importance, of course, for man-rated engines.

As you know, combustion instability is a common and expected problem in developing a new engine. In more than 250 test runs of the F–1 engine, combustion instability has occurred 7 times. We are applying the techniques for dealing with it that were developed in our other engine programs, including that of inducing instability, and the F–1 engine is responding to these techniques.

In a series of runs that currently is being conducted on 2 engines incorporating the latest improvements, we have made 23 tests through

Wednesday of last week (March 13, 1963). One of the engines has been operated 12 times, each time for more than 100 seconds; of these, five were for the full rated duration of 150 seconds. The second engine has been operated seven times, twice at full rated duration. Combustion has been 100 percent stable in all of these tests.

I might interject that, at the time certain members of the committee visited us, there were three engine test stands in operation, and a combustion chamber stand. You witnessed, closeup, one test, and, from a distance, a second test. The third stand also fired that day, as well as the combustion chamber stand. So, it was a good day. I am sorry they are not all as productive as that.

Let me observe at this point that an accurate and somewhat detailed description of the technical effort being applied in this area was given to this committee on March 7 by Mr. Brainerd Holmes, of NASA. We will be happy to provide additional information if desired.

Other areas in the F–1 development program requiring additional attention are more or less mechanical in nature and subject to straightforward engineering solutions. As each problem manifests itself, special engineering attention is focused in that direction and modifications are designed and installed on the earliest available test engine. Currently, three test positions are operational, engines are installed on each and undergoing various tests, and adequate hardware is on a standby to back up the program.

Some of the details Dr. von Braun mentioned this morning are representative of the problems that we encounter, solve, and correct.

To summarize, we are subjecting the F–1 to more severe tests than any previous engine. On the basis of our accumulated experience, we have been able to establish new criteria for testing and judging performance that are more penetrating and sophisticated than those applied to earlier engines by at least an order of magnitude. There are techniques that were unknown at the time the program started, and have just reached fruition in the past 12 or 14 months.

The engines to be delivered this fall will provide the performance required to support the static test schedule of the first-stage vehicle. We are confident that the 3 years remaining before the first flight date are sufficient to achieve the final increment of reliability necessary for man-rated used. We will have developed the F–1 prior to first flight to a point reached by past engines after perhaps 100 flights. It will be superior to and better qualified by time of first flight than any engine we have produced in the past.

J–2 ENGINE

The J–2 will be used in the upper stages of the Saturn I–B and Saturn V vehicles. The J–2 has a thrust of 200,000 pounds at altitude; five will be clustered to provide a million pounds of thrust for the second stage of the Saturn V. A single J–2 engine will be used for the second stage of the Saturn I–B and the third stage of the Saturn V.

The J–2 represents a more advanced state of the art, principally because it is fueled with liquid hydrogen. The high specific impulse or energy yield of this fuel in combination with liquid oxygen will provide upper stages with approximately twice as much weight-lifting capability as that available from conventional propellants.

The J–2 model, on a somewhat larger scale, is immediately in front of me to my left, which, of course, would be to the right of your chairman. The most obvious difference here in observing it would be the fact the two turbopumps are separated. Each pump has its own turbine and the two are tied together with hot gas, which drives first the turbine on the oxidizer side. The exhaust from that turbine goes to the hydrogen turbine. We get a four-stage turbine in this manner, and it makes a very nice installation. The pumps are smaller and the propellant inlets are very direct. We are able to get very high performance, particularly in the area of the inlet connections, so that booster pumps are not required from the tanks to the engine. The J–2 pumps will perform down to very low inlet pressures.

J–2 also has a feature that is not required in our other engines; that is, a multiple-start capability. It can be stopped, started, and restarted, actually, as long as propellants are in the main tanks.

Another advantage of the two separate pumps is that there is no compromise, or very little compromise, required between the operating speed of the pumps and the turbines. This is particularly important on a hydrogen-oxygen engine. Because of the very great difference in density between the two propellants, one pump wants to run much faster than the other; that is, the hydrogen pump requires a higher operating speed than the oxygen pump.

The J–2 contract was received in September 1960. We are well into the test period for the full engine, with preliminary flight rating test scheduled in about a year. Engines are under construction for initial deliveries in August of this year. Qualification and first flights are scheduled for 1965.

The J–2 has been operated at full thrust and to the full duration of 250 seconds that was originally specified. Since the specification duration has been changed to 500 seconds, it has been necessary to modify test facilities for this purpose. This, incidentally, is one of the changes that would have been involved in the S–II, itself, which Dr. von Braun mentioned this morning. You have one safety criterion for 250 seconds of operation. The increase to 500 seconds, of course, means twice as much propellant must be stored in the test area to operate the same vehicle stage. This also hits us in the engine program. We have to have larger tanks to run the engine.

These modifications will be completed by the middle of this year, at which time we will begin testing the J–2 engine at 500 seconds' duration. Being an upper stage engine, the J–2 will be subjected to extreme conditions of environment. The final phase of the development program will be to test it as full thrust and full duration in such environmental conditions.

From the beginning the J–2 development program has progressed quite satisfactorily. From the earliest tests, components such as the pumps, gas generator, and thrust chamber have demonstrated excellent performance and durability. We have every expectation of maintaining our schedule on the J–2, as well as on the F–1.

In conclusion, both the J–2 and F–1 have entered a period of high test frequency. Areas requiring further concentrated development effort are being isolated in these tests and corrective measures are being aggressively pursued and applied. Satisfactory progress is being made, and I am confident at this stage that the engines will be de-

veloped to operational status for manned flight within the schedule of launchings originally established for the Saturn programs.

It has been a privilege to appear before this committee and report the progress of these programs.

I am certain that some questions have occurred to you as I have been talking. Mr. Joseph P. McNamara, vice president and general manager of our Liquid Rocket Division, and Mr. D. E. Aldrich, our F–1 program manager, are here with me today. Between us, I believe we will be able to answer the questions you gentlemen may have.

Mr. TEAGUE. Thank you, Mr. Hoffman.

As you know, this subcommittee is working on the authorization of money for this program. We would be very interested in anything you might tell us as far as the budget is concerned.

Mr. HOFFMAN. On the budget: Basically, speaking in round numbers, without pulling out any charts, the F–1 is a $50 million R. & D. program, both in fiscal 1963 and 1964; the J–II is a $45 million program in each of those years. Both of these seem to be within the $5.7 billion budget that has been presented to this group.

We have, indeed, in 1963, with the emphasis on combustion stability, asked for and received additional funding from the NASA Huntsville organization.

Mr. TEAGUE. Was there any slippage last year because of money, Mr. Hoffman?

Mr. HOFFMAN. Not last year, no. I think the slippage would go back to 1961, or 1960—the year prior. Slippage means, basically, less hardware than one might like. To tie slippage to a specific number of months becomes very difficult; however, it brings us back to what might be termed a "success program."

Mr. TEAGUE. Has NASA indicated to you what funding you will receive this next year?

Mr. HOFFMAN. Yes, I think we are pretty much in accord on next year's program. For 1964 we have every reason to believe the NASA budget is in accord with the funding required for the work we have programed with NASA on these two engines. We believe we will have a reasonably funded program.

Mr. TEAGUE. Suppose you got 5 or 10 percent less than you thought you are going to get. How would this affect your program.

Mr. HOFFMAN. The program would become a much higher risk program. It would be very unwise to do it.

Mr. TEAGUE. What do you mean, "higher risk program"?

Mr. HOFFMAN. It would mean we would be able to do less in the way of, shall I say, backup programs, and investigations. For example, in the matter of combustion vibration, we are indeed putting in, I would say, overall at least 5 percent more than anyone may have contemplated at the time the program was let. This is really new work because I referred to it here we did not know at the beginning of the program how to do the things we are doing today, to be able to rate our engines by inducing vibration and seeing which engines are self-restoring.

This, particularly during the past year, fiscal year 1963, has meant a substantial amount of extra work—5 percent, perhaps 7 percent or more.

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Mr. TEAGUE. Mr. Bell, do you have any questions of your constituent?

Mr. BELL. Mr. Chairman, I would like to welcome Mr. Hoffman to the committee. It is a pleasure to have you here. I would like to commend you on your long background of efficiency in the field of greater propulsion.

Mr. HOFFMAN. Thank you, sir.

Mr. CASEY (presiding). Do you have a question, Mr. Waggonner?

Mr. WAGGONNER. Mr. Hoffman, do you feel that these engines have sufficient development when they come from Marshall; do you feel there has been enough test work done before they are let out to contract? Do you think the development center, itself, is doing enough test work before bringing the engine to you for production?

Mr. HOFFMAN. Sir, I don't know that I quite follow or understand your question, but we do the design and development of the components and engines at Edwards and Canoga Park, Calif. Later on in the program NASA-Huntsville do, indeed, make their own tests. This is good—people other than the ones who develop the engines, also test them.

So, basically, the testing they do there, in the main, will be on the complete engine after we have finished the development or are well along with the development. For example, the engine we deliver in October——

Mr. WAGGONNER. The first F–1?

Mr. HOFFMAN. That is correct. That engine will have been backed up by, on the order of, say, 300 R. & D. tests, plus many, many components tests. They will test that engine on a battleship tank down there and by the time the engines are flown, we will have had enough testing, as evidenced by the results, for example, of the Saturn I. The first three flights were all successful.

Mr. WAGGONNER. Has it been your experience that as we go further into new engine development programs, that the testing becomes more routine and we are able to make more rapid progress as a result of prior successful programs? Are we finding real application in up-coming programs for the experience we get from these past programs?

Mr. HOFFMAN. Yes, sir.

Mr. WAGGONNER. That is the reason you can say that in the case of the F–1 engine, at the time of the first flight, it is much further along than any previous engine?

Mr. HOFFMAN. Yes, sir, and, part of the reason is simply that we have more time. You might refer to the schedule in my prepared statement. At this time, we have engines that we have had quite a few full duration full-thrust runs, and we are still only halfway through the program, about 3 years away from manned flight.

The past programs we have been on have been largely, if you will, crash programs, that is, our missile program, Atlas, Thor, and Jupiter. We were concurrently developing, producing, and flying engines.

Mr. WAGGONNER. To go back to what Mr. Teague said earlier about the effect of a 5- or 10-percent cut: Was I to understand from your answer that you would just shorten some of these test procedures and quit doing some things we are doing now to try to maintain schedule? Or would you simply reduce everything by a proportionate amount and just drag the time out further?

Mr. HOFFMAN. We wouldn't reduce everything proportionately. Some things we must do. The first thing we would do I presume we would have to—would be to cut down the number of people on the program.

We would cut down the amount of hardware that would be in the system for backup, so if there should be a failure, we would have to wait longer for parts. And this would simply mean that we would have less running. We would also do one other thing: In the matter of combustion vibration, there are better injectors that can be made. We have two or three varieties.

Mr. WAGGONNER. You are saying the result of a budget cut really would be a reduction in reliability?

Mr. HOFFMAN. Yes, at any particular time. If you wanted to take a longer time to do it, you could end up with the same reliability by lengthening the time, say a year or 6 months.

Mr. WAGGONNER. But not necessarily, the extending time doesn't necessarily mean you save money by doing it?

Mr. HOFFMAN. No, it might even cost more. There is an optimum speed to go. The program we have now is not a crash program by any stretch of the imagination. It verges on being what I would call a success program, where you are counting on most things being successful either the first time or very shortly thereafter. It is a reasonable program, and one that I believe at this stage will carry us through, with engines that will meet the requirements of the missiles. They will be good, usable engines, and be suitable for manned flight.

Mr. TEAGUE. Mr. Fuqua?

Mr. FUQUA. You said a while ago, I believe, that we had appropriated some $50 million for R. & D. for the F–1 engine. Did you say that?

Mr. HOFFMAN. I don't know whether you have appropriated that or not.

Mr. FUQUA. Well, that is the budget?

Mr. HOFFMAN. The F–1 engine budget has $54,100,000 in it. You will find difficulty getting many of our numbers coordinated with the NASA budget categories because all of the money requested for a given engine program doesn't go to us.

Mr. FUQUA. In October, when you deliver this first engine to NASA, what is going to be the cost of the engine?

Mr. HOFFMAN. You mean the total money we will have spent?

Mr. FUQUA. Yes. That will be all your development money.

Mr. HOFFMAN. I don't know as I can give it to you to October. As of now, R. & D. on the F–1 is $144 million.

Mr. FUQUA. What is going to be the cost after you deliver the first one? Will it decrease for the later engines?

Mr. HOFFMAN. On engines, you know, it all depends on what you want to apply to the first engine. That probably ——

Mr. FUQUA. I understand it will be more for the first one.

Mr. HOFFMAN. Probably on the order of several million dollars. I don't have the number on the first engine. We figure them in blocks, and I think for a block on the order of 70 you are talking of $1½ million or $2 million per engine. The first one will be much more than that. This will depend on what sort of a learning curve we have as

we go down the line. But the amount of money spent to date is $144 million, give or take a small percentage.

Mr. GURNEY. Do you have any exact number of engines that you are contracted to produce on this assignment?

Mr. HOFFMAN. No, it is being currently negotiated. Two this year. You know the date of the first one. The schedules are more or less confidential at the moment. But in the spring we will hit on the order of two engines per month; and how long that extends, what the total will be, I don't know. But the first will be on the order of between 60 and 75 engines.

Mr. GURNEY. In the whole program?

Mr. HOFFMAN. Well, the program goes somewhat beyond 1965, and I think through part of fiscal 1966. On this you should be able to get better figures from NASA. These figures are being worked out.

Mr. GURNEY. Why do you manufacture that number instead of one-half or twice as many?

Mr. HOFFMAN. I think basically because there isn't money for twice as many in the whole program. NASA programs so many launch vehicles, and, as they work the money out, how much they have for the whole program determines how many total launches they have, and then it comes back to how many launch vehicles. So there is quite a period of adjusting on it. These are big amounts of money, and a very, very complicated program, so that our engines then become a component item, and——

Mr. GURNEY. Well, is there any exact science to this? Do you pull a figure out of a hat, or how do you get at it? There must be some way that NASA determines whether you are going to produce 50 or 25.

Mr. HOFFMAN. Certainly it is not an exact science. You start off with the program they want, or the country wants, and from that try to determine how many launches you might have to have, and how many failures there might be on the ground.

Mr. GURNEY. Do you sort of rework it each year, is that the thing?

Mr. HOFFMAN. Oh, I am sure they do, and we do, also; and then it ties in with the amount of money available for the program.

Mr. GURNEY. How about the tests? How do you determine what number of tests you are going to have?

Mr. HOFFMAN. The tests are based on past experience, largely. They are not exact. They should not be considered as such. They have to be considered with a grain of salt. For example, if one were to be real fortunate, we would like to be able to design the engine so there would be no failures, right from the very start, and therefore we would go through, let's say, qualification, or a preliminary flight-rating test in, oh, a matter of weeks. Incidentally, for a preliminary flight-rating test, the primary portion is six full duration runs. You can see that if you were to be completely successful and design the perfect engine, test it perfectly on perfect test stands you would have the major portion of your preliminary flight-rating tests done as fast as you could run six full duration tests on perhaps one or two engines.

This doesn't happen. So then, going into past experience, we study that and come up with numbers. And this is necessary for the planning, to get the propellants and everything else. In the early stage we will know, for example that we will average so many tests per

shift on a test stand. And we know these early ones will be short tests. We project this then, to the stage we are today, for example, on the F–1, where the frequency and the duration of the tests will have greatly increased. The logistics of the problem tie in with that, too—we need more propellant.

Mr. GURNEY. Did you schedule those so in the month of June you would tend to study X, Y, and Z phases of the program; or how do you set up the tests? I ask, because I suppose these are pretty expensive and up through Wednesday of last week you had, I believe, 264. How many do you plan in the whole program?

Mr. HOFFMAN. They are expensive, yes, sir. And I believe for the whole program it is approximately 1,000 tests.

Mr. GURNEY. Therefore, to come back to the basic question, we are spending, I suppose, hundreds of millions of dollars in the tests alone of this engine, aren't we?

Mr. HOFFMAN. The whole program will run in the order of $270 million, the engine, through to Apollo, and——

Mr. GURNEY. Of which a good portion will be testing?

Mr. HOFFMAN. Yes, sir.

Mr. GURNEY. So I come again to the question: Why do you test 1,000 times as opposed to 500 times?

Mr. HOFFMAN. Well, 1,000 is no magic number. We may reach the point we want before we get to 1,000 tests. If we are unfortunate we may go to 2,000.

Mr. TEAGUE. Don't you take the basic engine and test it until you think you have the bugs out of it?

Mr. HOFFMAN. That is right.

Mr. TEAGUE. As you build each engine, you test it, and if it runs perfectly it has fewer tests. If something happens within the engine it has more tests; isn't that right?

Mr. HOFFMAN. Yes, sir. There is no magic number. It bases the number of tests on experience, and how the engine works. And we change this, this goal changes on items, I wouldn't say daily, but on a weekly or monthly basis. We find we have trouble in a certain area, and we will step up the tests.

At the time we make the proposal, at the time we negotiate it, and as we go along with the reviews of program, we are constantly changing the specific test program for next month. What we can see next month we see quite clearly. This year we see quite clearly. Next year, and the farther we go into the future, of course, the cloudier the crystal ball gets, and so we change.

Mr. GURNEY. Do you attempt in each test to determine as much as you can out of the particular test, Mr. Hoffman?

Mr. HOFFMAN. Yes, sir.

Mr. GURNEY. Or do you test for one specific thing?

Mr. HOFFMAN. I would say almost never do we test for one specific thing; the tests are so expensive that we try to get many results from one test.

Mr. TEAGUE. Didn't they tell us out there that you got 300 items of information from the test last week?

Mr. HOFFMAN. Yes.

Mr. GURNEY. I recall they said they had quite a few.

Mr. HOFFMAN. And the test you saw shut off at 109 seconds was due not to the engine, but to a faulty reading on one of these 300.

This is one of the penalties one pays for having so much instrumentation.

Mr. RIEHLMAN. Would you explain your statement, "faulty reading on 300"?

Mr. HOFFMAN. We had a reading that indicated a lack of pressure at a certain point. The crew running the test have what we call "red lines," on certain instruments. These limits are never exceeded. The engine was shut down, and it was found the instrument was reading incorrectly.

Mr. RIEHLMAN. I see. That was not the fault of the injector or vibration in the engine?

Mr. HOFFMAN. No, sir. It had nothing whatsoever to do with it, any more than the thermometer that reads the temperature in this room has anything to do, per se, with the temperature.

Mr. RIEHLMAN. A moment ago you were talking of the vibration that was caused in the engine, and I think I recall that you said the majority of this was caused by the failure of the fuel injector; am I correct?

Mr. HOFFMAN. The injector is the most critical item of the engine, so far as combustion is concerned—and combustion vibration.

Mr. RIEHLMAN. You were saying, in response to Mr. Waggonner's question, that if your funds were cut down you would probably have to cut down in some areas, and you referred to injectors.

Mr. HOFFMAN. Yes, sir.

Mr. RIEHLMAN. Are you in a position, with the funds you have, to produce a better injector than you have today, and overcome the problems you have already discovered with respect to the present injectors?

Mr. HOFFMAN. The answer to that is yes, and NASA is to be complimented on the fact they recognized this, and more funds are coming in—and I imagine with some difficulty. The funds have been increased. And we believe, in the negotiations we are having with them currently, that this work will be maintained at a high level; and this will, indeed, pay off.

Mr. RIEHLMAN. And if it is, you have every confidence that many of the problems you are encountering at the present time with the F–1 injector, will be eliminated?

Mr. HOFFMAN. With combustion vibration, yes. And we will solve the other problems too. I don't want to leave you gentlemen with the impression that we will not have continuing problems, and I do not want to leave you not recognizing that as long as this engine is used there will be and should be a continuing R. & D. program, of lower level as time goes on, to feed in the new things that we can put into the engine.

Mr. RIEHLMAN. That will certainly require a continual test operation.

Mr. HOFFMAN. Yes, sir.

Mr. RIEHLMAN. So, responding to my colleague's questions, you cannot put a definite number of tests on any one of the engines, because of the constant changes being discovered, and the need for improvements in them?

Mr. HOFFMAN. As long as the engine is going to be used, testing should continue. Far enough out in the program it will be at a reduced rate, of course.

Mr. TEAGUE. Mr. Casey.

Mr. CASEY. How are the amount of funds that you will receive under this program determined? As I understand it, you have a contract to develop the F–1 engine. You started on this when? I don't recall now.

Mr. HOFFMAN. January 1959.

Mr. CASEY. Now, I presume a contract was given to you to develop this engine, and the contract gave certain performance specifications, is that correct?

Mr. HOFFMAN. Yes, sir.

Mr. CASEY. And what its mission would be?

Mr. HOFFMAN. Yes, sir.

Mr. CASEY. Did they just turn you loose? Is there a set fee or——

Mr. HOFFMAN. By no means have they turned us loose, nor do we want to be turned loose.

At the time we started—and this early start was very fortunate, indeed—there was no missile, per se, or no launch vehicle. So the things known to put in the specifications were the result of preliminary design studies. They knew, for example, that they wanted to build a launch vehicle with increments of 1½ million pounds thrust per engine, and truthfully, if we had known how I suppose they would have liked a 10-million-pound thrust single engine, but this would have been too "far out" at that time. So it was determined they wanted 1½ million pounds of thrust. The propellant combination was determined, and we proposed a certain configuration of the engine, substantially as you see it here. The turbopump would not have gears which would be quite a problem, with 60,000 horsepower to transmit. So, all of these general features were determined.

Then, as we went along with the design of the engine, final layouts, the detailed design, we have had continuous design reviews with the NASA people. Many of the details of the design, then, were worked out and involved changes. From the time you have the first concept, and as you go along in the details, you find ways to do things better. So these changes are cranked in.

Then, finally, as a launching vehicle is evolved there are still more changes to have the engine specifically fit the requirements of the missile.

So, partly, I think, coming to your question, part of it, the fee—I think you mentioned that—is determined at the start, on the basic work, and then as new work is negotiated adjustments are made.

Mr. CASEY. When you started out you had a basic price for research and development on this engine?

Mr. HOFFMAN. Yes.

Mr. CASEY. As changes come about, then, you renegotiate those?

Mr. HOFFMAN. Yes. We must negotiate changes. And——

Mr. CASEY. What I am getting at is this: You contracted to develop and deliver this engine by a specific date, next October. Will a cut in this budget change your contract, or is your contract set?

Mr. HOFFMAN. Yes. Well, it would change the contract, yes.

Mr. CASEY. How?

Mr. HOFFMAN. Certainly, as far as the delivery of engines is concerned, that goes directly with the cut, and fewer engines are going to cost more per engine than a larger number.

Mr. CASEY. What about the development time of the engine?

Mr. HOFFMAN. The amount we would spend in a given year for development work would be cut down. We would accomplish less in that year, therefore, we would have to go more years. If you do a job and get down below——

Mr. CASEY. Does your contract now call for you to deliver an engine in October?

Mr. HOFFMAN. Yes.

Mr. CASEY. It does, does it not?

Mr. HOFFMAN. Certainly.

Mr. CASEY. And it specifies that this engine must have certain capabilities?

Mr. HOFFMAN. Yes.

Mr. CASEY. As to thrust, and the configuration must not exceed certain dimensions so it can fit on the vehicle they propose to fit it on, right?

Mr. HOFFMAN. Right.

Mr. CASEY. Does the contract require so many tests, or are these tests required by you to determine whether or not you are delivering what you contracted to deliver?

Mr. HOFFMAN. In the contracts, we work out each month with the people, the NASA people, so many specified tests. This is only the logistics of the problem, getting enough propellant and so forth. And as far as test numbers are concerned: Running 100 tests, if every one fails, means nothing—I think you can see that—taking the extreme example.

Mr. CASEY. Yes.

Mr. HOFFMAN. You can run 100 short-duration tests, satisfactory tests, and it means something; or on the other hand I can run 10 long-duration runs.

Mr. CASEY. If NASA says that they want additional tests, you need additional money, right? You will charge additional money?

Mr. HOFFMAN. We need additional money, yes, if, within the general scope of those runs within the general scope of what we have worked out in runs we don't come near our goal—but if you try to rate the engine on the number of runs alone, you cannot do it.

Mr. TEAGUE. Mr. Hoffman, is it fair to ask you whether you are working on a larger engine than a million and a half pound thrust engine?

Mr. HOFFMAN. We are doing study work on a larger engine than a million and a half. We are doing this in connection with at least three launch vehicle organizations. There have been three contracts let by NASA, going beyond the present Saturn program study, the Nova, whether it should be solid, liquid, or a combination of both, and in what increments of engine size. We are working with the contractors making these studies, and in none of the areas do we want to make a final decision until we are further along.

Mr. TEAGUE. Are you people doing any work on engine recovery? Who is doing that? Is that work going on?

Mr. HOFFMAN. Work is being done on engine recovery. As for work on the engines, I suppose there are certain features one might

want on recoverable engines, but liquid engines inherently have the ability to be used over and over again. If the vehicle itself is recoverable, the engine life can be made practically indefinite.

The solid, of course, cannot. They are recoverable, but you don't recover enough to make it really worthwhile. This is one of the major differences between the two engine types.

Mr. TEAGUE. Any other questions?

Mr. Yeager?

Mr. YEAGER. How many F-1 engines have you built to date for development purposes?

Mr. HOFFMAN. At least 10.

Mr. MCNAMARA. We have built 11 new engines and rebuilt 6. We have rebuilt one engine that I think you saw—one at Edwards, an engine that had been run quite a few times; we brought it back from Edwards and put a new pump on it and a thrust chamber, and it was rebuilt. We have built 11, plus rebuilds.

Mr. YEAGER. How many were seriously damaged because of the combustion problem?

Mr. ALDRICH. Two.

Mr. YEAGER. Have those two been rebuilt?

Mr. ALDRICH. Yes.

Mr. YEAGER. You said out of your 250 test runs you had this instability 7 times. Were all seven instances involved in tests of full thrust and full duration?

Mr. HOFFMAN. I think not on the seven. A few were in the phase while we were learning the proper start sequence. Once the start sequence was determined, we had no more difficulty on that. Would you check me on that, Dave?

Mr. ALDRICH. No, that is not correct.

These seven were all involved in full thrust. We had a couple only in start at lower thrust early in the program.

Mr. YEAGER. The difficulty, when it arises, does have a relationship to the full thrust ratio, is that correct?

Mr. ALDRICH. The problem is more severe at full thrust than it is at the low thrust area.

Mr. YEAGER. Could you tell me the character of the instability? Is it a rotary vibration, or what type? And do you know precisely how to connect it at this time?

Mr. HOFFMAN. I think, if you care to get into this detail, I would like to have the two experts we put on this job full time. They don't happen to be here.

Mr. YEAGER. Just this last question: Do you feel you know how to connect this problem at the present time?

Mr. HOFFMAN. Yes, I can give you a general answer to the question, but not the one as to, for example, vibration, whether it is a rotary or axial mode, things of that sort.

Actually, several types have occurred over this period of seven, plus I guess two starts way back, but we have—we do have now—an injector which, at somewhat below the rated thrust, is dynamically stable.

Dynamic stability at rated thrust is our goal, and we are moving up toward it.

The reason we are confident that we can achieve this goal is because in at least three other engines where we have attempted this we have succeeded. We are confident we can do it on this engine. We have made several steps in this direction.

Mr. YEAGER. I realize you are not the developers of the A–3 engine, but is there any fundamental difference between the J–2 engine and the A–3 engine to your knowledge?

Mr. HOFFMAN. The A–3?

Mr. YEAGER. The Centaur engine, the other engine, the RL–10?

Mr. HOFFMAN. The RL–10?

Mr. YEAGER. Yes.

Mr. HOFFMAN. Yes, several. We use two individual turbopumps tied together with hot gas rather than a single turbine driving two pumps with gears. I think you can understand from the order of magnitude, size, and power required—that it would be very practical to gear the two pumps together in the case of a 15,000-pound thrust engine. With one 15 times that large it poses quite a problem.

The J–II also has the feature of being able to run at sea level without having an exhaust inducer for testing. This is an expensive piece of test equipment and providing it for a 15,000-pound engine is much different from doing it for 200,000 pounds.

Mr. YEAGER. What is your full duration on the F–1 engine?

Mr. HOFFMAN. 150 seconds.

Mr. YEAGER. Is that the length of time the first stages will burn when they take off on the Apollo mission?

Mr. HOFFMAN. Approximately, yes.

Mr. TEAGUE. Is my memory correct that they said out in California that the troubles with the F–1 engine will not delay the program?

Mr. HOFFMAN. That is correct, sir. It will not.

Mr. TEAGUE. Over the weekend the chamber of commerce said we should cut the space budget by about $1 billion. What is the thinking of an individual in the industry, right in the middle of the program?

Mr. HOFFMAN. Well, I don't know that I am competent to answer that, not knowing all the facets of the NASA space program, but I would suspect something would have to be cut out or extended, but I shouldn't try to answer that question because I don't know all the details.

Mr. TEAGUE. Mr. Casey?

Mr. CASEY. You say you think something is going to have to be cut out of the space program?

Mr. TEAGUE. If we cut $1 billion.

Mr. HOFFMAN. I would suspect, and this, gentlemen, is no better than the general public's understanding—the knowledge knowledgeable men on the street gain from reading: If you cut from 5.7 to 4.7, the jobs that have to come first, the engines cannot be cut—there is not that much money in the engines without stretching the whole program. I assume that you would have to stretch the whole program, and I suppose some of the future programs would have to be forgotten until later.

Mr. TEAGUE. Any other questions?

Mr. CASEY. I don't think that is responsive to the question.

Mr. TEAGUE. I think Mr. Hoffman said that if you are going to cut out $1 billion, you are going to have to cut out some of the program.

Mr. CASEY. I understood the chairman to ask what was his opinion of the effect of cutting out $1 billion.

Mr. TEAGUE. Well, he says you would have to cut something out.

Thank you for coming, Mr. Hoffman.

The committee is adjourned until 10 o'clock tomorrow morning.

(Whereupon, at 2:30 p.m., the subcommittee was adjourned, to reconvene at 10 a.m., Tuesday, March 19, 1963.)

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1964 NASA AUTHORIZATION

TUESDAY, MARCH 19, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON MANNED SPACE FLIGHT,
Washington, D.C.

The subcommittee met at 10 a.m., the Hon. Olin E. Teague (chairman of the subcommittee) presiding.

Mr. TEAGUE. The meeting will come to order.

I would like to say to the other members of the committee that we have tried to explore the different methods of getting to the Moon and to find out whether or not there was agreement or disagreement on the lunar orbit rendezvous approach.

I have a short statement here from Mr. Edward C. Welsh, Executive Secretary of the National Aeronautics and Space Council. Mr. Welsh was scheduled to appear this morning, but he will be unable to make it. However, I would like to put his statement in the record, if there is no objection.

I will read the last sentence, to tell you the gist of what he says.

He states:

There are pros and cons regarding each of the possible techniques, but the decision to use LOR seems to be well founded on factors of relative cost, relative safety, and relative timing.

(The statement is as follows:)

MARCH 13, 1963.

LUNAR FLIGHT METHOD

In recent testimony before the House Committee on Science and Astronautics, Brainerd Holmes, the man in charge of the lunar project in NASA, said:

"Scientists and engineers in NASA, other Government agencies, industry, and universities devoted more than 1 million man-hours to studies of the Apollo mission. The three main approaches, plus variations of each, were evaluated in extraordinary detail. After careful analysis, we found that the lunar orbital rendezvous approach offered the greatest probability of success at a lower cost and on a faster time scale than the earth-orbital rendezvous or direct ascent techniques."

It is noteworthy that various methods were studied in detail and that those who are responsible for doing the lunar trip came out unanimously in favor of the lunar orbital rendezvous technique. Also, it is significant that the alternative methods of direct flight from Earth to Moon to Earth and of Earth-orbit rendezvous to Moon to Earth were studied as carefully as was the ultimately chosen LOR technique.

NASA experts briefed the Space Council as well as representatives of other interested agencies in the Government, on the various methods. It was uniformly agreed that any of the methods was feasible. It was clear, therefore, that the decision called for weighing such factors as relative safety, time schedules, and costs.

The Space Council took no action to rule on those various factors, but rather left it to the responsible agency, NASA, to make the decision, after being assured that the matter had been studied thoroughly.

The direct flight methods called for the largest booster or smallest payload, none of the valuable spacecraft rendezvous experience, and a later date for completing the mission. As such, it was the first to be ruled out in the process of selection. The LOR and EOR methods indicated more advantages and similarities and hence warranted an even more careful weighing of their relative merits.

Comparison between the EOR and LOR techniques brought out a number of pertinent points:

1. LOR calls for one launch from Earth, rather than more than one as in the EOR;

2. LOR requires about one-half of the payload weight, as compared with EOR. This smaller mass has a bearing on lower costs;

3. LOR permits optimization of the lunar landing spacecraft and—in parallel development—also permits a corresponding optimization of the Earth reentry module.

In other words, by not combining both landing and reentry competences in one craft and compromising one for the other, each can be tailored for its specific mission. In the EOR method, the landing and reentry spacecraft are the same;

4. LOR provides greater astronaut visibility in rendezvous docking, and lunar landing, as compared to EOR;

5. If all other factors were equal, rendezvousing in Earth orbit would be somewhat less hazardous than in lunar orbit. However, there are offsetting factors in favor of LOR:

(a) in LOR, the velocities of the rendezvousing spacecraft are much lower than in EOR (approximately 5,000 feet per second compared with 26,000 feet per second);

(b) in LOR both vehicles are manned and hence each can maneuver toward the other;

(c) in LOR, the rendezvousing and attachment of a 4,000 pound module is easier than doing the same maneuver with a module in excess of 200,000 pounds as in EOR;

6. In the LOR method, only two men will actually land on the Moon as compared with three in EOR. However, the number landing should not be considered as crucial a factor as vision and module optimization. Moreover, there is a safety advantage in having two descend while one stays in lunar orbit where he can observe, monitor the critical landing phase and report the operation back to Earth;

7. Earth orbit rendezvous is an important technique and will be needed for many space activities. However, in developing lunar orbit rendezvous there will be a substantial amount of rendezvousing exercise in Earth orbit before the mission to the Moon is undertaken. Hence, this valuable technique will be developed regardless of which mode were to be used for the lunar mission.

In summary, it appears that this complex matter has been studied with a great deal of care and that there is much to support the judgment made in favor of the LOR method.

There are pros and cons regarding each of the possible techniques, but the decision to use LOR seems to be well founded on factors of relative cost, relative safety, and relative timing.

E. C. WELSH,
Executive Secretary, National Aeronautics and Space Council.

Mr. TEAGUE. We have this morning Mr. Joseph Gavin, Jr., from Grumman Engineering Aircraft Corp. I told him that our committee was trying to paint as clear a picture as possible of the space program, and that this is the basis of our asking him to come here.

He has a prepared statement, and later he will be available for questions.

Mr. Gavin, we are glad to have you with us.

STATEMENT OF JOSEPH GAVIN, JR., VICE PRESIDENT, LEM GRUMMAN ENGINEERING AIRCRAFT CORP.; ACCOMPANIED BY THOMAS KELLY, LEM PROJECT ENGINEER, GRUMMAN AIRCRAFT ENGINEERING CORP.; AND JOHN BUXTON, RESIDENT MANAGER, HOUSTON, GRUMMAN AIRCRAFT ENGINEERING CORP.

Mr. GAVIN. Thank you, Mr. Chairman, and gentlemen.

Grumman is appreciative of this opportunity to appear before you in connection with our assignment in the Apollo program—the lunar excrusion module. We regard quite soberly the responsibilities assigned to us; all of us on the LEM program feel a deep personal involvement.

Because our go-ahead date was January 14, 1963, we cannot today present an impressive list of milestones completed.

Mr. TEAGUE. Before you get too far, do you want to bring the other gentlemen up to the table with you and introduce them?

Mr. GAVIN. I have with me Mr. Thomas Kelly, the LEM project engineer, and Mr. John Buxton, our management representative at Houston, the Manned Spacecraft Center.

I would like to leave them where they are, because I have assigned some duties to them.

Mr. TEAGUE. All right. Thank you.

Mr. GAVIN. Because the LEM is the last module of the Apollo system to be defined and started, we have the advantage of having a well developed set of requirements and ground rules which govern our efforts. As a corollary, the fact that the other elements of the Apollo system have a headstart implies that the LEM development has no slack and must move ahead efficiently and rapidly in order to meet the program schedules.

It is fortunate, indeed, that we have over 3 years' engineering study of the Apollo mission as a sound background for the LEM program buildup and acceleration in which we are now involved.

We are off to a good start. The preproposal and proposal efforts are paying off. During the 6 weeks prior to Christmas the Manned Spacecraft Center at Houston conducted a unique and well-planned negotiation with Grumman which resulted in rapid agreement on contract terms. This series of discussions examined in greater detail than ever before in our corporate experience the scope and nature of the tasks to be done and the costs associated with these tasks. We think that this resulted in a remarkably thorough mutual evaluation of the LEM program by the procuring agency and the contractor.

As I mentioned earlier, authorization to proceed was received on January 14, 1963. The final contract document completed NASA approval processing on March 8, 1963.

In earlier testimony the Apollo mission and the role of the LEM have been well outlined. I would like to describe at this time some of the design features which are evolving and to comment on some of the problems we consider most critical.

I think we would like to move to the first slide (fig. 132).

The overall appearance of the LEM is essentially the same as the pictures you have seen in various publications.

The first slide shows a photograph of a model, which I picked primarily to indicate the size of the vehicle with respect to the man.

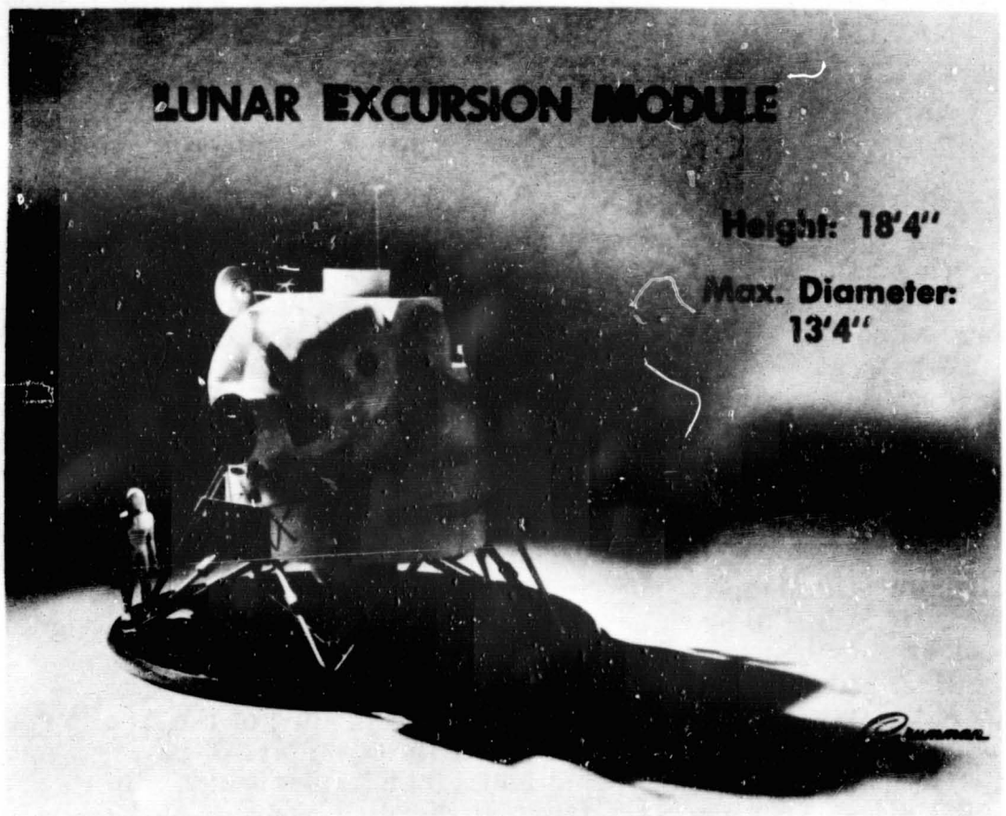

FIGURE 132.

The little man standing down here is a standard 6-footer and the height is approximately 18 feet overall and maximum diameter about 13 fee

The general arrangement derives from requirements for crew visibility—you will note the windows—the crew ingress and egress, the management of large quantities of fuel and oxidizer carried, landing impact, and staging. This vehicle has been tailored to the requirements of the lunar landing. The ability to do this is one of the principal advantages resulting from selection of the lunar orbit rendezvous type of mission.

On the next slide (fig. 133) we have shown a side view, what we call an inboard profile, of the vehicle, and this shows in more detail some of the features.

For example, I am going to speak about staging. This dividing line represents the break point between the lower or landing stage and the upper or ascent stage.

We have color coded a few of the key features, the pressurized crew compartment, the rocket motors, the descent engine, the ascent engine.

We have two hatches, the initial docking hatch, and then the hatch that provides access to the lunar surface, which also serves at the rendezvous hatch.

The first stage, below this line, contains the descent engine, fuel and oxidizer and the landing gear, and not a great deal else.

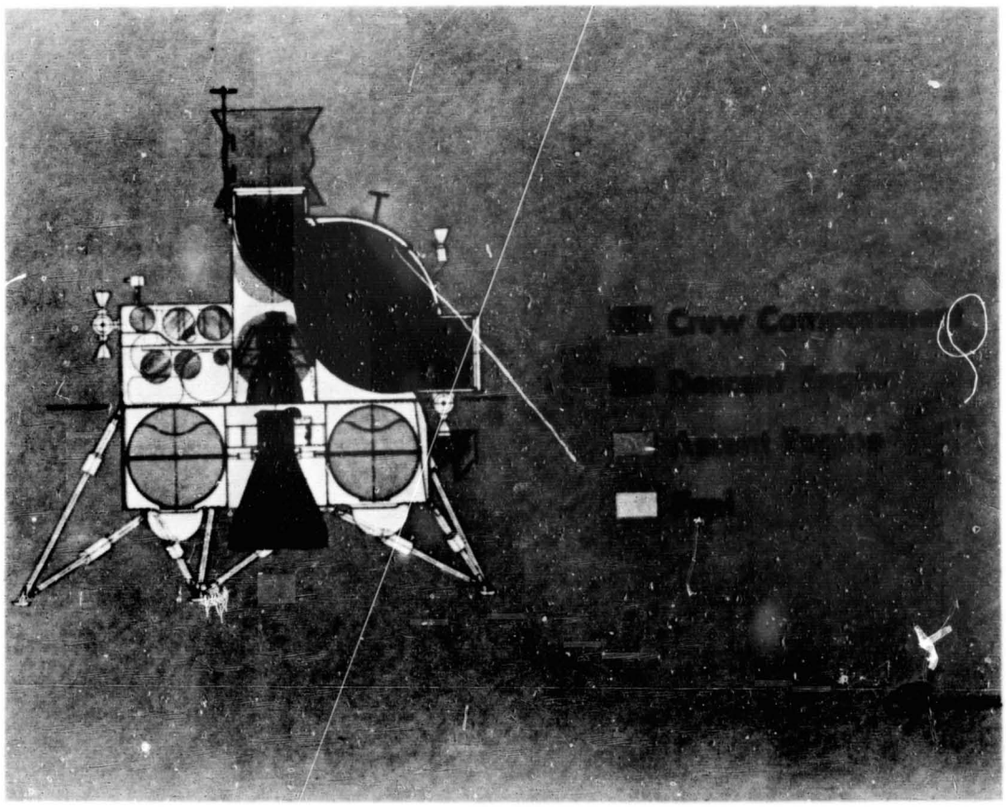

FIGURE 133.

The ascent stage, above this line, contains the crew's provisions, most of the working systems of the vehicle, the attitude control, communication and navigation equipment, and, of course, the ascent engine and its fuel and oxidizer.

This staging I mention is analogous to booster staging, in that it provides for a larger payload, with respect to the initial weight than would an unstaged design.

We have not distinguished between fuel and oxidizer, but in this and the following slide (fig. 134) you will see some impression of the amount of fuel and oxidizer that is contained in the vehicle.

The next slide (fig. 135) is a somewhat similar top view, which shows perhaps a little better how the fuel and oxidizer is packed in the vehicle. This view also shows the spread of the five-legged landing gear. I think that is perhaps enough of this slide. We will go to the next one.

This shows the staging. We have separated the model here so the ascent stage appears as it would in the takeoff maneuver. The fact that we leave behind the landing stage with its used-up fuel capacity, and so on, is indicative of the amount of energy that is required in getting from orbit to the lunar surface and back again. And we have prepared an approximate weight history to illustrate the problem involved here (fig. 136).

Here we have tabulated the initial gross weight and initial fuel and oxidizing weight. That is up on this corner of the matrix and, as you

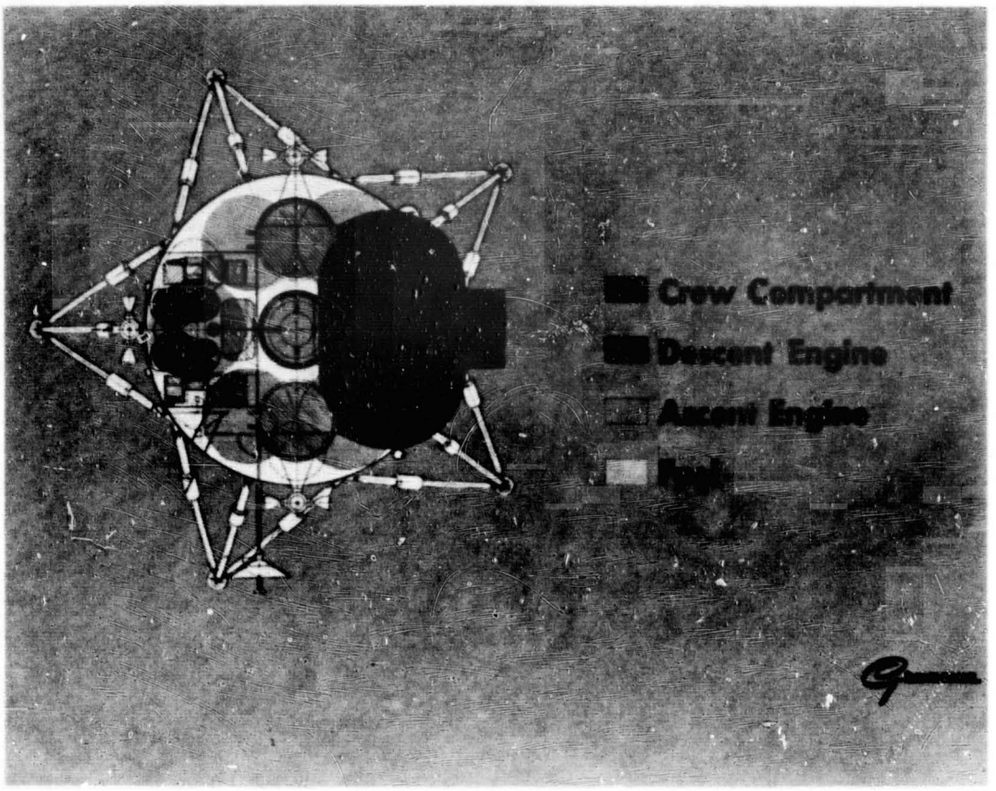

FIGURE 134.

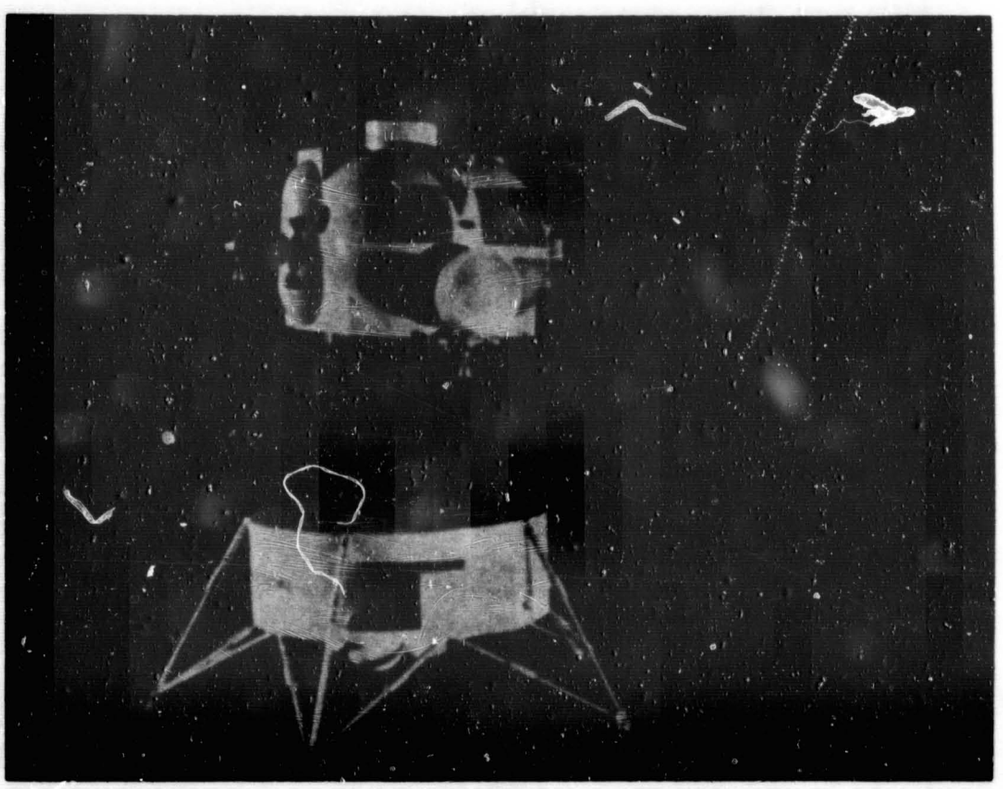

FIGURE 135.

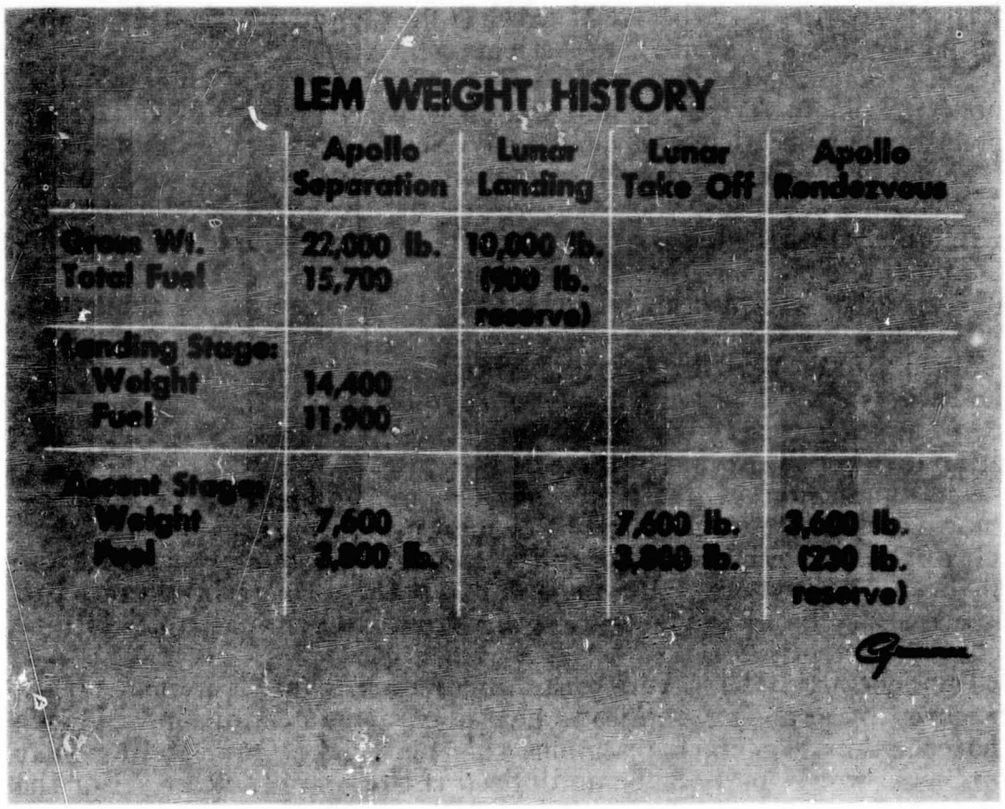

FIGURE 136.

can see, the weight at landing has decreased by quite a bit, by virtually the amount of fuel in the landing stage, except for the reserve.

If you pursue this a little further you find the ascent stage is rather lighter, and by the time you get back to rendezvous you have about 16 percent of the initial gross weight.

Another way of looking at it is as follows. During a little over 6 minutes of burning time during descent 11,700 pounds of fuel and oxidizer are consumed and the vehicle velocity is changed from over 5,000 feet per second to zero with respect to the lunar surface. It is obvious that there is little room for error. Navigation and fuel management precision must be first class.

The two columns on the right show the start of ascent and rendezvous conditions. As you can see, only 16 percent of the initial weight returns. Another interesting way to evaluate the significance of the energy involved and the quantities of expendables involved is to consider the penalty resulting from adding a pound to the payload. For example:

(*a*) An additional pound of equipment to be carried down to the lunar surface and back requires a growth in initial weight of 5.1 pounds.

(*b*) An additional pound to be raised from the lunar surface—say geological specimens—results in an increase in lunar takeoff weight of 2.7 pounds, and an increase in initial vehicle weight of 4.4 pounds.

These examples of the consequences of weight management are severe enough considering only the LEM. Similar growth factors can, of course, be traced back to the original launch vehicle.

In other words, if the LEM exceeds its weight greatly this can be traced all the way back to the Earth launch vehicle.

I have mentioned already two of our major problems, fuel management/precision navigation and weight control. I would like to comment further on other areas currently identified as being particularly difficult. As mentioned earlier, the descent to the lunar surface is a challenging problem—and a key to its success is the development of a reliable, throttleable rocket motor. This descent rocket motor development is so vital that NASA has decided to carry two separate and different schemes on into the test-firing phase before final commitment to one scheme.

Mr. TEAGUE. Who is doing that work?

Mr. GAVIN. We are committed only to one parallel effort, so far.

We are negotiating with Rocketdyne, and have just started a competition to select the second of these two parallel contractors.

The lunar surface itself presents a major problem. Until more is known, we have no recourse but to maintain a conservative and flexible approach to the design of the landing gear, primarily with regard to footprint pressure. A number of hypotheses have been voiced to describe the lunar surface—ranging from deep impalpable dust to baked rock froth.

Incidentally, I have here a sample of rock foam Grumman manufactured by exposing pumice to heat and vacuum conditions. I hope that the lunar surface resembles this material. Our landing gear problems would perhaps be minimized if this were the case. For the present, however, we must await real information.

Mr. TEAGUE. Do you know how much is going on, and what is going on, in order to get the information?

Mr. GAVIN. Yes, sir; we are familiar with the Surveyor program, which I think is the most likely program to return information regarding the surface geology.

Another major concern is reliability. In brief, we have two goals. The first is to make all the vehicle subsystems so that no failure will occur—this has some practical limit.

The second goal is to provide the astronaut with information and the means for doing something about it in the event of a failure. These two goals lie right at the heart of manned vehicle design. One of our principal efforts, then, involves supplying the astronaut useful information as to the progress of the flight, permitting him to make the decision to continue, to correct errors, or to abort, and providing backup modes of operation which make the best use of his capabilities.

A further concern which involves both the astronaut and reliability is the use of equipment or components which are already under development in other parts of the Apollo program.

For example, I think it is pretty obvious that the astronauts' controls and displays of the command module and the LEM should have considerable similarity.

We are right now in the throes of evaluating what "common usage" can be practically accomplished. This involves the consideration of requirements which are not quite identical. In many cases the LEM does not require all the features of the command module component or system. The weight sensitivity of the vehicle mentioned earlier is just one constraint on "common usage."

With regard to technical problems, I think it would be best to summarize at this point by saying that the undertaking is essentially conservative in that no major breakthrough in the engineering state of the art is required.

In the remaining minutes I would like to outline briefly the industrial organization so far developed for LEM.

Going to the next slide (fig. 137), this is quite abbreviated, but points out the fact Grumman is the prime contractor for the lunar excursion module, that we work for the Manned Spacecraft Center in Houston, that there are other people in the Apollo program, who have other tasks, namely, MIT, the Guidance and Navigation System; MIT

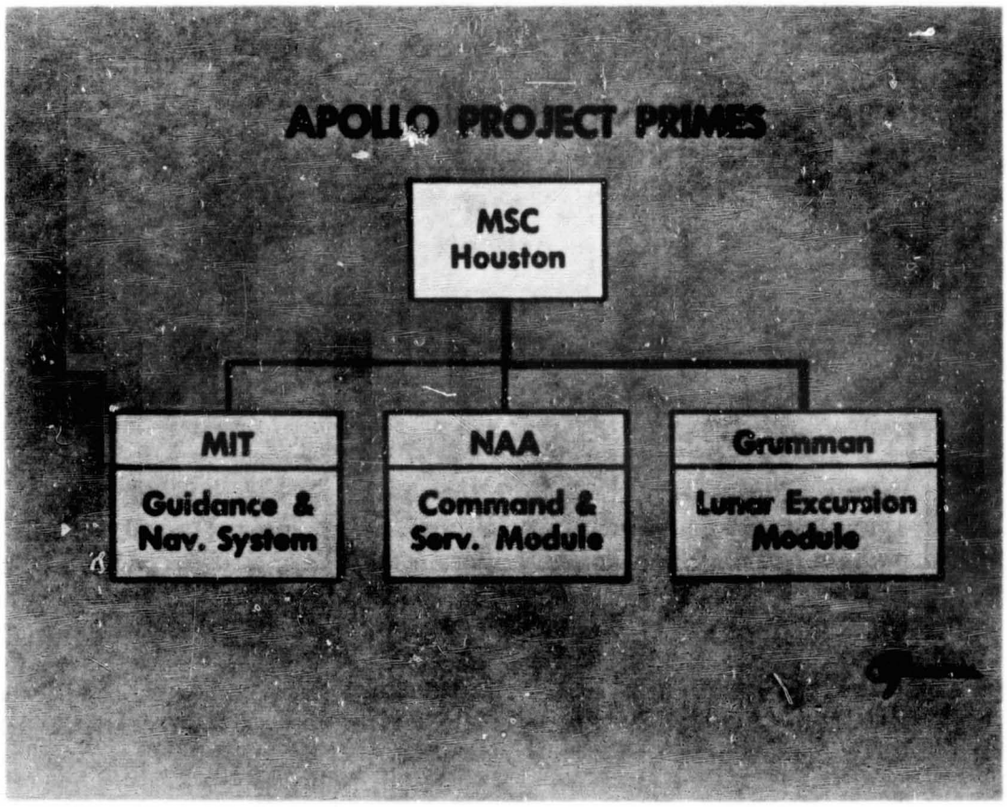

FIGURE 137.

is the contractor for it. And then, of course, the largest part of the program is the role North American plays with respect to the command and service module.

These people all have to work fairly closely together, and it has been gratifying to see that a good exchange of information is already underway and we have had quite a number of useful meetings.

I would like to comment briefly on the Grumman organization. The LEM program operates very much like a small company within a company (fig. 138).

This is a pretty abbreviated description. But the point here is that within the program management for LEM are the elements required to do the job. This is the type of division of responsibilities you would expect in any business.

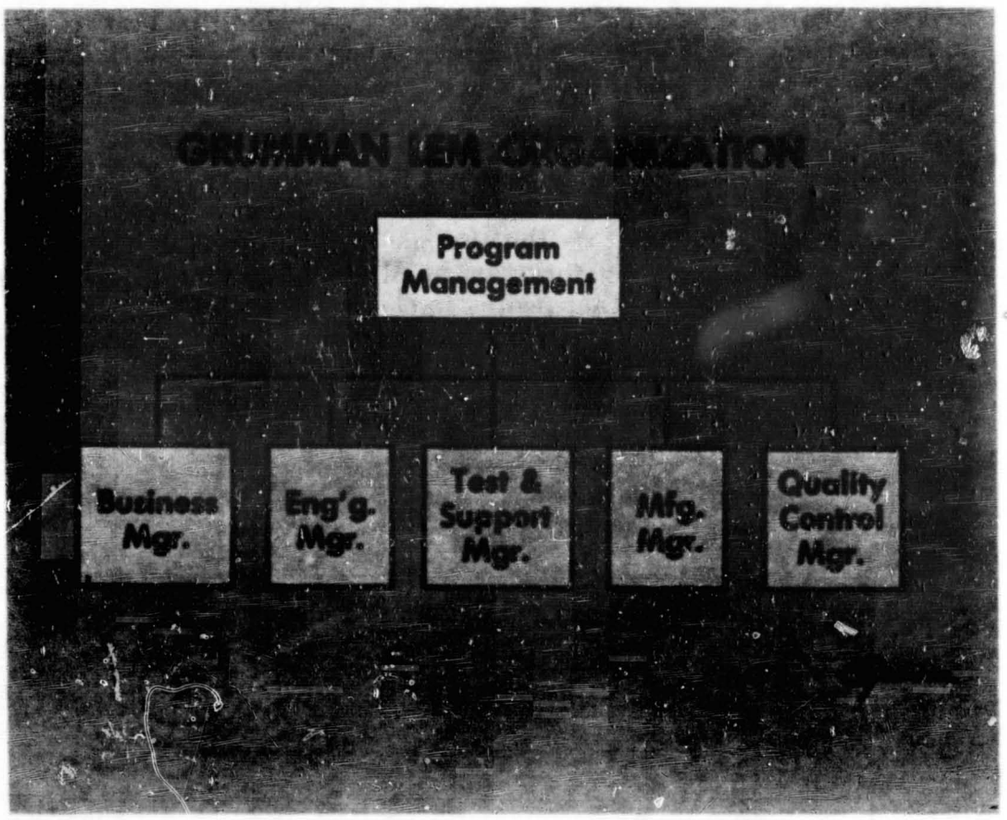

FIGURE 138.

We have our own business office, our own engineering and so on.

This type of arrangement has been called a highly projectized operation, and we feel this is the type of thing necessary to provide the coherence necessary in handling the responsibilities of a program of this nature.

At the same time, this LEM organization has very well considered ties with the traditional company departments, to insure the availability of their experience.

Within the scope of Grumman responsibilities, there are included a number of subcontracts. Selection has been made and negotiations are currently in progress with the following subcontractors:

For one of the two descent engines: Rocketdyne.
Ascent engine: Bell.
Reaction control components: Marquardt.
Environmental control system: Hamilton-Standard.

A competition has just been launched to select a parallel descent engine source. A number of subcontracts in the communication, radar, and stabilization and control areas will evolve after requirements are further defined and "common usage" studies are completed.

In summary, gentlemen, we are hard at it—we think we've gotten off to a good start. We've assigned a talented group of experienced people to the program. Considering the newness of our program, I think I have said enough; I would prefer to let time demonstrate our accomplishments.

Mr. TEAGUE. Does the LEM contract specify rates of funding and time schedules for testing and delivery?

Mr. GAVIN. Yes, sir. It does. The contract specifies a total amount of money, and also specifies the amount—the limitation to be observed through the end of fiscal 1963.

The program scheduling is a subject I would rather not discuss in detail, because I believe parts of it are classified, but it is, as far as I know, consistent with the NASA program that has been presented to you.

Mr. TEAGUE. Would you consider this funding level a tight schedule on a rather liberal schedule?

Suppose you got a 5 or 10 percent cut?

Mr. GAVIN. I think our impression is that getting past the end of this fiscal year is a key point, and that the next fiscal year, fiscal 1964, is a rather important year, in that this is the portion of the program in which a lot of major decisions are made and selections made as to the directions in which to go.

I think it is fair to say if the funding is changed, particularly in fiscal 1964, the schedule will have to give in some manner.

The CHAIRMAN. Mr. Gavin, if we ask you for classified material, please just say so.

Mr. GAVIN. Yes, sir.

Mr. TEAGUE. Any questions on funding?

Mr. Daddario?

Mr. DADDARIO. Mr. Gavin, what amount do you estimate that you will need for next year?

Mr. GAVIN. As I recall, about $134 million, something on this order.

Mr. DADDARIO. For this year, what is the sum?

Mr. GAVIN. Let's see. For this year I believe our contract limits us to something on the order of $30 million up to the end of the year.

Mr. DADDARIO. When you showed the chart, you had North American in the center as the, as I understand it, prime contractor. Is that correct?

Mr. GAVIN. Well, in the terminology, I think we have to be careful. These are separate contracts. Perhaps this is analogous to something the Air Force has done in terms of associated contractors.

Mr. DADDARIO. Then, you have them in their relative position under MSC, rather than swinging down from North American.

Mr. GAVIN. That is right.

Mr. DADDARIO. North American is the prime contractor for the command and service module?

Mr. GAVIN. That is right.

Mr. DADDARIO. North American also has an overall management responsibility at MSC does it not?

Mr. GAVIN. I think it is correct to say they have responsibilities in the area of integration and preparing for the launching, which are beyond the design and manufacture of the command and service module.

Mr. DADDARIO. As I understand it then, this managerial function is not one which relates to the performance of your contract responsibilities?

Mr. GAVIN. That is correct. I think this is pretty clear.

Mr. DADDARIO. Well, is it pretty clear, or is it clear?

How sharp are the lines of delineation in their responsibilities in both of these directions?

Mr. GAVIN. Our contract defines precisely what we have to do, defines precisely our relationships with MSC-Houston, and it points out areas where we have to be aware of what the other contractors are doing, and the interfaces we must observe with them.

But there is no question for whom Grumman is working; we are working for MSC.

Mr. DADDARIO. Another point on the experiments which will take place is to develop some knowledge as to the surface of the Moon. As you have set out, it is very important to learn whether or not the surface of the Moon is variable. If the experimentation shows it to be one thing, and you land in an area where it happens to be something else, and this is an area from which a launching might be difficult, does the vehicle then have the capacity, and the fuel capability, to move to a more favorable launching site?

Mr. GAVIN. This is a thing that has occurred to us a number of times. To illustrate: I think if two probes landed in the United States, say, one in southern Vermont and one in Texas, it would be very difficult to predict what the rest of the country looked like. That is an example.

Hopefully, the Surveyor reports will be indicative of the general area where the landing is planned. We would like to know what the surface is like so we could design the landing gear more precisely. We have gone at this in a fashion so that we will not get trapped, even if Surveyor does not report anything back. We have tried to be conservative enough in the design so that if the worst comes to the worst I think we can show that the landing gear can be done adequately to go ahead and make the landing.

There is enough reserve in the fuel so that the craft can be maneuvered over a large, sizable area during the last part of the touchdown. It is not a question of having to land just exactly wherever you come down.

Mr. DADDARIO. You will have some hovering capacity?

Mr. GAVIN. Yes.

Mr. DADDARIO. But once committed to a landing, that will be the place from which you will launch?

Mr. GAVIN. That is right.

Mr. DADDARIO. You will not have the opportunity to choose another landing site?

Mr. GAVIN. I think the launch is not as critical as the landing. If the landing can be made successfully the launch follows without too much difficulty.

Mr. DADDARIO. The chairman poses a point: Suppose you do land in what looks like a good spot and it happens to be a very deep dust area, this being one of the possibilities, the landing might be a safe one, but this might then not be sufficiently hard enough for you to launch from.

Mr. GAVIN. It is my feeling if the dust is that deep the crew had better abort before touchdown.

Mr. WAGGONNER. You think they will be able to do that?

Mr. GAVIN. Yes. They will be able to do that. And I think the ability of the descent engine jet in stirring up this dust will give

them a pretty good indication whether it is a shallow layer or a deep layer.

Mr. DADDARIO. I understand they can abort at any time before they commit themselves. But once committed and landed, it is not planned at the moment they would have the capability to move to what might be a more favorable launching area?

Mr. GAVIN. Once you have landed from the hover point you do not have the opportunity to pick up and, say, go 5 miles away.

Mr. TEAGUE. Mr. Fuqua?

Mr. FUQUA. Do you have enough information so that the data which we receive from the Surveyor flight will not require you to change the basic design of not only the landing gear, but other factors of the landing module?

Mr. GAVIN. It is pretty hard to foresee all the eventualities.

Mr. FUQUA. But it is possible you may have to change the basic design of the entire LEM?

Mr. GAVIN. Things could be worse than anyone anticipates. However, the approach is pretty conservative. And the design of the landing stage being separate from the ascent stage limits the effect of changing the landing gear drastically, and we are designing the descent stage in such a fashion that it will handle a variety of assumptions concerning the landing gear itself.

So you can think of it as being a progressive problem. If there are difficulties observed in the surface presumably the first thing that would be affected would be the pad at the foot of the landing gear. If the difficulty were a little greater it would affect, perhaps, the struts of the landing gear. If it got beyond that you might get into the overall geometry.

Mr. FUQUA. But you have enough knowledge to go ahead safely with the basic design of the LEM that you have already set forth, not counting the landing gear?

Mr. GAVIN. We have taken two broad assumptions, one that the surface is pretty hard, the other that the surface is pretty soft, and we are trying to make sure if it comes out in between it will be all right.

Mr. FUQUA. You mentioned taking materials back after a successful landing. Do you contemplate having the crew leave some of their equipment on the surface of the Moon so that they can therefore bring back more material, such as the little excursion device that you have that they can ride around on?

Mr. GAVIN. We have a requirement to be able to carry back so many pounds of geological specimens. This can be done without leaving any vital part behind.

Mr. FUQUA. I don't mean "vital," I mean something they won't need to make a successful rendezvous back with the command module, such as the little excursion cart that they plan to have, and some other equipment that they might have, so that they maybe could bring back more samples of the Moon.

Mr. GAVIN. We tried to put the equipment that could be left behind in the landing stage, so it would be automatically left behind.

Mr. TEAGUE. Mr. Gurney?

Mr. GURNEY. Back to the abort business, you say the men will have the capability to abort prior to landing if the surface is not as they expect it might be.

How about rendezvousing? As I recall, at Grumman last year, or somewhere along the line, someone said there had to be a very precise takeoff time for the LEM to rendezvous with the command module in orbit. How does that correspond with the abort business?

Mr. GAVIN. The fact you are in the descent maneuver automatically sets the timing with respect to the command module.

The place you get into the timing problem in takeoff is where you have been on the surface for a while, time has elapsed, and the relationship of the command module to the LEM has gotten out of phase.

You see, as you are in the descent maneuver you bear a predictable relationship to the command module, so the timing is pretty well set.

You are not going to stay there in midspace long enough to get out of synchronization.

Mr. GURNEY. Actually, what does happen?

If the LEM goes down like this and takes off again, do you catch the command module the next time around?

Mr. GAVIN. Yes, more or less, yes.

As you come down the command module bears a certain relationship to the LEM, and if you abort anywhere along the way it is not quite, but almost, a reversal of what happens on the way down, and you do gradually get back into the matching orbit.

Mr. GURNEY. And you catch it the next time around?

Mr. GAVIN. It is not quite that simple, I am afraid.

You overtake it.

Mr. GURNEY. Well, not to pin you down, but in any event, when you do say you can abort, this has been figured out so that when you are back up again a rendezvous can be possible?

Mr. GAVIN. That is right. And this is, frankly, one of the most difficult problems from an analytical point of view, because, obviously, you can abort from any part of the descent phase of the mission, and the problem of—the problem at any instant of selecting the proper course to get back into the right orbit to match up with the command module is a very interesting analytical problem.

From what we have done so far it appears that it is feasible. I am sure if I were one of the astronauts I would insist that this be practical.

Mr. GURNEY. I think you are right.

Mr. GAVIN. We intend to make it practical.

Mr. TEAGUE. Mr. Roudebush?

Mr. ROUDEBUSH. Have you given thought to the fact that Surveyor may give you atypical rather than typical analysis of the Moon surface?

Mr. GAVIN. Yes, we have worried about this.

Mr. ROUDEBUSH. I would if I were an astronaut. I will say that.

Mr. GAVIN. You would really like a number of Surveyor reports, or have some means for the Surveyor to look at more than a specific point.

Mr. ROUDEBUSH. Yes. Like the Prospector project that we planned originally, to give us a wider range.

Mr. GAVIN. That would have provided a wider range.

Mr. ROUDEBUSH. I want to ask you about some of these subcontractors you have listed here.

Where is the location of Rocketdyne?

Mr. GAVIN. That is in Los Angeles.
Mr. ROUDEBUSH. And Bell?
Mr. GAVIN. They are in Buffalo, N.Y.
Mr. ROUDEBUSH. And Marquardt?
Mr. GAVIN. Los Angeles. And Hamilton-Standard is in Hartford, Conn.
Mr. ROUDEBUSH. That is all I have.
Mr. TEAGUE. Mr. Waggonner?
Mr. WAGGONNER. Mr. Gavin, to this point, other than experiments you have conducted at Grumman, what else have you done to assist you in arriving at the decision as to what the surface of the Moon is actually like?
Mr. GAVIN. We have made a rather thorough search of the literature to see what has been hypothesized by the various people who have studied this.
The information is rather sparse, but there are some bits of information. We have some knowledge as to how the surface of the Moon reflects various length radar waves.
We know something about its optical properties. You can try to set up a model using known substances here on Earth, to duplicate these.
Mr. WAGGONNER. Primarily, the information we have at this point from optical observations have led us to believe that we are going to have some kind of a hard, smooth surface, is that right? Refractory qualities, or optical observations, have been such as to lead us to believe that?
Mr. GAVIN. Well, if you could get a consensus at this time, it is that there is some kind of a rock foam or porous rock, and on top of this there is some kind of a dust layer which may vary from a few inches to perhaps a few feet.
That, I think, is about it. There have been some assumptions made as to the sizes of major discontinuities, but it is pretty shaky.
Mr. WAGGONNER. Some scientists have projected the idea that possibly the dust might be similar to cement, inasmuch as the refractory qualities have shown about the same characteristics.
Mr. GAVIN. That is right.
Mr. WAGGONNER. What possible assistance at this point, certainly it is in the development stage, but if there was a further breakthrough with lasers, how could we utilize it to determine what the surface was going to be like at this point?
They have already, in the laboratory way, sent a signal by laser light to the surface of the Moon and back in two and a half seconds. What possible assistance might that be?
Do you have plans to employ laser in further use to help you determine what the surface is like?
Mr. GAVIN. I don't have a very satisfactory answer to your question.
Personally I am not sufficiently qualified to answer what could be done with laser.
Secondly, the second part of your question, we have currently no specific plan. I am not saying it may not have merit, but I personally cannot answer the question any better.

Mr. DADDARIO. Mr. Gavin, what help will the Gemini program be insofar as developing rendezvous techniques to bring together the excursion module and the command module?

Mr. GAVIN. I think one of the most obvious areas is the question of tolerable approach rates between the two vehicles.

I think you have all read of the possibility that without any reference frame such as we are accustomed to here on Earth that the ability of a pilot to judge the distance and closing rate to the rendezvousing vehicle may be impaired, compared to what you would expect from experiences here on Earth, so that with the Gemini program I think we will obtain our first direct experience as to what astronauts' capabilities are. This may in turn give us a better grip on the amount of fuel that would be expended in the LEM rendezvous maneuver.

Mr. DADDARIO. How does the development of this program contemplate at the moment the simulation of the rendezvousing of the command module and the excursion module? Is this going to be done automatically or must it always be done using a man or men?

Mr. GAVIN. Well, when you say "simulation," this, I suppose, has to be defined. There will be what we call simulation programs run on Earth with special test setups which permit visual and dynamic simulation of the task to be done. This produces two things: it provides for the development of engineering information to govern the design, and also provides for the training and development by the astronaut of what he thinks is required for the mission.

Now, the second part of your question, I think has to do with the first real docking maneuver.

Mr. DADDARIO. Yes.

Mr. GAVIN. And the present plan is to put the command module and LEM into Earth orbit, and with the command module manned—and that is the way you would start out. The present feeling is that there will have been enough background gained by that time so that it is a relatively simple step into manned operation.

Mr. DADDARIO. You mean the command module manned, and a separation of the excursion module unmanned, and then bringing them together through some kind of automatic procedure?

Mr. GAVIN. Not automatic. But through a piloted procedure.

Mr. DADDARIO. Through control from the command module itself?

Mr. GAVIN. Yes.

Mr. DADDARIO. Does this put it into position so that when the actual operation takes place, the command module will control completely the process from the time of launch to the point where they will come together and have the transshipment of the personnel?

Mr. GAVIN. I don't think we are visualizing quite the same events.

The command module would be launched in the same stack with the LEM, and its first maneuver would be to separate itself, and then to dock back on.

So I think there is not the automatic feature that you seem to have in mind.

Mr. DADDARIO. Is it practical to imagine that we will reach the point where there will be the kind of control that I speak of with the automatic docking?

Because when the excursion module is on the Moon and does take off, and the problem is such a severe one, that the responsibility for the whole trip will greatly depend upon the capabilities of the astronauts to bring these two modules together.

Mr. GAVIN. The ascent and rendezvous problem breaks down into several phases, really: first, the navigation problem of getting to the vicinity of the command module.

I think when we speak of docking we are talking about the last relatively few feet, and throughout our thinking at this time this last relatively few feet is a piloted maneuver as opposed to an automatic maneuver.

Now, getting to the vicinity can be done automatically, and the primary mode is that.

Mr. GURNEY. Mr. Gavin, why do you have two openings in the LEM? As I understand it, one is to get out on the Moon, and the other is to crawl from the LEM into the command module. Couldn't you do that with one opening? I am just curious.

Mr. GAVIN. That is one of the things we are rehashing at this point. as to whether two hatches are necessary. Our reasoning originally was that the upper hatch represented the desirable arrangement for the translunar flight, in other words, during most of the flight the command module would be docked to the LEM by the upper hatch, and that would represent a grip on the LEM which was on its axis of symmetry.

Then the other hatch came about because of the fact that it appeared that the rendezvous docking could be accomplished better if the hatch were more nearly in the same relationship to the astronaut as a refueling probe is to a pilot in an airplane, in front of him where he would have a good view of it.

We also found by putting it in that position it made possible easier access to the lunar surface. So at this point the design has the two hatches.

Mr. GURNEY. I see.

Mr. WAGGONNER. Do you feel there is any military value to be gained from this Apollo mission?

Mr. GAVIN. I guess that is the sort of question that must be answered on a personal opinion basis.

I think eventually, yes. I think all the technology involved here has ultimate military value.

Mr. WAGGONNER. Do you think the military had better be concerned about space in the time to come?

Mr. GAVIN. It is my personal opinion they should be.

Mr. TEAGUE. Mr. Yeager?

Mr. YEAGER. Following Mr. Daddario's line of questioning: As I understand it, there will be no way to actually practice docking the LEM with the command module on a real lunar mission. The first time you do it you will actually have men in it. For example, when they began the Mercury program they orbited a few times with animals, and so on. But this cannot be done with LOR, can it? I understand your practice will be in separating, and rendezvousing in

an Earth orbit, but when you go to the Moon, the first time you attempt LOR will have to be done with men?

Mr. GAVIN. That is right. I think you have to balance here the two possibilities. If you attempt to develop an unmanned preliminary operation you have to develop then some rather complex gadgetry to replace the man and in some of our experience the gadgetry to replace the man has proved to be more difficult than the basic mechanisms you are trying to prove out in the first place.

So it is not a clear-cut advantage to do it automatically first.

Mr. YEAGER. Do you think it would be desirable to have a lunar logistics system developed simultaneously with the LOR concept? Assume for your answer that cost were no factor.

Mr. GAVIN. The LEM program as it now stands is self-sufficient.

I think the advantage of the logistics system has to do with the intent concerning lunar exploration. It has been argued back and forth as to how long these people should stay there, what they do after they get there, and so on.

I suppose it would be some advantage to be able to have some additional supplies landed prior to the first manned landing. But the present program is a self-sufficient program and I think the logistics system has to be weighed by adding in the problems involved in the exploration.

Mr. YEAGER. Mr. Gavin, we have heard a great deal about the need for redundancy in various parts of the Apollo system, and subsystems, and so forth. There is no redundancy built into your ascent methods at the present time, is there? If one system fails, in other words, you have nothing to fall back on?

Mr. GAVIN. I assume you are referring to the rocket motor?

Mr. YEAGER. Yes.

Mr. GAVIN. The answer to that is this: You try to provide redundancy where it can be done and where it makes sense, and ultimately there are always a few items which turn out to be either impractical or just impossible.

In the case of the rocket motor I suppose we are in the same position that a single-seat, single-engine fighter is: you can't have it with more than one motor without having the size of the thing get out of hand.

So, in this respect it is true, the motor is not redundant. However, all of the control systems and other systems in the ascent stage have a redundancy where it seems to make sense.

Mr. YEAGER. Does LEM, as presently designed, have appreciable reserves of fuel in case you have errors of navigation or timing?

Mr. GAVIN. This is a matter that we are still evaluating. Obviously, this determines the size of tanks and so forth.

One of our present exercises is to weigh the matter of the amount of reserve. Initially, we conceived that something on the order of a 10-percent energy reserve might be reasonable.

Mr. YEAGER. Is that still the feeling?

Mr. GAVIN. We are still debating this. If anything, it will go up, I suspect.

Mr. WAGGONNER. Mr. Gavin, what do you anticipate the rated thrust of this descent engine will be?

Mr. GAVIN. About a 10,000-pound full-thrust engine.

Mr. YEAGER. One more question: Do you have any notion now about how much weight you can carry back with you? We assume that once they land they will want to bring back some dust, rocks, things of that nature. Do you have any idea how much it can bring back?

Mr. GAVIN. I think that we have allowed something over 100 pounds.

Mr. YEAGER. Would this be weight on the Moon or on the Earth?

Mr. GAVIN. These are Earth pounds.

Mr. TEAGUE. Any other questions? Thank you, Mr. Gavin. We appreciate your coming down. That is all we have today.

The committee will adjourn until tomorrow morning at 10 o'clock.

(Whereupon, at 11 a.m., the committee was adjourned, to reconvene at 10 a.m., Wednesday, March 20, 1963.)

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1964 NASA AUTHORIZATION

WEDNESDAY, MARCH 20, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON MANNED SPACE FLIGHT,
Washington, D.C.

The subcommittee met at 10 a.m., Hon. Olin E. Teague (chairman of the subcommittee) presiding.

Mr. TEAGUE. The committee will come to order.

We have with us this morning Dr. John A. Hornbeck, president of Bellcomm, Inc.

Do you have a prepared statement, Dr. Hornbeck?

Dr. HORNBECK. I do, sir.

STATEMENT OF DR. JOHN A. HORNBECK, PRESIDENT, BELLCOMM, INC.; ACCOMPANIED BY W. J. WHITTAKER, VICE PRESIDENT AND GENERAL MANAGER, BELLCOMM, INC.; AND F. C. CHILDS, GENERAL ATTORNEY, BELLCOMM, INC.

Dr. HORNBECK. May I first introduce my colleagues?

On my left, W. J. Whittaker, vice president and general manager of Bellcomm; on my right, Mr. F. C. Childs, our general attorney.

Mr. Teague. Thank you.

(Biographical sketch of Dr. Hornbeck is as follows:)

DR. JOHN A. HORNBECK, PRESIDENT, BELLCOMM, INC.

Dr. John A Hornbeck, before joining Bellcomm, Inc., as president and a member of the board of directors, was executive director, Semiconductor Device and Electron Tube Division at Bell Telephone Laboratories, Inc.

Dr. Hornbeck joined Bell Laboratories in 1946 as a research physicist in the physical electronics department. In 1951 he transferred to the transistor research department. He headed groups specializing in semiconductor physics from 1952 to 1953, and in solid state device development from 1953 to 1955. He was named director of electron device development in 1955 and assumed the position of executive director, Semiconductor Device and Electron Tube Division in October 1958.

Dr. Hornbeck is a native of Northfield, Minn., and a graduate of Central High School, Kalamazoo, Mich. He received the A.B. degree from Oberlin College in 1939 and the Ph. D. in physics from Massachusetts Institute of Technology in 1946.

During World War II he was associated with the National Defense Research Committee's Physics Division and Land Mines Committee.

Dr. Hornbeck is a fellow of the American Physical Society, a fellow of the Institute of Radio Engineers, a member of the American Association for the Advancement of Science, Phi Beta Kappa, Sigma Xi, and Delta Sigma Rho. He is also a member of the Visiting Committee, Department of Physics, of MIT. He is the author of numerous technical articles which have been published in the Physical Review.

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Dr. Hornbeck and his wife, Emily, reside in Sumner, Md. They have three sons and two daughters.

Dr. HORNBECK. Mr. Chairman and members of the subcommittee, I welcome the opportunity to appear this morning to discuss Bellcomm's efforts on behalf of the National Aeronautics and Space Administration. Before describing the work in which we are involved, it may be useful as background information to review, briefly, how Bellcomm was founded and the nature of our present organization.

An exchange of letters early in 1962 between the National Aeronautics and Space Administration and the American Telephone & Telegraph Co. led to the founding of Bellcomm and defined its job. This correspondence, copies of which are appended to this statement, consists of a letter dated February 21, 1962, from Mr. James E. Webb, Administrator of NASA, to Mr. F. R. Kappel of A.T. & T., and a reply from Mr. E. J. McNeely, president of A.T. & T. to Mr. Webb, dated March 1, 1962.

(The correspondence referred to is as follows:)

FEBRUARY 21, 1962.

Mr. F. R. KAPPEL,
President, American Telephone & Telegraph Co.,
New York, N.Y.

DEAR MR. KAPPEL: As you know, the National Aeronautics and Space Administration is primarily responsible for the Nation's space exploration program, including manned space flight. Our mission in the manned space flight field during the present decade extends from Earth-orbital flights of short duration to lunar exploration involving the landing of men on the Moon and their safe return to Earth. It will require not only the rapid solution of some of the most complex technological problems ever faced but also, from the management side, the efficient and effective coordination of a large number of separate organizations in the industrial, university, and governmental sectors.

In carrying out this unprecedented task, NASA could be greatly assisted, I believe, by utilizing the resources and experience of an organization such as the Bell System. The job of coordinating a worldwide communications network must have presented many of the same kinds of system planning, engineering, and integration problems, on a very large scale, that we expect to encounter in carrying out the Nation's program of manned space exploration.

It would be a public service of the very first order of importance if the Bell System would undertake to assist NASA in this work by providing an organization of experienced men capable of giving the responsible NASA officials the benefit of the most advanced analytical procedures and the factual basis they need to make the wide range of system engineering decisions required for the successful execution of the manned space flight mission.

My view at this time is that such an organization should be under the guidance of the senior officials of the American Telephone & Telegraph Co., the parent organization of the Bell System, and that it should be able to utilize the talents and experience of the Bell Telephone Laboratories, Western Electric Co., and other associated companies. The form of corporate organization to be employed for such a task should be so arranged as to maximize those features which will make for efficient and effective operation, and we would have no objection to the establishment of a separate subsidiary corporation to do the job. After a study of the work contemplated, and the alternatives available, a cost-plus-a-fixed-fee contract appears to us to be the appropriate basis for defining the business relationships and the respective rights and obligations of NASA and such an organization. The fee would, of course, provide a reasonable profit for the services performed.

I know you understand that any such arrangement can in no way impair NASA's direct responsibility for all decisions in the planning, engineering, and procurement areas. There will be no delegation of such responsibility to a non-Government organization. What we are seeking is not a means of diluting the responsibility or authority of NASA's appropriate officials, but rather the most skilled and experienced assistance available to enable us to exercise that responsibility and authority in the most effective manner.

I am sure that you and your associates in the Bell System are fully aware of the importance of the manned space flight program to our Nation. I hope that your organization will find it possible to assist in accomplishing this mission by participating with us in the way I have indicated in this letter.

Sincerely yours,

JAMES E. WEBB, *Administrator.*

MARCH 1, 1962.

Hon. JAMES E. WEBB,
Administrator, National Aeronautics and Space Administration,
Washington, D.C.

DEAR MR. WEBB: Thank you for your letter of February 21, addressed to Mr. Kappel, asking the Bell System to furnish certain assistance to the National Aeronautics and Space Administration in carrying out the Nation's program of manned space exploration.

We in the Bell System are keenly aware of the importance of the man-in-space program to our Nation and of the heavy responsibilities which it places on you and your associates in NASA. Ours is an organization which is dedicated to the provision of nationwide and worldwide communications. As you know it is not our practice to seek work for the Government or for others which is outside the communications area. However as citizens we hold to the belief that the national interest must come first in industry as well as in every other segment of our national community, and we have invariably accepted and embraced requests from the Government to undertake work in the national interest wherever our organization is especially qualified to be of assistance. For this reason, we will be glad to assist you in accomplishing the mission described in your letter.

As I am sure you will understand the provision of the expert personnel which will be required will place a not insubstantial drain upon our organization. For this and other reasons we believe we can do this job most effectively through the formation of a separate subsidiary corporation within the Bell System which will be in a position to draw on the talents and experience of this company as well as Bell Telephone Laboratories, Western Electric Co., and our other associated companies.

Further discussions between our respective organizations will, of course, be necessary to work out the details of these arrangements, and we will be ready to undertake these discussions at your convenience.

Mr. Kappel is away from the office. However I have discussed this matter with him fully and he is in complete accord.

Sincerely,

E. J. MCNEELY, *President.*

Dr. HORNBECK. The substance of these letters is given in the following paragraphs, parts of which are excerpts. Mr. Webb's letter states:

It would be a public service of the very first order of importance if the Bell System would undertake to assist NASA * * * by providing an organization of experienced men capable of giving the responsible NASA officials the benefit of the most advanced analytical procedures and the factual basis they need to make the wide range of system engineering decisions required for the successful execution of the manned space flight mission.

Second, it goes on to say:

The form of corporate organization to be employed * * * should be so arranged as to maximize those factors which will make for efficient and effective operation, and we would have no objection to the establishment of a separate subsidiary corporation to do the job.

Third, it states further:

* * * a cost-plus-a-fixed-fee contract appears to us to be the appropriate basis for defining the business relationships * * *

Fourth and lastly, it emphasizes—

* * * such arrangement can in no way impair NASA's direct responsiblity for all decisions in the planning, engineering, and procurement areas. There will be no delegation of such responsibility to a non-Government organization. What we are seeking is not a means of diluting the responsibility or authority of NASA's appropriate officials, but rather the most skilled and experienced assistance available to enable us to exercise that responsibility and authority in the most effective manner.

Mr. McNeely's reply says that—

* * * we hold to the belief that the national interest must come first in industry * * *

and

* * * we will be glad to assist you in accomplishing the mission described in your letter.

The letter continues:

* * * we believe we can do this job most effectively through the formulation of a separate subsidiary corporation within the Bell System which will be in a position to draw on the talents and experiences of the company as well as Bell Telephone Laboratories, Western Electric Co., and our other associated companies.

The separate subsidiary corporation of which Mr. McNeely wrote is, of course, Bellcomm, Inc.

I would like next to say a few words about the new company. Bellcomm, Inc., was incorporated March 21, 1962, under the laws of the State of Deleware. Its capital stock, which at present is $700,000, is owned jointly in equal amounts by the A.T. & T. Co. and the Western Electric Co.

A list of the board of directors is appended hereto. For our purposes, at the moment, it is perhaps sufficient to say that the board comprises a chairman and eight others. The chairman is Mr. R. R. Hough, vice president, engineering, A.T. & T. Co. Of the others, two are from A.T. & T.; two are from the Western Electric Co.; two from the Bell Telephone Laboratories; and two from Bellcomm, Inc. It was intended at the outset that the board be a working board in both a technical and business sense. For this reason it contains highly qualified technical people and people with extensive business experience.

(The material referred to is as follows:)

BOARD OF DIRECTORS, BELLCOMM, INC.

R. R. Hough (chairman), vice president, Engineering Department, American Telephone & Telegraph Co., 195 Broadway, New York 7, N.Y.
H. W. Bode, vice president, Military Systems Engineering, Bell Telephone Laboratories, Inc., Whippany, N.J.
L. R. Cook, Engineer of Manufacture, Western Electric Co., 195 Broadway, New York 7, N.Y.
J. A. Farmer, general attorney, American Telephone & Telegraph Co., 195 Broadway, New York 7, N.Y.
J. A. Hornbeck, president, Bellcomm, Inc., 1737 L Street NW., Washington 6, D.C.
C. M. Mapes, assistant chief engineer, Engineering Department, American Telephone & Telegraph Co., 195 Broadway, New York 7, N.Y.
K. G. McKay, executive vice president, Systems Engineering, Bell Telephone Laboratories, Inc., Murray Hill, N.Y.
H. G. Mehlhouse, vice president, Personnel & Public Relations, Western Electric Co., 195 Broadway, New York 7, N.Y.

W. J. Whittaker, vice president and general manager, Bellcomm, Inc., 1737 L Street NW., Washington 6, D.C.

Dr. HORNBECK. The president of Bellcomm and the heads of its two technical divisions came from Bell Telephone Laboratories. Its vice president and general manager came from the Long Lines Department of A.T. & T. The other officers are a comptroller and a secretary-treasurer, the former from A.T. & T., and the latter from W.E. Co.

We have attempted to gather together in Bellcomm people representing the variety of skills and experience required by the technical breadth of the tasks in which we are involved. This has been done in the framework of first providing the essential management and technical leadership and then filling out the organization. We are still carrying out this process. As is the case with any newly organized group of people, we have been learning how to work together as an effective unit. This is particularly important when one is engaged, as we are, with problems that have many facets and interactions.

As of this date, Bellcomm consists of 96 technical people and a supporting staff of 60. About two-thirds of our technical staff is from the Bell System, primarily from Bell Telephone Laboratories. In terms of educational background, 24 percent have a Ph. D. degree, 46 percent an M.S. degree and 29 percent have a B.S. degree.

A chart showing our organization and assignments of responsibility is shown in figure 139.

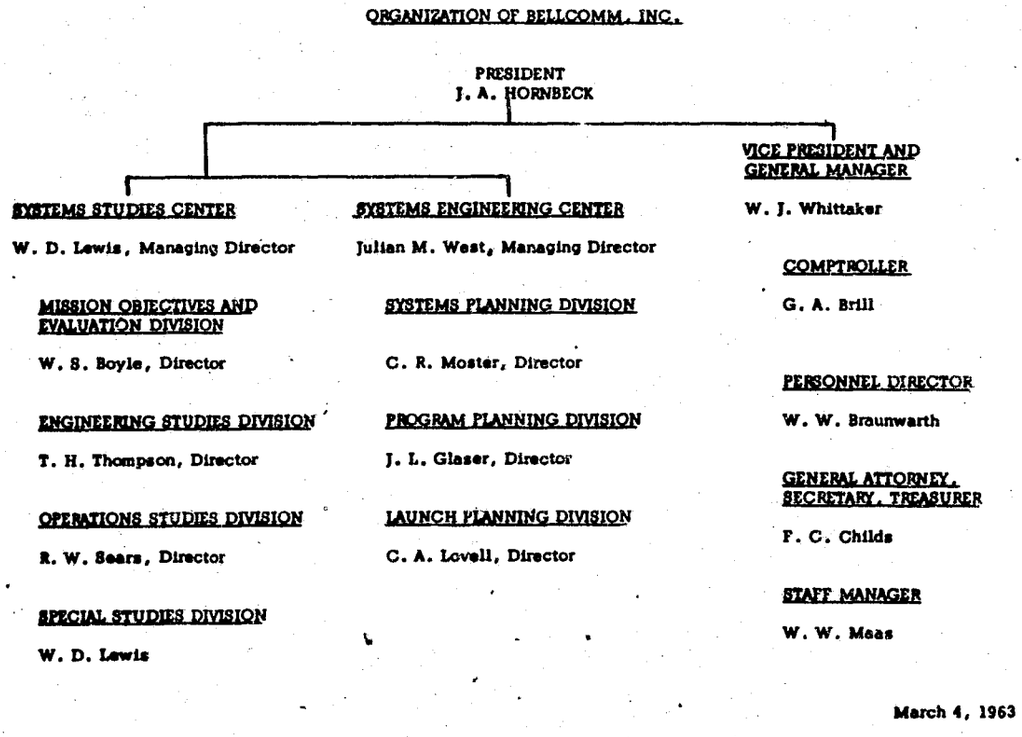

FIGURE 139.

Our plans are to grow such that by the end of this year we shall be an organization of about 250 people, with two-thirds technical and the balance administrative support. We do not plan to grow much in size beyond this. In our judgment, quality of personnel in this kind of activity is much more important than quantity.

In addition to the people provided by Bell Laboratories to Bellcomm, it was contemplated from the beginning that Bellcomm would also draw on specialized skills of Bell Laboratories and that the level of this effort would vary from time to time. At present, about 20 technical people are assigned to Bellcomm work at Bell Telephone Laboratories in New Jersey.

For the 18-month period ending September 30, 1963, the estimated amount of our contract with NASA is approximately $8.5 million. According to the statement of work in the contract, we are—

to perform studies, technical factfinding and evaluation, analytical investigations, consulting effort and related professional activities in support of manned space flight and related programs of NASA.

We conduct our business in leased office space in downtown Washington. We are within walking distance of the Office of Systems in the Office of Manned Space Flight, with whom we are most closely associated in our daily activities.

The general nature of our work is that which we in the Bell System for a long time have called systems engineering. Let me explain in a few sentences what we mean by systems engineering. Any larger system is a complex assembly of diverse, specialized parts and functions. The requirements and objectives of a system, for example, operational, technical, and economic, often are conflicting. These requirements must be formulated and understood. Then the system is planned, or designed, so that all its specialized parts and functions are balanced according to the weighted system objectives.

The final result is an integrated assembly of interrelated parts that act together as a whole. Achievement of this goal involves iterative steps and successive refinements of imperfect approximations. It is a continuing activity during the development of a system. Systems engineering ends with an evaluation of the completed development to assess how well the system meets its objectives.

These words may not be too informative by themselves and I would next like to give you a more definite impression by describing some of the work we are undertaking for the Office of Systems, which has overall systems engineering responsibility. It should be clear that our work benefits from frequent interactions with NASA personnel both in Washington and at the several Centers. The Bellcomm studies produce technical information and evaluations which can help in the solution of the complex system problems. The NASA staff makes use of these studies and forms its own independent conclusions.

Considerable Bellcomm effort has been devoted to assisting NASA in the preparation of an overall Apollo system specification. The purpose of this specification is (1) to define the objectives for the Apollo system an its major subsystems; (2) to define the technical approach to be used to accomplish these objectives; (3) to establish system and critical subsystem performance requirements necessary for the Apollo system to meet its objectives; (4) to specify system performance parameters which affect crew safety, design margins,

capability for growth and program schedules; and (5) to establish a uniform set of system design data.

The specification will reflect the combined thinking and judgment of the appropriate NASA Centers and the Office of Manned Space Flight. The initial draft of the specification, which is being discussed now, will be incomplete in some major aspects because all of the necessary system planning has not yet been done. Thus, continuing effort will be devoted to this task. A copy of the table of contents of the specification document is included for your information.

(The document referred to is as follows:)

APOLLO SYSTEM SPECIFICATION

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Dr. HORNBECK. Bellcomm has also been carying out studies leading to the classification and characterization of those physical processes in space which might affect manned flights. A number of studies relating to meteoroids, radiation, and the lunar surface have been undertaken. A study was made of the available data concerning the meteoroid environment with particular attention to the uncertainties in the information. This study and subsequent consultation with a number of specialists in the meteoroid field led to the conclusion that earlier models used for calculating meteoroid penetration effects were unduly conservative. A new model was generated which indicates that shielding requirements may be lowered.

A study was completed which estimated the radiation exposure arising from natural and manmade radiation belts. The effects of variations in some of the orbital parameters of the flights and of possible future changes in the radiation environment were considered.

Existing knowledge of solar flare proton radiation has been reviewed. At this time only a limited number of flare-proton events have been observed, and only a very tentative probabilistic description of their occurrence is possible. Studies are continuing with the

objective of establishing more precise values of the radiation exposure arising from solar protons, galactic cosmic rays, and the high-energy proton and electron belts surrounding the Earth. The results will provide a basis for evaluating the shielding provided by the command module against these effects.

Consideration is being given to the types and extent of lunar surface data needed for carrying out the mission. A model of the lunar surface for use in Project Apollo is in preparation.

Information on space environment that will be required for the Apollo program has been summarized and compared with the probable information-collecting capabilities of the unmanned program.

As another example of our work, Bellcomm has been actively studying possible manned lunar exploration programs. These studies are an attempt to come to grips with the questions. What should our operations be both on the lunar surface and in the vicinity of the Moon?

There is a variety of possible answers to this question. As a part of planning and for planning purposes, one can test a possible answer by in effect "trying it on for size" and determining the systems implications; for example, requirements for logistic support on the lunar surface and the characterization of a support system. Studies of this nature are fundamental inputs to the intelligent planning of the entire program.

Preliminary studies of this kind suggest that the characteristics of a "good" site for early exploration might be (1) on a lunar sea, (2) 10 miles from a continent, and (3) 10 miles from a postmarial crater.

Such a site, and there are many which meet these requirements, offers the prospect of exploration on one landing of the natures of the maria, a crater, and a continent; that is, three major features of the Moon. With information from this exploration, another site might be chosen to optimize the return of additional scientific information.

From such studies one might also argue that a limited program of 3 or 4 years' duration comprising the exploration of two or three sites could fulfill our needs for lunar exploration. Depending on what is discovered, an extensive manned lunar base might or might not later be called for.

While it is possible in a short period of time to indicate only a part of the work in which we are engaged, perhaps enough has been said to clarify its nature. This is the type of service that is being asked for and we are endeavoring to give so long as NASA has need for us.

I hope that my remarks have been of some use and interest to you. I will, of course, try to answer any questions which you may have.

My colleagues will be happy to be of assistance also.

Mr. TEAGUE. Any questions, members of the committee?

Mr. Waggonner?

Mr. WAGGONNER. Dr. Hornbeck, you spoke of three different areas of the Moon on which we might effect a successful landing. What study method do you employ to arrive at an answer as to which area would be the most feasible?

Dr. HORNBECK. We are not recommending a specific site at the moment, but rather considering various sites. The sort of consideration that comes into making the selection of a good site for the first landing primarily would be the safety of the landing—that will be the paramount thing. In the beginning you would want to stay away from a continent by a considerable distance, just for safety reasons.

What we need to know, in time, is how rough the local terrain, the kind of slopes involved, what the bearing strength is, that kind of thing. If one knows this type of information about a site, and once one knows how accurately one can place a lunar excursion module on the surface, then you know how close you dare land to other sites.

Mr. WAGGONNER. What methods have you employed in your studies, to this point, to determine what the lunar surface is actually like?

Dr. HORNBECK. I would not say we have used any special methods. We have reviewed what data and information there is available. We realize we have large gaps in our present knowledge on what it is like.

Mr. WAGGONNER. Your analysis has not gone further than reevaluating or analyzing data that others have compiled and published?

Dr. HORNBECK. That is correct.

Mr. WAGGONNER. Are you conducting studies other than those concerned with the communications systems in manned space flight?

Dr. HORNBECK. Definitely. I think all these I mentioned are examples.

Mr. WAGGONNER. Do you know of any duplication of work by other contractors in which you are performing in areas other than communications?

Dr. HORNBECK. I think there are other people working in this same general area, but I cannot at this time quote a specific contract which we are duplicating.

Mr. WAGGONNER. When you spoke of possible water or lunar sea landings, is this something that might be a little bit forward, in view of the fact that the excursion module has been accepted which does not anticipate a water landing?

Dr. HORNBECK. Sir, "lunar sea" is a term, for an apparently flatter part of the Moon than a continent or a mountain, and does not imply there is any water there.

In fact, there is no evidence of water there.

Mr. TEAGUE. Then, to an extent this is a misnomer?

Dr. HORNBECK. We can thank the astronomers through the ages for this.

Mr. WAGGONNER. Apparently you are doing a good bit of analysis work as far as man's space flight and lunar flight are concerned. Are you doing anything to indicate what the military value of a lunar flight would be?

Dr. HORNBECK. We are not, and I do not anticipate that we will be.

Mr. WAGGONNER. In your opinion, is there any indication that there is a military value to be had from the Apollo mission?

Dr. HORNBECK. I would hesitate to voice an opinion on this, because I dont think I would be competent to give an opinion.

Mr. WAGGONNER. Your study does not involve anything other than the peaceful uses of outer space?

Dr. HORNBECK. That is correct.

Mr. WAGGONNER. You are in no respect concerned with what the future military value might be?

Dr. HORNBECK. We have not become involved in this.

Mr. WAGGONNER. No further questions at this time, Mr. Chairman.

Mr. TEAGUE. Dr. Hornbeck, in the overall company of A.T. & T. do you have your own people or committees that work with the Defense Department on the military aspects of space? Dr. Baker, for example?

Dr. HORNBECK. The Bell Laboratories does get involved on occasion, I believe.

Mr. TEAGUE. Would you please tell us something about your contract with NASA, the length of it, and something about your funding level for 1964?

I wish you would comment on whether or not there is a possibility that A.T. & T. or Western Electric would be in a preferred position for future research and development contracts with NASA as a result of Bellcomm.

Dr. HORNBECK. That is a broad series of questions.

Our contract——

Mr. TEAGUE. Those are the questions we get asked.

Dr. HORNBECK. Our present contract with NASA is through September 30, 1963, and is in the amount I mentioned.

Of course, there is provision for renewal at that time if NASA so desires. The only requirement is that we agree on what the estimated costs and the fee will be for the next period of time, which, presumably, would be another 12 months.

So far as funding for fiscal year 1964 is concerned, our contract-break period comes in that year. We are funded to the end of September 1963 and do not plan to discuss funding with NASA for several months for the following period.

You can tell from the organization the kind of money involved here, probably less than $10 million for a 12-month period.

The final part of your question had to do with possible preferred positions in R. & D. work for the Bell System on account of us.

Mr. TEAGUE. That is correct.

Dr. HORNBECK. I don't know of any way in which this has come up so far. Would you care to ask a more specific question, Mr. Chairman?

Mr. TEAGUE. Of course you expect this company will continue throughout the Apollo program?

Dr. HORNBECK. If NASA so desires.

Mr. TEAGUE. Could NASA possibly get along without using Bellcomm? Suppose your budget was cut out completely, what effect would it have on NASA?

Dr. HORNBECK. I think perhaps it would be better if NASA itself would answer those questions. To the best of my knowledge I think they felt they had need for us; they invited us to help out, and I suspect they would answer that they would continue to need us for some time.

Mr. TEAGUE. What kind of budget do you feel that you have? Do you feel it is a tight one?

Dr. HORNBECK. We have, we feel, a very tight budget, and we try to run a tight shop in every sense.

Mr. TEAGUE. Certainly in the kind of work you are doing, it could not be expanded to just any length.

Dr. HORNBECK. We work with papers, pencils, slide rules, and we have no hardware work or experimental laboratories on which to spend money. So in that sense it is a very simple budget picture.

Mr. TEAGUE. Mr. Fulton?

Mr. FULTON of Pennsylvania. Actually, it would not be possible for NASA to recruit a team at the uniformly high level which you

have placed at NASA's disposal through Bellcomm at this time, or when you started, would it?

Dr. HORNBECK. I believe NASA felt that when they invited us to come in.

Mr. FULTON of Pennsylvania. By supplying this readymade scientific team that has a balance of judgment on the management of scientific programs your company has been doing a favor to NASA, because NASA did not have to go through a recruitment process over a period of months.

You were able to do the job promptly with people that previously have worked together in this field?

Dr. HORNBECK. Yes.

Mr. FULTON of Pennsylvania. Could you amplify that a little?

Dr. HORNBECK. I think Mr. Webb's correspondence makes it clear NASA wanted the benefit of our experience and technical and management ability, and we felt it was a good thing and proper thing to do, to come down and enter into this very interesting program in the way they wanted.

Mr. FULTON of Pennsylvania. You feel, then, that your services have been very helpful to the space program, first to help make it more efficient, and secondly, by making it shorter in time.

Dr. HORNBECK. I certainly hope so.

Mr. GURNEY. Dr. Hornbeck, do you work with any other people except NASA on this program? For example, do you work with North American or Grumman?

Dr. HORNBECK. We have contracts with the other contractors, yes.

Mr. GURNEY. How is your work with them? Can you give an example of it?

Dr. HORNBECK. A simple example might be on the design of the shielding in the command module, or shielding of the service module.

Is there enough skin thickness to prevent meteoroid penetration, and so forth?

Mr. GURNEY. As these contractors work on the program, if they come across a problem that they feel they need further information on, they come to you for assistance. Is that the idea?

Dr. HORNBECK. Not necessarily. I think particularly in the early stages of the program we go to them and say, for example, "This is what a study seems to indicate. Have we taken care of this in the design?"

Mr. GURNEY. You step forward and give any information you feel might be helpful to them.

Dr. HORNBECK. Yes.

Mr. GURNEY. What is your working relationship with NASA? How does NASA go about requesting information?

Dr. HORNBECK. It is done in a variety of ways, and I think quite effectively.

There may be a phone call on a short-range thing, or "we have a problem this afternoon," and so forth. There are things that come up occasionally and also on a continuing basis.

We have agreed on tasks between the Office of Manned Space Flight and ourselves that require a continuing amount of work. These tasks are defined, written down, and reports are submitted on them.

Mr. GURNEY. A combination of specific tasks plus things that come up from day to day?

Dr. HORNBECK. Yes.

Mr. RIEHLMAN. Do you have people from your organization stationed at all the NASA centers?

Dr. HORNBECK. At none of them.

Mr. RIEHLMAN. Your work is all directed out of Washington, D.C.?

Dr. HORNBECK. Our office is here, but we are on planes a lot.

Mr. RIEHLMAN. Are they ever directed to go to Cape Canaveral to observe activities there?

Dr. HORNBECK. Yes, sir.

Mr. RIEHLMAN. Are you going to Houston to watch the construction work that is going on down there, or are your activities confined solely to the technical end of Apollo program?

Dr. HORNBECK. They are, but we have frequent contacts with the other parts of the organization.

Mr. RIEHLMAN. What relationship do you have to the manufactures? As soon as the research work is completed and they go into manufacturing, are you tied in with this for NASA?

Dr. HORNBECK. We have not really tied in at all yet with the manufacturing end. The manufacturing is the responsibility, clearly, of the centers. They let the contracts for the hardware, and so on.

I hope later we will be able to make contributions of a general nature in terms of reliability, quality control, and such important things. But we don't have any control directly, or responsibility, for the contracts.

Mr. RIEHLMAN. Are you going to be duplicating any of the work that other people will be doing in these fields?

Dr. HORNBECK. Let me answer this way: I think a certain amount of overlap in a broad systems engineering program is necessary and should be present in a program, so that things don't fall into a chink and so that the program is integrated. But other than the necessary amount of overlap of the whole thing, we have no desire or need to overlap with other people.

Mr. RIEHLMAN. The actual work you are doing, what NASA asks you to do, is to keep them abreast of technical information they need to carry out these programs?

Dr. HORNBECK. That is primarily so, yes.

Mr. RIEHLMAN. You have no authority to make any decisions? You are an information and technical services to the people in NASA?

Dr. HORNBECK. That is correct.

Mr. TEAGUE. Mr. Fuqua?

Mr. FUQUA. Yesterday we heard testimony from Grumman Aircraft Co. Suppose they are interested in information about the surface of the Moon, do they go to NASA and NASA asks you, or do you have a relationship that they can come directly to you?

It seems to me there still is an overlap of work that might be costing us an excess of money in this one field.

Dr. HORNBECK. There is no reason we cannot talk directly to Grumman, or visit them, and in fact we have done so on more than one occasion; so there is a natural, open communication between us, in either direction.

The nature of our work would tend to come out through the Office of Systems in the form of requirements.

Mr. FUQUA. There is never any delay or breakdown of communication between the flow of information between you and, say, Grumman, or North American?

Dr. HORNBECK. There are people involved in this, and whenever people are involved there are problems of communication. I think we have those normal problems.

Mr. FUQUA. But there does not seem to be an unnecessary delay in transmission of this vital information between the two?

Dr. HORNBECK. I don't think so.

Mr. FUQUA. You are not "managing the news," so to speak, between the two?

Dr. HORNBECK. We don't have a serious problem there.

Mr. FULTON of Pennsylvania. Let it be known that that question came from the other side of the aisle.

Mr. ROUDEBUSH. I have listened with interest to the description of the tremendous and broad task laid down for Bellcomm. I would like to ask you a series of questions.

It is my understanding that over the past 18 months, or the 18 months preceding September 1963, you will have received about eight and a half million dollars from the U.S. Government for this task. Now, are the people who work for Bellcomm full-time employees of Bellcomm, or are their services divided with, say, A.T. & T.?

Dr. HORNBECK. Everybody in Bellcomm is full time.

Mr. ROUDEBUSH. All their salary does accrue from Government payment?

Dr. HORNBECK. That is correct.

Mr. ROUDEBUSH. I understand you have 96 technical people and a supporting staff of 60, and that you may go to a total of 250 people. How are these people employed? Are some located at the Bell Laboratories?

Dr. HORNBECK. They are in addition. The 96 technical people are all within our own staff in Washington here.

Mr. ROUDEBUSH. The people at Bell Laboratory, then, are not included in the 156.

Dr. HORNBECK. They are not.

Mr. ROUDEBUSH. But they are salaried from Bellcomm?

Dr. HORNBECK. Yes. The laboratories give us a bill that we pay and pass on to the Government.

Mr. ROUDEBUSH. Are they totally salaried from Bellcomm?

Dr. HORNBECK. Not necessarily, however, most are full time.

Mr. ROUDEBUSH. What recommendations have you made on the Apollo system? You speak of the critical subsystems, performance parameter, and design margin. Those terms are rather broad.

What specific recommendations has Bellcomm made to NASA regarding our Apollo system? I will say, what general recommendations have you made? That may make it easier to answer.

Dr. HORNBECK. We don't have a simple case of sitting down and writing a note to the Office of Manned Space Fight and saying, "We recommend thus and so."

Rather, we have passed on quite a few reports in which specific studies and work are delineated, and the conclusions from those are obvious to the technical people in the Office of Manned Space Flight.

We have talked privately with such people as Dr. Shea and argued position, and so forth.

Mr. ROUDEBUSH. One final question: I notice on page 10 of your statement you mentioned "depending on what is discovered on the lunar surface." How do you make recommendations and do engineering planning for a mission that involves unknown quantities? For example, how do you design and make recommendations for a lunar mission when we don't really know what we will find on the surface of the moon?

Is it a question of putting the cart before the horse, Dr. Hornbeck?

Dr. HORNBECK. First, I don't think anybody likes to plan with gaping holes in one's information. You much prefer to have sufficiently definite information to do an effective job. One handles this, as we do in the space program, in several ways. One tries to effect designs that are on the safe side from what we expect to find, so that one doesn't have to redesign hardware later.

For example, the landing structure on the lunar excursion module you try to make as rugged as you can afford. Then there is some basis for guessing from what we know, that most probably it will be all right.

But we are not really happy until information comes back from, say, the unmanned program, prior to actually carrying out a landing, which tells us what the nature of the lunar surface is on rather a fine scale, so we know what we are getting into.

Mr. ROUDEBUSH. Are you referring to discoveries that would accrue from the Surveyor program?

Dr. HORNBECK. Yes.

Mr. ROUDEBUSH. Are we going too fast with the design on the LEM? For example, should we be holding up some of these designs until we do know more about the lunar surface?

Are we perhaps progressing too fast and perhaps designing a vehicle we cannot use?

Dr. HORNBECK. There is always the possibility that when we really know the situation, it will be much more adverse than we expect. This is always the possibility, in which case we, meaning the United States, would have designed the wrong thing.

Mr. ROUDEBUSH. Yes. I am not speaking now of Bellcomm, but of the overall effort.

Dr. HORNBECK. Yes.

Mr. TEAGUE. General Electric is a part of this so-called brain of NASA. Do you people have any relationship with General Electric, or work with them?

Dr. HORNBECK. Our relation with them up to this time has been minor, but I believe it is developing more.

Mr. TEAGUE. Does most of your direction come from NASA, or does North American or any other company that has a problem come to you directly?

Would you be able to take one specific problem you have worked on, and tell us how it developed and what happened?

Dr. HORNBECK. Most of the problems we have not gotten all the way through yet.

But let's take one that is very much in the process of being worked out; actually it is in a difficult stage. We have been asked to look from a system engineering viewpoint into checkout for the entire program; how checkout on the ground ties to checkout in-flight and to checkout operations on the lunar surface.

Now this is a problem that really cuts across all the major Centers, and there are major constraints that it places on the entire system. Working out a checkout philosophy, what is important to do, and when, is something that must be thought through so that we can set down the basic ground rules and fundamentals of the thing. It is something we were asked to look into by the Office of Systems. We have spent considerable time with the Cape on this.

We have also talked with Houston on parts of it. For example, we have talked with North American in Houston, where they are concerned with the in-flight tests, which is part of the checkout problem, but just a piece of it.

It is through this interaction across the board with the entire program that collectively we are going to come up with a checkout philosophy and the beginnings of an implementation plan, or definition of a plan, that would go into the systems specification and tie the various parts together.

Mr. TEAGUE. Any other questions?

Mr. Yeager?

Mr. YEAGER. Dr. Hornbeck, following Mr. Roudebush's line of questioning, generally what type of background do the people have that work for you?

Dr. HORNBECK. Chemists, propulsion, aeronautical, electrical people, a wide spectrum.

Mr. YEAGER. Could you perhaps provide for the record a percentagewise breakdown of what background these people have?

Dr. HORNBECK. I will be very happy to do so.

In fact, I even have it with me.

(The information referred to is as follows:)

BELLCOMM, INC.

Formal education of technical staff

Field	Non-graduate	Highest level degree			
		Bachelor	Master	Doctor	Total
Mathematics		4	3	2	9
Physics		2	6	10	18
Physical sciences		0	1	2	3
Science		1	0	0	1
Philosophy		0	1	0	1
Public administration		0	0	1	1
Psychology		0	0	2	2
Engineering:					
Aeronautical		1	0	1	2
Chemical		0	1	0	1
Electrical		15	23	4	42
General		3	4	0	7
Mechanical		2	5	1	8
Nongraduate	1				1
Total	1	28	44	23	96
Percentage	<1	29	46	24	100

Mr. YEAGER. Does Bellcomm do other work besides its Apollo work?

Dr. HORNBECK. No, sir. We have only this one contract.

Mr. YEAGER. Why did you deem it desirable to incorporate Bellcomm? What was the thinking behind that? Why couldn't you have just assigned a task force?

Dr. HORNBECK. I think, as Mr. McNeely said to Mr. Webb—it was an administrative decision that they could most effectively use the va-

rious parts of the Bell System including Bell Laboratories by forming a separate corporation.

Mr. YEAGER. Was there any particular reason for organizing it jointly with your subsidiary, Western Electric?

Dr. HORNBECK. I am not sure I know the answer.

My own speculation has been that the thinking at the time was to pattern it after the Bell Laboratories, which is owned 50 percent by A.T. & T. and 50 percent by Western Electric—and, that is the way it came out.

Mr. YEAGER. Would you say Bellcomm has any management or quasimanagement functions with respect to the Apollo program? I am not speaking of advice to management, which obviously you give. But do you make any decisions which might be called quasi-management decisions?

Dr. HORNBECK. I am not sure exactly what you mean.

I think we are a management tool in the sense that, say, Mr. Holmes can use us for information. Ours is an input to the decisionmaking pool.

Mr. YEAGER. Do you get into the economics of the decision at all, as to what is or is not feasible from the systems point of view?

Dr. HORNBECK. We are concerned with the cost and try to find the most economic ways, clearly.

Mr. YEAGER. And you do provide information of that type as well as technical information?

Dr. HORNBECK. In our systems work, technical work, this must come in.

Mr. FULTON of Pennsylvania. I would like to ask how you make your decisions on the method of activities in reference to the surface of the Moon. For example, in the sunlight the Moon will be 14° above zero, and on the dark side of the Moon at the same time it will be about 243° below zero. In addition, you may get all sorts of a temperature gradient even within the sunlight area. For example, if there is a shaded area because of a mountain cliff you might have tremendous degree of temperature variance that we don't even know of on Earth, and you might have it on smaller objects, as well.

Who makes the decisions on what the Moon's surface is so that you can make these postulates to form your equipment policies upon? Who is deciding these basic questions? My point is, Dr. Hornbeck: Does Bellcomm decide a basic question like that, or does NASA?

Dr. HORNBECK. This would be NASA.

And the decision has not basically been taken yet as to whether they will land in lunar night or lunar day, or just where on the surface.

As you point out, the temperature variations are so wide that some equipment you would design for operation in the lunar night probably would not be effective for the lunar day. These equipments are important engineering jobs and tough things to figure out.

Mr. FULTON of Pennsylvania. I use this as an example of where Bellcomm would fit in the decisionmaking process.

Dr. HORNBECK. We might submit studies on the technical problems associated with landing in sunlight and its advantages and disadvantages, or studies on what are the technical problems associated with landing in lunar night but with Earth shine on the Moon.

It would be studies of this kind of a technical and factfinding nature that we would give to NASA.

Mr. FULTON. You would not get into field of whether the Moon is an old body and a gradually cooling volcanic mass, or whether the Moon does have current volcanic eruptions. Likewise, you would not get into the fact that there may be pools just slightly covered where cracks show on the surface, and we might be putting the astronauts down on an open lake?

Dr. HORNBECK. We would be very much interested in that.

Mr. FULTON of Pennsylvania. But you do not make decisions in that direction?

Dr. HORNBECK. We are not in the decisionmaking role.

Mr. FULTON of Pennsylvania. Yours is a technical judgment. You are given parameters to operate within, and then you advise NASA as to the technical approach to those conditions?

Dr. HORNBECK. That is correct.

Mr. FULTON of Pennsylvania. That is more what you do?

Dr. HORNBECK. That is correct.

Mr. TEAGUE. Mr. Gurney?

Mr. GURNEY. Are you familiar with the Aerospace Corp.?

Dr. HORNBECK. I visited there once, and I have read of it.

Mr. GURNEY. As I understand it, it is the corporation which is the research and development or scientific arm of the Air Force, in the space business. Perhaps some of the functions they perform are some of the same functions you perform for NASA in this specialized Apollo program. Is there any exchange of information between Bellcomm and the Aerospace Corp.?

Dr. HORNBECK. Let me say, first, I think their role is more of a management function, as I understand it, than we have in Bellcomm.

We have not had very much interaction with Aerospace at this time, but we have had some contacts with them ever since they were formed, and are familiar with them.

Mr. GURNEY. Is there any overlapping of function?

Dr. HORNBECK. I know of no overlapping function.

Mr. TEAGUE. Any other questions?

Thank you, Dr. Hornbeck. We appreciate your coming up here.

We will next hear from Mr. Richard Shetler, general manager, Command Systems Division of General Electric. Do you have assistants with you?

Mr. SHETLER. I do have, Mr. Chairman, but I prefer not to bring them up, unless there are questions later to be directed to them.

Mr. TEAGUE. Whichever way you prefer, sir.

STATEMENT OF RICHARD L. SHETLER, GENERAL MANAGER, COMMAND SYSTEMS DIVISION, GENERAL ELECTRIC CO.

Mr. SHETLER. I have a prepared statement, Mr. Chairman. May I read it?

Mr. TEAGUE. Yes, sir.

(Biographical sketch of Mr. Shetler is as follows:)

RICHARD L. SHETLER, GENERAL MANAGER, COMMAND SYSTEMS DIVISION

Richard L. Shetler is general manager of General Electric's Command Systems Division, with headquarters at Daytona Beach, Fla. This division has plants in other major operations at Daytona Beach; Lynchburg, Va.; Oklahoma City, Okla.; Bethesda, Md.; and Syracuse, N.Y.

He was born in Strasburg, Ohio, on January 9, 1922.

Following graduation from Ohio University in 1943 with a bachelor of science in electrical engineering, he joined General Electric's engineering training program, working on long-range navigation equipment.

In 1944 he became a design engineer. The following year he went on detached assignment with the Radiation Laboratory of MIT as a development engineer.

Shetler became a production project engineer for General Electric at Schenectady in 1946. He was named liaison engineer in the former electronics division in 1947, and soon became a major project engineer working on one of the Nation's priority radar search systems.

Shetler was appointed supervisor for ground radar engineering in 1950 and 2 years later was named department engineer. In 1955, he was selected to manage special radar projects with responsibility for the development of the longest range radar systems built in this country.

In 1957 Shetler was appointed manager of the newly formed missile guidance section with overall responsibility for the design and production of the radio-command guidance system for Atlas ICBM guidance.

In 1958 when the defense systems department was established, Shetler was named general manager to supervise the development and production of complex systems and products required for defense and aerospace programs.

He is active in the Institute of Radio Engineers, and is a member of the Air Force Association, and the American Ordnance Association.

He is a member of two national honorary engineering fraternities at Ohio University—Tau Beta Phi, and Eta Kappa Nu which honored Shetler "in recognition of his attainments and services in the advancement of the science of electricity and the profession of electrical engineering."

Shetler was awarded a Certificate of Merit for Science from Ohio University in 1959.

Mr. SHETLER. Mr. Chairman, I am Richard L. Shetler, general manager of the Command Systems Division of General Electric Co. This division includes our Apollo Support Department, which has the principal responsibility within the company for the performance of our contract in support of NASA's program for the integration, reliability assessment, and checkout of the Apollo mission.

At the present time I am also acting general manager of that department.

In response to your invitation I am here to discuss our work under that contract. I think it would be helpful if I began by briefly relating how General Electric undertook this job.

Somewhat over a year ago, in January 1962, General Electric submitted a proposal to the Space Administration to meet what we ascertained to be the Administration's requirement for a contractor in the integration, reliability assessment and checkout areas of the Apollo manned lunar landing program.

In due course it was concluded that the Space Administration would, in addition to its other contractors, require a contractor to concentrate specially on this area.

It was also concluded that General Electric was qualified to do this work, and that we were willing to undertake the contract.

In February 1962, we received NASA letter contract NASw-410.

Our work began upon receipt of the letter contract. The first phase of the work was a series of studies aimed at more specifically analyzing and defining the scope and content of the work which was needed to be done. The first of these studies were completed last fall.

While our negotiations on other parts of a definitive form of contract 410 have proceeded, we have agreed with NASA on the initial stages of work in each of the three principal areas involved—integration, reliability assessment, and checkout—and are going forward.

I am pleased to be able to report that our contract negotiations are proceeding apace, and we are confident, as I believe the Space Administration is, that agreement on all of the provisions of a definitive contract will be reached in the near future.

Our studies to date on the scope of this work have been very helpful—and indeed necessary. As Mr. Holmes indicated in his statement to this committee a few days ago, the integration, reliability assessment and checkout features of a vast program like Apollo are less tangible areas than some others, but they are vitally important to the program's success.

The successful achievement of the objectives of the Apollo program will require that the major system elements be conceived, designed, assembled, tested, and documented so that they are compatible with each other and adequate for the attainment of those objectives.

That brief statement of principle implies an integration effort of enormous detail. Starting with the conception and design of basic components and elementary systems, it imposes a rigorous integration discipline which must be faithfully observed by all participants in the program—and through the ascending orders of complexity to spacecraft and launch vehicles, to the complete assembly ready for launching, flight, and return.

Methods and procedures to assure this integration must be established, and their operation must be continually reviewed and appraised as the program proceeds.

Similarly, the success of Apollo will require detailed knowledge by NASA concerning the reliability of the critical system components. This knowledge must be continuously acquired throughout the design, manufacturing, test, and operational phases of the program.

Here again the magnitude of the Apollo effort involves the development of methods and procedures—methodology, criteria, and standards of reliability testing and assessment—which will enable the Space Administration to make an informed judgment about system reliability and safety levels.

This involves continuing reliability assessments first of the critical components as they are developed and produced and finally of the whole system—prior to launch.

Given these integration and reliability standards and criteria, the important and continuing question, as the components are manufactured and assembled, in subsystems, major system elements, and finally in the manned space vehicle, the question is how to know if the system is ready to achieve the objectives of its mission. The checkout function—by techniques, procedures, and equipment—is to answer that question.

Obviously, no single contractor could do all of these things—the total integration, reliability assessment, and checkout job—for the entire Apollo program. Not only is the program too vast, comprised of too

many pieces, but the basic and first steps must be taken by the supplier-Government teams which produce the system parts.

As Mr. Holmes indicated, our role is to furnish overall support to the Office of Manned Space Flight and the Centers in integration, reliability assessment, and checkout—for example, in the Office of Manned Space Flight's general programs, and at the interfaces between the work areas assigned to the Centers, or at those which have not been assigned to a Center, and for the integrated launch control and checkout system.

As you know, the Apollo program is directed from four principal points. These are: the Office of Manned Space Flight at NASA Headquarters here in Washington; the Manned Spacecraft Center at Houston; the Marshall Space Flight Center at Huntsville, Ala.; and the Launch Operation Center at Cape Canaveral.

You may recall that last year, shortly after we started this work, our Dr. George Haller explained that the initial planning phase of the work was assigned to our defense systems department, with a view to the continuing work being reassigned to another company department for performance.

That is what has been done. To direct our performance of this contract, General Electric established the Apollo support department. Our analyses indicated that our work, like the program itself, would culminate in the Cape Canaveral-Merritt Island area. After a detailed survey, therefore, we selected Daytona Beach as the site of that department's headquarters.

In cooperation with the Office of Manned Space Flight, and the NASA Centers, that Department is in the process of establishing staffs at each of the Centers at Houston, Huntsville, and Cape Canaveral, together with a central group at Daytona, to furnish the support required by these NASA organizations in each of the contract work areas.

As I noted earlier, this staffing activity, and the establishment of the appropriate working relationships, have proceeded in order to enable us to get forward promptly with this work while our negotiations have been going on.

In general, our contract work will be in two broad categories. There will be continuing engineering studies to furnish the reports which will be required by the Office of Manned Space Flight and the NASA Centers in their respective areas of responsibility for integration, reliability assessment, and checkout. Secondly, we will furnish a quantity of specially designed checkout hardware, including that which will provide the integrated launch control and checkout system.

In reviewing our work under this contract, one point should be specially borne in mind. The dimensions and complexity of the overall Apollo integration, reliability assessment, and checkout program will require a very broad range of management and technical skills and facilities.

As I have noted, our Apollo support department has the principal responsibility for our performance, but we should all be quite clear that the Government's contractor for this work is our whole company.

We have already drawn on other company components for key personnel. In addition, through this department we will utilize any portion of the company's more than 100 operating departments, with their highly diversified technical and scientific staffs, technological

skills, laboratories, and other specialized facilities, which the work may require.

This fact, and the nature of the work, have raised a question in some quarters whether this contract might in some way give General Electric an unfair advantage over others in industry with respect to other Space Administration Apollo procurement.

I should like to deal very plainly with the matter.

We do not believe that this contract should or that it will give us any such advantage. We have undertaken to negotiate provisions covering this point in the definitive contract. Ultimately, however, all of us—the Government, others in industry, and General Electric alike—will have to rely on the facts.

The Apollo program is a complex and massive national undertaking. Success will require a broad marshaling of our national resources—governmental, scientific, and industrial.

We feel emphatically that it would not be in the public interest—and we are sure it would not be in ours—for the very substantial resources of General Electric Co., over and above those which will be utilized in the performance of this contract, arbitrarily to be placed beyond access by the Government.

Proceeding in this area on a factual and objective basis—and we believe the Space Administration plans to do just that—will not only afford the best protection for the competitive system. It will also offer the best assurance of the Government having available the full range of procurement possibilities the Apollo mission will require.

Now I think it might be helpful for me to give you some details of our initial staffing for this work:

To date, a total of approximately 1,250 people have been assigned to this program. Some two-thirds of these are professional employees. This staff will be geographically distributed to the NASA Centers and Daytona Beach. This will include approximately 290 employees at the Marshall Space Flight Center, 85 at the Manned Spacecraft Center, and 140 at Cape Canaveral. Approximately 600 have been assigned to Daytona Beach.

For facilities, we have acquired, or are in the process of acquiring for the company, several buildings at Daytona Beach which will provide 250,000 feet of floor space. Three of these buildings will be new construction.

At Huntsville, we are acquiring company facilities which will provide 20,000 feet of space. Our facilities at Houston and Cape Canaveral presently provide 27,000 and 20,000 feet of floor space, respectively.

Let me emphasize that we are still in the very early stages of performance of this contract. Our organizing efforts thus far have drawn on our own management resources, and largely on our company technical and scientific staff for operating personnel.

As this brief outline has perhaps suggested, the performance of this contract will present many organization and management, as well as operating, complexities. We have tried, and will continue, to apply our full capabilities to these areas as well as to the scientific and engineering problems involved.

While to date our studies and work with the Space Administration have enabled us to draw broad outlines of what will be required in

the future to enable us adequately to support NASA, very many of the details of the work will only take clear definition as we progress. In the final analysis, these details will determine the geographical and technical size and balance of our staff, and the facilities they will require.

In conclusion, I think I should make one additional point.

We are very proud to have been given this assignment in the Apollo program. It is questionable whether our company, or perhaps any other, has ever undertaken a more complex and delicate job. And while we are indeed proud of the distinction, please be assured that we approach our work with a deep sense of humility, and with a set determination to make a success of it.

This concludes my prepared remarks. I will be happy to answer any questions your subcommittee may have.

Mr. TEAGUE. Thank you, Mr. Shetler.

You told us about personnel. Would you tell us what you can about your funding?

Mr. SHETLER. Yes. Since February 1962 our total expenditures have run in the neighborhood of $12 million.

We would expect our total expenditures through the end of the fiscal year would be in the neighborhood of some $25 million.

Mr. TEAGUE. Could you tell us approximately what part of that will go into hardware?

Mr. SHETLER. So far none of these funds have involved hardware.

We are in the process of defining the integrated launch control and checkout equipment hardware.

Major hardware procurement and design and fabrication would not occur until the next fiscal year, fiscal 1964.

Mr. TEAGUE. Suppose you did not receive $25 million but only get about $20 or $15 million, what effect would that have?

Mr. SHETLER. This is as I see it, a very tightly drawn program, it is a vast undertaking, and we are running I would say a very tight operation. Reductions in funds would have the possible effects of two things, either in combination or singly. One effect would be a stretchout in the accomplishment of some objectives, if not the overall objective; and secondly, it could have the effect of increasing the risk on the program, the risk of success.

These are very hard and intangible to evaluate. But these are the things I see.

Mr. TEAGUE. Mr. Fulton?

Mr. FULTON of Pennsylvania. How is your fee set? What proportion of the total gross contract cost is the gross profit to your company?

Mr. SHETLER. We have not completed our negotiation on our contract and the fee has not been negotiated yet. The figures I gave you were basically cost figures.

Mr. FULTON of Pennsylvania. So really you were working without having a contract fee or gross profit margin set at this time?

Mr. SHETLER. That is right.

Mr. FULTON of Pennsylvania. Isn't that unusual?

Mr. SHETLER. On the first initial portion, which was completed in September, we had an agreement on the gross fee for that. It is the portion which has——

Mr. FULTON of Pennsylvania. Will you explain that to us?

Mr. SHETLER. The initial portion, which was a letter contracted to do the study, the results of which were issued in report form in September, was a specific initial portion of the task we were to do, and we have negotiated this portion.

Mr. FULTON of Pennsylvania. Is that like a letter of intent?

Mr. SHETLER. Yes, Initially we worked on a letter contract basis.

Mr. FULTON of Pennsylvania. What has the fee been on that, in dollars, and also in percentage of expense?

Mr. SHETLER. I don't have that.

Mr. FULTON of Pennsylvania. Will you give that to us?

Mr. SHETLER. Yes, indeed.

(The information requested is as follows:)

The NASA-General Electric preliminary agreement on fee for the initial work under contract NASw-410 was for $166,000. The cost to the Government of this work was $2,380,000, so that the fee was at the rate of approximately 6.97 percent of cost.

Mr. FULTON of Pennsylvania. You are the ones who are to watch the program and see that the checkout systems and reliability systems measure up to requirements. What kind of control does NASA have over your expenditures, both on policy and within certain policy programs and on the allocation of expenses? For example, you are charging a certain amount of overhead; you are charging other factors of expenses into this program from other parts of your company. Would you outline to us how you keep this separate, and also how NASA watchdogs you?

Mr. SHETLER. Yes. We have, as I explained, established a separate department for this Apollo work, which works exclusively for Manned Space Flight.

The allocation of work that relates to assessment of reliability, integration, launch control, and checkout; the basic allocation is made by the Office of Manned Space Flight. They have through their normal contracting processes full auditing staffs and control staffs to insure that our expenditures both applied as well as overhead are done in the normal form that we use in business with the Government.

Mr. FULTON of Pennsylvania. Does that checking by NASA occur after-the-fact or before it happens?

Mr. SHETLER. These checks are before they happen. We submit quotations for the effort which we are expected to do. They audit those quotations in great detail to determine that the detailed makeup of the cost estimates are correct and adequately stated.

Mr. FULTON of Pennsylvania. What proportion of the general administrative expense of the company is transferred to this particular department to bear as an expense?

Mr. SHETLER. I could not give you exact figures.

Our normal operating procedure has been for the full range of operating departments in the General Electric Co. to carry their proportionate share of the administrative burden of the executive office.

Mr. FULTON of Pennsylvania. That is correct. I would like to have what it is for this department, and its correlation with the other departments. To see how it compares.

(The information requested is as follows:)

ALLOCATION OF GENERAL COMPANY ADMINISTRATIVE EXPENSES

In 1962 the amount of company general and administrative expenses allocated to our work under contract NASw–410 was aproximately $128,500. This allocation was the result of the application to the work of the Apollo support department of the formulas for the distribution of such expenses to work under General Electric's Government CPFF contracts which are agreed upon annually in negotiations between General Electric and the Government audit agency which is assigned responsibility for negotiations. The 1962 allocation to the Apollo support department of these costs in the foregoing amount compares with total costs to the Government under contract NASw–410 of approximately $8,250,000 during the same period. We anticipate that there will be a comparable ratio between the allocation of company general and administrative expenses, and total costs under the contract in 1963 and later years.

Mr. SHETLER. Yes.

Mr. FULTON of Pennsylvania. What size contract do you expect this to be with NASA in the long run, and how long do you expect it to last?

Mr. SHETLER. The total size of the contract is difficult to assess, because we are just in the throes of determining what is the most economical, efficient, and effective integrated launch control and checkout system.

This involves hardware, and therefore, the total cost of this hardware. And until you have the system broken down into its finest detail it is hard to estimate.

I should say for fiscal year 1964 this could run in the neighborhood, including this hardware, of $150 million.

Beyond that it is difficult to assess. I would say I would anticipate our participation in the program to be through the launch of the lunar landing mission.

Mr. FULTON of Pennsylvania. So that your contract as it looks now would run through 1969–70, or through this decade? What proportion do you intend to charge as an overriding fee on the amount of work you do?

What is the area of reference as to the sizes of that fee? What will it be, 3, 5, 7, 10 percent, or what?

Mr. SHETLER. Fee negotiations are extremely difficult negotiations, and I would prefer not to negotiate this contract in this committee session.

Mr. FULTON of Pennsylvania. That is why I ask the question.

I want to see what you are thinking, to see whether it is worthwhile to have you do it or better to have the Government do it inhouse.

Mr. SHETLER. We have accumulated for this work the technical resources across the company, to cover the very broad disciplines necessary to do adequately this kind of work.

I would suspect on that basis I suspect the fees that should be given to that kind of work would be equivalent to the average kind of fees one receives in normal Defense Department activities.

Mr. FULTON of Pennsylvania. What do they run, about?

Mr. SHETLER. These fees run in various kinds of jobs, depending on the technical complexity fee and resources, in areas from 6 to 10 percent.

I would like to make a point for the record, that I am not proposing to negotiate those fee numbers here.

Mr. FULTON of Pennsylvania. I agree. But we are looking now at the background to see the parameters within which these negotiations will take place. We are inquiring into the fiscal matters of the Government to see whether the expense should be borne by the Government.

Do you feel it is better that you, as a private company with a profit fee, should do this work, and that it can be done better that way rather than through in-house Government facilities?

Mr. TEAGUE. I think you should have been told that there are members of this committee who believe NASA is making a big mistake with Bellcomm and you people, and others. That it should be an in-house job.

Mr. FULTON of Pennsylvania. There is no inference in my question.

Mr. TEAGUE. No. There is no intention to put General Electric on the spot. But if we are going to go on the floor and argue this budget, we have to know something about how it works and what you do.

Mr. SHETLER. Yes. I think the best way to approach this question is to describe in general detail what the launch control and checkout system is.

Mr. FULTON of Pennsylvania. I wish the Chairman would give us permission to have you put a carefully drawn statement in the record on that.

Mr. TEAGUE. Certainly.

(The information requested is as follows:)

GENERAL SPECIFICATION (M–SI 6200.001) FOR AN INTEGRATED LAUNCH CONTROL AND CHECKOUT SYSTEM (ILCCS) [1]

1.0 SCOPE

1.1 General

This general specification covers the equipment comprising an integrated launch control and checkout system (ILCCS) for the Merritt Island launch area (MILA). The ILCCS shall consist of facilities for checkout, monitoring, and launch control association with the Apollo space vehicle and its supporting facilities. The concept and implementation of the ILCCS shall support the overall Apollo mission requirements by providing the highest possible assurance of crew safety and ultimate mission success. Speed and efficiency of prelaunch operations, consistent with narrow launch windows and high launch rates, and the need for flexibility to accommodate changing space missions are additional requirements to be met by the ILCCS.

1.2 Systems components

The ILCCS shall consist of the following major subsystems:

(*a*) Spacecraft checkout and control subsystem.
(*b*) Launch vehicle checkout and control subsystem.
(*c*) Launch operations center subsystem.

3.0 REQUIREMENTS

3.1 General

The ILCCS shall support the ground checkout, monitoring, and control of the spacecraft modules, the integrated spacecraft, the launch vehicle, the integrated space vehicle, and the associated Merritt Island launch area facilities. The system shall incorporate automatic checkout and fault diagnostic techniques to the maximum practical extent. In addition, the ILCCS shall provide the facilities necessary for centralized control of countdown and launch operations and for those data recording, control, and monitoring functions as may be required to support the integrated mission control center (IMCC).

[1] For more detailed description, see also app. C, meeting of the Subcommittee on Manned Space Flight, Committee on Science and Astronautics, held Mar. 29, 1963, in Daytona Beach, Fla.

3.1.1 Checkout and control functional requirements

3.1.1.1 Spacecraft checkout: The ILCCS shall provide for those data processing, display, control, monitoring, stimulation, response measurement, and communication functions necessary to conduct automated ground checkout of the command module, the service module, the lunar excursion module, and the launch escape system of the integrated spacecraft. The ILCCS shall work in conjunction with, but not include, carryon checkout equipment, flight instrumentation, and onboard checkout equipment.

3.1.1.2 Integrated launch vehicle checkout: The ILCCS shall provide for those data processing, display, control, monitoring, stimulation, response measurement, and communication functions necessary to conduct automated ground checkout of the integrated C–5 launch vehicle configuration. The ILCCS shall also provide the functions necessary to conduct stage checkout of the S–IC and instrument unit in the high bay area prior to complete launch vehicle assembly. The ILCCS shall work in conjunction with, but not include, onboard checkout and flight instrumentation equipment. The ILCCS shall also provide for the checkout of the C–1B launch vehicle if this vehicle is designated for launch from Complex 39.

3.1.1.3 Alternate unmanned payload checkout: The ILCCS shall provide for those data processing, display, control, monitoring, stimulation, response measurement, and communication functions necessary to conduct automated ground checkout of alternate payloads (e.g., lunar logistics module) launched from Complex 39.

3.1.1.4 Integrated space vehicle checkout and support of launch operations. The ILCCS shall provide those additional data processing, display, control, monitoring, and communication functions, as an extension of spacecraft and integrated launch vehicle checkout functions, necessary to support the checkout, countdown, and launch of a space vehicle from the Merritt Island launch area (MILA).

3.1.1.5 Support of the IMCC: The ILCCS working in conjunction with the central instrumentation facility (CIF), Atlantic Missile Range (AMR), and the integrated mission control center (IMCC) shall provide those real-time data processing, display, control, monitoring, and communication facilities at MILA necessary to support the initial monitoring, in-flight checkout, and control of a space vehicle after liftoff as may be required to support the mission responsibilities of the IMCC. In addition, as requested by IMCC, the ILCCS shall provide for the recording of appropriate checkout data in a format suitable for direct utilization by the IMCC for in-flight evaluation of space vehicle performance.

3.1.1.6 Maintenance support: The ILCCS shall provide those special test and equipment calibration functions necessary to conduct test, repair, and preventive maintenance operations on the ILCCS itself.

3.1.2 Primary operational requirements

The operational requirements identified below shall be considered of primary importance in the design of the ILCCS.

3.1.2.1 Assurance of mission success: The ILCCS shall be designed to perform checkout and control functions in a manner which will provide the maximum possible assurance of crew safety and overall Apollo mission success. Validity and reliability of testing shall be primary considerations.

3.1.2.2 Speed and efficiency: The ILCCS shall be designed to provide speed and efficiency of operation consistent with the requirements of narrow launch windows and high launch rates. These requirements shall be met through the application of automatic checkout and control techniques which shall be implemented in a manner consistent with ILCCS equipment operational availability requirements.

3.1.2.3 Flexibility: The ILCCS shall be designed to accommodate changing space vehicle missions and configurations. This flexibility shall be provided through application of inherently general purpose checkout and control techniques and through a design which provides modification and expansion capability.

3.2 ILCCS operating interfaces

In order to insure operation as a system, the ILCCS shall provide the necessary system interfaces with the following:

(*a*) Spacecraft.
(*b*) Launch vehicle.
(*c*) Launch pad facilities.
(*d*) Ordnance tower facilities.
(*e*) Launch umbilical tower facilities.
(*f*) Vertical assembly building facilities.
(*g*) Central instrumentation facility.
(*h*) Atlantic Missile Range.
(*i*) Integrated mission control center.
(*j*) NASA Headquarters, Washington, D.C.

Mr. SHETLER. The integrated launch control and checkout system is a very complicated system which will collect the electrical and mechanical data from the various stages of the overall Apollo system, and analyze these in such fashion as to determine the operational readiness.

This is a pure electronic data manipulation, gathering and hardware system.

It is my personal opinion that this requires the long-time experience of people doing automated data systems.

I don't feel it would be best for the Government, which has not done this kind of work, to set up a manufacturing operation to conduct this activity, this design, production and operational kind of activity.

Mr. FULTON of Pennsylvania. Did you have responsibility for any part of the guidance and control equipment on Mariner I?

Mr. SHETLER. Yes, for the radio guidance equipment for the Atlas booster.

Mr. FULTON of Pennsylvania. I was down at the site of Mariner I. They had over 300,000 simulated runs in the programing to see how the booster would work out in the various parameters on the subsystem. When it came right down to it, there was a $12 million loss because of the failure of the guidance equipment. This $12 to $14 million is a direct loss figure; there was probably another $5 to $8 million of indirect losses, plus the holding back of the program when we were in a race with Russia. It took about 90 days to get Mariner II ready, and we almost missed the opening for the lunar shot.

Why was it that someone failed to put in the minus sign, and whoever was his backup failed to catch it, so that there was this tremendous $16 to $20 million loss of the taxpayer's money?

My other question is this: When we know in advance that because of the ionization of the exhaust you get a garbled signal, and that the ground command was going to be interfered with, why wasn't this difficulty corrected by the preprograming of the rocket. Why wasn't it anticipated? Someone came before this committee and said: "Well, we just did not have enough imagination to think that out."

To me, that is the kind of reliability that we on this committee must see is increased, or it is going to be very difficult to go on the floor and tell the American taxpayers in justifying this program that it is a tight program.

I would appreciate it if you would take 2 minutes to explain that to me. I have been very interested in the Mariner I flight: What went wrong? Why did it happen? To me it looked like simple carelessness.

Mr. SHETLER. I think you pose a very difficult problem. I will

attack it from two ways. One relates to how did we participate, and as I explained, we had the radio guidance equipment on the Atlas booster.

I am proud to say we have not had an in-flight failure in our radio guidance equipment.

The difficulty experienced on Mariner I was, as I understand it, as you suggested, an inaccuracy—I should not say an inaccuracy, but an omission in the trajectory equations.

In retrospect, this could have been solved by additional simulated runs of those equations through the computer.

I can assure you that from all I have read on this subject such simulated runs, rechecking of the trajectory equations are now being done.

Mr. FULTON of Pennsylvania. But you are saying to us that your company is competent on these reliability checkouts and equipment checkouts, to make sure we don't run into these things. Then I cite you a tragic loss on which your equipment was involved. I want you to justify this so that we can see that the contract is worthwhile.

Mr. SHETLER. Sir, in the case of the Atlas program, we have had no responsibility assigned relating to the establishment of the trajectory equations.

Our design was against certain limitations or boundary conditions for guidance equations which it would accept, and what the guidance system does in this instance is to take the signals that are generated from these equations and, indeed, makes the maneuvers, if you will, that the equation said it should.

I believe that is just what happened in this case.

We were not contractually nor in any way responsible for these guidance equations fed into the computer.

Mr. FULTON of Pennsylvania. Operationally you were not responsible, though you had the equipment and the reliability factor of the equipment.

Mr. SHETLER. Yes, sir, and the equipment worked very well.

Mr. FULTON of Pennsylvania. But on this type of contract that you have now you are assuming a larger responsibility, so that this kind of tragic failure will be prevented because of a larger responsibility, is that right?

Mr. SHETLER. That is correct.

I think it is easy to draw these other comparisons, and I would say on this contract our responsibility to NASA is for reliability assessment, and we supply NASA data and criteria and methodology which they can use to determine the readiness of the mission.

We fully accept that responsibility. We did not have that responsibility in this example that you have cited to me.

Mr. FULTON of Pennsylvania. Let me ask you a question on how detailed you are on these inspections. When I was down there on this same Mariner flight, there was a postponement because of the failure of a fuse connection that flickered on and off. When the fuse was taken out it was evidently put on a mat that contained other fuses, and unfortunately they could not tell from among the five, six, or eight fuses, which was the bad one that was taken out. They had to check everything out again, and that means a postponement and the additional cost, I guess, of a whole day and of all the crew.

Are you people in this kind of contract going to protect the program from the lack of a horseshoe nail type mistakes and accidents?

Or are you always going to be dealing with the tremendously complicated systems, and leave these smaller reliability checks to other people? The aggravating thing to me is the number of small things that have gone wrong. I have mentioned many times the five things that went wrong within 1 hour of the Glenn flight that were off the shelf items.

I may yet put in an amendment to put in a Government inspection system separate and apart from NASA. I am getting completely discouraged about the tremendous losses that accrue from these smaller failures on types of equipment that are ordinary procedures, the off-the-shelf and over-the-counter-type of thing, in the space industry.

Mr. SHETLER. You get into a very difficult problem and one in which I share your concern.

The integrated launch control and checkout philosophy is to insure that these things do not happen. I could not sit here today nor do I think anybody in the business of making these terribly complicated systems could say we can fully automate something to eliminate to 100 percent, human error. What we try to do is to increase the probability of success of a mission to the point where it is reasonable, beyond almost all doubt, to expect the mission will not fail.

But I don't think anybody can guarantee against some human error creeping in. We do everything we can to avoid that.

Mr. FULTON of Pennsylvania. Do you go into this kind of check to see that we will be saved from these embarrassing failures that cost us worldwide prestige? What is your responsibility on that?

Mr. SHETLER. We are supplying NASA with criteria for the selection and evaluation of reliable components, and I believe this will aid very, very materially in this.

I am avoiding 100 percent assurance, because I don't think, in my technical judgment, that it would be wise to give it.

Mr. FULTON of Pennsylvania. We have been in the field a long time, so we understand how you have qualified your judgment.

But you feel this contract will add to or increase the reliability standards and assist on the checkout of the equipment materially, so that the money spent is worthwhile?

Mr. SHETLER. Indeed I do.

It is inconceivable to me without the vast reliability program and the assessment of the reliability programs at the various prime contractor's plants and without a highly integrated checkout system, can we successfully perform this mission, or I would not be involved.

I feel very deeply on this.

Mr. FULTON of Pennsylvania. Thank you.

Mr. TEAGUE. Mr. Riehlman?

Mr. RIEHLMAN. You have people stationed now at the Cape, at Houston, and at Marshall.

Mr. SHETLER. Yes.

Mr. RIEHLMAN. In connection with your responsibilities during the term of your contract up to this point, have you at any time come up with new designs, or any new type of construction, that is necessary to carry out your responsibilities? I am sure that will tie in with the manufacturers who have these contracts.

Mr. SHETLER. Yes. Our activity does not relate to the development of any new designs for components that are not part of the checkout system.

We, rather, assess the reliability programs of these prime contractors for the various centers, and assist NASA in assessing the results of these.

We are just now in what I would call the system design part of the integrated launch control and checkout.

We have nothing marked "invention" to talk about this morning. But I don't believe that in the integrated launch control and checkout system invention is so important from the hardware standpoint as the careful programing of this hardware system with all its subroutines; and here is the area of creative uniqueness necessary to this program.

I would relate this to the difficulty in the kind of program where if you look at a weapons system you may have several hundred thousand parts and a requirement to operate for only several minutes or a half hour.

In this complicated program you have several million parts that may have to operate for periods in excess of one week, so that gives you sort of a feeling for the vastness of the requirements for reliability.

Mr. RIEHLMAN. You do have some responsibility in keeping NASA informed as to whether or not the contractor is providing the proper materials and equipment, do you not?

Mr. SHETLER. Indeed we do, in terms of reliability program reviews I was merely answering the question and saying that we have not developed new components for these other people.

Mr. RIEHLMAN. If you find that there are some components that need new design or a new approach, it would be your responsibility, would it not, to call it to NASA's attention?

Mr. SHETLER. Yes, indeed, again in terms of program assessments.

Mr. RIEHLMAN. Under the contract you have with NASA, would you have the authority to design this type of equipment or manufacture it yourself?

Mr. SHETLER. We would not have authority under this contract to design such components nor to manufacture them.

It would be a separate matter. My offhand reaction would be for our recommendations as to requirements for reliability programs would go to NASA and go through their regular management channels for them to obtain them from their normal suppliers.

Mr. TEAGUE. May I ask a question?

Mr. RIEHLMAN. Certainly.

Mr. TEAGUE. In other words, all your hardware pertains to your reliability tests?

Mr. SHETLER. Launch control and checkout, which encompasses this broad reliability assessment feature.

Mr. TEAGUE. But take the Saturn shot that is coming up soon, is there any hardware that came from your company in that shot?

Tell us what part your company will play in the upcoming Saturn shot.

Mr. SHETLER. We will not be involved in the upcoming Saturn shot.

Mr. TEAGUE. No reliability tests or anything?

Mr. SHETLER. No, we will not have equipment involved in making reliability tests on that Saturn shot.

From the data that is generated under the current Saturn work going on we will use these numbers as well as the total results of the system, to give a reliability assessment for that—probably not that

Saturn shot specifically, but a model which is part of the total reliability assessment.

In the end program, the total Apollo program, we will furnish hardware which will give, as the countdown proceeds, the operational readiness of the total system.

I think I have to differentiate here between the Saturn shot which is a test, and primarily test equipment will be used, as opposed to launch control and checkout, which is an operational readiness complex.

Mr. RIEHLMAN. You heard the gentleman from Bellcomm testify this morning, Mr. Shetler. Do you feel that any of the activities that you are carrying out under your contract with NASA would overlap to any degree with what Bellcomm is doing?

Mr. SHETLER. I do not believe our activities overlap those of Bellcomm. I listened carefully this morning. The portion Dr. Hornbeck mentioned this morning relating to overall checkout relates to the overall philosophy of checkout, not to the specifics of system design or equipment design.

So I do not see any overlap in this area, other than that overlap required to transfer knowledge. I think you have to have a method of communicating.

Mr. RIEHLMAN. One other question, Mr. Chairman.

In your activities so far at the different centers, you are coming in contact with people in the manufacturing field who are furnishing equipment. What has been your relationship with them?

Let's take one specific case. What about North American?

Mr. SHETLER. Our method of operating with the prime contractors of NASA centers, in this case North American being a prime contractor of the Manned Space Flight Center in Houston, is to have our relationship with them relating to reliability assessment and checkout established with the NASA Center which has that prime contractor cognizance and for the checkout of the spacecraft we are in the process of system design, again relating to the prelaunch automatic checkout equipment for the spacecraft.

So our relationship here is one of communication with these people through the centers. I think we would be unwise to communicate directly, that control and management of this program must belong to NASA throughout and, from the standpoint of this program, the headquarters in the three centers.

We are very careful not to go around that and violate that prerogative.

Mr. RIEHLMAN. Well, you have people at Houston.

Mr. SHETLER. That is correct.

Mr. RIEHLMAN. And certainly North American has some people there.

Mr. SHETLER. That is right.

Mr. RIEHLMAN. Could you give us any idea of what your relationship has been with North American in their activities at Houston?

Mr. SHETLER. Yes. Our relationships with North American have been through specifically designed and stated tasks by such people as those people at Houston, to direct us to obtain such information as we need from North American to do both reliability assessment and to have concept design, or to have systems design, really, for the preflight automatic checkout equipment for the spacecraft.

So it is a specifically directed effort.

Mr. RIEHLMAN. Have you been able to get that information?

Mr. SHETLER. We have had no abnormal difficulties in that area.

Mr. TEAGUE. Any other questions?

Mr. YEAGER. You are still operating under the letter contract at the present time?

Mr. SHETLER. That is right.

Mr. YEAGER. I believe you gave us the date of February 1962?

Mr. SHETLER. That is correct.

Mr. YEAGER. Why has it taken this length of time to complete a finalized contract? Are there any particular stumbling blocks?

Mr. SHETLER. There are at this time no particular stumbling blocks. The overall launch control and systems checkout system is very, very complicated. It slashes across the total system. To define this properly we took a great deal of time, to be sure to define this so everyone had full knowledge of what we are doing.

I would have preferred to take this extra time to be sure what we were doing, rather than to have had a broad and loose contract. We are hopeful to have this completed now in very short order.

Mr. YEAGER. What percentage of funds that you have had so far has been devoted to construction, or the purchase of land, buildings, this kind of thing?

Mr. SHETLER. We have not used any of the NASA funds to purchase construction and facilities.

Our facilities and construction are, as has been our usual practice, against General Electric funds and credit, which are charged off on a proportion to the amount of work we do for you, as to our other contractors.

Mr. YEAGER. Do you contemplate this arrangement will continue in the future?

Mr. SHETLER. I see no reason to believe there should be special facility funds for our work.

I say "facility funds."

I don't know about highly specialized tools or test equipment.

Mr. YEAGER. Could you provide us for the record, as we asked Dr. Hornbeck to do, the professional background of your people who are working on this, whether they are engineers, physicists, chemists, mathematicians, electronics experts, that kind of thing?

Mr. SHETLER. Yes, sir.

(The information requested is as follows:)

Apollo support department technical staff as of Mar. 20, 1963

Location	Mechanical engineering	Electrical engineering	Other engineering	Physics	Mathematics
Daytona Beach	73	193	21	44	27
Huntsville	53	137	15	9	5
Cape Canaveral	22	59	7	9	5
Houston	17	44	5	3	2
Total	165	433	48	65	39

Mr. YEAGER. Thank you.

Mr. TEAGUE. Are there other questions? Mr. Bell?

Mr. BELL. Are all of your personnel of a technical nature? In other words, you won't be dealing with any unions or anything of this kind?

Mr. SHETLER. My statement related to the people we have on board at the moment, which I stated to be—that about two-thirds of our people were professional or technical people.

As we proceed with the construction of the total checkout system we will have direct labor personnel constructing hardware.

Mr. BELL. Construction personnel?

Mr. SHETLER. Fabrication, I should say, electronic fabrication.

Mr. BELL. That would be in the construction end of the business, the constructing of material?

Mr. SHETLER. That is right.

Mr. BELL. In other words, it would be subject to the Davis-Bacon Act; is that correct?

Mr. SHETLER. I do not know that answer; I am sorry.

Mr. TEAGUE. We do, Mr. Shetler.

Mr. BELL. My questioning was relative to the problems that we have had in the past in this type of work.

Mr. SHETLER. If I may just make a comment: When I think of construction I think of the construction trades, and in electronics I think of fabrication. There will be electronic fabrication.

Mr. TEAGUE. Are there no other questions? Thank you very much Mr. Shetler. The committee will adjourn until 10 o'clock tomorrow.

(Whereupon, at 11:45 a.m., the committee was adjourned, to reconvene at 10 a.m., Thursday, March 21, 1963.)

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1964 NASA AUTHORIZATION

THURSDAY, MARCH 21, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON MANNED SPACE FLIGHT,
Washington, D.C.

The subcommittee met at 10 a.m., Hon. Olin E. Teague (chairman of the subcommittee) presiding.

Mr. TEAGUE. The committee will come to order.

We have with us this morning Dr. Robert Seamans, Jr., Associate Administrator of NASA, and Dr. Brockway McMillan, Assistant Secretary of the Air Force for Research and Development.

(The biographical sketches of Dr. Seamans and Dr. McMillan follow:)

ROBERT C. SEAMANS, JR., ASSOCIATE ADMINISTRATOR, NASA

Robert C. Seamans, Jr., was appointed Associate Administrator of the National Aeronautics and Space Administration on September 1, 1960. Dr. Seamans occupies the top career post at NASA, serving under the presidentially appointed Administrator and Deputy Administrator.

In this position, he is responsible for the general management of NASA's operations, which include laboratories, research centers, rocket testing and launching facilities, and a world network of tracking stations.

Previous to his appointment at NASA, Dr. Seamans was chief engineer of the Radio Corp. of America's Missile Electronics & Controls Division at Burlington, Mass.

Born October 30, 1918, in Salem, Mass. he earned a bachelor of science degree from Harvard University in 1939. He received a master of science degree in 1942 and a doctor's degree in 1951 from the Massachusetts Institute of Technology.

Dr. Seamans has been active in the fields of missiles and aeronautics since 1941. From 1941 to 1955, he held teaching and project-management positions of increasing responsibility at MIT, including from 1949 to 1955, associate professor of the department of aeronautical engineering; from 1950 to 1955, chief engineer of Project Meteor, and from 1953 to 1955, Director of the Flight Control Laboratory.

Dr. Seamans joined RCA in 1955 as manager of the Airborne Systems Laboratory and chief systems engineer of the airborne systems department. In 1958 he became chief engineer of the Missile Electronics & Controls Division, supervising all scientific engineering and technical personnel in the division.

From 1948 to 1958, he served on technical committees of NASA's predecessor organization, the National Advisory Committee for Aeronautics. From 1957 to 1959 he served as a consultant to the Scientific Advisory Board of the Air Force, and has been a member of the Board since 1959.

Dr. Seamans is a member of Sigma Xi, the Institute of Aerospace Science, the Institute of Radio Engineers and the American Ordnance Association. He was the recipient of the Naval Ordnance Development Award in 1945 and the Lawrence Sperry Award for the year 1951 given by the Institute of the Aeronautical Sciences.

He is married to the former Eugenia A. Merrill. They have five children and reside in Washington, D.C.

DR. BROCKWAY MCMILLAN, UNDER SECRETARY OF THE AIR FORCE

Dr. McMillan was born March 30, 1915, in Minneapolis, Minn. He attended public schools at Hinsdale, Ill. He received his B.S. at Massachusetts Institute of Technology in 1936 and his Ph. D. in 1939.

Dr. McMillan was an instructor at MIT from 1936 to 1939. At Princeton University he was a Procter fellow, 1939–40; an instructor, mathematics, 1940–41; and a research associate, 1941–42. He served with the Office of Scientific Research and Development in 1941. Dr. McMillan served on active duty with the U.S. Navy during the period 1942–45. He was associated with the Los Alamos Laboratory, AEC, in 1946. From 1946 to 1959 he was research mathematician and from 1959 to June 1961 he was director of military research, both at Bell Telephone Laboratories. He was one of the founders and president of the Society for Industrial and Applied Mathematics from 1959 to 1961.

Dr. McMillan served as a member of the local board of education, appointed by the mayor of Summit, N.J. He is a member of the Mathematics Society and the Institute of Mathematical Statistics. Among his publications are: "Statistical Mechanics of Interacting Systems," "Electrical Networks Theory," and "Probability Theory and Random Processes."

One June 1, 1961, Dr. McMillan was appointed Assistant Secretary of the Air Force for Research and Development, and on June 12, 1963, was sworn in as Under Secretary of the Air Force, both under the Secretary of the Air Force.

He married the former Audrey Wishard in 1942, and they have three children: two sons, Douglas and Gordon, and a daughter, Sarah. The family resides at 2524 44th Street NW., Washington, D.C.

Mr. TEAGUE. I believe, Dr. Seamans, you have a prepared statement.

STATEMENT OF DR. ROBERT C. SEAMANS, JR., ASSOCIATE ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Dr. SEAMANS. I have just a short statement, Mr. Chairman, I would like to read before we address ourselves to any particular questions you or other members of this subcommittee may have on the Gemini planning board.

The NASA–DOD agreement on Gemini was put into effect by Secretary McNamara and Administrator Webb on January 21, 1963. This agreement represents another important example of the manner in which both the Department of Defense and the National Aeronautics and Space Administration are striving to maximize the technological productivity of national space flight programs such as the Gemini.

I think it is significant that in announcing the agreement, Mr. McNamara and Mr. Webb emphasized the national character and importance of the Gemini project and reiterated their intentions to insure that Gemini is utilized in the national interest and to avoid unnecessary duplication of effort in this area as in all others.

The Gemini agreement actually represents one of many key agreement arrived at between the DOD and NASA over the past several years. As you know, two other important agreements which illustrate our close working relationships cover the national launch vehicle program and operations at the launch area on Merritt Island and Cape Canaveral.

With your permission, I would like to submit for the record at this time a copy of the Gemini agreement and briefly run through its several provisions.

Mr. TEAGUE. Without objection, it will be placed in the record at this point.

(The document referred to follows:)

AGREEMENT BETWEEN THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION AND THE DEPARTMENT OF DEFENSE CONCERNING THE GEMINI PROGRAM

This document defines the policy agreement for arrangements to insure the most effective utilization of the Gemini Program in the national interest.

1. Objectives of the Gemini program

The Gemini program constitutes a major portion of the current near-Earth manned space program in the United States. It is the intent of this agreement to assure that the scientific and operational experiments undertaken as a part of the Gemini program are directed at the objectives and requirements both of the DOD and the NASA manned space flight program.

2. Establishment of the Gemini program planning board

A Gemini program planning board is hereby established reporting jointly to the Administrator of the NASA and the Secretary of Defense. The Associate Administrator of the NASA and the Assistant Secretary of the Air Force for Research and Development will serve as Co-Chairman of the planning board. The board will include two additional representatives of each of the two agencies. Members will be named by the Co-Chairman and approved by the Administrator of the NASA and the Secretary of Defense.

3. Functions of the Gemini program planning board

The Board hereby created is intended to assure that the Gemini program is planned, executed, and utilized in the overall national interest, in accordance with policy direction from the Secretary of Defense and the Administrator of the NASA, so as to avoid duplication of effort in the field of manned space flight and to insure maximum attainment of objectives of value to both the NASA and the DOD. The functions of the Board in carrying out this responsibility shall include the delineation of NASA and DOD requirements and program monitoring to insure that they are met in:

1. The planning of experiments.
2. The actual conduct of flight and in-flight tests.
3. The analysis and dissemination of results.

Should actual project plans fail to meet the requirements specified by the Board, or should competing requirements produce resource or schedule conflicts, the Co-Chairmen shall so inform the Administrator of the NASA and the Secretary of Defense.

4. Gemini project management

NASA will continue to manage the Gemini project. It is, however, agreed that the DOD will participate in the development, pilot training, pre-flight checkout, launch operations and flight operations of the Gemini program to assist NASA and to meet the DOD objectives.

5. Funding

In recognition of its interest in the program, the DOD will contribute funds to assist in the attainment of Gemini program objectives. The amount of such support will be determined on the basis of recommendations submitted by the Board.

6. Additional programs

It is further agreed that the DOD and the NASA will initiate major new programs or projects in the field of manned space flight aimed chiefly at the attainment of experimental or other capabilities in near-Earth orbit only by mutual agreement.

ROBERT S. MCNAMARA,
Secretary of Defense.

Date Jan 21, 1963.

JAMES E. WEBB,
Administrator, NASA.

Date Jan 21, 1963.

Dr. SEAMANS. The first important element I have already mentioned; i.e., to assure that the scientific and operational experiments undertaken as a part of the Gemini program are directed at the objectives and requirements both of the Department of Defense and the NASA manned space flight program.

In this regard, it is important to note that for many months now we have had detailed agreements at the working level on Gemini between our Office of Manned Space Flight under Brainerd Holmes and the U.S. Air Force Systems Command under General Schriever.

As you know, General Schriever has assigned General Ritland as a full-time coordinating official with the Office of Manned Space Flight.

General Ritland and his staff have offices in the building occupied by D. Brainerd Holmes and his people. We have found this arrangement to be very helpful in insuring close coordination between various elements of the Systems Command and our own Office of Manned Space Flight.

The second key element of the Gemini agreement concerns establishment of a Planning Board cochaired by Dr. McMillan and myself.

In addition to Dr. McMillan, DOD representation on the Board includes Dr. Lawrence Kavanau, Special Assistant (Space), D.D.R. & E., and General Schriever.

NASA representation includes my Deputy for Defense Affairs, Adm. W. F. Boone, and Mr. D. Brainerd Holmes.

The Board's principal function is to assure that the Gemini program is planned and executed so as to be fully responsive to technical requirements of both NASA and DOD and, by so doing, preclude unnecessary duplication of effort in the field of manned space flight.

In our three meetings to date, the Board has been reviewing Gemini program plans and status in light of the technical objectives set forth by NASA and the DOD.

The third key element of the agreement concerns DOD participation in significant elements of the program such as hardware development, astronaut training, and flight operations. As you know, the DOD already is participating heavily in the Gemini project as exemplified by Titan II, Agena, and recovery responsibilities.

However, the intention here is to broaden this participation wherever possible in order to maximize the benefits of this technology in light of potential military utilization.

I think it is important to point out here that increased DOD participation in the Gemini does not alter the peaceful and experimental character of the program. We are driving forward to advance the technology of manned space flight, including rendezvous and designated docking and to understand man's effectiveness under prolonged conditions of weightlessness.

In carrying out this program, NASA continues to be solely responsible for the management of the Gemini project.

As a final word, I would like to point out that the Board has been operating most effectively during the very short time it has been in existence.

For my part, I am convinced that it provides both Dr. McMillan and myself with an extremely helpful mechanism for insuring that the program is well conceived and executed and that it provides a maximum return for the investment the Nation is making in it.

That concludes my statement.

Mr. TEAGUE. Thank you, sir.

Expressing my personal opinion, I was very pleased to see this agreement. I happen to believe there is a military mission in space, and that it is time we got on with it.

We keep hearing rumors here on the Hill that there is to be another agreement. Is this the only agreement, or do you expect to have another one?

Dr. SEAMANS. Obviously there will be additional agreements. This is the one for Gemini. We have, as I indicated, an agreement to have the operation of the Atlantic Missile Range. We are currently discussing an agreement with the Air Force for the Atlas and the Agena, and each project has to be reviewed in order to insure that we are obtaining a maximum benefit from it, and in some cases it warrants my participation, and in these cases we want to define the roles of each agency.

Mr. TEAGUE. As far as the Gemini program is concerned——

Dr. SEAMANS. I know of no forthcoming amendments or additions to that agreement.

Mr. TEAGUE. How many meetings has your Planning Board had?

Dr. SEAMANS. Three, sir. Two executive sessions, and we had a third meeting to review the program in detail; with presentations from all the participants.

In addition this last week we went on a trip with the Secretary of Defense to Houston, so he had an opportunity himself to review the Gemini program along with Dr. McMillan and Dr. Brown and General Schriever.

Mr. TEAGUE. Would you discuss funding for us. Has the fact that the Air Force came into the program added any funding problems as far as NASA is concerned?

Dr. SEAMANS. It has not added funding at this time, because the program has not been altered. We are still proceeding with all the elements of the project as originally conceived and discussed with your committee.

However, we are reviewing both NASA and DOD requirements, and it may be we will want to expand certain of the experiments, in which case the Board, Dr. McMillan, and myself will present recommendations to the Secretary of Defense and the Administrator of NASA for possible increased funding that might involve the use of DOD funds.

Mr. TEAGUE. Then the Planning Board will decide what contribution DOD should make and what NASA should make?

Dr. SEAMANS. Not decide, but they will make a recommendation. The decision for DOD participation will be that of Mr. McNamara.

Mr. TEAGUE. What does the last paragraph of the agreement mean?

Dr. SEAMANS. The last paragraph relates to programs beyond those already approved; by that I mean programs beyond Gemini and Apollo, and Dyna-Soar. It states that, for example, if there were to be a manned space station, this would be a program that would be in its makeup a consideration for both NASA and DOD requirements, that the management of the project would be—and the conduct—would be jointly approved by both the Secretary of Defense and the Administrator of NASA.

Mr. TEAGUE. Does this paragraph mean that neither the Air Force nor NASA can start a program without the agreement of the other?

Dr. SEAMANS. This says that is the indication for any "new major program," and the word "major" is important.

It does not refer to systems studies, for example, it does not refer to advanced technological developments.

It does refer to programs of the scope of Gemini, Apollo and Dyna-Soar.

Mr. FULTON of Pennsylvania. Who asked for this arrangement?

Dr. SEAMANS. This is an item both Mr. Webb and Mr. McNamara felt would be necessary before either party would be willing to go ahead, and felt it would be desirable to have it in writing so there would be no misunderstanding on anybody's part.

Mr. FULTON of Pennsylvania. Will it help eliminate duplication?

Dr. SEAMANS. Yes, that is really the reason for the Gemini agreement, to eliminate duplication.

And looking at it the other way, to get maximum return from this very major investment of the taxpayer.

Mr. FULTON of Pennsylvania. What near-Earth orbits would the Air Force have that NASA would not be interested in?

Dr. SEAMANS. Would you care to discuss that?

STATEMENT OF DR. BROCKWAY McMILLAN, ASSISTANT SECRETARY OF THE AIR FORCE FOR R. & D., ACCOMPANIED BY COL. HERMAN DORFMANN, EXECUTIVE TO THE ASSISTANT SECRETARY OF THE AIR FORCE, R. & D.

Dr. MCMILLAN. I can't visualize any that NASA would not be interested in to some degree.

Mr. FULTON of Pennsylvania. I would imagine adverse encounter would be one.

Dr. MCMILLAN. As far as actual operational military systems are concerned, surely the DOD has a primary interest, and NASA almost by definition would not have an interest.

But in thinking of experimental programs I cannot visualize the military would want to engage in a program that was not of some interest to the NASA.

There are differences in our interests in details of experiments, of course.

Mr. FULTON of Pennsylvania. Do NASA and the Air Force have identical interest in these near-to-Earth orbits?

Dr. MCMILLAN. I would not say identical, no.

The military has interest in achieving rendezvous with noncooperative targets, and that is not of direct or immediate interest to NASA, though I am sure in case of emergency the NASA would like to have the same capability.

In the long run the Department of Defense has interest in achieving rendezvous with targets that are trying actually to evade. I am sure this is a matter that would be of only very peripheral interest to the NASA.

Mr. FULTON of Pennsylvania. This paragraph does not show the peacetime uses of space and the military uses of space, so your own separate interests cannot be distinguished.

Is this a melding and molding of the two programs? If so, the question comes up, shouldn't we have just one program; why two?

Dr. MCMILLAN. I don't see that this paragraph commits either party in the long run to a melding or molding or unification of programs.

It just requires that both parties agree to the content and conduct of the program and its desirability before the program is undertaken.

Mr. FULTON of Pennsylvania. When did the Air Force decide that it had a mission in space under DOD policy?

Dr. MCMILLAN. I don't understand the question, sir.

Mr. FULTON of Pennsylvania. We have been hearing from the Department of Defense that there were no missions in space for the DOD (and if there were any, they were very doubtful). Also, that they could not visualize weapon resistance in space that could be anything more than could be done in an Earth-to-orbit ballistic missile approach. This committee has heard such testimony over the past several years by the Department of Defense, and I must say it has not come from the Air Force. The question naturally arises, when did this beautiful marriage of ideas occur between the Air Force and the Department of Defense?

Dr. MCMILLAN. I think my best answer to that would be to say on February 22 a year ago the Secretary of Defense wrote a long, rather detailed, and classified, memorandum to the Air Force specifying a great many, or describing a great many desirable features of military systems to be investigated in space, and setting down ground rules under which he felt the Air Force ought to consider experimenting with both manned and unmanned space flight for military purposes.

Mr. FULTON of Pennsylvania. Can you release any of that memorandum? That is of major significance not only to our taxpayers but to this program. We should know what these programs are if they are not classified. If they are general policies, I see nothing wrong with declassifying them.

Dr. MCMILLAN. I can take that question up with the Secretary of Defense.

Mr. TEAGUE. Some of it has been released to the papers within the last 10 days, has it not?

Dr. MCMILLAN. I am not sure of the contents of the particular memorandum that I have reference to.

Mr. FULTON of Pennsylvania. With the chairman's permission I would like to request that.

Mr. TEAGUE. Yes.

(The memorandum referred to is classified and may be found in the committee files.)

Mr. FULTON of Pennsylvania. Let me ask you this further question: On the Gemini program, will you be equal partners? Will you be working together so that there is an equality of status? Or does either NASA or the Department of Defense have the ultimate policy direction and decision at the administrative level?

Dr. SEAMANS. As I indicated, the management responsibility for the Gemini is vested in NASA; and our project people, coming under Brainerd Holmes, have the responsibility to see that technical objectives are achieved and that the program proceeds on schedule and stays within funds.

Mr. FULTON of Pennsylvania. Suppose the Air Force says "We want so and so for Air Force purposes? Who says yes or no, or who says "the two of you go together"?

Dr. SEAMANS. It is the purpose of the Policy Board to review at all times on a continuing basis both the DOD requirements as well as

NASA requirements, and if DOD has a requirement that is not being met in the conduct of the Gemini program it is reviewed by Dr. McMillan and myself, and if, in order to meet these requirements, we would have to change the project in some substantive way, this would have to be reviewed by Mr. Webb and Mr. McNamara before that change would be made. The final determination as to what NASA does would be made by the Administrator of NASA.

Mr. FULTON of Pennsylvania. It is the Administrator of NASA who makes the final determination. The Board only makes a recommendation of policy, so that the Board is in a consultative position, is that correct?

Dr. SEAMANS. That would be my definition, yes.

Mr. FULTON of Pennsylvania. Does the Air Force agree that the ultimate decision is in the Administrator of NASA on these programs?

Dr. MCMILLAN. I think the Air Force interprets the agreement much in or exactly the way Dr. Seamans describes his interpretation, that the Gemini Planning Board makes recommendations on matters of substance to the Secretary of Defense and to the Administrator of NASA.

I would like to add a word——

Mr. FULTON of Pennsylvania. Before you leave that, what we are trying to find out is who makes the ultimate decision. I am sure that was the point of the chairman's question earlier.

Dr. MCMILLAN. Well, the agreement provides that our recommendations be made both to the Secretary of Defense and to the Administrator of the NASA.

Mr. FULTON of Pennsylvania. But Dr. Seamans, representing NASA, has said the ultimate decision is under the direction of the Administrator of NASA.

Is that correct?

Dr. MCMILLAN. The agreement also specifies the program will remain under NASA management.

Dr. SEAMANS. But I believe we are saying the same thing.

I am sure you recognize that the intent here is to satisfy the DOD requirements. And if the Secretary of Defense feels that some change or reorientation in Gemini is required for national security, I can assure this committee that Mr. Webb would be as responsive as he possibly could be.

Mr. FULTON of Pennsylvania. What effect do the Office of Science and Technology and the Space Council have on these policy decisions of this Board regarding the NASA–DOD Gemini agreement?

Dr. SEAMANS. This was discussed with the various offices at the executive level prior to the signing of the actual agreement. But the actual implementation of this policy is entirely the responsibility of the DOD and NASA.

Mr. FULTON of Pennsylvania. Isn't this coming around to the military-civilian liaison board setup that we had in the original NASA Act of 1958?

Dr. SEAMANS. I would say this is for a very specific purpose, whereas the Board you refer to was for general liaison between the two agencies, and was for that reason more comparable to the Aeronautics and Astronautics Coordinating Board.

Mr. GURNEY. Mr. Chairman.

Mr. TEAGUE. Mr. Gurney.

Mr. GURNEY. Could you amplify this element on page 3 of your statement about the DOD participation?

Dr. SEAMANS. What is your specific question, sir?

Mr. GURNEY. What is the participation of the DOD going to be in the Gemini program?

Dr. SEAMANS. First, let me tell you what it is now. The Department of Defense, specifically the Air Force, is today responsible for the Titan II booster which will launch Gemini into orbit.

Mr. GURNEY. Who is going to actually fire the Titan II?

Dr. SEAMANS. The instructions, requirements, overall specifications for the Titan II are the responsibility of our Houston project management team, who give and transmit these specifications, instructions to the Air Force, which is there in the same geographic area, of course.

Then the Air Force, working with the Martin Co., who are the contractors for Titan II, must so carry out the development that it meets these overall requirements, and if there are any deviations naturally keep the NASA project office informed.

When the Titan II is going through its tests, it is the responsibility of the Air Force to see the proper test data is obtained and that again the test data substantiates the fact that Titan II does meet the requirements.

Mr. GURNEY. Who makes the tests? The Martin people?

Dr. SEAMANS. The Martin people will be responsible for testing of the Titan II. Following the test the actual vehicles go to the cape area and the Air Force people there must, again, assure that the Titan II is ready for launching, and take that responsibility. They will then be part of the total launch team on Gemini.

Mr. GURNEY. When you say "part of the total launch team," who is the boss of that team?

Dr. SEAMANS. NASA assumes overall responsibility for the launching and flight operation of Gemini.

Mr. GURNEY. Who are the personnel who do the launching?

Dr. SEAMANS. Air Force and contractor and NASA people, with NASA bossing the job.

There has to be one boss, on any job, and the flight director, who is a NASA man, assumes total responsibility at the time the mission is going through countdown and launch.

Mr. GURNEY. Up to now, hasn't the Air Force done most of the launching in these fields?

Dr. SEAMANS. This is exactly analogous to Mercury, where the Air Force has been responsible for the booster. Mr. Williams, a NASA man, is responsible for the overall flight operation, and he has to have information from not only the booster people, but also the capsule personnel and the aeromedical people and the tracking station people, to make his final decision whether or not to go ahead with the flight.

Mr. GURNEY. It occurs to me as though, obviously, the reason for this contract is to make sure that the Department of Defense gets proper training, orientation, and experience in the field of space. Since they are working with their own booster, it occurs to me that it would be far more sensible if they did the job. How better can you get training than doing the job?

Dr. SEAMANS. I agree 100 percent. I believe that is what they are doing.

In addition to Titan II, they are also responsible for the Atlas-Agena, which is used during the Gemini tests on rendezvous. Agena will be placed in orbit by the Air Force team, and controlled in orbit by the Air Force team. So they are participating with us on three major subsystems of the total Gemini system—the Agena, Atlas booster, and Titan II.

Mr. FULTON of Pennsylvania. Would you yield on that point?

Mr. GURNEY. Yes.

Mr. FULTON of Pennsylvania. If you look on page 3 of your statement in the second paragraph, you say:

> The third key element of the agreement concerns DOD participation in significant elements of the program such as hardware development, astronaut training, and flight operations.

When you add the booster to that, what would NASA be doing?

Dr. SEAMANS. Let me say, NASA is responsible for the development of the Gemini capsule itself, which is, of course, a major piece of the hardware, for all the flight instrumentation, as well as for the worldwide tracking net which makes use of Mercury, but which is being augmented for maneuvers in space. So NASA does have a major development test and operational responsibility.

Mr. RIEHLMAN. Would the gentleman yield?

Mr. FULTON of Pennsylvania. Yes.

Mr. RIEHLMAN. Mr. Chairman, following the questioning of Mr. Fulton, what about the training of astronauts? Is the Air Force going to have a program of training astronauts, too?

Dr. SEAMANS. Well, most of the astronauts come from the Department of Defense. However, the training will be primarily at Houston and at the Cape.

At Houston we are building a mission control center, which I believe has been discussed with this subcommittee, and it will be used not only for the rendezvous operations themselves, and the flight operations, but also for training purposes, using capsules that simulate the actual flight profile.

Mr. RIEHLMAN. Mr. Chairman, we have been trying for a long, long time to get definite information as to exactly what the DOD's program in space is. I think it is time that we had some information for this committee. If it is classified, let the committee have it in classified form. We have been given what I think is the go-around on this question. When interrogating people from the DOD last year, they stated that they had no program, and that they had no particular interest in space. Now we are getting a statement today that they do have an agreement; that they do have an interest, and that they do have a program.

I want to know whether there is duplication of effort on the part of these programs. Are we going to have a program of training astronauts in one group for peaceful purposes, or are we going to train them for military purposes?

Mr. TEAGUE. If the gentleman would yield, we have a meeting scheduled for April 2 on military missions. If it is classified, we will have a closed meeting.

Mr. RIEHLMAN. I think that is what we should have. It is not fair to the committee or the public if we have this type of program and are not getting the information.

Mr. FULTON of Pennsylvania. I think the kind of information that should be made public is that there is a policy and need for the Air Force. If there is one, why don't you tell us?

Mr. TEAGUE. Would you go back to a very basic question and tell us the schedule for Gemini and Apollo? Just what we are going to get from Gemini, and what hardware from Apollo will be in the Gemini flights? While you are talking about that, will you comment on whether Dr. Dryden is trying to get the Russians to tell us about their long flights, which might reduce a lot of our requirements for long flight?

Dr. SEAMANS. I believe Mr. Holmes and others have testified on this in front of your subcommittee, and I may be repetitious. However, I will be happy to summarize the Gemini and Apollo programs for you.

The Gemini is first scheduled for flight the end of this calendar year, unmanned, suborbital. That schedule stands.

Mr. TEAGUE. Still stands?

Dr. SEAMANS. Yes, sir.

Following the suborbital flight we have scheduled manned orbital flights, calendar year 1964, which will not permit us to carry out rendezvous operation, but will give us an opportunity of long-duration flights, of a week or more.

The reason we will not have rendezvous flights in calendar 1964 is because we won't have the Mission Control Center in full operation until early 1965. It is in this time period, that is, calendar 1965, that we will be running the rendezvous operations, mating with the Agena, trying out various methods for the rendezvous guidance, optical, radar, and so on.

Following the actual docking of the Agena and the Gemini, after we have achieved that kind of operation, we will then during the final phase of the presently planned Gemini 12 flights be able to carry out some maneuvers using the Agena propulsion, when it is coupled to the Gemini. This will allow us to carry out small changes in the orbital plane, as well as get to eccentric type orbits, get into higher altitude, for example.

The first Apollo flights are scheduled for the Saturn I. The Saturn I will have a flight next week, with the live first stage and dummy second stage, and at the end of this summer is scheduled for live second stage.

We have several additional development flights for Saturn, some of which will have Apollo hardware aboard, prototype equipment, and the first manned flight for Apollo is in 1965, I can't give you the exact date.

Also during calendar 1965 we will carry out the development flights on the Saturn I–B, which is the vehicle that has the second stage, which is essentially identical with what will become the third stage of Saturn V.

After four of these development flights we will in calendar 1966 be able to carry out missions that involve not only the Apollo capsule, but also the lunar excursion module and service module, so that in orbit we will be able to separate the two modules, that is, the lunar

excursion module and command module, and bring them back together, in order to fully check out the equipments that will be used in rendezvous about the Moon.

Following the operation with the Saturn I–B, and again during the time period when we will have manned flights with I–B, we will be carrying out development flights with Saturn V, so in the ensuing years, but still within this decade, we will be able to carry out the lunar program.

You asked about the carryover from Gemini to Apollo——

Mr. TEAGUE. If NASA did not have the Gemini program, what effect would it have on getting to the Moon?

Dr. SEAMANS. A very serious effect on getting to the Moon, for a number of reasons: One is that the detailed technology that is needed for Apollo missions will be proven out in Gemini.

For example, the rendezvous type equipment, for example the digital computer, the fuel cells needed for the longer duration, we cannot just use batteries for flights of a week or more.

Moreover, I believe even more than this is the fact we must carry out here on Earth the type of rendezvous operation that will be needed when one takes off from the lunar surface and goes up and meets with the command module that is in lunar orbit. We can and will do this, you might say in simulated fashion on Earth with the Agena in orbit, and the Gemini having to take off at a particular time in order to achieve rendezvous in docking.

Mr. TEAGUE. Won't you do the same thing in the flight testing of the Apollo capsule?

Dr. Seamans. No. We cannot—we don't plan to.

What we are doing is to take both the command module and excursion module up together, separate them, bring them together, but not carry out the complete mission, that is with putting the command up with one booster and the lunar excursion module up with another booster.

We cannot completely duplicate that with Apollo hardware.

It can't be put in the time scale at a time to allow us to still feed the results into the Apollo effort.

We need even more to build up a competence in this country that permits us to carry out these operations.

At the time of an operation we are probably involving tens of thousands of people—these are people in tracking stations; at Cape Canaveral, of course, it involves the astronauts, but they are just one of a very large number of people who must work as a team, starting with Mercury, through Gemini, the various Apollos, and ultimately the lunar program.

If this team of people went through a period of several years when in effect they were not carrying out any operations I believe it would be serious for us, for our lunar effort.

Mr. TEAGUE. Isn't the Gemini program going to be so close in time to Apollo that they will somewhat overlap?

Dr. SEAMANS. Well, as I described the program, there is a gap of something like a year to a year and a half between the manned Gemini and manned Apollo.

You have also to remember the first Apollo flights will be fairly primitive, just circular orbits.

And at the time we are getting into the circular orbit flights with Apollo, we will be getting into the maneuvering flights, which are much more complex, with Gemini. And this is very important operational experience.

Mr. TEAGUE. Why do you go to a different escape system in Gemini from what you use in Mercury, and from what you are going to use in Apollo?

Dr. SEAMANS. The escape systems involve ejection of the astronauts from the capsule, which is tied in, of course, with the desire to develop the paraglider for landing.

Once the decision is made to have a paraglider capability, it is no longer possible, or it is very difficult, to configure a capsule with an escape capsule on top.

We feel the paraglider is a very important development, if the Gemini is to become a workhorse, and for that reason, following this line of endeavor.

It is not, obviously, essential to the lunar program, but for—this is one of the reasons the Gemini has attractive features from the standpoint of Department of Defense.

With a parachute you can come down to a given point on Earth with an accuracy of within 4 or 5 miles, and this is not close enough to permit coming down over land, and then does necessitate water recovery.

Mr. TEAGUE. If the paraglider is successful, I assume you will attempt later to use it with Apollo.

Dr. SEAMANS. We currently do not have in our approved plan the use of paraglider for Apollo.

But obviously that is something that will be considered.

Mr. TEAGUE. Mr. Fulton?

Mr. FULTON of Pennsylvania. Since there is little or no atmosphere on the Moon, what kind of escape mechanism do you have on the rocket for Moon ascent to earth trajectory?

Dr. SEAMANS. The only way to return to the Earth from the Moon is to stay in the lunar excursion module.

Mr. FULTON of Pennsylvania. You will really have a two-man countdown and launch on the Moon; that will be a tremendous accomplishment. First, you will have no pad, and you will have no parachute, and you will have no checkout, will you, in the vehicle? You have no Mercury control, no blockhouse, no umbilical cord, no cherrypicker, and no on-ground command.

If you are able to do that on the Moon under conditions where it has never been done before, why do you need all those contraptions on the Earth?

Dr. SEAMANS. There are a number of answers.

First of all, the equipment on the Moon won't be as complex as the 360-foot vehicle sitting on a pad at Complex 39 at Cape Canaveral.

Secondly, there will be communication between the lunar excursion module and Earth during the time of the countdown on the lunar surface. So it will be possible for people on Earth to participate in the countdown.

But, obviously, not to the extent they do at Merritt Island.

Mr. FULTON of Pennsylvania. What do you have in Mercury that cannot be done in Gemini? Why don't you combine the two programs and eliminate the extra Mercury flights?

Dr. SEAMANS. The reason for the next Mercury flight is to stretch the time to a little more than a day to get the 22 orbits, and——

Mr. FULTON of Pennsylvania. Is that worth risking a man's life for?

Dr. SEAMANS. There is risk in every flight. Unless you take these kinds of risks you can't move a program ahead.

Mr. TEAGUE. Have the Russians told us anything about their long flight?

Dr. SEAMANS. I have not seen any detailed information about the Russians' flights.

Mr. TEAGUE. You are not planning on their furnishing you information that might help you in your long Gemini flight?

Dr. SEAMANS. We are not in our program counting on any information from the Russians.

That seems the safest way.

Mr. TEAGUE. Is Dr. Dryden trying to get information from them while he is over there?

Dr. SEAMANS. He has, as you know, just completed review of three different areas where we may, or plan to, cooperate with the Russians.

These are in the areas of passive communications satellites, meteorological satellites, and the gathering of information on the magnetic fields around the Earth.

Mr. TEAGUE. We are not asking them to tell us any information that would help us in our Moon program?

Dr. SEAMANS. Yes. We are trying to put pressure on the Russians to tell us about their programs, by so conducting our programs that they can see that there is benefit in releasing this kind of information in the world arena.

Mr GURNEY. Would the chairman yield on that point?

Mr. TEAGUE. Mr. Gurney?

Mr. GURNEY. When the representative of the Department of Defense, General Ferguson, was here explaining the military missions in space, it is my recollection he had four main points that the military were interested in. At any rate, one of them was communications and another concerned gathering weather data.

How in the world can we propose to cooperate with the Russians in these two fields if these are the prime areas in which the military is interested in space? It does not make any sense to me.

Dr. SEAMANS. Well, cooperation does not involve working on all communications satellites with the Russians, nor does it involve a full use of all of our resources.

These are specific projects in these two areas.

Mr. GURNEY. It must involve some exchange of information on the knowledge we gather. How can we avoid that?

Dr. SEAMANS. Yes, we have been exchanging knowledge with the Russians on our scientific and technical space program.

There is a world bank in Moscow of information, a world bank in Washington and another in England.

The results of our scientific programs go into each of these banks and are available to them as well as to ourselves.

Mr. FULTON of Pennsylvania. Would you yield?

Under the original enabling act of NASA in 1958, NASA has the policy direction from Congress, and signed by the President, that it

is to make available for world scientists in all the scientific communities the information which will be of scientific value. In contrast to that, the Department of Defense and the Air Force have the specific requirement of keeping secret anything that might in any way affect the security of this country, and the leaning is, therefore, toward classification.

Now, how do you conform those two different and varying policies when you come up with NASA–DOD agreement on Gemini, putting together the civilian scientific research and the military?

The other problem is this: when Russia has her program purportedly under their Academy of Science, a civilian body, and we now move halfway to putting our space programs into a Siamese-twin arrangement, one-half NASA and one-half DOD-Air Force, won't that tend, in the future, to make each of the scientific systems of Russia and the United States mutually exclusive? And, alternatively, does it give them a little advantage, because they can say that in the U.S. program, the Air Force is even training the astronauts and has taken over the training program and the flight program? That is what concerns me when NASA moves out of the flight training and the field in space.

It leaves you, it seems to me, with a string of zeros.

Dr. SEAMANS. First, it has always been NASA's policy, as it was of the NACA, to observe the same security that the Department of Defense does on those technological developments that could affect the national security.

This is not a change in policy. This is what we have always done and will continue to do.

When you talk about scientific information, we are talking about measurements in space of magnetic fields and radiation and environmental conditions that are of general interest and importance to mankind.

So what we have done here does not represent a change.

It is still our policy and will be our policy on the Gemini to have the scientific results unclassified and disseminate them as we have the results of the Mercury flight.

Mr. FULTON of Pennsylvania. The Air Force, though, is the one to decide whether or not it will be released, is that correct?

Dr. SEAMANS. No, the responsibility for disseminating information from Gemini will be NASA's responsibility.

But, obviously, we will honor any particular technological areas that should have been classified.

We have done this on the Mercury program. There is a great deal of the booster technology in the Atlas that is classified.

Mr. FULTON of Pennsylvania. When NASA has had the experience of training the astronauts, why does it move out of that field and make it completely military?

They are military men in uniform, trained in the military, and now under the direction of military. If you can tell me where the peaceful uses of space are concerned, I would like to hear it.

Dr. SEAMANS. NASA has been given the primary responsibility for the exploration of space, including near space, ultimately lunar landing, ultimately trips to the planets.

We have been training our astronauts to carry out these missions and so they can contribute to the flight profile and make certain scientific measurements in these flights.

Mr. FULTON of Pennsylvania. Why don't you continue?

Dr. SEAMANS. We are continuing.

There is no change contemplated in our operation at Houston. The astronauts we have there will carry out the Gemini flights.

Mr. FULTON of Pennsylvania. Mr. Waggonner?

Mr. WAGGONNER. On the contrary, I think there is a great deal of duplication eliminated by this arrangement.

This agreement looks good to me, with NASA as the project manager, and we are not duplicating a lot of services. I do not think allowing the Air Force to train these astronauts will, in any way, relieve NASA of any of its responsibility. I think it will avoid some future duplication.

One further thing about cooperation with the Russians, since we are on that subject. Dr. Seamans, to your knowledge, have the Russians built a communications or weather satellite which is operative?

Dr. SEAMANS. Not to my knowledge.

Mr. WAGGONNER. The agreements which have just been reached in Rome really mean we are just giving to them what we know about communications and weather satellites; is that the case?

Dr. SEAMANS. No; I don't think that is the case. In the communications area, there will be experiments carried out using the Echo II balloon. This has been open knowledge now for several years, since the Echo I flight in 1960. There will be experiments that cannot actually be carried out between the United States and Russia, because of the geography.

There will probably be flights to make measurements between England and Russia, possibly using the Jodrell Bank.

This will add to your fund of knowledge on aberrations that may be encountered, tracking the balloon, and so on.

It has been the policy that in setting up these projects that they would be of benefit to the United States as well as to the U.S.S.R.

That is, by setting up the project we would gain something that could not otherwise be achieved, and Blabanrovov has stated exactly the same principle of the Russians.

Mr. WAGGONNER. In other words, they are going to use our satellites, but they are going to pay for the ones they launch there?

Dr. SEAMANS. Yes—I have actually not had a chance to talk to Dr. Dryden following the talks and discussions they have held in Rome.

But the concept is, for example, approximately in the measurement of the magnetic fields, the Russians would launch a probe at the same time we launch a probe, and we would agree on the orbits that each of the probes would follow, so we would obtain, simultaneously, information that could not be achieved unless we put up another probe.

But in this way we are getting important information, because we can correlate the magnetic field strengths between two points at half the cost.

And the Russians can do the same thing.

Mr. GURNEY. Will the gentleman yield?

That makes sense, but getting into the weather and communications what are we to gain there?

Mr. WAGGONNER. If the gentleman would yield back, there, we certainly need worldwide weather information.

Mr. GURNEY. Certainly. But——

Mr. TEAGUE. Gentlemen, I think we are getting far afield, and asking Dr. Seamans things he should not have to answer. He is not on that committee. We might ask Mr. Fulton, who is on the committee with Dr. Dryden.

Mr. FULTON of Pennsylvania. Let me tell you this: With each country using separate installations, with no joint facilities, and with each one releasing its own coded information that it wants to put into the bank, it is hardly cooperation. It is a complementary program where we each work separately, but might exchange information.

Wouldn't you agree, Dr. Seamans?

I have been at negotiations in Geneva, and I have a feeling of what these results have been.

Dr. SEAMANS. Well, the chairman indicated you are the expert in this room, and I will abide by his ruling.

Mr. FULTON of Pennsylvania. May I say, to bring the old adage of the camel and the tent up to date, we on the committee are looking to see if this might not be the camel in the capsule, this NASA–DOD agreement?

Mr. TEAGUE. Do you have any figures you could give us on the cost of the Gemini flights?

Dr. SEAMANS. We have priced the total cost of the hardware and the flight operations for these flights, and have a total figure that runs approximately $850 million.

Mr. TEAGUE. Was a less sophisticated system considered, using Thor-Jupiter, something like that, instead of the Atlas?

Dr. SEAMANS. You mean instead of Titan II?

Mr. TEAGUE. Right.

Dr. SEAMANS. No; there has never been any deviation on the Gemini booster. There has been a review of the Agena-Atlas to be sure that we are using the best payload for the rendezvous flights.

Mr. TEAGUE. It is an expensive program. Has every consideration been given to assure that we are going to get our money's worth, and that we have to have this information before we can go to the Apollo program?

Dr. SEAMANS. We feel it is an extremely important program.

Mr. FUQUA. Dr. Seamans, how many Gemini flights are you planning?

Dr. SEAMANS. There are 12 scheduled.

Mr. FUQUA. Do you think all 12 are necessary?

Dr. SEAMANS. I think 12 is a very minimum to satisfy the NASA requirements for the manned lunar landing program, and I would think also in order to satisfy some of the DOD scientific and technical requirements we may want to add a number of flights.

Mr. TEAGUE. Mr. Gurney?

Mr. GURNEY. Referring to the Gemini agreement, Dr. Seamans, you did tell us quite fully about the participation of the Air Force in the actual launch and the development of the Titan. Then you went on to say of what tremendous importance it was to train a team in this launch business, tracking, and also rendezvous and docking, which, of course, is necessary. What part is DOD going to play in this?

What is it going to have at Houston or other places around the world to develop their own team to gain knowledge that is very necessary in this field?

Dr. SEAMANS. That is a very good question, and one the board is actually reviewing right now, Mr. Gurney.

We have jointly agreed that there will be an Air Force task team, immediately, at Houston, to review the Gemini project in the light of the DOD requirements, and that, there will be, following this, a permanent Air Force group at Houston.

Perhaps Dr. McMillan would like to add to that.

Dr. MCMILLAN. That represents the status of our actions to date.

That group has been named from the Air Force and the DOD. It will be in Houston next week to work in detail with the Gemini project office in Houston to try to develop the degree of participation of the Department of Defense in the early Gemini program, ultimately, of course, leading to possible additional Gemini flights in the long run to meet specific Department of Defense objectives that cannot be met within the framework of the present NASA program.

Another part of the responsibility of this team is to, as Dr. Seamans said, develop recommendations and a plan for increased direct participation of DOD personnel in the planning and flight operations of the Gemini program. The team will also provide for a transfer of training and gaining of experience across the whole matter of flight operations as distinct from simply the launch operations, which will be important to the Department of Defense, no matter what we do or what kind of vehicles we are interested in the future.

Mr. GURNEY. We will know that information in due course?

Dr. MCMILLAN. Yes.

Mr. FULTON of Pennsylvania. There is duplication, then, because there are more people there than are necessary?

Dr. MCMILLAN. I don't believe that follows from what Dr. Seamans or I said. It seems to me that, if they are to learn, the Department of Defense personnel that fit into the NASA structure will have to assume responsibilities appropriate to the positions they are understudying.

Mr. FULTON of Pennsylvania. So there will be no more military personnel than are required to do the job?

This is not really a combined NASA operation with military trained personnel. What is it? Is it a joint operation or training?

Dr. MCMILLAN. I don't think we can generalize as to what precisely it is. This is a matter of detailed planning as we go along.

For example, with respect to launch operations, the Department of Defense people will be performing a complete function for NASA and not duplicating any NASA actions, but taking over complete responsibility. That is one example. In other areas there may be DOD people who are much more nearly like observers stationed for short periods of time.

Mr. FULTON of Pennsylvania. How many personnel do you expect to put into the operation in relation to NASA? What percentage of the total will the DOD supply?

Dr. MCMILLAN. This is of course what is really being planned now, the planning for this is just being initiated.

I hesitate to prejudge the outcome of the plans.

Mr. FULTON of Pennsylvania. Is it looked at as being pretty even, a 50–50 division, or is it 60–40——

Dr. MCMILLAN. I could only give really the most preliminary of estimates. But it would appear to me that—well, let me put it this way: at the present time as I understand it, and perhaps Dr. Seamans can help on this—as I understand it, at the present time, for example, during an actual launch of say a Mercury, which is at least analogous to the situations that will prevail with Gemini, there are some 15,000 people involved around the world in launch, tracking, and the whole operation, including recovery forces, and I believe at the present time the majority of these are Department of Defense people who provide the recovery project.

Mr. TEAGUE. You can see that when these budget estimates for Gemini were made, NASA had expected to fund the whole operation, since this was before the NASA–DOD agreement was entered into on Gemini.

Then you come in and say you are putting in personnel not just for training, but to participate and really supplant NASA people. You should give us an estimate of what is going to be involved in dollars of contribution by DOD and Air Force to NASA, so we can then reduce NASA's budget by the equivalent amount.

Mr. WAGGONNER. Would the gentleman yield?

I think it has been NASA's policy to reimburse the Air Force for the services rendered on those projects, so they would not be due for a reduction in its funding.

Dr. SEAMANS. That is correct.

Mr. FULTON of Pennsylvania. Well, the question on this is: Is the funding always going to be through NASA, or are you going to have separate military requirements that NASA should not be called upon to meet? For example, you mentioned the unidentified encounter, or an uncooperative rendezvous?

Dr. MCMILLAN. The way we are now operating and thinking in the planning group is that the present program as now set forth is the NASA-approved program, and the NASA will fund that.

If there are significant changes in that program or additions to that program to meet military requirements, naturally the military will have to fund for the additional cost.

Mr. FULTON of Pennsylvania. So this is really a place where NASA on its funding is funding not part of the Department of Defense training, but part of the Department of Defense operations?

Dr. SEAMANS. Well, to take an example, if an additional flight were required in order to satisfy the joint requirements, funds could very well be transferred for this, under this agreement, from the DOD to NASA, to be included with the other project funds made available to Mr. Holmes and his team.

Mr. FULTON of Pennsylvania. This is a different arrangement than Patrick Air Force Base, where the Air Force is host and NASA is a tenant. You have here a Siamese twin arrangement where your funding is, it looks like, a cost funding of operations.

Dr. MCMILLAN. Of course, we are now talking, just discussing a transfer of funds in a direction different from that we have experienced before. But in connection with the DOD's present responsibilities to the NASA Gemini program, for example, funds are transferred from NASA to the DOD.

Mr. FULTON of Pennsylvania. How can this be called a peacetime program for peaceful uses of space?

Mr. TEAGUE. Oh, don't ask him that.

Mr. FULTON of Pennsylvania. All right.

Mr. TEAGUE. Mr. Gurney?

Mr. GURNEY. This may be embarrassing in view of the chairman's comments, but I was curious as to why, on page 3, it was important to point out that this is a peaceful program. I don't mean to say we should point out that it is a warlike program, but why should we mention it one way or the other?

Mr. FULTON of Pennsylvania. I guess you better withdraw that, too.

Mr. TEAGUE. I don't think we should ask Dr. Seamans or Dr. McMillan that question. Maybe we ought to ask the President or a few other people. Mr. Waggonner?

Mr. WAGGONNER. How much planning has been done toward making a similar agreement between NASA and DOD on the Apollo program?

Dr. SEAMANS. So far there have been no detailed discussions for Apollo along the same lines as Gemini.

We have the Department of Defense informed about the Apollo program, and, of course, jointly reviewed the launch vehicles for it, had a joint planning group for the launch vehicles.

At the time we expected to use the lunar rendezvous mode we discussed this prior to finally making our decision, with the Department of Defense. But we have not gone into the same kind of detailed review on Apollo as we have on Gemini, because it is a mission that does not appear to have possible military ramifications.

Mr. TEAGUE. Dr. McMillan, a number of the committee members were in California last week and talked to your people at Edwards Air Force Base, and to the people from the Aerospace Corp.

In the last few days we have heard from the General Electric Co. and NASA. It would seem many of the problems that the Aerospace Corp. is working on for the Air Force are the same problems that General Electric is working on for NASA.

Is there a duplication there? Don't you have coordination between the two groups that are working on the same problems?

Dr. MCMILLAN. I don't know of any great duplication here. I assume you are discussing some of the problems of reentry into the atmosphere.

Aerospace Corp. has only a few people working in this area, to my knowledge. They are greatly interested in it. I think it is important the Air Force have within its own resources knowledgeable people in this field.

We are not, however, funding any great amount of effort in this direction.

Mr. TEAGUE. Dr. Seamans, do you care to comment on that?

Dr. SEAMANS. Yes.

There is, of course, another broader area where Aerospace is supporting the DOD missions and General Electric is supporting the NASA missions, in the area of overall reliability review and checkout. These are matters that have to be done on the specific projects, and it is a question of having the right competence in the individuals; in the organization doing the job.

I don't see that there is any duplication between the role that Aerospace has for the Air Force and GE has for NASA, even though much of the methodology may be similar.

Mr. GURNEY. Is there any effort between the Aerospace Corp. and Bellcomm to exchange information on the field they are probing in, and what information they are getting?

They are both research and development teams, one backing up the Air Force, and one the NASA space effort, where there must be related efforts—in fact you just mentioned one.

Dr. SEAMANS. My remarks here would be really the same, that Bellcomm is working with the NASA, planning the working out of a concept for the various flight missions, getting this down to sufficient detail, carrying out trajectory analyses, and so on, so that we can specify the major elements in the total system that are needed for the job.

Aerospace—I am not as familiar with their operation, but I believe this is one of the roles they perform on various weapons systems for the Air Force.

Here again, many of the methods you use for carrying out these analyses are similar, but they are for specific objectives in every case, and you need the teams of people in each case to do this kind of work.

Mr. GURNEY. Admittedly that is true Doctor, and in no sense of criticism at all, don't you think it would be a good idea that if there are two very efficient—we will assume—scientific bodies, that there should be an exchange of ideas between them?

Dr. SEAMANS. I assume that is being done.

Mr. GURNEY. We asked the men from NASA and from General Electric, and apparently their recollection was as bad as yours.

Dr. SEAMANS. The coordination here must be between the agencies; namely, DOD and Air Force, and NASA, certainly some exchange of information is appropriate between contractors, but the real coordination must come between the various project organizations in the two agencies.

We believe we are doing this at various levels in the organization, and this is the reason we set up General Ritland and his group to work directly with Brainerd Holmes, so you would have this close exchange.

Mr. TEAGUE. NASA has its own vehicle, the Saturn, and it has Bellcomm and General Electric working on problems there. Likewise, the Air Force has Aerospace Corp. working on its problems with the Atlas and Titan. Now NASA is fixing to use a Titan, and it has been using the Atlas, which is an Air Force missile. Yet when we talk to NASA, the Air Force, Bellcomm, or Aerospace, they hardly seem acquainted with each other. There just doesn't seem to be any coordination, as far as the problems are being worked out.

Dr. SEAMANS. When we reviewed the Gemini program recently, the Aerospace people responsible for Titan II are the ones who came in to discuss their progress with the NASA–DOD responsible parties.

Mr. TEAGUE. Do you have any questions, Mr. Roudebush?

Mr. ROUDEBUSH. I would like to ask Dr. Seamans, what peculiar problems does GE work on that Aerospace doesn't? I mean, there must be a difference in their missions.

Dr. SEAMANS. Yes. One group works for NASA and the other for DOD.

Mr. ROUDEBUSH. That is just my point. But how about the projects they are working on? I am not talking about Project Gemini or perhaps the Project Apollo. I am talking of problems that are related, problems of reentry. Isn't there a great deal of similarity to the problems they are working on?

Dr. SEAMANS. It is true both groups must use the same environmental information that does affect the flight, and there, of course, the exchange of information is important. But to achieve reliability, for example, in a weapons system, or in one of NASA's launch vehicles, is only done by very careful design, by running the right kinds of components and subsystems and full systems tests, and by the manner in which the whole vehicle is assembled and the manner in which the checkout takes place. And you have to have a team of people addressing themselves to the specific project in order to do this.

Mr. ROUDEBUSH. But the problems that would affect the specific project to which this team is addressing itself might be similar problems to those that affect other projects, isn't that true? Do you understand the question?

Dr. SEAMANS. Yes.

One problem is that of wind shear. When you go up through the atmosphere you can get into changes in the atmospheric velocity that could cause a structural failure.

Mr. ROUDEBUSH. All right. Stay with that. That problem exists for a number of our different projects?

Dr. SEAMANS. That is right.

Mr. ROUDEBUSH. And it is being studied by a number of different groups?

Dr. SEAMANS. On the contrary. When we realized the seriousness of that problem we set up with General Ritland a team of people headed by Dick Rhode of NASA, but with full Aerospace-Air Force participation, look at what the problem really was, and come up with criteria for the design of these vehicles, to minimize the effect of wind shear, and also established a problem for measuring this kind of atmospheric turbulence.

Mr. ROUDEBUSH. I see.

Mr. TEAGUE. Any other questions?

Mr. FULTON of Pennsylvania. May I ask one?

Mr. TEAGUE. Mr. Fulton?

Mr. FULTON of Pennsylvania. Why wouldn't it be wise to set up a civilian-military liaison board under statutory authority the way we thought it would have been advisable to set it up under the original authorized enactment for NASA?

You are doing it on many levels, but shouldn't you have general rules set up so the Congress can see that you are giving this cooperation and getting the liaison?

Dr. SEAMANS. We have the Aeronautics and Astronautics Coordinating Board providing this kind of liaison. We feel that by using the board we have involving people who have line responsibility within the two organizations, and that this is a better way of implementing the coordination than by having sort of a separate and distinct group of people who have no other responsibility than liaison, and hence don't really know what is going on.

Mr. FULTON of Pennsylvania. You would rather have interface between the line officials who are actually operating, the policy people, than between liaison groups set up as representatives back and forth between the Air Force and NASA?

Dr. SEAMANS. Yes, that is the concept of the double ACB.

Mr. FULTON of Pennsylvania. Is that what you believe, too?

Dr. MCMILLAN. Yes.

Mr. YEAGER. Are there any specific requirements the Air Force has placed on the Gemini program, or that it contemplates in the near future, as the result of this agreement that you told us about?

Dr. MCMILLAN. The Air Force has had in mind for some time and has presented to the Gemini program planning board a rather long list of experiments of various kinds that we would like to perform, during manned space flight, many of which we think it might be possible to incorporate into the present Gemini program as NASA has it laid out, without interfering with NASA objectives.

The first task before this group that I mentioned earlier as being set up in Houston is to go over this list of experiments in detail with the NASA people, to determine which of them are feasible within the present NASA program and what the requirements would be to set them up.

This, I think, will be the first set of formal requirements that the Department of Defense lays upon NASA, for experiments to be performed in flight during the presently scheduled Gemini flights.

These experiments may involve considerable preparation on the part of DOD, independent of NASA effort, but the experiments will be conducted in NASA flights.

Mr. YEAGER. Could those experiments be supplied for the record or have they been classified?

Dr. MCMILLAN. We could supply a fair number of them for the record.

Mr. YEAGER. Would you do that?

Dr. MCMILLAN. Yes.

(The material requested is as follows:)

List of experiments which the Air Force believes can be accomplished during the presently planned NASA Gemini test program

(*a*) Visual definition of objects in space.
(*b*) Cooperative target inspection.
(*c*) Angle-track-only rendezvous guidance.
(*d*) Hybrid IR/Laser guidance equipment.
(*e*) Passive infrared star and satellite tracking.
(*f*) Visual definition of terrestrial features.
(*g*) Observation of missile launches.
(*h*) Extravehicular operations.
(*i*) Autonomous navigation.
(*j*) Radiation levels within the space capsule.

Mr. YEAGER. The agreement says that no new major programs are to be initiated on near-earth orbit experiments without mutual agreement. Suppose either NASA or Air Force decided it wished to drop out of the Gemini program.

Could that be done unilaterally?

Dr. MCMILLAN. I seriously doubt that it would be done unilaterally.

Dr. SEAMANS. Certainly if the Department of Defense found that there were not any missions, which I very much doubt, or any experi-

ments that could be carried out with Gemini, and that we are carrying out all the things that need to be done, we would still like to have the participation of Dr. McMillan and the board members, continuing to review our program.

Mr. YEAGER. Could you describe for us what you mean by "near earth orbit"?

Dr. SEAMANS. Yes. We are differentiating between orbiting manned spacecraft, and those that are used for missions to the Moon and the planets.

Mr. YEAGER. Is there any fixed altitude beyond which is not considered "near earth orbit"?

Dr. MCMILLAN. A convenient definition we have sometimes used informally, and I would not attach it specifically to the words in the agreement, but as far as the military discussions of this problem are concerned, I think the military feel that at the present time they have primary interest in orbits out to and including the earth synchronous orbit at approximately 22,000 miles, and very little interest in orbits that go much beyond that.

Mr. YEAGER. One last question: You mentioned the possibility of a manned orbiting space station as an example of the type of thing that might come up in the future.

Are there any other examples that you can think of or that you contemplate at the present time, or other new major programs?

Dr. SEAMANS. There may be. But that at the moment is the project that both DOD and NASA may very well have a great interest in, in some near time frame.

Mr. TEAGUE. Thank you, Dr. Seamans and Dr. McMillan.

We appreciate your coming up.

Dr. SEAMANS. Thank you.

Mr. TEAGUE. Would the committee stay just a few minutes for a short executive session?

(Whereupon, at 11:30 o'clock a.m., the committee proceeded in executive session.)

1964 NASA AUTHORIZATION

MONDAY, MARCH 25, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON MANNED SPACE FLIGHT,
Washington, D.C.

The subcommittee met at 10 a.m., Hon. Olin E. Teague (chairman of the subcommittee) presiding.

Mr. TEAGUE. The committee will come to order.

This morning we will hear from Mr. Albert F. Siepert, Director of the Office of Administration, and Mr. Ernest W. Brackett, Director of Procurement and Supply of NASA.

Do you have other gentlemen with you?

Mr. SIEPERT. Yes. I will introduce them in my prepared statement.

Mr. TEAGUE. I understand that is your swan song; that you will be leaving Washington and going down to the Launch Operations Center in Cocoa Beach, Fla.

Mr. SIEPERT. Well, I believe, really, I will be back quite a bit, sir.

Mr. TEAGUE. You have a prepared statement?

Mr. SIEPERT. Yes, sir.

(The biographical sketches of the witnesses are as follows:)

BIOGRAPHY OF ALBERT F. SIEPERT, DIRECTOR OF ADMINISTRATION

Albert F. Siepert has been Director of Administration since the National Aeronautics and Space Administration was established in October 1958. During the previous 11 years he was Executive Officer of the National Institutes of Health.

Born in Peoria, Ill., in 1915, Siepert received a bachelor of arts degree from Bradley University in 1936.

After graduation, Siepert became one of the first Government "interns" (trainees) under the auspices of the National Institute of Public Affairs. He served his internship with the Farm Credit Administration, and has since held administrative posts with the Home Owners Loan Corporation, the Alien Property Custodian and the Bureau of State Services of the U.S. Public Health Service.

Named Executive Officer of the National Institutes of Health in 1948, Mr. Siepert had a key role in the major reorganization and expansion of the Institutes during the initial years of his NIH appointment. He received the Arthur Flemming Award in 1950 for his contribution to this effort.

In 1955 he received the Department of Health, Education, and Welfare's Distinguished Serivce Award for his administrative leadership. He was awarded the Bradley University Distinguished Alumnus Award in 1960.

Mr. and Mrs. Siepert and their two children live at Bethesda, Md.

BIOGRAPHY OF ERNEST W. BRACKETT, DIRECTOR, PROCUREMENT AND SUPPLY DIVISION

Ernest E. Brackett was appointed Director of the NASA Procurement and Supply Division in January 1959. The functions of that Division include transportation and logistic planning. Prior to coming to NASA, Mr. Brackett was a contract specialist on the staff of the Director of Procurement and Production at Headquarters, Air Materiel Command, USAF, Wright-Patterson Air Force Base, Dayton, Ohio.

A native of Mohawk, N.Y., Mr. Brackett attended local grammar and high schools. He received a bachelor of arts degree in 1925 from Cornell University, Ithaca, N.Y. From 1925 to 1942 he practiced law in Utica, N.Y., and was a member of the firm of Griffith & Brackett. While in Utica he served as president of the Rotary Club.

Mr. Brackett was an officer in the U.S. Army Air Corps from 1942 to 1946. During his active military service, he was concerned primarily with Government procurement and supply activities.

After returning to civilian life, Mr. Brackett joined the Department of the Air Force in Washington, D.C., as Chief of the Contracts Branch, Procurement Division. From 1950 until his appointment to the NASA staff, Mr. Brackett was a contract and procurement specialist in the Headquarters of the Air Materiel Command.

Mr. Brackett is a member of the New York State and District of Columbia Bar and has been admitted to practice before the U.S. Supreme Court. He currently holds the rank of colonel in the U.S. Air Force Reserve.

He is married to the former Beatrice L. Paul. They have one daughter, Mrs. Jaclin Farrell, living in Arlington Heights, Ill. The Bracketts live at 2820 Northampton Street, Washington, D.C.

BIOGRAPHY OF WALTER L. LINGLE, JR., ASSISTANT ADMINISTRATOR FOR MANAGEMENT DEVELOPMENT, DEPUTY ASSOCIATE ADMINISTRATOR FOR INDUSTRIAL AFFAIRS

Walter L. Lingle, Jr., as Deputy Associate Administrator for Industrial Affairs, is responsible for overall relationships of the National Aeronautics and Space Administration with industry and for a review of NASA-wide procurement policies and procedures. In addition, as Assistant Administrator for Management Development, Mr. Lingle reviews and develops recommendations on major management activities.

Mr. Lingle joined NASA in June 1962, in a temporary capacity as Deputy Assistant Administrator for Public Affairs. In August he became Assistant Administrator for Management Development and in March 1963 he was assigned additional responsibilities as Deputy Associate Administrator for Industrial Affairs.

Walter L. Lingle is a former executive vice president of the Procter & Gamble Co. He joined the company in 1931 and was elected vice president of oversea operations in 1948. He also had been in charge of the firm's toilet goods, paper products, and oil mill divisions since 1954.

Prior to joining NASA, Mr. Lingle served as Deputy Administrator of the Agency for International Development.

A native of Atlanta, Ga., Lingle received a B.S. degree from Davidson College, Davidson, N.C. He has been a member of the Board of Directors of the Cincinnati Chapter of the American Red Cross, National Executive Board of the Boy Scouts of America and campaign chairman of the Cincinnati United Appeal.

Mr. Lingle is married to the former Alice Lewis. They have one son and two daughters.

STEPHEN P. LEJKO, BUDGET OFFICER

Stephen P. Lejko joined NASA July 1, 1962, as NASA headquarters budget officer. Prior to joining NASA he was Assistant to the Administrator of the Agricultural Research Service, Department of Agriculture, from December 1956 to June 1962. From January 1950 to December 1956 he was budget officer with the ARS.

Lejko was born August 3, 1920, in Yugoslavia. He attended school in Bethlehem, Pa. He attended Cincinnati University in 1943 and was a pilot in the U.S. Army Air Corps from 1942 through 1946.

Lejko completed his college work at American University, Washington, D.C., receiving a bachelor of science degree in 1954 and master of arts in 1959.

Lejko is married to the former Ann Marie Kientz. They have a son, Stephen P. Lejko, Jr. The Lejko's live at 6531 79th Place, Cabin John, Md.

BIOGRAPHY OF DR. THOMAS L. K. SMULL, DIRECTOR, OFFICE OF GRANTS AND RESEARCH CONTRACTS

Age: 46. Children: Sharon, 16.

Education: B.A. (1937) Ohio Northern University; B.S. (Aeronautical Engineering) (1939), University of Michigan; B.S. (mechanical engineering) (1939) University of Michigan; and Sc. D. aeronautical engineering (1948), Ohio Northern University.

1960, Director, Office of Grants and Research Contracts; 1958–60, Assistant Chief, University Programs, NASA; 1950–58, Chief, Research Coordination Division, NACA; 1948–50, Aeronautical Research Scientist, NACA; and 1942–48, Aeronautical Engineer, NACA.

Staff, President's Air Policy Commission, 1947; consultant, Research and Development, Congressional Aviation Policy Board, 1948; registered professional engineer, State of Ohio; and member of the Council of the Armed Forces-National Research Council Committee on Hearing and Bio-Acoustics.

Societies: Associate Fellow, Institute of the Aeronautical Sciences American Geophysical Union; Alpha Phi Gamma; and Theta Alpha Phi.

Organizations: National Aeronautics Association; Aero Club of Washington; Sigma Phi Epsilon; University Club of Washington; Hampton Yacht Club; and West River Sailing Club.

Publications: New Horizons in Aeronautical Research; Aviation Annual for 1946; Today's Research for Tomorrow's Aircraft, Aviation Annual for 1947; and contributor, Collier's Encyclopedia.

STATEMENT OF ALBERT F. SIEPERT, DIRECTOR OF ADMINISTRATION, NASA; ACCOMPANIED BY: DR. THOMAS K. SMULL, DIRECTOR, OFFICE OF GRANTS AND RESEARCH CONTRACTS; STEPHEN LEJKO, BUDGET OFFICER, NASA HEADQUARTERS; AND WALTER LINGLE, ASSISTANT ADMINISTRATOR FOR INDUSTRIAL AFFAIRS

Mr. SIEPERT. It is a privilege to discuss with you today the procurement and contracting program of the National Aeronautics and Space Administration. Our agency places responsibility on the Headquarters Office of Procurement and Supply to execute the procurement function within policies established and approved by the Associate Administrator, the Deputy Administrator, and Administrator.

Since more than 90 percent of the funds appropriated go outside the Government in the form of contracts, the top management of NASA has taken a continuing personal interest in assuring careful planning and execution of our program, and, as you know, takes personal responsibility for the award of all major contracts over $5 million based upon evaluations which are presented by source evaluation boards.

Mr. TEAGUE. Are you saying your Centers have authority to make contracts for anything less than $5 million?

Mr. SIEPERT. The Centers have authority to select the contractors. No Center has a delegation to approve a contract, without review of the contract and its terms in headquarters, if it is over $1 million.

Three of the Centers have million dollar authority, smaller ones have to half a million, some as low as $100,000.

Mr. TEAGUE. Which are the three?

Mr. SIEPERT. Marshall, Houston—Cape Canaveral is half a million dollars—and the Western Operations.

The cape is $500,000, Goddard is $500,000, and the Ames Research Center is $500,000.

Excuse me. I would correct that. We recently extended these delegations because of the size of the program. Correctly, I should say, all of our centers have $1 million authority now except Ames and the Launch Operations Center, with $500,000 authority, and the Flight Research Center and Wallops Station at $100,000.

The Procurement and Supply Division is currently one of the elements of the Office of Administration. The Director, Mr. Ernest W. Brackett, on my left, who reports to me, is here with us today, and will outline in some detail the major elements of our procurement operations.

NASA makes a practice of publishing statistics concerning its procurement operations in some detail, and this information is made available rather widely through its annual procurement report. The latest issue covering fiscal year 1962 has recently been printed, and copies like this have been sent to each member of the Committee on Science and Astronautics.

In concluding these introductory remarks, let me say that NASA feels Mr. Brackett and his top staff have been able to bring into the organization an exceptionally competent group of procurement specialists both in headquarters and at the field centers.

They have had a somewhat crushing job to do since the growth of the program in terms of their procurement workload has more than doubled in each of the last 3 fiscal years. Faced with an urgent technical program, the NASA technical staff understandably seeks to shorten any procurement leadtimes which may affect their ability to achieve flight schedules on time.

As I am sure the committee will understand, this presents challenges for any procurement staff which is interested, as ours is, in the negotiation and award of contracts which represent soundly drawn agreements as to the scope of the work and adequate understanding as to the terms, costs, and fees involved. We believe substantial progress has been made in realizing these objectives.

There is a very recent development in the procurement area which I believe Mr. Webb mentioned earlier to this committee.

During the past week we announced the designation of Mr. Walter L. Lingle as a Deputy Associate Administrator under Dr. Seamans. His particular responsibility will be for industrial affairs. For some time NASA has sought to bring into its organization people who have had senior executive responsibility in handling the operations of large corporate enterprises. All of us feel exceedingly fortunate to have acquired the services of Mr. Lingle. He comes to the public service from the position of executive vice president of the Proctor & Gamble Co. where he was in charge of oversea operations.

Mr. Lingle joined NASA in a staff role to Mr. Webb with the title of Assistant Administrator for Management Development. In this

capacity in recent months he has been most helpful in opening up new channels of frank communication with the top corporate leadership of the major contractors which are lined into the key NASA programs. Therefore, it seems appropriate at a time when NASA is entering a critical new phase of its major hardware procurements to establish Mr. Lingle as the Deputy Associate Administrator under Dr. Seamans.

There will be transferred to him immediate operating responsibility for agency procurement functions related to policy development, procurement regulations, review of major procurements, contract administration, and evaluation of field center procurement operations.

In the near future, Mr. Brackett and his deputy, Mr. George Recchietti, as well as the assisting staff related to these functions will be formally transferred to report to the Office of the Associate Administrator through this new deputy position for industrial affairs.

I have taken the liberty of inviting Mr. Lingle to the hearing and he is at the table on Mr. Brackett's left.

Considerable thought has gone into the making of this move. Mr. Brackett and I both joined in recommending this step as helpful in sharpening up the responsibilities of the procurement function and in furthering a channel for direct communication to the NASA general management, and to the leadership of American industry on vital matters affecting procurement operations.

Mr. TEAGUE. Any questions of Mr. Siepert before we go to Mr. Brackett's statement?

Mr. Riehlman?

Mr. RIEHLMAN. I think Mr. Siepert has elaborated to some degree, in his last paragraph or two of his statement, on the question I want to ask.

On page 2 of your statement you mention Mr. Brackett and his staff, and say that they have been able to bring into the organization these outstanding people, and so forth. How large a staff does Mr. Brackett have? I also would be anxious to know something about the qualifications of the people he has in the procurement office.

Would either you or Mr. Brackett answer that?

Mr. SIEPERT. Let me take part of it. Mr. Brackett can elaborate in any way you wish.

Mr. RIEHLMAN. All right.

Mr. SIEPERT. Mr. Brackett has a headquarters procurement staff which handles the whole agency policy and also procures headquarters contracts. The current authorization I believe is 127 people. This is a recently authorized expansion.

The current staff is approximately 100. We are building it up because of the much greater load that faces us in the months immediately ahead. The people whom we have brought into this organization have come from a variety of procurement experience drawing all the way across Government. Of course, the great majority of the people have come from major responsibility in one of the Department of Defense services, since this is the kind of procurement that is most directly comparable with our task.

Mr. Brackett comes to us from the Air Force. He joined NASA within the first year of its operation.

However, in his staffing he has been quite careful to diversify the experience so we could in effect sample the best experience of the services, rather than concentrate on one way of doing it.

Mr. RIEHLMAN. I am very interested in the qualifications of the people you have in the procurement office, which, to me, is quite important.

Mr. BRACKETT. The deputy, Mr. George Vecchietti, is a native Washingtonian, a lawyer, who was on the staff of the Department of Defense, lastly with the Air Force, where he represented them on the Armed Services Procurement Regulation Committee, which drafts the regulations implementing the Armed Services Procurement Act of 1947. I think he has had approximately 15 years of this type of experience.

Mr. Brewer, who heads the Office of Procurement Review, was the Navy representative on the Armed Services Procurement Regulation Committee. Prior to that, he was head of the Navy Purchase Office in the Los Angeles area for some years, with a much larger staff than our office has at present. He also did procurement inspection work in the field.

Mr. Brooks Preacher, a special assistant, came from the Department of the Army, where he had had approximately 18 years of procurement experience. He was in charge of some of the plant offices during the war for the Army.

Mr. Christenat, who was for some years with the Navy heading their pricing staff, later retired, worked 2 years for General Electric, reached their mandatory retirement age, and has come back to us to head our pricing section. He headed up when he was with the Navy what is called the Christenat committee, for the three military departments; it did their pricing policy work.

Mr. Carl Schrieber, for 20 years with NACA and NASA in procurement, heads our office that develops procurement policies and regulations.

Mr. LaVerne Hanson heads the property management section. He was formerly at the NACA at Langley Field. He has been here in headquarters I think approximately 10 years.

Mr. James McCollum heads up the transportation office, and was formerly in the transportation section of the Air Force at Andrews Field.

Mr. Reginald Barber heads the facilities and priorities office, and he also was with the NACA for some years.

Would you like to know something about the people who head up the field organizations?

Mr. RIEHLMAN. Well, to get back to a previous statement made either by you or Mr. Siepert, most of these people come from Government agencies.

Mr. BRACKETT. That is right.

Mr. RIEHLMAN. I can understand to some degree why you need people who have had experience in procurement on the Government side. Do you have anyone from industry in the procurement office?

Mr. BRACKETT. Otto T. Hess recently joined us. He was formerly secretary of Jack & Heintz for a number of years. He was working largely from the contractor's viewpoint on development type contracts. This is his first work in civil service capacity, coming from industry.

We have found that people who have had procurement experience in one of the departments usually understand and are more quickly amalgamated into the system. It takes a length of time for people without this experience to learn the background, and so forth.

Mr. RIEHLMAN. Sometimes we question whether or not this is a good policy to bring in people who are easily persuaded to the thinking of—I hate to use the word— perhaps a bureaucratic operation. People from industry, where they have the responsibility to produce for business, may have a much more cautious attitude when spending the taxpayer's money.

Mr. BRACKETT. Several of those, such as Mr. Christenat, have had experience with industry. Personally, I practiced law for 17 years and represented industrial companies, before the war.

Mr. RIEHLMAN. I don't want to belabor the question, Mr. Chairman, but I think it is important.

Mr. TEAGUE. Go right ahead, and take as much time as you want.

Mr. BRACKETT. Mr. Lingle is strictly from industry.

Mr. RIEHLMAN. We understand that, but he has just arrived. I hope he will represent the viewpoint that I am referring to.

Mr. TEAGUE. Mr. Fulton?

Mr. FULTON of Pennsylvania. Mr. Brackett, there are two or three items in your statement which I would like to mention.

First, there is no comment on how you are going to make sure there is a division of contracts among small business.

Second, there is nothing in the statement to show how you are going to monitor subcontractors to see that NASA gets lower prices for the Government's money by competitive bidding.

Mr. BRACKETT. I will touch on those in my statement. I will be glad to go into more detail.

Mr. FULTON of Pennsylvania. I have a third point that I have made repeatedly. I would like to see the separation of contracts into lower components, so that contracts for millions of dollars, or tens of millions, or even hundreds of millions, are not awarded without public competitive bidding.

My experience has been that there should be a much greater separation of the research and development components in contracts. If NASA came up with adequate specifications for these contracts, there could be a great saving to the Government by the public bidding of portions of these contracts that really amount to engineering and construction work.

I have some contact with NASA officials in the field of the high-vacuum facilities, for example. I understand that you are now offering these contracts at public bid as a result of my objections to research and development contract specifications.

One other point I would like to make is that NASA is procuring and hiring professional personnel. There has been quite a dispute over the awarding of a controversial advertising contract. One of the staff members of the original firm that had the NASA contract resigned from the firm and, rather peculiarly, the contract followed—shall we call him—the dissident or the one who ran away.

My objections to this questionable administrative decision were based on the facts that this man had had little experience in the advertising field, had only been in this country for, I think, a period of 5 years, and had had no experience of any degree in the field other than with the original firm. I had insisted that NASA get a large advertising professional group to work with him, so that NASA would have the backing of people of competence.

I understand a firm was chosen, and it was utilized for about a year. The advertising firm was given to understand they would only work a year, because the whole contract would be taken over by the dissident on the basis that he could do it better alone and give his whole time to it. Now I understand the contract is being given to this single chosen instrument, and NASA is paying him $20,000 a month to make up advertising.

I would like to put in the record a few facts from the Naval Ordnance Laboratory, at White Oak, Silver Spring, Md., showing that there is a naval officer, called an employment officer, who does this type of work.

Obviously, I want to see that the taxpayers get their money's worth. I do not like the idea of a contract always and continuously awarded one person.

I have read an article in an advertising journal publicizing the tremendous success of this person who is without adequate experience, and who is handling not just one phase of the recruitment of NASA technical personnel, but many phases.

Mr. Patten, who is the Congressman from New Jersey, has complained bitterly about the inside track this man has. I would like to ask for an investigation into this matter.

I make no charges, but I just want to know what the contract covers; what work is being done, and if another part of it is being done differently, whether or not it can be done cheaper.

(The information requested is as follows:)

RECRUITMENT ADVERTISING

Paid advertising is one of several approaches used by NASA in connection with its recruitment program. The use of recognized advertising agencies for the placement of recruitment ads was determined to be more advantageous to NASA than to try and manage the effort by acquiring additional in-house personnel.

After soliciting proposals from 17 recognized advertising firms, NASA awarded a draw contract in December 1961 to 1 of the proposing firms, for advertising services in recruiting professional and scientific personnel. To provide a basis for comparison of services a second draw contract was let on January 12, 1962, with another of the proposing firms for the same type of services. In neither contract did NASA guarantee to place any definite amount of advertising by month or otherwise. A conscious effort was made to divide the service about equally. It became apparent during the year that both contracts were in effect, that working with two contracts caused NASA certain management problems. Following a review of both contractors' services at the end of 1962, NASA decided to exercise the 1-year extension option provided in the contracts on one contract, only. This decision was based primarily on two factors: (1) One contractor had changed the designated advertising agency representative for the NASA account four times during the year which resulted in more difficult administrative problems in dealing with the contractor and, (2) the total cost to the Government per ad placed by that same contractor was higher than the other. Consequently, it was decided to extend the contract with the agency that had regularly provided more responsive service at lower cost to the Government.

NASA does not presently have the in-house skills required for the preparation and placement of advertising copy of the type used in the national magazine field. Customarily, these skills are obtained from an advertising agency whose costs and profit, other than charges for production costs, lie in the commission which the agency obtains from the standard space rate charges established by the publishers. Since publishers do not provide such a commission to the Government, there is no cost advantage to NASA in directly placing its advertisements with the publishers. Furthermore, to provide the in-house capability needed for layouts, related art work, rate determination, handling of individual billings, and related clerical and administrative help, NASA would need additional employees.

NASA has determined that when utilizing paid advertising for recruiting it is to the best interest of the Government to contract for services of this type with

accredited advertising firms. The present NASA draw contract for these services is with S. G. Stackig, Inc. The total cost under this contract for the period July 1962 through March 1963 was $129,100, representing orders placed in national journals, college journals, newspapers, and production costs for ad preparation.

Mr. TEAGUE. Mr. Brackett, let's have your statement since a number of points Mr. Fulton asked are covered in the statement. Then we will go back to the questions.

STATEMENT OF ERNEST W. BRACKETT, DIRECTOR, PROCUREMENT AND SUPPLY, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. BRACKETT. Mr. Chairman and members of the subcommittee, since NASA became an operating agency its procurement functions have become increasingly important. During fiscal year 1962, approximately 90 percent of funds appropriated by the Congress were spent by contracts as compared to 64 percent in fiscal year 1960. In fiscal year 1964 the percentage of funds going to contractors may increase further. NASA appreciates its responsibility to see that this money is spent prudently, economically, and in accordance with the intent and policies laid down by the Congress and the President.

DECENTRALIZATION OF NASA'S PROCUREMENT OPERATIONS

Each of NASA's centers places contracts in support of the projects assigned to their cognizance. Four other NASA offices also do contracting for the agency. In addition, the Jet Propulsion Laboratory, which is operated under a contract by the California Institute of Technology, spent over 60 percent of the dollars provided by NASA in fiscal year 1962 on contracts with business firms.

Procurement policies and procedures are issued by NASA headquarters. These follow quite closely those promulgated by the Armed Service Procurement Regulation. We are facing many of the same procurement problems faced by the military departments, our basic statutory authority is the same as theirs (the Armed Service Procurement Act of 1947), and we are dealing with much of the same segments of industry. This uniformity is advantageous to industry as it simplifies contract systems and contractual provisions.

Major contracts are reviewed and approved by NASA headquarters. This includes a review by the Office of General Counsel for legal sufficiency. Authority is delegated to the Marshall Space Flight Center, the Manned Spacecraft Center, and the Western Operations Office, those being the procurement offices which place most of the larger contracts, to issue contracts up to $1 million without headquarters approval.

Now the Goddard Space Flight Center, Headquarters Procurement Branch, Langley Field Research Center and Lewis Research Center, have also been given this same $1 million authority.

The other procurement offices have lower maximum contracting authority without headquarters approval.

The reasons for review and approval by headquarters is to assure compliance with NASA's procurement policies, contractual provisions, and sound business principles. The reason for the different limitation amounts is to assure a review of a representative number of contracts from each procurement office.

METHODS OF COMPETITION

The most difficult part of procurement is the selection of contractors. It is our policy to advertise formally for items we procure whenever this is possible. This is where there are adequate detailed technical or performance specifications available so that all bidders will understand and bid on the same thing.

However, NASA is predominantly procuring research and development items, things which have never been made before such as the Apollo spacecraft, where there are no specifications and various engineering designs should be considered. For this reason most of our contract dollars go into contracts which must be negotiated. In fiscal year 1962, 64 percent of our contracts were negotiated under the authority of 10 United States Code 2304(a)(11) which authorizes procurement by negotiation for research and development. Fourteen percent of our contracts were negotiated with educational institutions under the authority of 10 United States Code 2304(a)(5). This includes the contract for operation of the Jet Propulsion Laboratory.

When a contract is negotiated it does not mean that competition is waived; usually it is just as possible to get competition by negotiation as it is by formal advertising. Our policy is to obtain competition whenever it is feasible and possible under a negotiated procurement. There are instances when clearly one company should be chosen, and it would be a disservice to other companies to invite competition. An example is the contract for development of the Gemini spacecraft which is a follow-on to the Mercury spacecraft. In this case the contract was let to the same contractor because of similarity in design, the technical experience of the contractor on the Mercury project, and because the Gemini project is planned to follow the Mercury flights with little intermittent time delay. However, it should be noted that this contractor secured the Mercury contract competitively.

NASA procurements for research and development of over $100,000 start with a procurement plan which sets up the method, steps to be taken, type of contract which will be used, and other details.

In instances where the estimated cost is over $5 million the plan is submitted to the NASA Associate Administrator for approval; if under that amount, the Center Director approves the plan.

SOURCE EVALUATION PROCEDURES

In nearly all of the competitive research and development procurements, a Source Evaluation Board is appointed to evaluate the proposals submitted. The Board is made up predominantly of technical members with representatives from business management offices. This Board determines the criteria which will be used in the evaluation, and these points are then set forth in the requests for proposals. Usually a technical and a business committee are appointed by the Board, who do much of the detailed examination of proposals. The Board makes its report to the Director of the Center, if the estimated cost is under $5 million, who selects the company with which a contract will be negotiated if satisfactory terms can be arranged. If the estimated cost is over $5 million, NASA's general management at headquarters makes the choice.

Companies which are considered to have the capability to perform the work are invited to submit proposals; however, any company may submit a proposal which will be evaluated on the same basis as those invited. During evaluation, companies which submit proposals are checked to determine their performance on work done for other Government agencies and in some instances for commercial customers. The results of this system are competition, which gives all interested companies an equal opportunity, impartial evaluations, and selection by high-level, responsible officials within NASA, of contractors who are considered to have the best chance of successfully accomplishing the work at a reasonable cost.

TYPES OF CONTRACTS

NASA uses the fixed-price form of contract whenever it is possible to fairly determine what the cost should be. This can be done where standard items are purchased or there is a basis for determining price. However, in most research and development projects this is not the case and cost-plus-fixed-fee contracts are usually made. The fee for the work is fixed in advance, but the contractor's actual costs necessary to perform the work are paid as they accrue. The fees on our contracts in fiscal year 1962 ranged from 1.85 percent to 9.65 percent with the average being 6.33 percent, which is slightly less than the year before when fees averaged 6.65 percent. Forty percent of the fees are between 6 and 7 percent.

The cost-type contract does not give a contractor a real incentive to hold down costs, and NASA is trying to find other ways of contracting which will encourage economy. One way is to enter into a design contract, and when the design is completed and detailed specifications are known, to enter into a fixed-price contract for production of the end item. A second way is to place provisions in research and development contracts which give contractors a financial incentive to reduce costs and to produce articles which will perform in a superior manner. The conventional incentive-type contracts have a formula by which the fee or profit is computed. This formula sets the fixed-cost or performance targets with a premium fee or profit paid for completion of work below the target cost, or for performance of the article better than the target specification with a deduction of fee or profit if costs exceed the target, or performance is less than the target. The difficulty NASA is experiencing with this type of incentive contract is that our projects are so new that there is no history of cost or performance on which to base a fair target.

On the other hand, NASA is trying a new contract system which we hope will accomplish the incentive objectives. The base fee in the contract will be lower than the usual fee. Criteria will be set up in the contract for evaluation of the contractor's performance. These criteria may include reduction and control of costs, excellence of performance, delivery on schedule, and other points. Periodically a NASA board, also specified in the contract, will evaluate the contractor's performance and may award some higher fee, up to a set maximum, if the facts justify an increase.

CONTRACT ADMINISTRATION

After a contract is placed it must be managed and monitored during its performance. There must be close technical checks maintained to assure quality control and to obtain the best possible performance. Much of this is done by NASA engineers assigned to the contractor's plant. Also, such things as audit of vouchers, keeping accountability of Government property in the hands of the contractor, approval of overtime, and other contract administration work must be performed. NASA has an agreement with each of the military departments to do a major part of this work for us. These agreements save the Government the cost of setting up duplicate organizations, and efficiency is obtained by having the contractor transacting this type of day-to-day business with one Government agent. In plants where NASA has all or substantially all of the contract work, it administers its own contracts.

CONTRACTS MADE BY OTHER AGENCIES FOR NASA

Other Government agencies, largely the military, contract for some of NASA's requirements where they are contracting for the same items or services for their own requirements. For instance, the Air Force bought the Atlas boosters used in Project Mercury. In the last fiscal year approximately 21 percent of NASA's contract dollars were expended through other Government agencies. These contracts are the contracts of the procuring agent, including such details as selection of source, pricing, and contract provisions.

DOLLAR DISTRIBUTION OF NASA CONTRACTS AND SUBCONTRACTS

NASA appreciates the increasing impact of its contracts on the national economy and is attempting to see that consideration is given in placing its contracts so that they will aid the economy while at the same time bearing in mind its duty to carry out the civil space program in a timely, efficient, and economical manner. It is the judgment of management throughout NASA that the ultimate success of the program depends to a large extent on placing contracts with companies which are found best qualified to perform the work. It should be recognized that certain companies have successfully performed similar work and have acquired unique technical experience, facilities, and equipment, which would cost hundreds of millions of dollars to duplicate. It is technically and economically advisable to utilize the services of such companies wherever they are located or whatever their size.

However, the fact that one of these companies receives a prime contract does not mean that the money obligated on the contract is spent in that company's plants. We estimate that at least half, on the average, is spent in subcontracts. We requested nine of the largest NASA prime contractors to report on the volume and place of their first-tier subcontracts. They reported they had subcontracted 50 percent of the dollars to approximately 10,000 first-tier subcontractors in 46 States.

By permission of the Bureau of the Budget, we have recently initiated a simple report by postal card of the placement of the larger first- and second-tier subcontracts placed by 12 of our larger prime

contractors. Reports are starting to come in and the early returns already show 2,172 subcontractors totaling $427,196,444 placed in 37 States. It is interesting to note that during the last fiscal year, 40 percent of NASA prime contracts, by dollars, were placed in labor surplus areas.

In order to assist companies, both large and small business concerns, in knowing where to solicit subcontract work, NASA synopsizes in the Department of Commerce Business Daily all pending procurements for research and development where the estimated cost is $100,000 or more, listing the names and addresses of the companies which are being invited to submit proposals.

SMALL BUSINESS PARTICIPATION

Small business concerns also have participated substantially in NASA's prime contracts. They received 16 percent in dollars of new contracts placed in fiscal year 1962. Of a total of approximately 128,000 contractual transactions, large and small, small business companies received 66 percent. In procurements where small business companies bid for prime contracts they were successful in obtaining contracts for 57 percent of the dollars. Of the 100 companies which received the largest dollar amount of NASA contracts in fiscal year 1962, 24 were small business concerns. The above facts apply only to prime contracts and it is probable the participation of small business concerns in NASA subcontracts is somewhat larger.

IMPROVEMENTS IN CONTRACT SYSTEM

We are constantly trying to further improve our procurement practices and procedures. The Administrator has appointed a committee to study NASA's source selection procedure, means of using incentive type contracts, and a system of evaluating contractor performance. It is anticipated that constructive innovations will be made as a result of its efforts. NASA recognizes its responsibility in the expenditure of the money appropriated by the Congress and will continue to exert its best efforts to see this trust is properly carried out.

Mr. TEAGUE. Thank you, Mr. Brackett.

I have not discussed this with other members of the committee, but most of the complaints that come to me are on the human side of your contracts. Last Friday for example, a man came in—he wouldn't let me use his name—and a large prime contractor had selected him as a subcontractor. He had done the same work for Air Force and Navy for many years, and had letters of commendation from both. Yet, at your center, someone vetoed his subcontract, saying he was not large enough. From the papers he had, it looked as if someone made a rather arbitrary decision.

I get three or four of those a week. Most of those who come in are afraid to have anything done about it because they are afraid that they will lose even more business in the long run.

How would you handle a situation like that?

Mr. BRACKETT. If you would tell me the facts, I would be glad to look into it.

Mr. TEAGUE. We are all human, and I guess that if I had a good friend that wanted a contract, as did someone else who I knew nothing

about, I probably would be less than human if I did not favor the man I knew.

Mr. BRACKETT. Our office does have a say in hiring the No. 1, and the No. 2 man usually, at each of the centers.

Below that the centers have the authorization to hire their own people. I believe they hire the best people they can get, but I can't argue that people don't make mistakes, as we are all human.

We do periodically review the operations at the centers; check whether they are complying with the regulations. But it is difficult to be there from day to day, and see how everybody individually is doing their job.

Mr. TEAGUE. A company—which asked me not to use their name—said they were interested in the crawler contract at Cape Canaveral. Mr. Horner testified here last year that the company put their best men on making the proposal.

He contended that there was one company in the country qualified to build the crawlers. The way the contract was let was changed in the middle of the negotiations; either it started as competitive bid, and changed to negotiation, or vice versa. In any case, a company that had not built anything like this before sent in a very detailed proposal, and it was contended that the selection was made more on the basis of the proposal than on the basis of what the company could do.

Are you familiar with that contract?

Mr. BRACKETT. Yes, sir. This started out as noncompetitive, to one company. I believe it was at this headquarters' insistence it was changed and put on a competitive basis.

Several companies had indicated some interest in the prime contract. All the companies that had indicated an interest were invited to submit proposals. Two proposals were submitted, one by Bucyrus-Erie Co., the other by the Marion Co. A source evaluation board was appointed by Dr. Seamans, which spent considerable time in reviewing and analyzing the proposals, checking with the various customers that both these companies had done business with—this is one I mentioned in my statement—that we check commercial customers at times; neither company had done much Government business.

So the board went to various customers of each company and got their evaluation of performance. One of the things that was checked was their reputation for living within their estimates of costs. The Marion Co.'s proposal was about $3 million lower than Bucyrus-Erie. That was the company chosen for the contract.

The technical evaluation was approximately equal, but the Marion Co.'s estimate was about $3 million less than the other. And there is an incentive fee in this contract. There is an incentive fee in this contract for delivery on time, and for saving of costs. If the company does not live within the amount that it says it can do the job for, its fee goes down.

If it does not deliver on time, its fee goes down. We think this was a fair selection, on a strictly competitive basis. And the choice of the Marion Co. was made by Mr. Webb, Dr. Dryden, and Dr. Seamans, after hearing the report of the Board.

Mr. TEAGUE. Did the Board recommend the company that got the contract?

Mr. BRACKETT. As I recall it, the Board said that both companies were considered qualified—the one company, Bucyrus-Erie, was slightly ahead on technical points, technical features; the Marion Co. was quite a bit ahead on the business features.

Mr. TEAGUE. Why was the way of selecting the contractor changed?

Mr. BRACKETT. From without competition to having competition?

Mr. TEAGUE. Correct.

Mr. BRACKETT. I think the original idea was that the Bucyrus-Erie Co. had done something that was quite similar to it; they had specifications, drawings, tooling, and so forth, that could save the Government quite a bit of money, rather than going to some other company that would have to duplicate this.

When negotiations were started, this did not prove to be exactly the case, and prices were apparently somewhat higher. I am not familiar with all the details. But that is the way I understand it.

Mr. TEAGUE. It did come out of the Cape Canaveral center?

Mr. BRACKETT. Yes.

Mr. TEAGUE. As I understand your statement on page 3, you say that where the estimated cost is over $5 million, the plan is submitted to the general management of NAA for approval.

Under that situation, what happens if Dr. Debus does not approve it?

Mr. BRACKETT. This is just the plan to start the procurement. This is not the choice of contractor. When it comes to choice of contractor, if it is over $5 million, the general management makes the choice.

Dr. Debus was present at the time the Board made its report to Mr. Webb, Dr. Seamans, and Dr. Dryden.

Mr. TEAGUE. I certainly hope that NASA will not have something similar to the TFX problems.

Mr. BRACKETT. We hope not, too.

Mr. TEAGUE. But each week, not knowing a thing about the contracts, I am getting an increasing number of complaints, and it always concerns the human factor—somewhere, someone made a decision. A university professor last week told me that you can trace the university contracts by tracing the man who makes them.

Mr. FULTON of Pennsylvania. You can do the same on advertising.

Mr. TEAGUE. We get this sort of thing all the time. The charge is made that when you go to make a university contract, they can tell you where it is going because of the friends the man has.

Mr. RIEHLMAN. That is one reason I want to know what people are in charge of these programs. When these people have always been shifting around in Government, they will bring with them to NASA the contracts and friends that they have made through their years of letting contracts in other agencies.

I think this is one field where an effective program could be successfully carried on.

Mr. TEAGUE. Mr. Gurney?

Mr. GURNEY. How would you suggest handling such a situation as the chairman has brought up?

Mr. TEAGUE. The trouble is, Mr. Gurney, these people won't let you use their names. The only one who would let me use his name was the one on the crawler.

Mr. GURNEY. Even so, there must be some procedure to get to it.

Mr. SIEPERT. Mr. Chairman, a good bit depends on what the allegations or complaints are, as to how NASA would handle it. If the allegation is that a company was not permitted to compete, or be selected as a subcontractor because someone in the procurement side says, "You are too small" this is the kind of thing that if we have nothing more than the center or the name of the individual who did this, we don't need to know the company.

And I think Mr. Brackett's people are resourceful enough that the company would not be put to any injury by our following it through.

The second possibility, though, is that we do get allegations that really run not to a mistake in procurement policy, but allegations that there may be something improper in the actual relationship between a Government representative and a contractor.

Mr. TEAGUE. Frankly, I told the company I thought they were unfair to me to come in and make a charge like this, and then ask me not to use their name.

Mr. SIEPERT. In this latter type of case, we set up a year ago in November an Investigation Division. These people have no ties to any of the procurement people. They are headed up by topflight investigator personnel, the head being a person with extensive FBI and congressional staff experience as well as executive agency experience.

This is a small staff, but they have been able to handle allegations of the sort you are speaking of, and protecting the individual, if that is the only way we can get cooperation in running these to the ground.

Mr. FULTON of Pennsylvania. Could I have a statement of that Division's functions put in the record, Mr. Chairman?

This is the first time I ever heard of it. If anyone else on the committee heard of it, I would like to know about it.

Mr. TEAGUE. Could you supply that for the record, Mr. Siepert? We would like to have the names of the inspectors.

Mr. SIEPERT. Certainly.

(The information requested is as follows:)

[Chapter 2. No. 2-1-8.9. Effective date: January 15, 1962]

NASA MANAGEMENT MANUAL

PART I. GENERAL MANAGEMENT INSTRUCTIONS

SUBJECT: FUNCTIONS AND AUTHORITY—INSPECTIONS DIVISION

1. Purpose

This instruction establishes the functions and authority assigned to the Inspections Division.

2. Organization location

The Director of Inspections reports to the Director of Administration.

3. Responsibility

The Inspections Division is assigned the responsibility for establishing and conducting a comprehensive program designed to prevent and to detect illegal and unethical conduct of NASA employees.

4. Functions

The Inspections Division will:

(*a*) Review and appraise the adequacy of regulations relating to conflicts of interest, outside employment and financial interests of NASA employees, and the conduct of NASA employees in the performance of official duties.

(*b*) Develop policies, standards, and procedures relating to investigations and inspections, both in the field and at NASA headquarters, to detect violations of

laws and regulations by NASA employees and to disclose conditions which might lead to such violations.

(c) Conduct or arrange for the conduct of investigations to detect unlawful or unethical conduct on the part of NASA employees.

(d) Conduct or arrange for the conduct of investigations to detect fraud or other illegal activity by contractors or others which affects NASA.

(e) Conduct or arrange for the conduct of periodic inspections for the purpose of disclosing conditions which might lead to violations of laws and regulations by NASA employees.

(f) Maintain liaison with the Department of Justice, including the Federal Bureau of Investigation, on matters referred to that agency for investigation or other action.

(g) Conduct such other investigations as may be directed by the Director of Administration or higher authority.

5. Scope of authority

The Director of Inspections is authorized to take such action as is necessary to carry out the functions assigned to him within such limitations as may be established by the Director of Administration or higher authority or by applicable law or regulation. He is authorized to redelegate to personnel under his jurisdiction such of his functions and authority as he may consider necessary and which are not specifically restricted to him by statute or regulation.

6. Relationships with other officials

In performing the functions assigned to him, the Director of Inspections is responsible for recognizing the responsibility and authority of other officials and for insuring that actions he may take are properly coordinated with other headquarters groups having joint interests and are in accordance with NASA policies.

7. Approval of organization

The basic organization of the Inspections Division is outlined in the attached organization chart (attachment A). Modifications or changes in the basic organization structure are subject to the approval of the Director of Administration.

ALBERT J. SIEPERT,
Director of Administration.

The following is a list of professional personnel in the Inspections Division:
Charles G. Haynes (Washington, D.C.), Director.
J. Maxwell Dickey (Washington, D.C.), Inspector.
Angus W. Sanders (Washington, D.C.), Inspector.
Ralph F. Winte (Washington, D.C.), Inspector.
Roy E. Wood (Huntsville, Ala.), Inspector.

Mr. TEAGUE. How do they work with the General Accounting Office?

Mr. SIEPERT. It does not work normally with the General Accounting Office. We have an Audit Division under Mr. Ray Einhorn, who came to us from the General Accounting Office. The Audit Division is the one that works day in and day out with the General Accounting Office. However, there have been situations in which, where we have had an investigation going, that if it was in an area that the General Accounting Office had evidenced interest in, we do at that point deal directly with them.

Mr. GURNEY. Who is the man that you contact in cases like this?

Mr. SIEPERT. If they will get in touch with Mr. Charles Haynes, or another way one can do it, if you get this kind of thing, merely call Paul Dembling's office; he will immediately put this person directly in touch with us, without your relaying the information to anyone in Dembling's office.

Mr. FULTON of Pennsylvania. There was that instance of the vacuum facility with a company that had done over $50 million worth of business in this field with Government agencies. They wanted to bid on another high-vacuum facility in the southern part

of the United States. It was brought down to a certain number who could bid, and they were not even allowed to bid. I pressed the case for them and asked NASA why they were rejected. NASA said, "Well, the proposal did not have enough imagination." So I said, "Well, what kind of imagination was needed to make a bid?"

I am afraid that NASA has the tendency to select an elite group of contractors who can do everything, and have had the previous experience. Anyone else who does not fit into that group, either a larger or a smaller company, may find themselves out.

On that particular instance you did change and offer the contract by public bid. As I commented, there wasn't enough research and development in the total high-vacuum-facility contract to call it an R. & D. contract; it was mostly construction and engineering, and the meeting of certain standards that can be set by NASA specifications.

I also had a criticism on the Goldstone deep radar dish procurement which was a $15 million contract in California. There again, very competent companies offered proposals, but the winning company was selected personally rather than by bid. My feeling is that when there are competent companies in the field that vary as to technical competence, details of proposals, or methods of accomplishing the job, that you have to make them bid. I want to save the taxpayers money. I don't like what you call competitive selection. My feeling is that we must have a broad-based industry for NASA to deal with. If the companies are competent and have good teams of technical people, are financially responsible, and are competent in the field, then they should have the opportunity to make a competitive public bid. To find that so many of the NASA contracts are being put out on just a selection basis, I think confronts us with a great danger here.

I agree with the chairman that we don't want another TFX situation coming up in NASA where even its basic methods and systems are questioned.

Did I see in your statement that the Jet Propulsion Laboratory is contracting out 60 percent of the money provided by NASA in 1962 on contracts with business firms?

Mr. BRACKETT. Sixty percent of the dollars on the JPL contract?

Mr. FULTON of Pennsylvania. On JPL contracts?

Mr. SIEPERT. Of the amount that is carried in the NASA contract to the California Institute of Technology for the program they work with us on, 60 percent of those dollars are in turn subcontracted to industry.

Mr. FULTON of Pennsylvania. Your statement certainly does not say it:

> In addition, the Jet Propulsion Laboratory, which is operated under a contract by the California Institute of Technology, spent over 60 percent of the dollars provided by NASA in fiscal year 1962 on contracts with business firms.

Mr. BRACKETT. That was 60 percent subcontracted to commercial companies.

Mr. FULTON of Pennsylvania. You also spoke of 37 States receiving contracts in one place, and in another place 46 States.

Mr. BRACKETT. That was two different reports.

Mr. FULTON of Pennsylvania. Which are the States left out?

Mr. BRACKETT. I can tell you the States that are in.

Mr. FULTON of Pennsylvania. We better put it in the record. There may be some complaint on being left out, because that is all the taxpayers money being put into the contracts.

(The information referred to is as follows:)

The statements referenced at this point in the testimony are found on page 7 of the prepared statement of Mr. E. W. Brackett, Director, Procurement and Supply, NASA, to the subcommittee. These statements are set forth below:

"By permission of the Bureau of the Budget, we have recently initiated a simple report by post card of the placement of the larger first- and second-tier subcontracts placed by 12 of our larger prime contractors. Reports are starting to come in and the early returns already show 2,172 subcontracts totaling $427,196,444 placed in 37 States."

"We requested nine of the largest NASA prime contractors to report on the volume and place of their first-tier subcontracts. They reported they had subcontracted 50 percent of the dollars to approximately 10,000 first-tier subcontractors in 46 States."

The States in which subcontracts were placed under the two reports referenced herein are listed in the answers to Questions Re Procurement and Contract Policy, questions No. 18 and No. 19, which show the distribution of subcontracts by States for the two reports. (Questions referred to are inserted at the conclusion of the day's hearing.)

Mr. BRACKETT. On the crawler procurement, Mr. Fulton, no one person made the selection there. It was a board; I can't recall just how many; I would say 12 to 15 experts on the board—most of them engineers, some of them on the business management side—who did this detailed evaluation; made their report to Mr. Webb, Dr. Seamans, and Dr. Dryden, who made the choice of the Marion Co. As far as the technical side was concerned they were practically even; on the business side, Marion was ahead.

Mr. FULTON of Pennsylvania. When you had two competent companies, tremendously experienced in the field, and you have engineering and technical people in NASA who can come up with the specifications on the load requirements, speed, and stability requirements, why didn't NASA come up with good specifications and have these companies bid at public bid?

Mr. BRACKETT. The engineers felt they could not come up with the type of detailed specifications that would be necessary. Nothing like this had been built before. They were anxious to get from various companies their different engineering approaches and then evaluate to see what would probably be the best way to do it.

Mr. FULTON of Pennsylvania. You see, there is criticism of this. You are using a company's best talent in making proposals that may cost hundreds of thousands of dollars to prepare, and then in some cases, the company is not even permitted to make a bid because NASA eliminated them in the preliminary review.

I believe that NASA is wasting engineering talent by not having the in-house capability to come up with adequate specifications on something like that tremendously large caterpillar tractor which was mainly engineering and construction work with little research and development.

There has been criticism, too, that NASA's contracts are going the same way they have also gone in the aircraft industry, and other people cannot get in to make the contracts.

Likewise, these same large contractors have their favorite and chosen subcontractors, and the subcontracting always goes through the same old channels, which in a way makes a closed industry.

Another complaint I have heard is that there is too great a concentration among too few States. On the $3.7 billion authorization for fiscal year 1963, I understand that six States got $2.5 billion of that money channeled through industry in those States.

In my view, this is a new industry of tremendous size, and actually it is changing America because it is commanding so much of our resources.

There are also complaints from cities that NASA teams are procuring scientists, research men, engineers, physicists, chemists, and electronic engineers from these cities, thereby draining certain areas of scientific talent. The allegation then is that you are centering, with the taxpayer's money, all of this scientific and engineering competence in certain favored areas which are in tremendous booms, while the other areas are suffering and not being given adequate consideration.

I have just one other thing, Mr. Chairman.

The center of the country, such as the Midwestern States, have given me many complaints that they are practically omitted from the program, and that all the contracts are given to States on the east coast and west coast.

I would like you to put in the record some answers to these criticisms which have come in to me. They are serious criticisms, and I think they should be met.

A question likewise arises about setting up some sort of independent inspection system. I was in the Navy triple A priority section of the Bureau of Aeronautics working on procurement in World War II. I was also one of the Navy representatives at Wright Field to the aircraft scheduling unit on plane procurement. So I have some experience in this. It is my experience that NASA's inspection facilities on the followup and reliability checks of over-the-counter and off-the-shelf components is not tight enough. I make that as a personal criticism. I think it needs to be tightened up very considerably.

I have made a suggestion, too, regarding items which are not research and development items and which are supplied for these manned space flight countdowns. If there is a failure of an ordinary component that is regularly used in the space industry, the manufacturer should forfeit a bond or pay a penalty.

The penalty does not have to be high—$5,000, $10,000, $15,000 or $20,000, but it would highlight the importance of this and publicly show the manufacturer whose product failed. My criticism is that now you can never tell who failed.

On the Glenn flight there were five problems, because very ordinary things went wrong. I would like you to look into the question of setting up bonds when we are not dealing with research and development items.

(The information requested is as follows:)

In the Mercury program, most of the problems have shown up during preinstallation checkout of components or during complete systems tests prior to launch. The detection and resolution of malfunctions at this time is relatively easy. Failures that occur during flight are another matter and often require considerable time and effort to pinpoint. It is not enough to simply know that a part has failed; it must be determined why it failed. Sometimes the only way to do this is to run simulated mission tests and try to duplicate the failure. It is not always possible to simulate the exact local environment of a component during

flight because the spacecraft cannot carry the instrumentation necessary to give us such detailed data.

In the Mercury flight history, while all malfunctions have been solved, it would be very difficult to place the blame for a particular malfunction on any one person, group, or company. All components in the Mercury spacecraft are subjected to man-rating qualification whether they are off-the-shelf items or R. & D. items. This man rating consists of rigorous duty cycle, structural, and environmental tests to qualify the units for flight.

The inclusion of bond requirements in NASA contracts would increase the cost of NASA procurements. Further, if such bond requirements are to be effective, NASA would have to develop very clear-cut evidence that failure in a particular instance is essentially the fault of the supplier. NASA may not be able to do this or may be able to do this only at substantial cost to the Government. The bonding procedure, besides being impractical, overlooks the fact that the ultimate responsibility is NASA's, and that in discharging this responsibility NASA must require an item to meet rigid acceptance criteria prior to Government purchase.

Mr. TEAGUE. Mr. Daddario?

Mr. DADDARIO. Would you give us some idea of the growth of personnel and the increase in cost during the past couple of years in contract administration?

Mr. BRACKETT. We have agreements with the Army, Navy, and Air Force, three separate agreements, to do contract administration for us, particularly where they have such an organization in a company's plants.

Take Grumman Aircraft, for instance: I believe we are asking the Navy, who are in there, to do much of the detailed day-to-day things, such as approving overtime.

We have also our own engineers in there in limited numbers to watch the quality control and inspection work.

Much of the detailed inspection is still left to the Navy, for the reason that we don't have the number of people to do all that work; but primarily it is because it means only one Government agency is in there, and it saves the taxpayers money to do it this way.

In the plants where we have the largest amount of work—such as the North American plant at Downey, where we have approximately 85 to 90 percent of the work, and in the plant at Michoud, New Orleans, where we have all the work, and, I believe, in the Pratt & Whitney plant in Florida—we have our own contract administration people there.

I can't tell you the numbers. I believe in the North American Downey plant it is approximately 200.

The military departments had allotted—I have to call on my memory a little bit—something like 2,000 people to do this work for NASA.

We will compensate them for their direct expense—no overhead—for the work they do. I may be wrong here, but I think the average cost of these people is about $7,000 per head, on the average.

We are insisting on a somewhat tighter type of inspection and quality control work than the military departments have been usually doing for themselves. Their inspection work is a surveillance system. They take a look at the contractor's inspection system, and if they find it good they don't do the inspection. We insist on much closer detailed inspection. We have come up with the type of inspection we need, it is made part of our contracts and the military are going to follow that for us.

Mr. SIEPERT. Mr. Daddario, may I supplement that?

Mr. DADDARIO. Surely.

Mr. SIEPERT. I don't think we have given you quite all the facts, figures, that we have available. Up until this year, the work of the kind Mr. Brackett is describing has been done by the Air Force staff without any reimbursement by NASA.

The Army and the Navy almost from the beginning have charged us for identifiable direct-added costs if they have to add people in any way to take care of it.

This has been a relatively small expense to us.

Because of the sizes of our program, Mr. Webb proposed to Mr. McNamara that the NASA needed to get this work done and should be prepared to reimburse the Department of Defense for the work that was identifiably undertaken on behalf of NASA.

As a result, there were negotiations involving the Bureau of the Budget, and this year there are now agreements that we will be paying the billed costs of labor, from the quality area, inspection area, and procurement and contracting area.

The Bureau of the Budget's personnel estimates on this is 5,500. The 2,000 figure Mr. Brackett referred to is, I believe, the estimate of those that would be involved on the procurement side.

Mr. BRACKETT. These are both sides——

Mr. SIEPERT. I am sorry. He says the 2,000 is the estimated addition over the estimate of what was actually probably in the program before we entered into this agreement.

In other words, say we had around 3,000 people working with us, it will go up to 5,500, is the estimate this year. I want to emphasize this is an estimate supplied by the Department of Defense.

We will pay for the positions actually utilized on our work, not just pay a blank check for 5,500 people.

Mr. DADDARIO. This is 5,500 estimated within the Department of Defense?

Mr. SIEPERT. That is right; within their civilian employment ceiling.

Mr. DADDARIO. How many of your own people are involved? You gave a figure of 200 at North American?

Mr. BRACKETT. That is right. This is a guess, but I would say overall less than 500.

Mr. SIEPERT. We can supply more specific information to you on that.

Mr. DADDARIO. Then a question comes to mind, regarding the piece-by-piece inspection. Why do you feel that under these circumstances you need a tighter control than the military has felt was necessary in overseeing the same kind of program?

Mr. BRACKETT. Well, this is largely because we are in the research and development field. A surveillance system may be all right for a production type of work, making shoes, something like that.

But in the research field every little part is different, and counts. Some of the failures that have taken place have been because of failures of small items.

If these had had tighter inspections perhaps they would not have failed.

Take our Saturn shots: We have had three test shots of Saturns, all, I think, very successful.

And this is the type of inspection we have. These Saturn shots and many others will be very expensive. And to have it fail because

of some small item that is not properly inspected would be very costly to the program and to the country. In the manned space flight there is human life at stake. We are only buying a very limited number. Where the military buys perhaps 100 or 200 missiles for test purposes, and a few fail, that can be taken into consideration.

But where we buy such a few in number, any one failure hurts the program.

Mr. DADDARIO. Do you change the type of inspection you have as companies prove themselves?

For example, you mentioned the fact that McDonnell Aircraft Co., which I think is the company you referred to in the Mercury program, has been now given the followup program of Gemini. As a result of the experience of dealing with McDonnell, has NASA increased the number of personnel who inspect them, or has NASA decreased the number because McDonnell has been so qualified?

Mr. BRACKETT. I can't answer that definitely.

But it is my belief that as a company proves more capable and more reliable the inspection work will go down.

Take the Delta spacecraft, for instance, which has been very successful; it is my understanding inspection is not as stringent there as it would be on some new item.

Mr. SIEPERT. Because the company has learned how to inspect it rigorously.

Mr. DADDARIO. There is a very important point which Mr. Fulton has touched on time and time again, the problem of putting the responsibility on the contractor, where it properly belongs.

Could we have the figure on the number of people who are working now at McDonnell on the Gemini program as compared with the number of people performing the same type of work under the Mercury program?

Mr. SIEPERT. We will try to get it.

(The information requested is as follows:)

The attached table sets forth the number of Government employees by types and Government agency, working at McDonnell on the Mercury and Gemini programs as of the end of March 1963, the number of such employees at McDonnell at the time of peak employment under the Mercury program (December 1961), and the estimated number of such employees at McDonnell at the estimated time of peak employment under the Gemini program (October 1963).

NASA's quality assurance policy makes NASA installations responsible for the quality of procured articles, and this responsibility cannot be delegated to either contractors or other Government agencies. NASA may delegate quality functions at a NASA supplier's plant to another Government agency, but NASA provides technical direction to that agency to insure that articles conform to prescribed criteria and design intent.

NASA's inspection system is part of a quality assurance program to achieve high reliability of hardware in space operations. Direction to inspection agencies is made through NASA Quality Publication NPC 200–1, entitled "Quality Assurance Provisions for Inspection Agencies." Minimum requirements for the performance of quality assurance functions by existing Government inspection agencies, under the technical direction of the responsible NASA installation, are described in this publication. NASA Quality Publications NPC 200–2, entitled "Quality Program Provisions for Space System Contractors," and NPC 200–3, entitled "Inspection System Provisions for Suppliers of Space Materials, Parts, Components, and Services," define the responsibilities for quality assurance placed upon system contractors and suppliers of parts and materials, including planning, reporting, and feedback, as well as controls over purchases, testing, and processes.

NASA subscribes to the objective of reducing the amount of Government inspection as this can be done without risk to the successful accomplishment of

NASA programs. However, industry's present quality assurance procedures do not generally satisfy the high-quality standards set by NASA. As they do, NASA procedures provide for appropriate downward adjustment in the amount of Government quality assurance effort.

MERCURY PROGRAM

Present Government employment at McDonnell, Mar. 29, 1963

Type of personnel	Navy	NASA (resident)	NASA (transient)
Business representatives	0	0	0
Quality assurance	0	0	0
Technical representatives	0	0	0
Clerical	0	0	0
Total	[1] 0	[1] 0	[1] 0
MERCURY PEAK EMPLOYMENT, DECEMBER 1961			
Business representatives	4½	0	0
Quality assurance	8	5	6
Technical representatives	0	7	4
Clerical	1	2	0
Total	13½	14	10

GEMINI PROGRAM

Present Government employment at McDonnell, Mar. 29, 1963

Type of personnel	Navy	NASA (resident)	NASA (transient)
Business representatives	2	3	0
Quality assurance	3	15	0
Technical representatives	0	12	0
Clerical	0	6	0
Total	5	36	0
GEMINI PEAK EMPLOYMENT, OCTOBER 1963			
Business representatives	2	3	0
Quality assurance	3	25	4
Technical representatives	0	14	0
Clerical	0	6	0
Total	5	48	4

[1] Gemini personnel devote approximately 7 percent of their time to Mercury—will phase out December 1963.

Mr. DADDARIO. And it is your purpose to cut this down as companies prove themselves, rather than increase it?

Mr. BRACKETT. That is right.

Mr. DADDARIO. I think that is very important because this piece-by-piece inspection is necessary, of course, but it is a very costly program. It also ties up highly competent people spending a great deal of time sort of looking over each other's shoulders to see what is being done.

Mr. BRACKETT. That is true. But we feel it is important, to be sure nothing fails because of lack of inspection.

Incidentally, inspection is under a different office from procurement, the Office of Reliability.

Mr. DADDARIO. But as conditions improve in a company and as they show their competence, you do cut down?

Mr. BRACKETT. I have heard it stated in rough figures in the Department of Defense there are 30,000 people administering contracts, and that approximately 50 percent of them are on inspection work.

Mr. DADDARIO. One further question: When Mr. Fulton inquired into the amounts of money JPL was subcontracting out, I think 60 percent, do I understand from this that it is the general philosophy that JPL should contract as much work as they can to private business?

Mr. BRACKETT. I believe they are contracting for the development of most of the hardware.

Mr. DADDARIO. Why is it then that JPL is now building, or developing the capability to build, their own solid fuel motors?

Mr. BRACKETT. I don't know.

Mr. DADDARIO. Do you know the answer to that, Mr. Siepert?

Mr. SIEPERT. No, I don't. The facilities program with respect to the JPL operation is tied in with a master plan for their operation which will limit the number of personnel that they have physically on the JPL payroll.

The facilities that we are developing for them are tied, I believe, to an estimated employment maximum of—I better get my figures.

I was going to say 4,100. This puts a strong pressure on the part of JPL management to do everything it possibly can out-of-house, and so this is the reason you have a 60-percent figure now.

And if you watch it over the years I think you will find that percentage goes up rather than down.

Mr. DADDARIO. Well, there are several companies which have a competence in the solid fuel area who, as I understand it, could supply solid fuel motors to JPL for whatever experiments were necessary.

I would like you to check on that if you can and place it in the record. What is this capability that JPL is developing in the solid fuel field? What is it costing? What sort of facilities are involved? Why can't they obtain this equipment from one of the manufacturers?

Mr. SIEPERT. I will be glad to get that statement.

I can say this: the Jet Propulsion Laboratory has been very insistent in maintaining a degree of research competence in the field of solid fuel work.

They were the original seedbed for this entire technology, and coming out of Jet Propulsion Laboratory were, really, the nuclei for many of the major contractors of today.

They have an interest in continuing work in solid propellants, particularly as it may relate to understanding their use in some of the very exotic spacecraft that they have charged out as their missions.

But they are not responsible for developing major solid propellants systems, as I understand it.

(The information requested is as follows:)

JET PROPULSION LABORATORY POLICY ON IN-HOUSE SOLID ROCKET ACTIVITIES

It is a fundamental policy of the Jet Propulsion Laboratory to maintain an in-house competence in all major technological areas which are directly involved in the execution of the Laboratory's assigned missions. One of these areas is solid rocket propulsion. The Laboratory has been a pioneer in this field and by its efforts has contributed significantly to the formation and advancement of the solid propellant industry.

In-house competence in solid propulsion is maintained by carrying out a balanced program of research, development, and flight application. This work is carried on by somewhat less than 30 professionals and 30 nonprofessionals.

Implicit in the Laboratory policy is the desirability of continuously maintaining a single in-house solid rocket engine development project. On the average, this occupies approximately five professionals and five nonprofessionals of the above-mentioned staff.

The present onsite solid propellant facilities at Pasadena were constructed in 1948. With the increase in population density both in the residential area adjacent to the Laoratory and within the Laboratory proper, it became evident that the bulk of the propellant process and testing operations should be moved to a remote location. Permission to use 1 square mile of Edwards Air Force Base has enabled us to achieve this relocation. A $1.3 million facility adjacent to our existing liquid propellant tests facilities recently has been constructed. This facility is capable of processing and testing comparatively small rocket engines (less than 1,000 pounds in weight). This limits its capability to spacecraft engines and excludes launch vehicle or weapons system engines. Capability is also limited to small numbers of rocket engines. Programs requiring large numbers of units are turned over to industry. Current examples are Ranger and Surveyor.

We believe that the above outlined policies are in the best interests of, not only the Jet Propulsion Laboratory, but also the national space program and indeed the solid rocket industry. By maintaining itself as a knowledgeable customer the Laboratory can and does improve the products which industry produces for NASA.

Mr. TEAGUE. Mr. Patten, did you have any question?

Mr. PATTEN. No questions.

Mr. TEAGUE. Mr. Fuqua?

Mr. FUQUA. No, I have none.

Mr. TEAGUE. Mr. Roudebush?

Mr. ROUDEBUSH. I would like to ask two or three questions, if I may.

As I understand it, in line with Mr. Fulton's and Mr. Daddario's questions, 60 percent of our contracts are allotted to the Jet Propulsion Laboratory operated by the California Institute of Technology and about 21 percent of our contracts are purchases from Armed Forces.

That would make about 81 percent of the total contracts of NASA. Is that correct?

Mr. SIEPERT. No; we did not make that clear.

As Mr. Fulton pointed out, if you read the language quickly you might very well arrive at this conclusion. And I would like to correct that, if I may, for you.

The Jet Propulsion Laboratory contract is in the order this next year of, I think, $230 million, or $210 million, out of $5 billion-plus estimate. So the 60 percent figure we are talking about represents that portion of the $200 million to the California Institute of Technology.

Mr. ROUDEBUSH. Yes. Are the percentages which you quote dollar percentages?

Mr. SIEPERT. These are all dollar percentages unless we have indicated otherwise.

Now, the 21-percent figure that you referred to, that does tie to the total procurement—the total procurement dollars—and it represents the amounts that we place with them to buy hardware they have already developed, such as Atlas-Thor boosters, and the like.

Mr. ROUDEBUSH. And the 21 percent is also dollar volume?

Mr. BRACKETT. Yes, sir.

Mr. ROUDEBUSH. How many people does the Jet Propulsion Laboratory have in its employ?

Mr. SIEPERT. I think 3,800 or 3,900 at the present time.

Mr. ROUDEBUSH. What type of contract does NASA have with JPL?

Mr. SIEPERT. We have the contract with the California Institute of Technology, which is the manager of the laboratory. With them, we have a cost-type contract—written for a 3-year period.

Mr. ROUDEBUSH. You mean cost-plus?

Mr. SIEPERT. That is right.

Mr. ROUDEBUSH. What is the percentage of the "plus" in the case of the California Institute of Technology?

Mr. SIEPERT. Oh, the contract calls for NASA's reimbursing them for all the costs of the Jet Propulsion Laboratory, both their direct and their burden costs.

In addition we pay a portion of the overhead expenses of the California Institute of Technology for services that they perform on campus, as tied in with the Jet Propulsion Laboratory.

This is in accordance with audit principles worked out over the years.

Mr. ROUDEBUSH. Could you give me any idea of the amount of money that NASA is paying to the California Institute of Technology or in campus activity?

Mr. SIEPERT. $850,000, in 1962, in the campus pool. In addition we paid a management fee of $950,000 to Cal-Tech.

Mr. ROUDEBUSH. What is that?

Mr. SIEPERT. A fee, pure and simple.

Mr. ROUDEBUSH. The on-campus is how much now?

Mr. SIEPERT. $850,000.

Mr. ROUDEBUSH. And NASA is paying the California Institute of Technology a total of about $1½ million in addition to their costs?

Mr. SIEPERT. No; the $850,000 overhead allowance is an actual cost, expense incurred, of which this is our share, based upon criteria that have been worked out, and these are subject later to audit by the Army audit agencies.

Those are costs actually incurred.

Now, the management fee, Mr. Roudebush, is a fee that is paid to Cal-Tech.

Mr. ROUDEBUSH. When did NASA enter into the original contract with Cal-Tech?

Mr. SIEPERT. Well, we took over the Army contract when we acquired JPL in—the first of 1959.

When that contract, so-called ORD–18 contract, had run its time we then negotiated our own contract, called NASA–7.

So this would be 1960, I believe.

Mr. ROUDEBUSH. One other question: Why does the percentage of the fee on cost-plus contracts vary so much when there is no risk involved to the company?

Mr. SIEPERT. There is substantial risk involved in terms of what kind of management capability they need to put into a job to complete it satisfactorily. The fee varies.

Mr. ROUDEBUSH. But the risk in that case would be in parentheses, wouldn't it? It is an entrepreneur problem, rather than risk. It is compensation for taking their management capabilities and placing them at the Government's disposal, isn't it?

Mr. SIEPERT. Yes, but I think the heads of the companies would say that is a risk, too. There is also an institutional risk, in terms of whether they do a bad job or not.

The fee varies, and goes from, I believe, 2 percent to as high as, I believe, 9 or 9½ percent. However, it centers between 6 and 7 percent, and that will vary depending on how much of a job they have to do in-house as contrasted with subcontracting.

Sometimes, if the subcontracting is very difficult, by reason of the subcontracting rather than handling it in-house, they would get a greater fee.

But oftentimes when they are subcontracting large portions of the work, the subcontractor is assuming much of the management responsibility, and our negotiators move the fee downward in such a situation.

Another factor is, how difficult is the job, really, to do, in terms of similarity to how much of that kind of job they may have done in the past.

There are other factors.

Mr. BRACKETT. Yes. For instance, where we furnish a plant in New Orleans for the Chrysler Co. and Boeing Co., this would lower their fee.

The degree of engineering skills that go in is a big factor as to the amount of fee. Some of these contracts are rather small and take high engineering talent and there is no follow-on production. They have to put their best engineers on a contract and after it is over that is all they will get out of it.

On some of the large contracts for airplanes, for instance, there is a large follow-on for production, which is pretty profitable.

We are pretty solely in the research field, and there is no follow-on production, and that makes some companies feel they are entitled to a higher fee.

Mr. ROUDEBUSH. I do not know whether any of the other members of the committee have asked or not, but I would like to have a report on the number of dollars, both prime and subcontract dollars, that are spent in each of the States by NASA.

Mr. BRACKETT. We can give it to you on the primes. We cannot give it to you accurately on the subcontracts because we don't have it. We are getting a sampling.

Mr. ROUDEBUSH. Is that the post card report?

Mr. BRACKETT. Yes. We can give you what we have on that.

Mr. SIEPERT. I believe that will be a very good indication. This post card report covers the 12 biggest contractors we have, so it covers a pretty good segment of the program.

Mr. BELL. Would the gentleman yield?

Mr. ROUDEBUSH. This will be my last question. I have had a lot of criticism from my State—and preeminence on the committee does not limit the number of criticisms we have on the amount of expenditures. I noticed that one of our colleagues on the committee put out a press release the other day on the lack of dollars being spent in my home State of Indiana. I think more effort must be expended to split these space contract dollars—of course, to competent firms—among the various States.

Mr. TEAGUE. Mr. Bell?

Mr. BELL. Isn't it true, Mr. Siepert, in your analysis which the gentleman from Indiana just asked you to give of the prime contracts and subcontracts, that because a great number of the prime contractors, you are not able to give a clear picture of the subcontracts and therefore the water is muddied considerably?

Because I know that—I am certain we are all aware—a great many of the contracts made in California are subcontracted out to other States—perhaps to Indiana, I don't know. So when you are not able to give the subcontracts, I think you are getting only the prime contractors viewpoint, which, I might add, I don't believe may be accurate in the inference it gives.

I would much prefer, if you are going to do this, that you would see if it would not be possible to get the subcontracts, too. Maybe that is impossible, but I think giving the prime contracts alone does not give the true story.

Mr. SIEPERT. This is a problem we recognized quite early. It took a bit of persuasion to convince the Bureau of the Budget, and the like, that it would be in the public interest and business' interest to introduce one more reporting requirement, and so we developed this post card technique, which is very simple, and when a prime contractor awards to a subcontractor he fills out the card and shoots it directly to us.

We also ask him to send the post card to the subcontractor and when the subcontractor goes to the second-tier subcontracts, we would like to get that report, too.

In the sample studies we have done thus far we are highly encouraged about the shift, that is, the broad differences of the subcontracts.

And it is true that the California prime contractors do a substantial amount of business with other States. I don't recall the figure at the moment, but I think with subcontracting, nevertheless, about 60 percent will still be in the State of California.

Mr. BELL. I think that unless you add the subcontractors, you will not get a true picture. I think we ought to consider this fact.

Mr. SIEPERT. We will give all the information we have on both, primes and subs.

(The information referred to is as follows:)

The report on prime contracts is set forth in the attached table which gives the U.S. geographical distribution of NASA direct awards of $25,000 and over for fiscal year 1962. The report on subcontract awards under the post card reporting arrangement is furnished in the answer to questions re procurement and contract policy, question No. 19. (Questions referred to are inserted at the conclusion of the day's hearing.)

U.S. geographical distribution of NASA procurement—Direct awards of $25,000 and over,[1] fiscal year 1962

State	Actions		Obligations	
	Number	Percent of total	Amount in thousands	Percent of total
Total	2,707	100	$939,143	100
Alabama	220	8.1	81,264	8.7
Alaska	11	.4	4,227	.5
Arizona	18	.7	5,583	.6
Arkansas	1	(2)	37	(2)
California	784	29.0	441,179	47.0
Colorado	27	1.0	3,622	.4
Connecticut	45	1.7	3,796	.4
Delaware	1	(2)	34	(2)
Florida	85	3.1	50,925	5.4
Georgia	24	.9	3,352	.4
Illinois	63	2.3	8,403	.9
Indiana	23	.8	1,646	.2
Iowa	14	.5	1,898	.2
Louisiana	19	.7	18,534	2.0
Maryland	154	5.7	26,773	2.9
Massachusetts	141	5.2	19,737	2.1
Michigan	64	2.4	5,644	.6
Minnesota	31	1.1	2,927	.3
Mississippi	1	(2)	93	(2)
Missouri	40	1.5	70,600	7.5
Nevada	3	.1	435	(2)
New Hampshire	7	.3	320	(2)
New Jersey	130	4.8	26,980	2.9
New Mexico	9	.3	1,696	.2
New York	200	7.4	55,301	5.9
North Carolina	10	.4	1,695	.2
Ohio	114	4.2	11,320	1.2
Oklahoma	11	.4	687	(2)
Oregon	1	(2)	33	(2)
Pennsylvania	105	3.9	25,291	2.7
Rhode Island	3	.1	243	(2)
South Dakota	1	(2)	98	(2)
Tennessee	19	.7	2,163	.2
Texas	146	5.4	32,755	3.5
Utah	1	(2)	37	(2)
Vermont	3	.1	112	(2)
Virginia	91	3.4	13,785	1.5
Washington	4	.1	325	(2)
Wisconsin	23	.8	4,618	.5
District of Columbia	60	2.2	10,975	1.1

[1] Excludes awards placed with or through other government agencies, awards outside the United States and actions on the JPL contract.

[2] Less than 0.1 percent.

Mr. TEAGUE. Mr. Fuqua?

Mr. FUQUA. Getting back to the overhead costs in contract work with colleges and universities, do you use the same formula with other colleges as you do with Cal-Tech and the Jet Propulsion Laboratory?

Mr. BRACKETT. No, sir. There is a different type of contract used with other colleges.

Mr. SIEPERT. Well, Mr. Brackett, I think really the Congressman is asking a little different question, perhaps, than you think.

The Government's relationship to universities falls in two kinds of procurement actions. One is in the field of grants for research they do. The other is in the field of contracts for either research or development work they may do for us.

In the grant area, we have Dr. Smull here, and if you would like to pursue this he could elaborate further on that.

In the grants area we follow an overhead policy that is written into our basic appropriation. That is, we do not pay more than 25 percent of the overhead costs.

Now, on the research contracts side, here we pay a true overhead allowance figure based upon audited expenditures of the university, and this could run higher or could run less than 25 percent, depending on the actual experience.

Mr. FUQUA. Do the colleges get this managerial fee on these contracts?

Mr. SIEPERT. No, the only management fee we pay is for the Jet Propulsion Lab contract, that, a fee paid to a university, the reason being they are undertaking a major prime contractor's responsibility of handling all our hardware development in the lunar-space field. It is not an ordinary contract.

Mr. TEAGUE. Mr. Siepert, would you take a few minutes to describe the NASA budget process. Where and when did it start, and what steps did it go through before it finally got to this committee?

Mr. SIEPERT. I will do that, with one disqualifying statement: the last 2½ years the responsibility of putting the budget together and submitting it to Congress has not been the responsibility of my office, but D. D. Wyatt's Office of Programs.

Mr. TEAGUE. Let's take it as it pertains to your office—because certainly much of it must pertain to your office. We better ask Mr. Holmes and the others to be prepared to tell us the same information about their offices.

Mr. SIEPERT. Yes. Well, the budget that is before you now has its first involvement by an organization such as the Office of Administration in—let's see—in February of the year before you get it.

In other words, we started in February—that is, a month ago—on the budget you will not see until next year.

This is a preliminary call for our estimates of manpower, workload, and dollars, to accomplish whatever functions belong in my organization or belong in Mr. Holmes' organization.

These go to the Office of Programs, where they are put together in an overall agency budget estimate, that I would call a ballpark estimate. It is quite rough, though we get more detailed as we get more time.

One of the key elements in the detail is, of course, what is going on on the preceding year's budget as it is passing through the several committees in Congress.

Beginning sometimes in June, sometimes as late as August, we are in discussion with the Bureau of the Budget about our estimate, and this is the time when the Executive Office is attempting to fit the total space requirements in a rough sort of way into their original projections that have come out of their Office of the Economic Adviser.

In other words, they have at that time a rough idea of what they think the revenues of the Government are going to be, what they think the international commitments are going to be; and at that point, particularly on the civilian agencies which are not tied to space or military, they have gone a substantial way down the road of developing the closing figure.

This has not happened on the space budget.

I don't think it ever happened, certainly not since the decision for the manned lunar landing.

There are in this process some series of markups, or maybe I should call them markdowns, in which the individual program, such as my area, is told, "There is only a certain amount of money within the current figure we are talking about. Your share is this amount. What will you do with this?" In other words, you then decide what you will give up in terms of functions you cannot perform under a lower amount of money.

Our actual submission to the Bureau of the Budget comes quite late, in a budget of this size. They keep this open longer than many other agencies. We did not actually get a final markup from the Bureau of the Budget until well into December of this last year.

It is at that point, then, that final adjustments in our material art made in line with that markup, and then you have a submission that is submitted to you right after the first of the year.

Mr. TEAGUE. Any other questions?

Mr. Daddario?

Mr. DADDARIO. When you say they give you an opportunity to give up certain of your programs, giving you a ceiling beyond which you cannot go, financially speaking, what did you give up in dollar amounts this year, that you thought you might have done?

Mr. SIEPERT. To answer in general terms, my budget that I submitted was not in terms of submitting dollars, because I do not have program responsibility for any of the dollars we operate on here.

In other words, the procurement dollars we are discussing this morning are not Mr. Brackett's, they are Mr. Holmes procurement dollars, so our budget process differs from the process I have described, in that we are attempting to budget the people it takes to keep control of the policy elements of the program.

So they ask us the head count it takes, and the kinds of skills and the workload assumptions we make. We try to delay doing this until the last possible moment, because the final on the markup is what is the workload in terms of dollars, to us; so I cannot answer in terms of dollars.

Mr. DADDARIO. How many people did you give up?

Mr. SIEPERT. I would say this budget in front of you here represents probably—well, I don't have a figure immediately at hand. It probably represents a shrinkage of about 25 to 30 percent.

In other words, there are probably about two-thirds of the positions Mr. Brackett and others would have originally submitted to us as representing their requirements.

Mr. DADDARIO. This is the general theory which applies to the other department heads: They are given an opportunity to meet certain standards insofar as those sums of money which will be finally appropriated specifically to their programs, and as to the number of personnel they will have, and the amount of experiments?

Mr. SIEPERT. Yes, sir. Each program area makes this calculation and when it becomes necessary to make a reduction, if the time limit possibly allows, Dr. Seamans also have the estimate sent back to the responsible operating head for him to come up with what is the best program within those resources, rather than being given a program that says "That is it, and do it this way."

Mr. DADDARIO. What does that 25 to 30 percent shrinkage amount to in the number of personnel?

Mr. SIEPERT. Our Office of Administration at the present time has an allocation in the headquarters of 467 people, of which 125 are at the moment in the Office of Procurement.

To give you an idea of how big that function is in terms of our total operation, it is my recollection our figures were on the order of about 550, which we asked for in 1963.

In other words, Mr. Daddario, I am giving you a figure of what we are operating with in fiscal year 1963. The 550 figure—you notice if you look in our headquarters complement—this is close to what is asked in fiscal year 1964 staffing.

In other words, the buildup has been deferred about a year.

Mr. DADDARIO. You are making another attempt, then, to build up your personnel to the point you think it should be?

Mr. SIEPERT. In the areas where we know the workload is crushing us. In this case, Mr. Brackett's operation has had 100-percent increases in dollars in each of the last 3 years. He has never had an increase in personnel that was greater than 30 percent in any 1 year.

Mr. TEAGUE. Mr. Patten?

Mr. PATTEN. About those figures you are going to submit regarding where NASA is doing its business, I do not think it would mean much to me if you just categorically said that California is receiving 12 percent and Indiana 2 percent. Could you relate them to something?

Take my State of New Jersey, for example. We have 117 research centers in electronics, right now, with over 60,000 engineers. Certainly New Jersey has a big part in this program, for instance, the man from Bellcomm was a neighbor of ours. Naturally New Jersey has been a great research center ever since the days of Thomas Edison and Du Mont, and all these leaders. I think that to compare us to some of these Midwestern States that raise corn and wheat is not going to tell too much.

I don't know by what means you would make a comparison, but I don't think you can sit here and proportion your work by simply dividing it among the 50 States.

I think it would make more sense if you could correlate it in some way to private industrial practices. Or, you are talking of research and development, could you relate it to where research and development has been done by private industry?

Mr. SIEPERT. There is always the difficulty of getting figures that will have equal meaning to folks who are in divided camps on the way to handle this.

The most meaningful figure on the capability of the country for our work would be the scientific and engineering capability. That is, where is the manpower through the country, for research and development primarily tied to the aerospace and electronics fields? These are the fields that I would say take 85 percent of our dollars. The problem, and it is a national problem, that the other committee members have well pointed out, is that the aerospace and electronics fields are concentrated for the most part on the coasts, just as the inland areas are the areas of industry where there is a heavy concentration of what is known as heavy production industry.

And there are problems for any research and development agency in being able to contract electronics work in an area which may not have a major concentration of the electronics field.

In other words, if you take the electronics field, there are very encouraging signs of real centers of capability building up, up in the Minneapolis area, down in the St. Louis area, even in the Chicago area; but if you were to compare it quantitatively, those concentrations are eclipsed by the concentration in the Los Angeles Basin area and in the Northeast.

And this is, of course, where the facilities are—which in many cases were built with Government money, you see, and are Government-owned plants that are run by the contractors.

Mr. TEAGUE. Are you through, Mr. Patten?

Mr. PATTEN. Yes; I am.

Mr. TEAGUE. I would like to say that Mr. Siepert cannot be here this afternoon. Mr. Lingle and Mr. Brackett are available this afternoon if the committee wishes to complete this testimony. There is no business on the floor. If we don't meet this afternoon, our next meeting will be Wednesday morning when we will start on the NASA budget books.

Mr. BELL. One more question?

Mr. TEAGUE. Mr. Bell?

Mr. BELL. I assume, Mr. Brackett, when you speak of procurement and supply you also include in addition to the contractors, the procurement and supply for all of NASA's in-house installations?

Mr. SIEPERT. Yes, sir.

Mr. BELL. To what extent are your procurement and supply programs tied into the DOD? In other words, do you operate independently of the DOD procurement and supply programs, or do you dovetail your efforts so that you reach the largest preponderance of economy?

Mr. BRACKETT. I think we dovetail a bit, in this sense. First, take the policy, and our policies are very similar, because we are under the same procurement statute, and we are doing business with the same types of companies.

We are buying things for the military, such as the Scout vehicle. We started it, bought the first ones; they needed some, and asked us to buy it for them.

Conversely, we asked them to spend 21 percent of our dollars during the last fiscal year.

We have a form, already developed by us, that we send to each other, when we want anything purchased by the other.

Also, they do much of our contract administration work for us.

We draw on them quite heavily for machine tools or facilities that they have in reserve, or in storage somewhere, that they are not using. They have been very helpful in supplying those to us. It saves us that money.

When it comes to the point that either of us has contractors' materials left, we offer it to each other, if either of us can use it. At times, we have drawn on their supplies out of their supply depots, though that is not a usual thing.

Our supply function in contrast to the military is very small. We stock in our centers say 12,000 to 50,000 line items, where they would stock 100,000 in one of their depots. This is for our in-house work.

Mr. BELL. As you know, the DOD has a long background in this kind of thing. In my own mind, I have questioned in the past whether we are doing enough of this coordination of effort with the DOD. For example, in regard to the depots, installations, and so forth that you spoke of.

Can you see anything that NASA could do toward taking over some of the activity, or melding your efforts in these depots, along with DOD, and pursuing this program further? It is my feeling that there would be economies in this, and that a greater effort in this direction could save the NASA program a considerable amount of money.

Mr. BRACKETT. We are constantly trying to do that. One of the big things we do, as I understand, is to furnish each other a list of surplus items; these are screened, and they draw them from us, or we draw them from them.

Mr. BELL. Isn't there a possibility that at times you could actually let DOD take over certain areas of procurement for you?

Mr. BRACKETT. We have; in 21 percent of our dollars they have done that.

Mr. SIEPERT. We might mention two other areas.

I just happened to get a report on the Michoud plant, which is Government-owned. DOD furnished us some $3 million of tooling that went into that plant, because we screen all our requirements through them on their excess tools.

I would like to refer to two other areas: Mr. Brackett in his statement mentioned the Administrator has a staff studying group now that has been working really all this year on efforts to improve our source evaluation processes, efforts to work out a simple way of evaluating a contractor's performance so that other procurement people can remember a good job and a bad job when the next award comes around.

This is a NASA study that involved going around to a number of the top contractors with an open door, asking them what did they think was wrong with the procurement process; and in that travel around we involved the Department of Defense, invited them in to hear the same thing, so we were able to trade and exchange that experience.

A similar thing going on now is that there is a study of the Department of Defense called Project 60, and I believe the "60" means it is one of the studies the Secretary of Defense set up to look at what might be done to improve contract administration on the part of all of the services.

Very early in the process NASA was invited to be a formal member of that project.

We have had people working full time for 7 or 8 months, working with DOD, going all over the country to find out how we can improve the actual administration of these contracts once they are awarded and placed in the plant.

Both Mr. Brackett and I are involved in this project. I am in the top group, with Brackett in the advisory group immediately underneath it, and when I leave for my new post Mr. Lingle will take up that post as our representative on the Project 60 Task Force.

Mr. BELL. Are all your programs similar to the DOD's, exactly similar, with respect to your contract arrangements and DOD's?

Mr. BRACKETT. Generally speaking, I would say yes.

Mr. BELL. If there is any question about it, I would like to know it. I would like to get a report for the record of any differences that exist.

Mr. SIEPERT. Suppose we gave you that, Mr. Bell, for the record. There are a few places where for reasons that we think are self-explanatory, we do things a little differently. These are really very minor, as contrasted with the areas we do on a similar basis. We will put them in the record for you.

Mr. DADDARIO (presiding). Would you supply that for the record?

Mr. SIEPERT. Glad to.

(The information requested is as follows):

NASA contractual arrangements differ from those employed by DOD in the following areas:

Patents.—NASA is required under the provisions of section 305 of the National Aeronautics and Space Act of 1958 (42 U.S.C. 2457) to obtain title to inventions made in performance of a contract, and to require contractors to furnish written reports on inventions, discoveries, improvements and innovations made during contract performance. The DOD does not have a similar statutory requirement and generally obtains a comprehensive license which permits royalty-free use of patents developed under its contracts.

Gratuities.—The 1952 DOD Appropriations Act enacted into permanent law (5 U.S.C. 174d) a requirement for the inclusion of a "gratuities" provision in DOD contracts which permits the Government to terminate a contract where the contractor has offered or given a gratuity with a view toward securing favored treatment in contract transactions. NASA does not have a similar statutory requirement.

Excess profits.—Pursuant to 10 United States Code 2382 and 7300, DOD contracts in excess of $10,000 for construction or manufacture of any part or complete aircraft or naval vessels are required to contain an "excess profit" provision. These statutes do not apply to NASA.

Indemnification.—Under the provisions of 10 United States Code 2354, DOD is authorized to indemnify a contractor against unusually hazardous risks arising out of direct performance of contracts for research or development, or both, NASA does not have similar statutory authority.

Miller Act (40 U.S.C. 270(a)–(e)) —The provisions of this act require construction contractors to furnish payment and performance bonds. Secretaries of the military departments are authorized to waive this statutory requirement in the case of cost-reimbursement type contracts. The Administrator is not authorized to make similar waivers.

Mr. DADDARIO. Mr. Fulton?

Mr. FULTON of Pennsylvania. We had made certain allegations, and there have been certain complaints that have been relayed to you.

With the chairman's permission, I wish you would take those from the record, and just answer them explaining each situation. For example, capsulize what the situation is, and give us your answer.

Mr. DADDARIO. Any objection to that?

(The information requested is as follows:)

Allegation:

1. Referring to the crawler procurement, NASA's selection process requires contractors to use their best talent preparing proposals and spending large sums of money so that NASA gets various kinds of proposals "for nothing." NASA is wasting engineering talent by not having an in-house capability to come up with adequate specifications on something that is basically engineering and construction and as little research and development as a tremendously large caterpillar tractor.

Answer:

NASA has been very much concerned about the talent and money involved in preparing proposals for performing NASA's development work. NASA uses various methods for keeping contractor costs for proposal preparation at a minimum, including the preparation of a request for proposals that carefully defines the tasks to be performed and limits the contractor's response to the minimum required for a good, competitive source evaluation, and the use of a preproposal screening process. NASA employs competent engineers in-house and also procures contractor studies for this purpose.

In the case of the crawler-transporter, NASA had a study made by one of the acknowledged leaders of this industry to determine the feasibility of a crawler-transporter as compared with the other means of transportation such as barge and rail. The results of this study were used as the basis for selecting the crawler approach and for developing the design criteria.

The procurement competition was started with a preproposal screening of 35 companies which had previously evidenced an interest. They were asked to consider the requirements based on the criteria and to exhibit their competence to perform the task. Twenty-two companies attended a technical presentation by NASA, but only two, Marion Power Shovel and Bucyrus-Erie, elected to submit formal proposals. Apparently, the remaining 20 companies recognized that it would not be worth their while to expend the talent and funds required to prepare formal proposals. The two proposers developed preliminary designs sufficient to demonstrate feasibility and to establish a cost estimate. This kept the proposal cost to a minimum.

Allegation:

2. NASA's contracts are going the same way they have gone in the aircraft industry; that is, they are going to certain companies, and others can't break in. Likewise, these same large contractors have their favorite subcontractors, and subcontracting then goes through the same old channels. This makes for a closed industry.

Answer:

It is the judgment of management throughout NASA that the ultimate success of NASA programs depends in a large measure on placing contracts with companies which are found best qualified to perform the work. It is recognized that certain companies have successfully performed work in areas of primary interest to NASA; in some instances, such performance antedates the advent of NASA. These companies have acquired unique technical experience, facilities and equipment, which would cost hundreds of millions of dollars to duplicate. It is a logical consequence, and it is in the best interests of the Government, for these companies to be important participants in NASA programs.

However, NASA is a research and development organization. As such, it is ever mindful of the need for, and importance of, new ideas, techniques, processes, and methods, and, because of this, the opportunities for new companies to participate in its programs are many.

The picture of contractor participation in NASA programs is not a static one. The list of 100 contractors receiving the largest dollar value of NASA awards to business during the first half of fiscal year 1963 includes 41 companies that were not on this list for the first half of the preceding fiscal year. Also, 27 of the contractors on the latest list are small business concerns as against 21 contractors on the earlier list.

NASA monitors the subcontracting of its prime contractors by including clauses in their contracts imposing obligations on them to subcontract to small business concerns or in labor surplus areas, by approving their "make or buy" programs, by approving individual subcontracts of certain amounts or types, and by reviewing their purchasing policies and procedures. Through these means NASA is in a position to prevent the development of fixed

subcontracting patterns by contractors. Reports received on first- and second-tier subcontracts over $10,000 from 12 major prime contractors during the period January 1, 1962, through February 28, 1963, under the NASA postal card reporting system disclose that the 2,405 subcontracts reported on (2,161 first tier and 244 second tier) were awarded to 820 companies. This dispersion is not indicative of a channelizing of subcontracting by major prime contractors

Allegation:

3. There is too great a concentration among too few States. On the $3.7 billion authorization for fiscal year 1963, I understand that 6 States got $2.5 billion channeled through the industry in those States.

Answer:

Table 1 (p. 466) generally supports the statement in the transcript to the effect that of the $3.7 billion authorization for 1963, six States got $2.5 billion channeled through the people in those States. Table 1 presents an estimated distribution of funds by appropriation by State for fiscal years 1961, 1962, and 1963, and it shows that for fiscal year 1963 it is estimated that the States of Alabama, California, Florida, Louisiana, Missouri, and Virginia would get $2,665 million of a total of $3,787 million. However, a subheading of this table points out that the distribution is based on prime contracts and that information on the distribution of subcontracts is not available. A footnote further explains that while the Mercury capsule contract is reflected under the State of Missouri only, a recent survey showed that there were approximately 4,000 subcontracts under the prime contract, which extended into 37 States, Puerto Rico, and Canada.

Table 2 (p. 468) shows how subcontracting results in the geographic dispersion of NASA's procurement dollars. This table presents a distribution of first- and second-tier subcontracts for the period January 1, 1962, to February 28, 1963, based on reports from 12 of NASA's major prime contractors under the postal card reporting system. The total amount of the subcontracts reported was $423.9 million. The first column of dollar figures shows the distribution of this amount based on the principal place of performance of the prime contracts; the total amount is distributed among seven States. The second column of dollar figures shows the net distribution of this amount based on the principal place of performance of the subcontracts; the total amount is now distributed among 38 States. Subcontracting is effective in bringing about a wide geographic dispersion of NASA's procurement dollars.

TABLE 1

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Estimated distribution of funds by appropriation, by State, fiscal years 1961, 1962, and 1963, based on prime contracts, subcontract information not available [1]

[In thousands]

States	Total			Salaries and expenses			Research and development			Construction of facilities		
	1961	1962	1963	1961	1962	1963	1961	1962	1963	1961	1962	1963
Alabama	$141,269	$224,964	$341,935	$47,771	$60,000	$70,370	$67,290	$158,110	$234,028	$26,203	$26,854	$37,537
Alaska	4,392	2,225	1,805				607	980	1,805	3,785	1,245	
Arizona	2,437	3,941	7,262				2,437	3,941	7,262			
Arkansas	27	44	80				27	44	80			
California	306,851	523,922	947,767	19,954	23,050	29,207	274,993	459,289	830,704	11,905	41,583	87,856
Colorado	2,900	26,592	58,646				2,900	26,592	58,646			
Connecticut	4,063	6,575	12,116				4,063	6,575	12,116			
Delaware	49	76	140				49	76	140			
Florida	89,987	209,878	543,262	3,800	5,600	6,500	58,641	94,857	174,799	27,546	109,421	361,963
Georgia	3,244	5,247	9,669				3,244	5,247	9,669			
Hawaii	178	294	542				178	294	542			
Idaho												
Illinois	4,805	7,772	14,323				4,805	7,772	14,323			
Indiana	1,370	2,221	4,092				1,370	2,221	4,092			
Iowa	949	1,535	2,828				949	1,535	2,828			
Kansas												
Kentucky	36	54	100				36	54	100			
Louisiana	88	48,016	395,352		458	1,750	88	46,578	359,102		980	34,500
Maine												
Maryland	48,932	84,499	146,685	16,307	27,516	43,425	23,125	47,463	78,480	9,500	9,520	24,780
Massachusetts	10,165	16,437	30,290				10,165	16,437	30,290			
Michigan	8,079	13,074	24,092				8,079	13,074	24,092			
Minnesota	2,301	3,200	5,898				1,977	3,200	5,898	324		
Mississippi		22,590	95,000			2,500					22,590	92,500
Missouri	47,270	107,260	264,898				47,270	107,260	264,898			
Montana												
Nebraska												
Nevada	55	15,087	40,160				55	87	160		15,000	40,000
New Hampshire	32	54	100				32	54	100			
New Jersey	13,991	22,631	41,704				13,991	22,631	41,704			
New Mexico	1,446	2,340	4,313				1,446	2,340	4,313			
New York	51,181	82,785	152,553				51,181	82,785	152,553			
North Carolina	150	5,254	3,941				150	239	441		5,015	1,300

North Dakota												
Ohio	56,452	79,346	163,619	26,617	30,682	43,260	20,245	46,754	75,536	9,590	1,910	44,833
Oklahoma	374	610	1,123				374	610	1,123			
Oregon	222	359	662				222	359	662			
Pennsylvania	12,773	20,661	38,073				12,773	20,661	38,073			
Rhode Island	92	152	281				92	152	281			
South Carolina												
South Dakota												
Tennessee	1,054	1,709	3,149				1,054	1,709	3,149			
Texas	14,653	111,557	135,284		7,314	30,304	14,653	44,243	73,225		60,000	31,755
Utah	31	54	100				31	54	100			
Vermont												
Virginia	91,670	116,948	171,436	40,793	43,738	43,632	35,170	58,653	102,030	15,707	14,557	25,774
Washington	110	174	321				110	174	321			
West Virginia	1,500	2,500	1,500				1,500	2,500	1,500			
Wisconsin	783	1,263	2,327				783	1,263	2,327			
Wyoming												
District of Columbia	19,037	44,430	85,848	10,729	18,392	29,826	8,308	26,038	56,022			
Various locations	21,733	9,420	34,000							21,733	9,420	34,000
Total	966,731	1,827,750	3,787,276	165,971	216,750	300,764	674,463	1,292,905	2,667,514	126,297	318,095	318,998

[1] For example, Mercury capsule contracts reflected under State of Missouri only. Recent survey shows approximately 4,000 subcontracts under this prime contract which extend into 37 States, Puerto Rico, and Canada.

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TABLE 2

Distribution of NASA 1st- and 2d-tier subcontracts Jan. 1, 1962, to Feb. 28, 1963,[1] summary table

	Distribution of subcontracts based on principal place of performance of prime contracts		State total		Net distribution of 1st- and 2d-tier subcontracts							
					Small business		Large business		Labor surplus areas		Non-labor surplus	
	Amount [2]	Percent of grand total	Amount [2]	Percent of grand total	Amount	Percent of State total	Amount	Percent of State total	Amount	Percent of State total	Amount	Percent of State total
Alabama	$1,512,599	0.4	$435,820	[illegible]	$270,576	62.1	$165,244	37.9	$216,937	49.8	$218,883	50.2
Arizona			4,022,237	.9	73,304	1.8	3,948,933	98.2			4,022,237	100.0
Arkansas			171,558	(3)	26,500	15.4	145,058	84.6			171,558	100.0
California	254,373,138	60.0	207,085,316	48.9	33,027,301	15.9	174,058,015	84.1	1,400,232	.7	205,685,084	99.3
Colorado			1,846,275	.4	69,683	3.8	1,776,592	96.2			1,846,275	100.0
Connecticut			12,717,188	3.0	1,197,380	9.4	11,519,808	90.6	686,388	5.4	12,030,800	94.6
Florida	3,672,706	.6	34,424,710	8.1	499,959	1.5	33,924,751	98.5	95,665	.3	34,329,045	99.7
Georgia			82,219	(3)	58,993	71.8	23,226	28.2			82,219	100.0
Illinois			6,707,030	1.6	1,700,139	25.3	5,006,891	74.7			6,707,030	100.0
Indiana			1,017,368	.2	91,809	9.0	925,559	91.0			1,017,368	100.0
Iowa			12,885,548	3.0			12,885,548	100.0			12,885,548	100.0
Kansas			524,209	.1	135,929	25.9	388,280	74.1			524,209	100.0
Louisiana	8,909,537	2.1	4,774,395	1.1	2,697,833	56.5	2,076,562	43.5	4,704,366	98.5	70,029	1.5
Maryland			12,344,894	2.9	279,084	2.3	12,065,810	97.7			12,344,894	100.0
Massachusetts			19,003,767	4.5	1,956,761	10.3	17,047,006	89.7	248,879	1.3	18,754,888	98.7
Michigan			3,650,177	.9	1,103,053	30.2	2,547,124	69.8	2,963,754	81.2	686,423	18.8
Minnesota			26,237,834	6.2	701,466	2.7	25,536,368	97.3			27,237,834	100.0
Mississippi			28,415	(3)	13,095	46.1	15,320	53.9			28,415	100.0
Missouri	134,095,285	31.6	2,005,239	.5	1,138,224	56.8	867,015	43.2			2,005,239	100.0
Nevada			1,099,452	.3	1,099,452	100.0					1,099,452	100.0
New Hampshire			19,332	(3)	19,332	100.0					19,332	100.0
New Jersey			7,647,172	1.8	1,713,790	22.4	5,933,382	77.6	2,070,429	27.1	5,576,743	72.9
New Mexico			15,576	(3)			15,576	100.0			15,576	100.0
New York	17,846,953	4.2	36,331,477	8.6	2,419,980	6.7	33,911,497	93.3	786,671	2.2	35,544,806	97.8
North Carolina			509,000	.1			509,000	100.0			509,000	100.0
Ohio			5,099,555	1.2	544,772	10.7	4,554,783	89.3	1,596,296	31.3	3,503,259	68.7
Oklahoma			452,113	.1	273,050	60.4	179,063	39.6			452,113	100.0
Oregon			573,250	.1	560,000	97.7	13,250	2.3			573,250	100.0
Pennsylvania			17,309,909	4.1	991,521	5.7	16,318,388	94.3	16,405,247	94.8	904,662	5.2
Rhode Island			68,503	(3)	33,465	48.9	35,038	51.1	68,503	100.0		
Tennessee			78,393	(3)			78,393	100.0	22,812	29.1	55,581	70.9
Texas	4,553,863	1.1	2,080,601	.5	164,966	7.9	1,915,635	92.1			2,080,601	100.0
Utah			256,901	.1	10,000	3.9	246,901	96.1			256,901	100.0

Vermont			41,589	(4)			41,589	100.0			41,589	100.0
Virginia			114,397	(4)	24,192	21.1	90,205	78.9			114,397	100.0
Washington			73,689	(4)	28,160	38.2	45,529	61.8	22,816	31.0	50,873	69.0
West Virginia			724,699	.2	80,048	11.0	644,651	89.0	161,067	22.2	563,632	77.8
Wisconsin			1,404,374	.3	52,967	3.8	1,351,407	96.2			1,404,374	100.0
Total	423,864,081	100.0	423,864,081	100.0	53,056,784	12.5	370,807,297	87.5	31,450,062	7.4	392,414,019	92.6

[1] Reporting program was established August 1962. Retroactive reporting to Jan. 1, 1962, was on a voluntary basis and such reporting is not necessarily complete. This is particularly true with respect to reports on 2d-tier subcontracts.

[2] This column shows the dollar value of the reported 1st-tier subcontracts distributed according to the principal place of performance of the applicable prime contracts.

[3] This column shows the net distribution of the 1st- and 2d-tier subcontracts according to the principal place of performance of the subcontracts. The total dollars are the same as in the 1st column since the 2d-tier subcontracts represent only further distribution of the 1st-tier subcontracts.

[4] Less than 0.05 percent.

Allegation:

4. The center of the country has complained it is practically omitted from the program, and that all the contracts are given out on the east coast and west coast.

Answer:

The largest part by far of NASA's procurement dollars flows into the aerospace and the electronics industries, and the research and development capability in these industries is concentrated in certain geographical areas, principally on the east coast and the west coast. A region that gains a long head start in a new and expanding field of procurement is bound to enjoy an enduring advantage, especially when research and development is a primary element. Factors influencing the location of awards, which are made on the basis of merit, include availability of highly specialized scientific, engineering, and technical manpower, specialized facilities, labor skills, production experience and know-how, together with competence and determination in the presentation of proposals. All these tend to be associated with research and development capability, and their presence fosters the climate in which long-scale research and development may flourish.

NASA heartily endorses the broadening of the base of research and development work throughout the country. By such means as the giving of wide publicity to its procurements and participation in conferences, seminars, and expositions, held in all parts of the United States, NASA contributes to the attainment of this objective. However, since awards are made on the basis of merit, NASA contracts flow into the areas where the capability exists. Thus, the basic responsibility rests with local communities and areas to take the initiative in creating and fostering capability responsive to the research and development needs of the civilian space program.

The development of research and development capability in a new area is usually a gradual process. Further, with respect to individual companies, such capability is commonly developed via the subcontract route. NASA is hopeful that the wide dispersion of subcontracts both on a geographic basis and on the basis of the number of subcontractors participating (both of which matters are discussed in the two comments immediately preceding this one) is indicative of a broadening of the research and development capability base throughout the country.

Allegation:

4. Some cities complain that NASA teams come in to procure scientists, research men, engineers, physicists, etc., and are draining certain areas of scientific talent. The allegation is that by such actions, NASA is centering all R. & D. engineering competence in certain favored areas which are in tremendous booms and that the other areas then are suffering and are not being given adequate consideration.

Answer:

NASA's scientists and engineers are geographically distributed among the following 14 main locations from coast to coast:

Scientists and engineers, by location, as of Dec. 31, 1962

NASA headquarters	477
Langley	1,423
Ames	628
Lewis	1,577
FRC	174
Wallops	59
Goddard	1,190
MSC	1,122
Marshall	2,347
LOC	167
WOO	32
SNPO	36
PLOO	5
NEO	3
Total	9,240

Mr. FULTON of Pennsylvania. I would like to have the number of NASA personnel, both overall and on procurement and supply, and their distribution by States. We have had that previously, and I would like that again for the record.

Mr. SIEPERT. This is the number of people?

Mr. FULTON of Pennsylvania. I would like to have a list of where the NASA employees are employed.

Mr. SIEPERT. Oh, by site of employment? NASA civilian employees?

Mr. FULTON of Pennsylvania. That is right. We have had that previously, and I would like to have it again for the record. I would also like you to add the changes from last year.

(The answer which was submitted is as follows:)

NASA-wide fiscal year 1964 budget estimates—Summary of procurement positions by installation, fiscal year 1962 actual, fiscal year 1963 and fiscal year 1964 estimated

	Actual, fiscal year 1962	Estimated		Change over 1963
		Fiscal year 1963	Fiscal year 1964	
NASA Headquarters	70	86	112	26
Ames	30	48	58	10
Flight research	11	15	17	2
Goddard	177	216	255	39
Langley	91	102	112	10
LOC	47	81	123	42
Lewis	95	137	152	15
MSC	93	195	210	15
MSFC	226	280	310	30
NEO		3	7	4
PLOO				
SNPO				
Wallops	18	21	28	7
WOO	36	66	86	20
Total	897	1,250	1,470	220

Mr. FULTON of Pennsylvania. Another point is having facilities throughout the country, so that large and small business can get procurement opportunities equally.

I think we should have your plan on that, and, secondly, how you could use the installations of the Government, and various other agencies, both military and civilian to provide this adequate coverage. For example, you have a Western Operations Office, now you are going to have a Northeastern Office. As our friend from Indiana points out, there seems to be a vacancy in the middle of the country.

(The information requested is as follows:)

NASA, through its installations and the Offices of the Small Business Administration and the Area Redevelopment Administration, Department of Commerce, located throughout the country, affords equal opportunity to large and small business to secure NASA awards. NASA has 14 offices, located in 8 States and the District of Columbia, at which information on pending procurements may be obtained. At three of these offices—The Office of Procurement, NASA Headquarters, Washington, D.C.; Western Operations Office, Santa Monica, Calif.; and the Northeastern Office, Cambridge, Mass.—there are procurement information offices which receive information copies of all unclassified requests for proposals (RFP) and invitations for bids (IFB), where the cost of the proposed procurement is expected to exceed $10,000, at the time bids or proposals are solicted.

These RFP's and IFB's are available for examination by interested business representatives to determine if the companies they represent are qualified to submit competitive bids or proposals on any of the proposed procurements.

In addition to the above method of publicizing pending procurement, NASA publicizes promptly in the Department of Commerce publication, Commerce Business Daily, every proposed advertised or negotiated procurement to be made in the United States, which may result in an award in excess of $10,000, with certain limited exceptions. Further, all proposed unclassified NASA research and development procurements to be made in the United States which may result in an award of $100,000 or more, except proposed study contracts or proposed contracts with educational or nonprofit institutions, are publicized in the Department of Commerce synopsis. In addition to the information normally included in a synopsis, the names and addresses of all firms which have been invited by NASA to submit proposals are furnished to the Department of Commerce. This procedure enables small business concerns and others interested in subcontracting opportunities under current research and development procurements to contact prospective prime contractors directly during the early stages of procurement.

Since it is not practical for NASA to maintain offices throughout the United States, NASA has instituted procedures for publicizing certain proposed procurements with the Small Business Administration and the Area Redevelopment Administration, Department of Commerce, thereby availing itself of the facilities at the field or regional offices of these agencies. In cases of pending unclassified procurements estimated to cost $250,000 or more, procurement offices are required to forward to the Industry Assistance Officer, NASA Headquarters, advance notice of such procurements, including a detailed description of the work, the estimated cost, the names and locations of the firms to be solicited, the estimated date of issuance of the IFB or RFB, whether a small business or labor surplus set-aside will be made, and any special requirements or unusual aspects of the procurement. The Industry Assistance Officer, NASA Headquarters, notifies the Small Business Administration, the Area Redevelopment Administration, Department of Commerce, and special State representatives who have registered an interest in being advised about such procurements, and invites them to suggest additional sources to be included in the solicitations. The Small Business Administration and the Area Redevelopment Administration develop these additional sources through information furnished by their field or regional offices.

NASA procurement personnel are constantly participating in conferences, seminars, and expositions held in all parts of the United States, at which they deliver talks and offer guidance and advice to those seeking information on NASA procurement procedures and programs.

In these ways NASA is effectively making its procurement programs known throughout the United States.

Mr. FULTON of Pennsylvania. I certainly disagree with one thing you say. On page 3 of your statement you say:

When a contract is negotiated it does not mean that competition is waived; usually it is just as possible to get competition by negotiation as it is by formal advertising.

I hope you will change that idea and that policy.

Another item on page 3 of the statement of Mr. Brackett with which I strongly disagree is:

There are instances when clearly one company should be chosen, and it would be a disservice to other companies to invite competition.

Then, you had said at the bottom of page 3:

In nearly all of the competitive research and development procurements, a source evaluation board is appointed to evaluate the proposals submitted.

I think you should outline to us more carefully how that is done, for example, who is on those boards, and what is your organizational setup, and also where you do not use them.

(The information requested is as follows:)

NASA procurement procedures require the use of source evaluation boards in connection with competitive negotiated procurements for research and development, (i) when the estimated cost of the contract will exceed $1 million; (ii) when

the estimated cost of the contract will not exceed $1 million but it is likely that the source selected will receive other contracts for later phases of the same project, which together with the proposed contract, would total more than $1 million, or (iii) when other factors, such as a requirement to select companies with which to place study contracts, make the use of source evaluation board procedures desirable.

The Associate Administrator appoints the source evaluation board, (i) when the estimated cost of the procurement exceeds $5 million and the approved procurement plan calls for the use of such a board, or (ii) when the head of a field installation has referred a procurement plan to the Associate Administrator for approval, and such plan, as approved, calls for the use of a source evaluation board. In all other instances, the head of the cognizant field installation appoints the source evaluation board when the approved procurement plan calls for the use of such a board.

Since the technical aspects of a research and development procurement are of prime importance, a board is composed chiefly of engineers and scientists familiar with the technical details of the procurement. However, each board also includes one or more representatives of the NASA business management staff. When the source evaluation board is appointed by the head of a field installation, it is customary for at least one representative from the headquarters technical and business management staffs, respectively, to serve on the board.

In the case of procurements of $5 million or more, the chairman of the board is required to appoint a technical committee and a business management committee. In the case of all other procurements, the appointment of such committees is discretionary with the chairman of the board.

These committees are the principal working groups utilized by the board in making a detailed evaluation of the various sources submitting proposals. Their membership is not limited to technical and business personnel of NASA, but may include personnel of other Government agencies qualified in special areas of particular importance in the case of a specific procurement.

The board reviews the statement of work for the procurement under consideration and prepares a statement, known as "General Guidelines for Proposal Evaluation," which (i) sets forth the type of information required to be submitted by each offerer both with respect to the technical aspects and the business management aspects of the procurement, and (ii) contains a list of the factors which will be considered in evaluating proposals, with a word description of the relative importance of these factors. While these factors will vary in certain details from one procurement to another, they generally cover the following:

1. The company's understanding of the scientific and technical problems involved in the proposed research and development project as evidenced by the content of the statement of its proposed technical approach to the project.
2. The qualifications of the engineering, scientific, and other technical personnel who would be assigned to the project.
3. The adequacy of the research, test, and production facilities that would be assigned by the company to the project. Evaluation of this factor would include consideration of the extent to which the company would have to use Government-owned facilities presently in its plants and the extent to which the company would require additional facilities from the Government.
4. The extent of the company's past experience in the chief branches of service or technologies involved.
5. The adequacy of the company's proposed method of achieving requisite reliability.
6. The adequacy of the management organization proposed by the company to administer the project and the extent to which this proposed management organization would have direct access to the company's top management for prompt action on major decisions that could only be made by the company's top management.
7. The adequacy of the company's manpower and financial resources, and the extent of the company's past experience with projects of comparable size.
8. The soundness of the company's proposed subcontracting program.
9. The reasonableness of the company's cost estimate for performance of the work, including the adequacy of the detailed breakdown of costs by elements in support of the overall cost estimate.

The statement of "General Guidelines for Proposal Evaluation" is forwarded to the cognizant procurement office for use in preparing the request for proposals. The request for proposals is reviewed by the board prior to its release by the procurement office to make certain that the request for proposals (i) calls for all

the information, both of a technical and a business management nature, that the board will require for a proper evaluation of proposals, and (ii) alerts offerers to the major factors that will be considered in evaluating proposals and furnishes a verbal indication of the relative importance of these factors. The request for proposals is then sent to those companies considered qualified to submit proposals. However, any company, so desiring may submit a proposal.

Usually, a preproposal briefing is arranged, at which Government technical and business personnel present pertinent information regarding the proposed procurement, and prospective offerers are invited to present questions. Any company having an interest in submitting a proposal may attend the briefing. Personnel in charge of such briefings stress the qualifications, experience, facilities and personnel considered necessary to successfully perform the proposed project in order to make certain that all prospective contractors understand the minimum requirements before incurring the costs of preparing a specific proposal.

Prior to the opening of the proposals received, the board develops a point rating system for the list of factors previously established for evaluation purposes and set forth in the request for proposals. Because of the primary importance of technical considerations, most of the points are assigned to those factors which measure a company's technical qualifications. The point rating system is made known only to those persons who require such information in performing their work for the board.

The technical and business management committees, or the board itself in those cases when such advisory committees are not established, fully investigate and carefully evaluate the qualifications of each responsible company submitting a proposal which is within a competitive range on the basis of the factors established for evaluating the proposals. Such investigation and evaluation include oral or written discussions with each such company, which can take such form as oral presentations by each such company to the board and advisory committees or visits of the board or designated representatives to each such company's plants.

Following evaluation of the proposals, the technical and business management committees report their findings to the board, and the board after completing its evaluation, arranges for an oral presentation to the Administrator or the head of the field installation, depending upon which official is to make the selection of source. Source selection is made by the Administrator whenever the board has been appointed by the Associate Administrator; in all other cases, the authority appointing the board makes the source selection. Official notification of source selection is authority for the procurement office to initiate contract negotiations with the company selected. Award of a contract to the company selected is contingent upon the successful negotiation of a contract considered to be in the best interests of the Government price or cost and other factors considered.

Source evaluation boards are generally not used in connection with competitive negotiated procurements for research and development when the estimated cost of the contract will not exceed $1 million. Source evaluation boards are not used in the case of noncompetitive negotiated procurements for research and development, regardless of the amount.

Mr. FULTON of Pennsylvania. Then, on page 4 of the statement, here is something I would like to question:

Companies which are considered to have the capability to perform the work are invited to submit proposals; however, any company may submit a proposal which will be evaluated on the same basis as those invited.

Down further in the same paragraph you state:

The results of this system are competition, which gives all interested companies an equal opportunity.

That, of course, brings up the question: How many volunteer interested companies have you chosen in the situation where you have invited other companies to bid? Have they actually had any chance, or is that just a hope? You see, you say they all have the chance, and that every one is treated equally. But show us that outside companies who have come in voluntarily and have not been invited have actually received contracts in a situation where you have invited other companies to come in. Thank you very much.

Mr. DADDARIO. Will you put a general reply to that in the record, Mr. Siepert?

Mr. SIEPERT. Yes. Of the items Mr. Fulton asks for, it is only the last one, Mr. Chairman, that gives me pause. I will have to see what is involved. I just don't think the data is available in a way to get it into the hearing early enough.

We can build this into our statistics.

Mr. DADDARIO. On the other items, as I understand it, Mr. Fulton was just disagreeing. As to the last one, if you could supply for the record at some later date a general reply, I think that should be done.

Mr. FULTON of Pennsylvania. The point is that we want an open field in the space industry, not just a chosen group of special friends. I think it is important to find out what volunteer companies have obtained contracts even in an invited list situation. I would doubt if there are any, but there may be just a few. I do not want a list of every contract, but I would like to see some of the situations. There has been very serious criticism that this is getting to be a closed industry.

(The information requested is as follows:)

A review was made of a representative sample of contract awards following source selection by the use of source evaluation board procedures, and no instance was found where award of the contract was made to a company from which a proposal was not solicited by NASA but which submitted a proposal on its own initiative.

The use of source evaluation board procedures is required in connection with competitive negotiated procurements for research and development when the estimated cost of the contract will exceed $1 million. The number of companies with adequate capability in a particular technical specialty to carry out research and development projects of the size involved at and above this dollar level is generally limited and their identity is generally well known so that NASA's mailing lists can be expected to cover the truly competitive field. It is not considered desirable to solicit proposals from companies considered to have a marginal capability, thereby encouraging them to incur the costs of preparing proposals, which can be substantial, when their chances of being the successful proposer are remote.

The source evaluation board procedures permit any company to submit a proposal, if it elects to do so. Any company having an interest may attend the preproposal briefing, when held, at which Government technical and business personnel present pertinent information regarding the proposed procurement and company representatives are invited to present questions. All proposals are carefully evaluated to insure fair treatment to all offerers. The records of the source evaluation board proceedings must show in adequate detail the technical and business reasons affecting the relative rankings of the proposals. The General Accounting Office in its review of NASA operations has unlimited access to the proposals and the source evaluation board's records of its evaluation of the proposals. There has been no instance of a charge by the General Accounting Office that there has been discrimination by NASA against proposers who submit proposals without direct invitation.

Mr. DADDARIO. Mr. Gurney?

Mr. GURNEY. Within your procurement program do you have checking and supervisory personnel?

Mr. SIEPERT. Yes. In the field of procurement?

Mr. GURNEY. Yes. Mr. Brackett might want to comment on that.

Would you supply for the record the number of NASA personnel who are in the checking and supervision field in procurement?

Mr. BRACKETT. We don't have them stationed in the field specifically for day-to-day check. We check how they are doing their job two ways: first, by a sampling of the contracts that they send in for our review and approval, because we see the complete file.

Mr. GURNEY. I am not talking about your procurement. I am talking about the contractors.

Don't you have supervision and checking by NASA personnel?

Mr. SIEPERT. Oh, we insist under the NASA contracts that we have with the prime contractor—we reserve to the Government really two things: one, that we reserve the right to approve their procurement policy, as to how they go about handling the procurement—this is the company's procurement policy.

Secondly, we reserve the right to approve subcontracts that they make above a given dollar level.

This is put in the contract. So that we have the chance, that is contracting officers at our field centers, have the chance to see the proposed subcontract, and how they went about it, before they sign off on it.

Mr. GURNEY. Well, say you procure an engine. Do your people in Procurement and Supply check the manufacture of the engine, the manufacturing process? Do you have supervision and checking personnel in the field?

Mr. SIEPERT. Not——

Mr. BRACKETT. We have so-called reliability and inspection, to see that the items they are producing come up to required standards.

Mr. GURNEY. Are these people under your Procurement Office?

Mr. BRACKETT. Under NASA's jurisdiction, or under the Department of Defense jurisdiction when they are doing this work for us.

Mr. GURNEY. If they are under NASA's jurisdiction, are they under your department?

Mr. SIEPERT. No.

Mr. BRACKETT. No, sir. There is a separate Office of Reliability, that handles that.

Mr. GURNEY. That was the long way around, but that is what I was getting at.

Mr. SIEPERT. On any key item of hardware, Mr. Gurney, where there is new hardware to be developed, the field center will probably have resident technical engineers in there.

Now, they are not quality assurance men, or inspectors, and they are not procurement types. That is why Mr. Brackett answered you in the negative. These are people directly out of the Program Office, that is the project offices.

Mr. GURNEY. These are the people I am really interested in.

Mr. SIEPERT. You would like to get a count of where they are, and——

Mr. GURNEY. Yes.

Mr. SIEPERT. We can get that.

Mr. GURNEY. There was discussion on the matter before, but I was not sure whether they were under your jurisdiction.

Mr. SIEPERT. A substantial number of them, right.

Mr. GURNEY. There is the Government side and the contractor side, of course, to this; there always is.

But I can tell you that many of these contractors are very distressed with NASA's checking. They say that they are being checked more and more and more, and a vast bureaucracy is being built up over what they are doing.

Another point is these companies have to train the people who do the checking; so they have to train the people to do the work, and the people to supervise them, and they contend that this is a waste of time.

The other complaint is that the system of checking keeps growing and growing and they feel that while they must be supervised, at the present time the hierarchy of supervision is growing to the point of strangling the effort. I know there is a real concern among the people actually doing the work; I know that from personal contact.

Mr. SIEPERT. We will be happy to supply the answer.

This is the kind of question on which I feel the subcommittee might well be interested in Mr. Holmes' view on this. We face a fundamental problem of putting together whole major systems, each larger than practically any weapons system, and we have to be able to have them work right; and they have to work right on a research and development test series of less than 10 shots. It is an order of magnitude different from anything else the Government has undertaken. This is the reason I think Mr. Holmes can go into this in more detail.

Mr. GURNEY. There are two sides of the story, of course.

Mr. BRACKETT. You might be interested, Mr. Gurney, in an observation one of our committees made when we went out and talked to some of these prime contractors and asked what they did about putting people into the subcontractor's plant, and found they are doing it more than we are.

And when we asked why, they said: "We have to be sure this is going to work, and that is the only way we can be sure."

Mr. GURNEY. That is precisely their complaint. They say that they have always done the job, but now this hierarchy of checking in NASA is taking over the job they were formerly doing, and there is duplication of effort, waste of manpower, and more cost involved.

Mr. DADDARIO. Would you like answers to these questions, Mr. Gurney?

Mr. GURNEY. Yes, I understand they are going to supply the number of people.

(The information referred to is as follows:)

Quality assurance personnel as of Dec. 31, 1962

Location	Professional	Nonprofessional		Total
		GS	WB	
Marshall	190	192	9	391
Michoud (additional to Marshall strength)	9	33		42
Manned Spacecraft Center:				
At project office at McDonnell	2	5	10	17
At Houston and Downey	5	2		7
At the cape			29	29
Lewis Research Center	15			15
Western Operations Office	8	2		10
NASA-Downey		60		60
Goddard	6			6
Headquarters	2			2
Total	237	294	48	579

Estimated number of NASA personnel assigned to contractor plants as of Dec. 13, 1962

Center	Contractor	Q.A.	Business	Technical	Total
Western Operations Office	Aerojet-General, Azusa	0	2	0	2
Lewis	Aerojet-General, Sacramento	0	2	0	2
Marshall	Arrowhead, Los Angeles	1	0	0	1
Do	Bendix, Teterboro, N.J.	1	0	0	1
Do	Boeing, Wichita, Kans.	1	0	0	1
Do	Cosmic, San Diego	1	0	0	1
Do	Douglas Aircraft Corp., Santa Monica, Calif.	1	0	2	3
Do	Flexonics Corp., Bartlett, Ill.	1	0	0	1
Goddard	General Electric, Valley Forge	0	0	5	5
Lewis	General Dynamics/Astronautics, San Diego, Calif.	4	7	16	27
Marshall	Hayes International, Birmingham	1	0	0	1
Western Operations Office	Jet Propulsion Laboratory, Pasadena.	0	9	0	9
Marshall	LTV, Dallas	2	0	0	2
Langley	do	1	0	0	1
Manned Spacecraft Center	McDonnell, St. Louis	11	4	14	29
Do	MIT, Cambridge	0	1	4	5
Do	NAA, Downey	5	6	14	25
Marshall	do	2	1	1	4
Western Operations Office	do	37	32	0	69
Marshall	NAA, Canoga Park	2	5	1	8
Do	NAA, Neosho, Mo.	1	0	1	2
Do	Pratt & Whitney, East Hartford	1	0	0	1
Do	Pratt & Whitney, West Palm Beach.	9	3	3	15
Goddard	RCA, Princeton, N.J.	0	0	5	5
Marshall	Republic Aviation, Long Island	1	0	0	1
Langley	do	1	0	0	1
Marshall	Solar Aircraft Corp., San Diego	1	0	0	1
Headquarters, Procurement Branch OMSF.	GE-Daytona Beach, Fla.	0	2	0	2
Manned Spacecraft Center	Grumman Aircraft Corp., Bethpage, N.Y.	0	3	5	8
Total		84	77	71	232

Mr. ROUDEBUSH. Mr. Chairman.

Mr. DADDARIO. Mr. Roudebush.

Mr. ROUDEBUSH. You are going to furnish me a list of the contracts in various States, I understand.

Mr. BELL. I object, Mr. Chairman.

Mr. ROUDEBUSH. For the record—not for me personally. I would like to have a list of the prime contracts and a list of your subcontracts. If it is being objected to in committee, would you supply it to me personally?

Mr. DADDARIO. Why not supply that and we will take a look at it to see if there is objection to putting it in the record.

Mr. BELL. As I understand it, Mr. Chairman, this will be strictly the prime contractors, is that right?

Mr. DADDARIO. No; the prime contractors and the full report of the postal survey, which I understand from Mr. Siepert, would give a pretty good indication of where the subcontract goes.

Mr. SIEPERT. First returns are from the 12 major primes; so it is a big segment of the program.

Mr. BELL. The only question in my mind, Mr. Chairman, was whether it would be adequate to show the subcontract assignments. If I may reserve the right to object——

Mr. DADDARIO. You may reserve the right to object. We will have the report. Mr. Roudebush can look at it, and we will all look at it. After you have looked at it, you may decide whether you want to object.

Mr. FULTON of Pennsylvania. I believe NASA has already put out a statement publicly on research and development contracts, as to the locations by States. I would like that in the record.

(The information referred to is shown on page 466 as table 1, "Estimated Distribution of Funds by Appropriation, by State, Fiscal Years 1961, 1962, and 1963.")

Mr. FULTON of Pennsylvania. Second, I would like to join with my good friend from Indiana in disagreeing with my good friend from California. I think that we should have the statements that have been requested by the gentleman from Indiana put in the record, with the necessary qualifications, of course, that NASA might feel were advisable in order to have the casual or the professional reader give proper weight to the statement.

I think from the statistical point of view it should be pointed out where they do cover and where they do not, so that it satisfies both the gentleman from Indiana and the gentleman from California.

Mr. BELL. Would the gentleman yield?

Mr. FULTON of Pennsylvania. Yes.

Mr. BELL. It was my understanding that Mr. Siepert and Mr. Brackett stated that they could not give a full coverage of the subcontractors. He stated that a large percentage of the prime contracts are subcontracted out of State, and he said also that he could not give a thorough coverage of the subcontractors.

My point is, if he cannot give a thorough and accurate picture of the subcontractors, it appears to me that it would be unfair to give just the prime contractors and an estimated amount of subcontractors, when the fact is that maybe he does not have accurate knowledge of the amount of subcontractors left out, or where they are.

Mr. DADDARIO. Mr. Bell, the Chair has already ruled as to how this matter will be determined. It will be determined at a later time.

If there is no objection, we offer to you, Mr. Siepert, a series of questions entitled "General Questions re Procurement and Contract Policy," and two additional questions entitled "General Questions re Procurement Construction Procedures," which we would like to have you answer for the committee. Mr. Yeager will give these to you.

We would like you to answer these questions so that we might have the answers for the record.

(The material referred to is as follows:)

QUESTIONS RE PROCUREMENT AND CONTRACT POLICY

SUBCOMMITTEE ON MANNED SPACE FLIGHT, COMMITTEE ON SCIENCE AND ASTRONAUTICS, MARCH 25, 1963

Question 1. Mr. Siepert remarks in his statement that the Annual Procurement Report for fiscal year 1962 has recently been printed. Is it necessary that this report lag so far behind the close of the fiscal year?

Answer. The Annual Procurement Report for fiscal year 1962 was published in January 1963. The extended interval between the close of the fiscal year and publication of the report was attributable to changes in internal NASA management procedures and the priority of other more urgent reports. The fiscal year 1961 annual procurement report was published in September 1961, and it is envisioned that the fiscal year 1963 report will be published in September 1963.

Question 2. What is the actual percent and the projected percent of NASA funds going to contractors for fiscal year 1963?

Answer. During the first 6 months of fiscal year 1963, 91 percent of NASA's funds were spent by contract, and it is estimated that expenditures by contract will continue at that rate for the balance of fiscal year 1963.

Question 3. Does each of NASA's centers have a contracting officer or a contracting officer's representative?

Answer. Each of NASA's centers has at least one contracting officer and one contracting officer's representative.

Question 4. What are the four other NASA offices which do contracting for the Agency?

Answer. The four NASA offices, other than the eight NASA Centers, which do contracting for NASA are—

1. Headquarters Procurement Branch, Washington, D.C.
2. Western Operations Office, Santa Monica, Calif.
3. Wallops Station, Wallops Island, Va.
4. Space Nuclear Propulsion Office (a joint AEC–NASA office), Germantown, Md.

Question 5. What is meant by "major contracts" which must be reviewed and approved by NASA headquarters?

Answer. The term, "major contracts," as used by Mr. E. W. Brackett, Director, Procurement and Supply, NASA, in the paragraph starting at the top of page 2 of his prepared statement to the subcommittee, means negotiated contracts or modifications which individually would obligate the Government to amounts in excess of the contracting authority granted to the NASA installation making the award. The limits of contracting authority presently in effect and the NASA installations to which they apply are set forth below:

(*a*) Flight Research Center, Wallops Station, $100,000.

(*b*) Ames Research Center, Launch Operations Center, $500,000.

(*c*) Goddard Space Flight Center, Headquarters Procurement Branch, Langley Research Center, Lewis Research Center, Manned Spacecraft Center, Marshall Space Flight Center, Western Operations Office, Space Nuclear Propulsion Office.[1] $1,000,000.

Question 6. Does each NASA contracting officer at its various centers have legal counsel immediately available?

Answer. NASA contracting officers at its various centers and offices have legal counsel immediately available, with two exceptions. Wallops Station, Wallops Island, Va., looks to Langley Research Center, Hampton, Va., for legal counsel, and Flight Research Center, Edwards, Calif., looks to Western Operations Office, Santa Monica, Calif., for legal counsel. An attorney from Langley or Western Operations is able to handle the present workload at Wallops or Flight Research, respectively, by a 1-day visit every 2 weeks. During the periods between such visits, any matters requiring special attention are handled by telephone or by speak trips between the installations concerned.

Question 7. It is stated that 64 percent of NASA contracts for fiscal year 1962 were negotiated. Does this percent refer to the number of contracts or dollar figures?

Question 8. It is stated that 14 percent of the fiscal year 1962 contracts were negotiated with educational institutions. Does this refer to the number of contracts or the dollar amounts? Can the dollar amounts be supplied for the record?

Answer. These questions refer to the following statements, included in the prepared statement of Mr. E. W. Brackett, Director, Procurement and Supply, NASA, to the subcommittee, starting at the bottom of page 2 of that statement:

"In fiscal year 1962, 64 percent of our contracts were negotiated under the authority of 10 United States Code 2304(a)(11) which authorizes procurement by negotiation for research and development. Fourteen percent of our contracts were negotiated with educational institutions under the authority of 10 United States Code 2304(a)(5)."

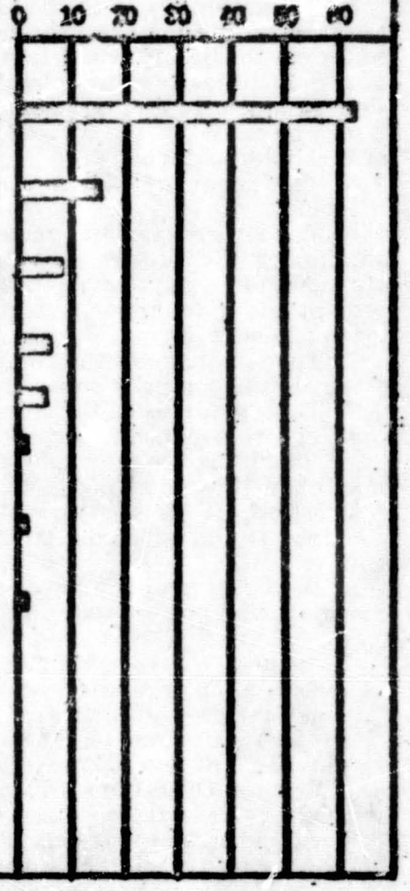
The percentages refer to dollar amounts obligated, and the dollar amounts are $732,370,000 in the case of 10 United States Code 2304(a)(11) and $164,507,000 in the case of 10 United States Code 2304(a)(5). Below is a listing of dollar amounts obligated and percentages of the total for all negotiation authorities used in fiscal year 1962.

[1] Approval of negotiated contracts or modifications in excess of $1,000,000 each require the prior approval of NASA or AEC headquarters, depending upon the fund source.

Negotiation authority—all direct actions

FISCAL YEAR 1962

	Authority 10 USC 2304 (a)	Thousands of Dollars	
	Total	$1,141,492	100
(11)	Research and Development	732,870	64
(8)	Educational Institutions	164,807	14
(10)	Advertising Impracticable	86,730	8
(1)	National Emergency	65,642	6
(3)	$2,500 or Less	61,444	5
(17)	Otherwise Authorized by Law	11,737	1
(4)	Personal or Professional Services	6,373	1
(14)	Substantial Initial Investment Required	6,021	1
(6)	Outside the United States	4,825	*
(2)	Public Exigency	2,729	*
(15)	Negotiation After Advertising	4	*



*Less than one-half of one percent.

Question 9. Under the theory that McDonnell was chosen for the Gemini spacecraft because of its experience with Mercury, why shouldn't McDonnell also have been selected for at least one Apollo module?

Answer. The Apollo spacecraft represents a marked increase in complexity and state-of-the-art development over that required for Mercury. The differences between Apollo and Mercury are such that all qualified contractors who had studied the Apollo mission were essentially at the same status of preparation for undertaking the Apollo spacecraft development activity. On the other hand, the Gemini spacecraft is truly a direct extension of Mercury technology and in many aspects represents only an improvement and increase in sizing of particular components. The shape and aerodynamic characteristics of Gemini, which is designed to reenter at orbital velocity as was Mercury, are identical with those of the Mercury spacecraft. (Answer supplied by Mr. P. E. Cotton, Office of Manned Space Flight.)

Question 10: Can you give examples of the criteria used in evaluation of proposals by source evaluation boards?

Answer. Examples of criteria used by a source evaluation board in evaluating proposals follow:

1. The company's understanding of the scientific and technical problems involved in the proposed research and development project as evidenced by the content of the statement of its proposed technical approach to the project.

2. The qualifications of the engineering, scientific, and other technical personnel who would be assigned to the project.

3. The adequacy of the research, test, and production facilities that would be assigned by the company to the project. Evaluation of this factor would include consideration of the extent to which the company would have to use Government-owned facilities presently in its plants and the extent to which the company would require additional facilities from the Government.

4. The extent of the company's past experience in the chief branches of service or technologies involved.

5. The adequacy of the company's proposed method of achieving requisite reliability.

6. The adequacy of the management organization proposed by the company to administer the project and the extent to which this proposed management organization would have direct access to the company's top management for prompt action on major decisions that could only be made by the company's top management.

7. The adequacy of the company's manpower and financial resources, and the extent of the company's past experience with projects of comparable size.

8. The soundness of the company's proposed subcontracting program.

9. The reasonableness of the company's cost estimate for performance of the work, including the adequacy of the detailed breakdown of costs by elements in support of the overall cost estimate.

Question 11. If a company is not invited to bid on a given NASA proposal, how may it find out about the invitation? Is this done by public notice? If so, how?

Answer. A company may find out about a pending NASA procurement, even though it was not invited to bid, by—

1. Reading the Department of Commerce publication, "Commerce Business Daily," in which NASA publicizes promptly every proposed advertised or negotiated procurement to be made in the United States, which may result in an award in excess of $10,000, with certain limited exceptions;

2. Visiting one of NASA's three procurement information offices—located in the Office of Procurement, NASA Headquarters, Washington, D.C.; Western Operations Office, Santa Monica, Calif.; and the North Eastern Office, Cambridge, Mass.—which receive at the time of issuance by the originating procurement office, and make available for examination, information copies of all unclassified requests for proposals (RFP) and invitations for bids (IFB), where the cost of the proposed procurement is expected to exceed $10,000; and,

3. Visiting the NASA procurement office which originated the RFP or IFB, when known, and requesting information on the RFP or IFB.

Question 12. What percent in dollar volume of procurement in fiscal year 1962 was let on a competitive lump-sum basis?

Answer. Under NASA's reporting system, information is readily available on the percentage and dollar value of NASA's direct awards to business that were placed on a competitive basis. Information is also readily available under NASA's reporting system on awards of $25,000 and over that were placed on a firm fixed-price (lump sum) basis. However, NASA does not regularly compile data showing the percentage and dollar value of direct awards that were both competitive and firm fixed price.

For purposes of responding to this question, an examination was made of all contracts of $100,000 and over with business firms that were not fiscally complete as of June 30, 1962. Awards under these contracts totaled $853 million during fiscal year 1962, and $60 million, or 7 percent, of these awards were both firm fixed price and competitive.

Question 13. It is stated that NASA uses the fixed-price form of contract when it is possible to fairly determine the cost. What factors, other than the purchase of standard items, may be a basis for determining such cost?

Answer. Other factors that may be a basis for determining the reasonableness of costs and thereby make possible the use of the firm fixed-price type of contract are—

1. The item, or a reasonable equivalent, has been previously procured, probably under a cost-reimbursement type of contract, and both production and cost experience has been generated. Such cost experience could offer a

basis for predicting costs under the new procurement with reasonable certainty.

2. The item, or a reasonable equivalent, has been previously fabricated in-house, and the production and cost experience generated offer a basis for estimating costs under the new procurement with reasonable certainty.

3. The item is an assembly of components which have been previously procured or fabricated in-house, and little development in involved. Here again, past production and cost experience could offer a basis for reasonably estimating costs under the new procurement.

4. Reasonably definite specifications are available to solicit competitive proposals supported by cost breakdowns from a number of prospective contractors. Analyses of the cost breakdowns and comparison of one with another could offer a basis for arriving at a reasonable estimate of costs under the new procurement.

Question 14. What percentage of NASA contracts for fiscal year 1963 are of the conventional incentive type? Is this type of contract inclined to result in high cost because of the lack of history on cost or performance?

Answer. Thus far in fiscal year 1963 and prior fiscal years NASA has placed eight contracts of the conventional-incentive type, that is, either fixed-price-incentive (FPI) or cost-plus-incentive-fee (CPIF) contracts. In the conventional-incentive type of contract, cost and performance targets are established in the contract. If a contractor can successfully better these targets he receives an extra profit, but if he fails to come up to the targets he loses profit, all in accordance with a formula set forth in the contract. In order to fix fair targets it is necessary to have past cost and performance data. Since NASA's projects are for the most part new and involve hardware never before produced, this past information is not usually available.

Use of this type of contract in situations where adequate past cost and performance data are lacking could result in the establishment of unrealistically high target costs. In such cases, a contractor could realize a profit windfall without any special effort on his part to effect more efficient performance.

Question 15. What type of people usually sit on NASA's contractor performance evaluation boards?

Answer. Since the technical aspects of a research and development procurement are of paramount importance, a source evaluation board is composed chiefly of NASA engineers and scientists familiar with the technical details of the procurement and expert in the technologies involved. Each board also includes one or more representatives of NASA's business management staff—that is, persons qualified in such areas as procurement, financial management, and cost and price analysis. When procurement responsibility for the project involved is assigned to a field installation, the source evaluation board appointed to evaluate proposals customarily includes at least one representative from each of NASA headquarters technical and business management staffs. In addition to NASA personnel, employees of the Jet Propulsion Laboratory (JPL) and other Government departments or agencies are eligible for appointment to NASA source evaluation boards.

Question 16. What percent of NASA contract administration is done by other Government agencies? Who does this work and what volume is handled in this way?

Answer. During fiscal year 1962, 721 new cost-reimbursement-type contracts of $25,000 or more were awarded directly to business and nonprofit institutions or organizations. The net value of these contracts totaled approximately $280 million.

Approximately 25 percent of the total number of contracts awarded in fiscal year 1962 were assigned to the Department of Defense for secondary contract administration. The following chart shows the number and net value of contracts assigned to other Government agencies for secondary contract administration:

	Number of contracts assigned	Percent of total number	Net value of contracts assigned	Percent of total dollar awards
Air Force	121	17	$48,609,000	17.3
Army	6	1	1,254,000	.4
Navy	54	7	8,280,000	3.0
Total	181	25	58,142,000	20.7

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Question 17. It is stated that in fiscal year 1962, about 21 percent of NASA's contract dollars were spent through other Government agencies. Can you give us a breakdown of this by Government agency?

Answer. A breakdown of that portion of the 21 percent or $321,760,000 placed with or through other Government agencies for actions of $25,000 and over in fiscal year 1962 is attached. A breakdown is not available for a small portion of the 21 percent involving actions of less than $25,000.

VI. PURCHASES AND CONTRACTS PLACED WITH OR THROUGH OTHER GOVERNMENT AGENCIES

(a) *Distribution by agency.*—As shown in the following table, approximately 51 percent of the dollar value of the actions placed with or through other Government agencies was placed with or through the Air Force; about 33 percent was placed with or through the Army, 4 percent with or through the Navy, and 6 percent with other Government agencies. The remaining 6 percent represented actions of less than $25,000. Placement statistics by agency are not complied on these smaller actions.

Purchases and contracts placed with or through other Government agencies, fiscal year 1962

	Net value	
	Thousands of dollars	Percent of total
Total	321,760	100
$25,000 and over:	303,560	94
Air Force	166,878	51
Army	104,801	33
Navy	13,520	4
Atomic Energy Commission	4,823	2
Interior Department	487	(1)
Commerce Department	2,947	1
General Services Administration	1,060	(1)
Miscellaneous	9,624	3
Under $25,000	18,200	6

[1] Less than ½ of 1 percent.

The extensive procurement through the Department of Defense reflects NASA's policy to avoid duplication of effort and to achieve the most effective and economic utilization of DOD and NASA resources. NASA procures through DOD those items which the military departments, because of their own programs, can most economically contract from industry.

Question 18. It is stated that NASA's 9 largest contractors have placed first tier subcontracts in 46 States. Can you show the dollar volume which went to each State?

Answer. This question refers to a special study made for calendar year 1961. The information requested is shown in the table below.

Geographical distribution of NASA 1st-tier subcontracts awarded by 9 major prime contractors, calendar year 1961

[In thousands]

State	Total	State	Total
California	$40,852	Nevada	(1)
Missouri	1,261	North Carolina	$89
Alabama	594	New Hampshire	24
New York	22,627	Hawaii	56
Florida	11,398	Oregon	24
Texas	1,143	Washington	390
Maryland	16,390	South Dakota	
Pennsylvania	11,010	Rhode Island	200
New Jersey	5,744	Utah	18
Ohio	4,261	Alaska	
Massachusetts	1,992	Arkansas	173
Virginia	194	Delaware	28
Michigan	3,252	Kentucky	294
Illinois	3,808	Idaho	
Connecticut	4,864	Kansas	12
Colorado	45	Maine	78
Georgia	683	Mississippi	(1)
Minnesota	3,353	Montana	(1)
Tennessee	224	Nebraska	10
Wisconsin	671	North Dakota	
Louisiana	5	South Carolina	3
Indiana	1,547	Vermont	6
Arizona	374	West Virginia	128
New Mexico	19	Wyoming	1
Oklahoma	14		
District of Columbia	788	Total	140,625
Iowa	2,038		

[1] Less than $500.

Question 19. NASA's recent postal card reports show over 2,000 subcontracts totaling over $400 million placed in 37 States. Can you break this dollar volume down by States?

Answer. The information requested is set forth in the following table.

Distribution of NASA 1st- and 2d-tier subcontracts, Jan. 1, 1962, to Feb. 28, 1963,[1] based on reports from 12 of NASA's major prime contractors

State [2]	Amount	Percent of grand total	State [2]	Amount	Percent of grand total
Alabama	$435,020	0.1	New Hampshire	$19,332	(3)
Arizona	4,022,237	.9	New Jersey	7,647,172	1.8
Arkansas	171,558	(3)	New Mexico	15,576	(3)
California	207,085,316	48.9	New York	36,331,477	8.6
Colorado	1,846,275	.4	North Carolina	509,000	.1
Connecticut	12,717,185	3.0	Ohio	5,099,555	1.2
Florida	34,424,710	8.1	Oklahoma	452,113	.1
Georgia	82,219	(3)	Oregon	573,250	.1
Illinois	6,707,030	1.6	Pennsylvania	17,309,909	4.1
Indiana	1,017,368	.2	Rhode Island	68,503	(3)
Iowa	12,885,548	3.0	Tennessee	78,393	(3)
Kansas	524,209	.1	Texas	2,080,601	.5
Louisiana	4,774,395	1.1	Utah	256,801	.1
Maryland	12,344,894	2.9	Vermont	41,589	(3)
Massachusetts	19,003,767	4.5	Virginia	114,397	(3)
Michigan	3,650,177	.9	Washington	73,689	(3)
Minnesota	26,237,834	6.2	West Virginia	724,699	.2
Mississippi	28,415	(3)	Wisconsin	1,494,374	.3
Missouri	2,005,239	.5			
Nevada	1,099,452	.3	Total	423,864,061	100.0

[1] Reporting program was established August 1962. Retroactive reporting to Jan. 1, 1962, was voluntary basis and such reporting is not necessarily complete. This is particularly true with respect to reports on second-tier subcontracts.

[2] Principal place of performance of subcontracts.

[3] Less than 0.05 percent.

Question 20. To what extent does NASA require prime contractors to monitor their subcontracts from the standpoint of giving consideration to the national economy?

Answer. NASA imposes important requirements on prime contractors to monitor their subcontracts from the standpoint of giving consideration to the national economy by including various clauses in their contracts. Thus, in order to comply with the provisions of the Buy American Act which requires that in the procurement of supplies and services only domestic source end products shall be acquired for public use except under certain circumstances, NASA inserts a "Buy American Act" clause in contracts for supplies and services. NASA requires its prime contractors to assume an affirmative obligation to subcontract with small business concerns by including certain clauses in their contracts. All contracts which are expected to exceed $5,000, with certain limited exceptions, contain the "utilization of small business concerns" clause which requires the contractor to accomplish the maximum amount of subcontracting to small business concerns consistent with the efficient performance of the contract. In the case of contracts which are expected to exceed $500,000 and which the contracting officer believes offer substantial subcontracting possibilities, the "small business subcontracting program" clause is also included. This clause requires the contractor to establish and conduct a small business subcontracting program which will enable small business concerns to be considered fairly as subcontractors and suppliers under the contract. Contractors are required to report semiannually to NASA on their subcontracting programs under this clause. To offer assistance to labor surplus areas, NASA includes the "utilization of concerns in labor surplus areas" clause in all contracts which are expected to exceed $5,000, with certain limited exceptions. This clause requires the contractor to use his best efforts to place subcontracts in areas of persistent or substantial labor surplus where this can be done, consistent with the efficient performance of the contract, at prices no higher than are obtainable elsewhere. NASA includes the "competition in subcontracting" clause in all negotiated contracts over $10,000, except firm fixed-price contracts where award is on the basis of effective price competition, or where prices are established by law or regulation. This clause requires contractors to select their subcontractors on a competitive basis to the maximum practical extent.

Question 21. How does the dollar volume of space contracts going to small business compare with the President's objectives for fiscal year 1962? What is the outlook for fiscal year 1963?

Answer. NASA believes that it met the President's objective for fiscal year 1962 to increase the opportunities for participation of small business in Government procurement to the maximum extent consistent with the nature of the projects and programs involved. In fiscal year 1962, NASA placed approximately $123 million of purchases and contracts directly with small business firms. This was $58 million or 89 percent more than total direct awards to small business in fiscal year 1961.

However, despite this actual dollar increase, small business' share of NASA's total direct dollar awards to business, both large and small, decreased from 15 percent in fiscal year 1961 to 12 percent in fiscal year 1962. NASA believes that the nature of its large research and development projects is such as to make it impossible for small business concerns to secure direct awards for such projects. The 10 largest contracts in terms of aggregate value of awards during fiscal year 1962 accounted for 35 percent of the total direct dollar awards to business during that fiscal year. These contracts are primarily for the development of major systems and major items of hardware which require technical and physical resources generally beyond the capability of small business firms on a prime-contract basis. Excluding the aggregate value of awards under these contracts during fiscal year 1962, small business received 18 percent of total direct dollar awards to business during fiscal year 1962.

For the first 6 months of fiscal year 1963, NASA placed approximately $71,600,000 of purchases and contracts directly with small business firms. This is equivalent to 9 percent of NASA's total direct dollar awards to business, both large and small. The 10 largest contracts in terms of aggregate value of awards during this 6-month period accounted for 46 percent of the total direct dollar awards to business during the period. Excluding the aggregate value of awards under these contracts during the first half of fiscal year 1963, small business received 16 percent of total direct dollar awards to business during this period.

Question 22. Would you comment on the limitations imposed on overhead costs for grants to nonprofit institutions for basic research?

Answer. NASA believes that the position of President Kennedy, as outlined in his letter of May 23, 1962, to Congress, is a reasonable course for the Government as a whole to follow in dealing with the universities. This letter as you may recall states opposition to the imposition of any rigid ceilings in terms of any given percentage.

Question 23. Could these limitations be removed without any added risk of additional costs?

Answer. NASA does not believe that there will be any great increase in governmental cost if these limitations are removed. We feel it is more likely that whenever schools may suffer because the limitations does not allow them to recover costs, they will conserve non-Federal funds by taking a smaller amount of Federal grants. This, of course, would hurt the particular Government program involved.

Question 24. What has your experience been, administratively, since this condition was imposed?

Answer. It has been our experience that where the bulk of the costs are essentially salaries and wages the application of the limiting factor of 25 percent has resulted in hardship to the institution in a number of instances.

Question 25. Describe the safeguards inherent in the NASA contracting procedures to prevent intentional low estimates by contractors.

Answer. Safeguards against intentional low estimates by contractors exist at different stages of the procurement process. Thus;

1. In-house estimates of costs are made starting prior to approval of the program, and these cost estimates are continuously updated as more program information becomes available up to the time the request for proposal is issued.

2. After receipt of proposals and during their evaluation prior to negotiation:

(*a*) In evaluating prospective contractors for performance of a research and development project, technical considerations are of paramount importance and cost considerations of secondary importance, since in the last analysis the company that is best qualified technically is usually able to perform the work in a timely and economical manner. Thus, the cost estimate in the case of a research and development procurement is of importance primarily for determining the prospective contractor's understanding of the project and his ability to organize to perform the work, and the likelihood that a low estimate by a contractor would be a controlling factor in his selection is remote.

(*b*) Comparisons are made, by cost components, between the cost estimates of the various offerors, and between such cost estimates and the latest in-house estimate.

(*c*) Analysis and evaluation of the cost estimate supporting each proposal. In this analysis and evaluation, comparisons are made with previous cost estimates submitted by the contractor, use is made of cost information in current audit reports of the contractor's operations, and spot checks may be requested of Government auditors in the field to confirm such items as labor rates, and overhead and general and administrative cost rates used by the contractor in preparing his estimates.

(*d*) Review of available information on and evaluation of the contractor's cost estimating and cost control systems.

(*e*) Review of the contractor's past history, if any, of cost overruns, and evaluation of the justification for such cost overruns.

3. During negotiation of the contract:

(*a*) Additional, intensive analysis of the contractor's cost estimate. This could involve in-house technical evaluation of the contractor's estimates of the types and quantities of technical effort required to do the work. It would also involve further validation by pricing and audit personnel of material cost estimates, labor rates, overhead and general and administrative cost rates, and special cost factors included in the contractor's estimate.

(*b*) The mandatory requirement that the cost estimate used as a basis for negotiating fixed fee for the original scope of work will not exceed the contractor's original cost estimate for that scope of work, and that additional fee will be allowed only on estimates of additional costs generated by new scope of work developed prior to definitization of the contract.

Question 26. Define the NASA procedures and methods of determining responsiveness and reasonableness of bid proposals submitted by contractors.

Answer. NASA's procedures and methods of determining the responsiveness and reasonableness of proposals submitted by contractors involve the combined efforts of technical, legal, and business management (that is, persons qualified in

such areas as procurement, financial management, and cost and price analysis) personnel.

In the case of competitive negotiated procurements for research and development when the estimated cost of the contract will exceed $1 million, source evaluation boards are used. A detailed description of source evaluation board procedures has been furnished to this subcommittee for insertion in the record at page 580 of the transcript. As explained therein, the board, which is composed of technical and business management personnel, and its technical and business committees carefully evaluate the proposals submitted on the basis of the technical and business criteria established for such evaluation. The evaluation submitted by the board to the Administrator or the head of an installation, as appropriate, gives the selection officer an excellent basis for selecting the contractor most likely to perform the required research and development at a reasonable cost to the Government within the projected time schedule.

Where source evaluation board procedures are not used, the responsiveness and reasonableness of bid proposals submitted by contractors are made on a team-concept basis. The contracting officer is responsible for performing, or having performed, all administrative actions necessary for effective contracting. In discharging this responsibility, he avails himself of the services of NASA specialists in the fields of contracting, finance, law, cost analysis, engineering, system reliability, and audit to the extent considered necessary. Technical evaluation and business evaluation of the proposals are made to determine their responsiveness and reasonableness. With respect to the evaluation of the reasonableness of proposals submitted, this agency's answer to written question 26 describes in detail the safeguards inherent in the NASA contracting procedures to prevent intentional low estimates by contractors.

Question 27. Provide for the record a list of all contracts over $5 million from fiscal year 1961 to date that have had to be renegotiated as a resutl of initial low contractor estimates. List by firm, original contract date, renegotiation date, original contract amount, renegotiated contract amount, and brief résumé of reasons for renegotiation.

Answer. Attached hereto are tables summarizing by NASA installations increases in the contract amounts of major contracts from date of award to approximately March 31, 1963. While these were originally prepared to respond to a request for information from another subcommittee of the Committee on Science and Astronautics, House of Representatives, it is believed they are substantially responsive to the subject question. Major contracts have been generally defined for the purposes of these tables as those which at the time of award had a contract amount of $5 million or more. Contracts executed prior to fiscal year 1961 are included in the attached list.

Increases in contract amounts since award are set forth in two categories; namely, (*a*) those due to the inclusion in the contract of additional work, which include increases due to changes within the existing scope of work as well as increases due to additions of new scope of work to the contract; and (*b*) those due to cost overruns. Where the contract is a letter contract, the dollar amount set forth is the amount funded under the letter contract as of March 31, 1963, rather than an estimate of what the amount of the definitive contract may be, because of the potential for inaccuracy in any estimate developed prior to agreement between the parties on the scope of work for the definitive contract and because of the inadvisability of publicizing information on the estimated amount of a contract prior to its definitization.

Many of these contracts involve numerous modifications which individually change the contract amount. Individual identification and description of these modifications, in order to be fully responsive to the subject question, would in this agency's opinion involve a disproportionately large amount of effort for the value of the resulting detail. However, if additional information is desired, NASA will use its best efforts to fulfill such desire.

Summary of increases in contract amounts of major contracts

GODDARD SPACE FLIGHT CENTER

Contractor	Contract No.	Description of work	Total contract amount at time of award	Actual increases to date—		Total contract amount to date
				Due to additional work	Due to cost overruns	
Grumman Aircraft Engineering Corp.	NAS5-814	Orbiting astronomical observatory	$32,050,000	$1,593,096	$23,666,062	$57,309,158
Space Technology Laboratories, Inc.	NAS5-899	Orbiting geophysical observatory	24,334,108	319,280	10,228,695	34,882,083
Hughes Aircraft Co.	NAS5-1560	Syncom I	4,889,000	2,825,936	2,150,000	9,864,936
Philco Corp.	NAS5-1757	40-foot X-Y tracking antenna systems	5,462,689	351,955		5,814,644
RCA	NAS5-1272	Relay	4,990,000	2,445,000	4,125,801	11,556,801
Do.	NAS5-877	Nimbus	2,127,500	1,744,187	5,419,031	9,290,718
Bendix Field Engineering Corp.	NAS5-734	Minitrack maintenance and operation	11,026,108			11,026,108
Do.	NAS5-1426	Mercury network	5,767,637	6,966,360		12,733,997
General Electric Co.	NAS5-978	Nimbus	8,482,185	2,062,225	4,000,000	14,544,410
Do.	NAS5-746	Integration of Nimbus subsystem	1,515,710	574,872	5,257,259	7,347,841
Motorola, Inc.	NAS5-1926	Goddard range and range rate system	4,261,058	312,130	501,000	5,074,188
Space Technology Laboratories, Inc.	NAS5-1302	Systems coordination and planning for project relay.	4,836,528	130,275		4,966,803

HEADQUARTERS PROCUREMENT BRANCH

Bellcomm, Inc.	NASw-417	Provision of systems analysis and study, planning, and technical support to Office of Manned Space Flight, Headquarters, NASA.	$8,562,000			$8,562,000
General Electric Co., Apollo Support Department.	NASw-410 (letter contract).	Provision of integration, reliability, and checkout support for Apollo program.	[1] 16,398,500			[1] 16,398,500

LANGLEY RESEARCH CENTER

Republic Aviation Corp.	NAS1-1945	Research, develop, design, fabricate, and support launch operations of reentry package subsystem for Project FIRE.	$5,000,000	$21,062		$5,021,062
Western Electric Co., Inc.	NAS1-430	Project Mercury tracking and ground instrumentation system.	33,058,690	20,792,938	$15,192,610	68,960,238
Chance Vought Corp., division of Ling-Temco-Vought, Inc.	NAS1-1295	Design, fabricate, ground test, and assembly of 14 Scout research vehicles.	8,651,000	8,889,368		17,540,368
Do.	NAS1-960	Design, fabricate, ground test, instrument assembly, and prepare for launch of 5 Scout research vehicles.	5,557,017	1,722,754	442,384	7,722,155

[1] Letter contract funding as of Mar. 31, 1963.

Summary of increases in contract amounts of major contracts—Continued

LEWIS RESEARCH CENTER

Contractor	Contract No.	Description of work	Total contract amount at time of award	Actual increases to date—		Total contract amount to date
				Due to additional work	Due to cost overruns	
General Dynamics Corp., Astronautics Division.	NAS3-3232 (letter contract).	Fabricate and deliver certain development vehicles and support equipment; flight readiness programs; support and sustain a development program and systems integration.	[1] $20,413,000			[1] $20,413,000
Do	NAS10-16 (letter contract).	Services, material, equipment, and facilities necessary to activate launch complex 36B, Atlantic Missile Range, to a configuration capable of accommodating and launching Atlas D 1st stage and Centaur 2d stage vehicles.	[1] 2,300,000			[1] 2,300,000
Aerojet-General Corp	NAS8-4014 (letter contract).	Design, development, and testing of a 1,500,000 pound thrust liquid hydrogen-liquid oxygen engine.	[1] 30,400,000			[1] 30,400,000
Do	NAS8-4015 (letter contract).	Design, fabrication, and acquisition of facilities required for M-1 engine development program.	[1] 13,200,000			[1] 13,200,000
Do	NAS5-417	Research and development program to obtain a SNAP-8 electrical generating system.	8,233,425	$5,210,961	$6,941,614	20,386,000

MANNED SPACECRAFT CENTER

North American Aviation, Inc	NAS9-150 (letter contract).	Apollo comand and service module	[3] $260,000,000			[1] $260,000,000
McDonnell Aircraft Corp	NAS9-170	Gemini spacecraft and auxiliary equipment	456,650,062			456,650,062
General Dynamics Corp., Convair Division	NAS9-492	Apollo solid suborbital vehicle	6,322,643			6,322,643
North American Aviation, Inc	NAS7-90(F) (letter contract).	Downey facility contract for Apollo command and service module.	[1] 6,191,800			[1] 6,191,800
Kollsman Instruments	NAS9-499	Optical subsystem for Apollo navigation and guidance system.	7,658,000			7,658,000
Raytheon Co	NAS9-498	Computer for Apollo navigation and guidance system.	15,029,420			15,029,420
A.C. Spark Plug	NAS9-497	Apollo system assembly and test for navigation and guidance.	35,845,000			35,845,000
Massachusetts Institute of Technology	NAS9-153	Apollo navigation and guidance system	4,375,000	$10,500,000		14,875,000
Grumman Aircraft Engineering Corp	NAS9-1100	Apollo lunar excursion module	387,900,000			387,900,000
McDonnell Aircraft Corp	NAS5-59	Mercury manned space capsules	19,500,000	70,500,000	$50,000,000	139,500,000

International Business Machines Corp.	NAS9-996 (letter contract).	Integrated mission control center, real time computer complex.	[1] 3,000,000			[1] 3,000,000
Philco Corp.	NAS9-1261	Integrated mission control center, implementation.	33,797,565			33,797,565
MARSHALL SPACE FLIGHT CENTER						
Douglas Aircraft Co., Inc.	NAS7-101	Design, development, and manufacture of S-IVB stages of Saturn IB and Saturn V.	$999,939	$142,362,779		$143,362,718
Chrysler Corp.	NAS8-6	Engineering services, Saturn, Mercury, and Juno.	7,609,987	6,755,219		14,365,206
Brown Engineering Co., Inc.	NAS8-20	Engineering, fabrication, and services, Saturn.	5,719,534	2,356,435		8,075,969
Do.	NAS8-2485	do.	5,268,235	11,399,853		16,668,088
Chrysler Corp.	NAS8-2488	Engineering services, Saturn program.	9,149,665	1,034,901		10,184,566
Mason-Rust Co., Inc.	NAS8-4004	Support services for Michoud plant.	1,215,128	14,821,572	$283,999	16,320,699
Boeing, Inc.	NAS8-2577	Preparatory effort on S-IC stage development for Saturn V.	8,910,962	39,569,838		48,480,800
Do.	NAS8-5606(F)	Facilities for S-IC stages.	7,736,371	43,100		7,779,471
Do.	NAS8-5608	Design, development, and manufacture of S-IC stages.	418,820,967			418,820,967
Chrysler Corp.	NAS8-4016	Fabrication of S-I stages for Saturn I and Saturn IB.	215,502,744	3,952,744		219,455,488
Do.	NAS8-2576	Preparatory effort on S-I stage development.	10,779,408	3,015,146		13,794,554
Do.	NAS8-5602(F)	Facilities for S-I stages.	7,102,322	37,497		7,139,819
North American Aviation, Inc., Rocketdyne Division.	NASw-16	Development of F-1 engine.	102,471,761	138,451,211	17,140,193	258,063,165
Do.	NAS8-5604 (letter contract).	Production of F-1 engines.	[1] 16,000,000			[1] 16,000,000
Do.	NAS8-19	Development of J-2 engine.	44,700,000	29,150,666		73,850,666
Do.	NAS8-5603 (letter contract).	Production of J-2 engines.	[1] 7,950,000			[1] 7,950,000
Do.	NAS7-190 (letter contract).	Development of H-1 engine.	[1] 4,500,000			[1] 4,500,000
Do.	NAS7-162 (letter contract).	Production of H-1 engines.	[1] 2,588,230			[1] 2,588,230
Do.	NAS7-3	Development and production of H-1 engines.	30,517,857	7,640,680		38,158,537
Do.	NAS7-4	Production of H-1 engines.	4,040,000	1,060,050	517,816	5,617,866
Pratt & Whitney Aircraft.	NAS8-2690	Development and production of RL-10 engines.	28,971,000	57,322,087	6,806,543	93,099,630
Do.	NAS8-5605 (letter contract).	Development of throttleable version of RL-10 engine.	[1] 3,485,000			[1] 3,485,000
Do.	NAS8-2691	Development and production of RL-10 engines.	22,890,000	17,774,304	13,741,248	54,405,552
Do.	NAS8-5607 (letter contract).	Production of RL-10 engines.	[1] 1,800,000			[1] 1,800,000
Douglas Aircraft Co. Inc.	NAS7-1	Design, development, manufacture, checkout, delivery and launch support (for flight stages) of S-IV stages of Saturn I.	68,838,160	31,372,832	25,500,000	125,710,992
North American Aviation, Inc., Rocketdyne Division.	NAS7-200	Design, development, fabrication, and testing of Saturn V, S-II stages.	319,922,328	48,977		319,971,305

[1] Letter contract funding as of Mar. 31, 1963.

Summary of increases in contract amounts of major contracts—Continued

MARSHALL SPACE FLIGHT CENTER

Contractor	Contract No.	Description of work	Total contract amount at time of award	Actual increases to date—		Total contract amount to date
				Due to additional work	Due to cost overruns	
Fairchild Stratos Corp.	NAS8-5615	Design and development of 3 micrometeoroid measurement capsules.	6,517,566			6,517,556
Lockheed Missile & Space Co.	NAS8-5600	Design, development, manufacture, assembly, and test of a nuclear-powered stage (RIFT program).	6,599,332	2,129,922		8,729,254

WESTERN OPERATIONS OFFICE

Douglas Aircraft Co., Inc., Santa Monica, Calif.	NAS7-220, (letter contract).	Design, develop, fabricate, test, and deliver 14 Delta space research vehicles.	[1] $3,500,000			[1] $3,500,000
Do.	NASw-38	Design, develop, fabricate, test, and deliver Delta space research vehicles and launch.	24,067,500	$6,027,031	$2,000,000	32,094,531
Do.	NAS5-1681	Design, develop, assemble, test, and deliver 14 Delta space research vehicles, including launch capability.	24,131,250			24,131,250
California Institute of Technology, JPL, Pasadena, Calif.	NAS7-100	Research, development, and operation associated with unmanned exploration of space.	48,508,978	266,067,503		314,576,481
North American Aviation, Inc., Space and Information Systems Division, Downey, Calif.	NAS7-90(F) (letter contract).	Facilities for development and production of Saturn S-II vehicle systems.	[1] 9,248,172			[1] 9,248,172

[1] Letter contract funding as of Mar. 31, 1963.

GENERAL QUESTIONS RE PROCUREMENT—CONSTRUCTION PROCEDURES

Question 1. Section 1c(i) Public Law 87-584 (1963 authorization) authorizes the use of R. & D. appropriations for items of a capital nature required for the performance of R. & D. contracts.

(*a*) Approximately what is the dollar volume of this type of construction per year?

Answer. Approximately $35 to $40 million per year.

(*b*) What means of control, supervision, and inspection does NASA exercise over such construction?

Answer. NASA exercises total control of these facilities from the development of design criteria through the completion of construction. For example: The criteria are developed under NASA's supervision and approved by NASA. If the Corps of Engineers or the Navy is our design and construction agent the approve criteria are transmitted to the design agency, who in turn selects the architect-engineer (A-E) for preparation of the design. The plans are reviewed jointly by the design agency, R. & D. contractor, A-E, and NASA at various stages of development. After NASA approves the plans for functional requirements, the construction agency supervises and inspects the construction of the facilities for NASA.

(*c*) Are design drawings and specifications reviewed by NASA prior to construction?

Answer. Not only are design drawings and specifications reviewed prior to construction as noted above, but they must receive the specific approval of qualified Government construction engineers. Design drawings and specifications are usually reviewed at the 30-, 60-, 90-, and 100-percent stages of development.

(*d*) Are any limits prescribed for design and engineering costs? For supervision and inspection costs?

Answer. The costs for design and engineering generally do not exceed 6 percent of the estimated cost of the related construction work. Costs limits are not prescribed for supervision and inspection. However, in all cases, cost limitations are accomplished through negotiations with the selected A-E firm. The selection of architect-engineers for professional services is based on the professional qualifications necessary for satisfactory performance of the required services and not on the basis of the evaluation of competitive bids or proposals. Costs are controlled by the requirement for the preparation of an independent Government estimate, prior to the initiation of negotiations, based on a detailed analysis of the costs to be generated by the work. The A-E is also requested to submit a detailed cost breakdown with his proposed fee.

During negotiations, the Government and A-E estimates, together with an estimate prepared in unusual cases by an outside independent estimating firm, are employed to effect an equitable pricing arrangement with the A-E firm.

(*e*) What is the frequency of audit by NASA of this type of contract?

Answer. R. & D. cost-type contracts provide for audit coverage whether or not they include construction provisions. Similar audit coverage is provided for separate cost-type facilities contracts. If the dollar amount is sufficiently material or the contract action is otherwise sensitive, audit coverage is provided on a continuing basis, generally by a resident audit staff located at the contract site. Contracts of lesser dollar amounts are audited periodically on a mobile basis, the frequency of which depends on the dollar amount involved, adequacy of prior experience, effectiveness of contractor's internal controls, etc. NASA's cost principles used in these audits are similar to those set forth in section XV of ASPR.

Question 2. Certain design and construction is accomplished at NASA installations by construction management contracts, such as the Mason-Rust contract at Michoud.

(*a*) Are these types of contracts usually the CPFF type?

Answer. Yes.

(*b*) Percentagewise, what is the contractor's fee as compared against construction dollar volume? Does this compare favorably with costs thus incurred where in-house engineering forces are used? Where U.S. Army Corps of Engineers is used?

Answer. (See following table.)

Construction design and maintenance costs (percent of project cost)

	Design and engineering services	Construction supervision and inspection	Total
In-house [1]	5.8	3.6	9.4
Construction management contract [2]	7.9	5.7	13.6
Corps of Engineers [3]	4.7	6.1	10.8

[1] Because of the need to consider only completed projects if meaningful percentages were to be developed, the cost experience has been limited to 20 projects at 4 centers totaling about $55,000,000 approved in programs for the fiscal years 1957 through 1960. These projects vary widely in complexity and the sample, therefore, is considered reasonably representative. The percentages shown include the costs for all architect-engineer services and all direct in-house costs which could be attributed to the individual projects for criteria development, design or design review, construction management, and construction inspection. The percentages do not include overhead costs for the research centers or for NASA headquarters since the NASA accounting system does not provide for collection and distribution of such costs to individual projects.

[2] These figures apply to construction at the Nuclear Rocket Development Station where facilities are being provided both by AEC and NASA. The Space Nuclear Propulsion Office at the Lewis Center is responsible for the development of criteria and design utilizing architect-engineer firms. The engineering services figures used cover only engine test stand No. 1 and the Engine Maintenance, Assembly, and Disassembly Building, both highly complex projects, totaling $29,182,000 in estimated construction cost. Construction supervision and inspection are performed under AEC contract with the Catalytic Corp. NASA participates in this contract. The percentage figure of 5.7 for construction supervision and inspection covers $6.1 million of work put in place. The percentage figures do not include NASA or AEC overhead.

[3] Includes 6 months cumulative costs through the second quarter of fiscal year 1963 and covers the Jacksonville, Mobile, Fort Worth, Los Angeles, Sacramento, and Albuquerque Districts performing work for NASA. The construction supervision and inspection percentage covers costs for $22 million of work put in place while the design and engineering services data has been compiled from over $108 million of estimated cost projects. The corps' cost system covers essentially the same costs in design and engineering services and construction supervision as the NASA system. The major difference is the inclusion of overhead and inspection in the corps' costs. The 10.8 percent figure includes 0.2 and 1.6 percent overhead applied to design and engineering services and construction supervision and inspection respectively to cover the overhead for corps' district and division offices and the Office, Chief of Engineers. Overhead comprises fiscal, personnel, legal, safety, supply, and similar general office services which cannot be charged directly to specific projects. Thus, if corps' costs are to be compared percentagewise with NASA costs, 1.8 percent should be deducted from the corps' figure leaving a net of 9 percent. However, for comparative purposes it should be remembered that this 9 percent figure does not include required NASA overhead costs involved in processing and handling the corps' managed projects.

Mr. DADDARIO. Are there any further questions?

If not, this committee will adjourn until Wednesday morning at 10 o'clock.

(Whereupon, at 12:15 p.m., the committee was adjourned, to reconvene at 10 a.m., Wednesday, March 27, 1963.)

1964 NASA AUTHORIZATION

WEDNESDAY, MARCH 27, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON MANNED SPACE FLIGHT,
Washington, D.C.

The subcommittee met, pursuant to adjournment, at 11 a.m., Hon. Olin E. Teague (chairman of the subcommittee) presiding.

Mr. TEAGUE. The committee will come to order.

We have this morning Mr. D. Brainerd Holmes, Director of Manned Space Flight, and, I believe, you have another title do you not Mr. Holmes?

STATEMENT OF D. BRAINERD HOLMES, DEPUTY ASSOCIATE ADMINISTRATOR, AND DIRECTOR, OFFICE OF MANNED SPACE FLIGHT, NASA; ACCOMPANIED BY WILLIAM E. LILLY, DIRECTOR, PROGRAM REVIEW AND RESOURCES MANAGEMENT, AND GEORGE M. LOW, DEPUTY DIRECTOR (PROGRAMS)

Mr. HOLMES. Yes, sir. I am also the Deputy Associate Administrator of NASA, with responsibilities for the Manned Space Flight Center at Houston, the Marshall Space Flight Center at Huntsville, and the Launch Operations Center at Cape Canaveral. I am responsible under that title to Dr. Seamans for the institutional aspects of those centers.

The gentlemen with me are Mr. George Low, Deputy Director, Programs, Office of Manned Space Flight; and Mr. William E. Lilly, Director, Program Review and Resources Management.

I thought I would describe informally the approach we have used in the preparation of our budget, Mr. Chairman.

By far the largest percentage of this budget of the Office of Manned Space Flight results from the continuation of programs started in earlier years. Therefore the estimates must be made with program runouts in mind, as well as expenditures in fiscal 1963.

I think if I approach the subject in a general way, and then talk specifically about this budget, it might be useful.

Mr. TEAGUE. Go right ahead.

Mr. HOLMES. In general for our budgets at NASA, Mr. Webb, with Dr. Dryden and Dr. Seamans, establish the general ground rules and ceilings within which we should work up estimates. Once this philosophy is established and the general ceiling set, we in the Program Offices in Washington put out a request to the field centers for cost estimates.

If a new program is invalued (one not under contract at all) most of this estimating is done in-house; that is, contractors are used just

as consultants, rather than as contractors for specific jobs. These cost estimates then come back to us in the Office of Programs where if a program runs across more than one Center we interleave the estimates. We review the time scale and schedules on which these estimates were made. We must look to the size of the estimates to be sure that they are consistent, under the rates at which we want to move at all Centers. Often, when the overall estimates are balanced against rates and the total ceilings, they are too high and must be adjusted. Of course we must have a balanced program. That is, for Apollo, for example, the booster must be developed and produced in the same time scale as the spacecraft. The two must come together at appropriate points so as to be tested and ready at the same time.

When this effort has all been completed at the Program Office, the proposed budget is sent back to the office of the Administrator. There it is reviewed in conjunction with the other program office inputs, and a total budget is established by the Administrator, transmitted to the Bureau of the Budget, and becomes a part of the President's request to Congress.

Specifically in this budget on Manned Space Flight, many of the cost estimates dictated by the program which was established and firmed up in fiscal 1963, and/or the time scale in which we wish to work.

As far as the costs on Apollo, Gemini, and on boosters, the costs are based primarily on contractor estimates. We also consider contract expenditures in the past. These figures are reviewed by our Center people, coordinated and then are reviewed again by the Office of Manned Space Flight. The various parts of the program are integrated, considering again the time schedule on which we plan to proceed. In this process we, of course, consider at all levels the demonstrated ability of the people to estimate past expenditure by looking at what they really spent. As before on new programs, when all this work has been completed it is forwarded to the office of the Administrator, the Bureau of the Budget, and eventually, if endorsed at each of these levels, becomes part of the President's request.

Mr. TEAGUE. How do you apportion the budget between the Centers? Where in the budget would the money appear to repay Navy for recovery operations, for example?

Mr. HOLMES. The flight mission responsibility is at the Manned Spacecraft Center at Houston and it is within their estimates that we include such expenses. Part of the R. & D. expense at the Manned Spacecraft Center on the Mercury program, for example, covered those recovery costs.

Mr. TEAGUE. When did the different major steps take place in the budget we are working on now?

Mr. HOLMES. We are starting now on the fiscal year 1965 budget, so it was about this time last year that we first directed attention toward the fiscal 1964 budget. We had at an earlier time directed our attention out 5 years. But this was in a more general way.

In all of these programs, of course, it is absolutely necessary to estimate total costs over the years ahead. But the time at which we specifically directed our attention to the 1964 budget was about a year ago.

Mr. Lilly, would you comment on that, too; on the time scale under which we put together the fiscal 1964 budget?

Mr. LILLY. Yes. The time scale starts in early February with the general guidelines Mr. Holmes mentioned. These guidelines provide general guidance on matters of agency policy, program scope and relationship. The program office then prepares more detailed guidance for the Centers' preparation of estimates and proposals. We got back the first-cut estimates from the Centers—the first preliminary submission—I believe in March of 1962.

These proposals and estimates were then discussed with the Centers and at the management council. This occurred right at the time of our mode selection deliberations. This was somewhat of a continual process on through until the mode decision was made. After the mode decision was made, more specific guidance on schedules and timing was given.

In September we received the complete detailed estimates from the centers which were reviewed—reviewed independently in manned space flight, with the centers, and in the management council meetings. At that time we put the budget together and submitted it to the Administrator in September or early in October.

The Bureau of the Budget conducted reviews until early December. We put the final budget books together in December and had them ready for printing shortly before Christmas.

Mr. TEAGUE. Then the next definite figure is after Congress finishes with the budget request, and you know exactly how much money you have to operate with?

Mr. LILLY. That is right. Of course as we go along we have to make certain assumptions as to what changes will be made. For instance, in the preparation of our fiscal year 1965 estimates it is our assumption we will get everything we ask for in 1964. These assumptions change as we go.

Mr. DADDARIO. Mr. Chairman.

Mr. TEAGUE. Mr. Daddario.

Mr. DADDARIO. I assume then from what you say, that this budget reflects agreements already reached with your contractors for this year?

Mr. LILLY. In many cases. At least it is on the basis of their requests and their stated requirements. Many contracts are still in process of negotiation. I can't say they are all definitized at this point.

Mr. DADDARIO. Then the budget does not reflect hard and fast agreements with all contractors. Some of them are subject to negotiation as of the moment?

Mr. LILLY. That is correct.

Mr. DADDARIO. Therefore the budget does reflect within itself certain estimates?

Mr. LILLY. That is correct. However, in our particular program most major contracts have been definitized. Some are in process of negotiation and in many cases are down to matters of difference on such items as contractual boilerplate clauses, rather than the scope of work and the cost estimates on it. We may still have a degree of difference with contractors on fee.

Mr. DADDARIO. When we talked to the North American people last week in California, it was my understanding that you were still negotiating with them and that there was a wide area of, not necessarily disagreement, but a wide difference between what your figure is at the moment and their figure, and that this figure might reflect a difference as of the moment of up to $100 million.

Mr. HOLMES. May I comment on that?

I am sure you are familiar with this, but I will review it generally. We prepare a program which considers schedules of work, manpower estimates, cost estimates, total runout curves versus time, and so forth. This series of schedule books, updated monthly, contains private, confidential information. Since we are in a negotiating position with industry, our position would be destroyed if we revealed our Government estimates.

If we took at face value contractors' estimates, and I speak as an ex-contractor, and didn't have our own internal judgment based on history of performance, we just could not run an efficient program. Our problem is complicated because of the length of time it takes in a democracy—and this is not a criticism at all—to properly review and authorize funds, as Congress has to do.

If we took estimates at face value, and did not apply judgment factors as to what we really believed it was going to cost to do the program, we would soon be faced with a disrupted program and with sharp cutbacks.

Our estimates here are based on contractors' estimates, but modified by what we hope is the objective judgment of people in Government qualified to estimate what we think the proper contingencies should be.

Mr. DADDARIO. It is understandable that you have estimates that you would not give to the contractor. I imagine the same thing works the other way also; they have estimates that they wouldn't like you to have either.

Mr. HOLMES. I have heard that was the case.

Mr. DADDARIO. I imagine that it is, during the negotiation phase, at least. But just to clarify the position which we find oursleves in as a committee, isn't it correct to say that this budget book does not reflect actual hard and fast figures? There are negotiations going on which could change these quite drastically because this reflects your own estimate of where you think you may be, past experience taken into consideration, with these contractors when you finally have a meeting of the minds?

Mr. HOLMES. To a degree what you say is certainly correct. We do have solid figures to back up the figures in these books which include considerable detail and which we could review with the committee. We would be happy to do that if you so desired.

If we went into all the detail on the figures it would probably be best to do it in executive session. But we could do it. The estimates we have here are very carefully reviewed and put together, and in general represent sounder figures than those we get from our contractors initially.

Mr. DADDARIO. But it is an estimate and, as all estimates are, it is subject to change. This may have something to do, might it not, with the reprograming in last year's budget?

Mr. HOLMES. Yes, it is an estimate which reflects the time scale against which we will proceed. As Mr. Webb has said, it is not the fastest program and it is not the slowest program. It is a program in which the speed is controlled by dollars. That is, we have a very carefully drawn estimate and any reduction would result in slowing down the program.

I believe personally that we at NASA will have a very great challenge to proceed to the time scale we have set, within this budget.

I think we will do it, but I think it is a very great challenge to do it. I certainly don't consider it has any extra money in it.

Mr. DADDARIO. And you do need reprograming flexibility to adjust differences that may occur?

Mr. HOLMES. Yes, sir.

Mr. GURNEY. Would the gentleman yield?

Mr. DADDARIO. Yes.

Mr. GURNEY. On page RDO 1-14 of the budget books, it says: "The amount required during fiscal 1964 is based on North American's cost proposal, which includes subcontractor costs," and so on, and says further that this proposal was analyzed, "and there was apparently a duplication on certain areas." Nonetheless, I gather that the budget figure is based on the contractor's proposal, is that correct? How do you explain this in light of our conversation here?

Mr. HOLMES. This way: It is based on the contractor's proposal, but not only the contractor's proposal. In all cases where we have a contractor working, it is fundamental to start with what he says it will cost, how many engineers he is going to have to put on, what shop facilities he needs, and so forth.

Above that we superimpose the judgment of our people, and come up with an integrated figure which is usually not the same as the contractor's figure.

Mr. GURNEY. How do you adjust—not the manpower, I might understand that—but how do you make adjustments on the pieces of hardware that ought to be produced? How do you arrive at the dollar figure in the analysis you have made?

Mr. HOLMES. We either have to cut down, or add to, his estimate based on factors which we think might arise that he has not included.

Mr. GURNEY. Is this your figure in the budget book, or the contractor's?

Mr. HOLMES. It is our figure, based upon the contractor's figures. Added to the contractor's estimate are the things that don't usually fall within the contractor's responsibilities. Also added are the things we think the contractor has not included. Sometimes, which is less usual, we subtract from the contractor's figure because we know of certain actions we are going to take to cut part of the program, or otherwise reduce the costs.

Generally it is the contractor's figure, plus our judgment.

Mr. GURNEY. Would you say you generally carve him down a fair amount?

Mr. HOLMES. No, I would say it is usually the contractor's figure, plus some amount.

Mr. TEAGUE. Mr. Riehlman?

Mr. RIEHLMAN. Following this question, could you give us an idea of the percentage of this budget that is now under firm contract with contractors?

Mr. LILLY. If you wanted an exact figure, I would have to supply that.

Mr. RIEHLMAN. Can you make an estimate?

Mr. LILLY. I would say offhand, excluding C. of F., limited to R. & D., probably 60 percent is actually under firm definitive contracts.

Mr. HOLMES. That takes interpretation. If one says North American is not under a firm contract since we are now negotiating that

definitive contract, this may be about right. If you add North American in, since they are for all intents and purposes all settled, then the percentage becomes much larger; maybe as much as 90 percent. There is no major element in the manned space flight program today for which we don't have a working contractor.

Mr. RIEHLMAN. Do you have any leeway at all in the funds you have asked for in this budget, and the contracts you have now pending?

Mr. HOLMES. There is a little leeway. The funds we have in here will probably cover the contracts. If there is a risk, it is that there is not enough money to cover them, and then we would have to slow the program down. There is not as much really uncommitted money for the emergency changes that always come up in a development program as I would like to have.

On the other hand, I think probably every program manager has said that in running every program.

Mr. RIEHLMAN. You are saying to the committee that practically 90 percent of the funds in this budget are now committed one way or another, whether or not it is under firm contract. You are in the negotiation period to firm up contracts which would obligate at least 90 percent of the budget?

Mr. HOLMES. Yes. That is not counting C. of F.

Mr. FULTON of Pennsylvania. You spoke of making up an overall budget estimate on these programs, and looking to the future. This committee has heard estimates that the total cost of the manned flight to the Moon will be approximately $20 billion. It has been some time since that estimate was made, and NASA has spent part of the money, through the authority of this committee for that purpose. Could you tell us how much of this $20 billion has already been spent for the trip to the Moon? Secondly, what is the current cost estimate of this total program? Has it changed from $20 billion? And how much more money is this committee expected to authorize for this purpose? May I point out that the last budget estimates for Mercury greatly exceeded in total cost the prior and preliminary estimates for Mercury.

There is also some evidence that both Gemini and Apollo are now running above their budget estimates. Would you project these costs proportionately at this point of time to the future? I think that both the American taxpayer and we, as representatives of the people, should have this estimate from you.

Mr. HOLMES. We will be glad to. We can give you the facts on Project Mercury, which will show that, from the first considered estimates Mr. Keith Glennan presented, to what we have spent to date, there is not a sizable overrun.

Mr. FULTON of Pennsylvania. One of our local trade magazines estimated it recently as being three to four times the total original estimate. Not that I believe this is necessarily correct, but I am inquiring.

Mr. HOLMES. I will address myself first to the overall question, if I may.

Mr. FULTON of Pennsylvania. Just put that other in the record, if you want to. I don't want to take the time.

(The information requested is as follows:)

In January 1959 Dr. T. Keith Glennan, then Administrator of NASA, indicated that the total cost of Project Mercury would exceed $200 million. In November 1959, after a more detailed assessment of requirements, the cost of Project Mercury was estimated at $346 million. This estimate included $293 million for research and development and $53 million for the tracking network. The estimate of $346 million excluded prorated institutional costs. The current estimate for Project Mercury, including the 1963 runout cost, is $312 million, $34 million below the November 1959 estimate. This amount includes $259 million for research and development and $53 million for the tracking network; it excludes prorated institutional expenses. If 1-day mission costs ($35 million) are added to the Project Mercury estimate, the combined Mercury/1-day mission cost totals an estimated $347 million, including $1 million for facilities.

Mr. HOLMES. All right. All our present estimates, if you look at the hard-core program for going to the Moon (the program in the Office of Manned Space Flight, not the unmanned programs) we should be able to do this for $20 billion or less.

What we have spent to date, if you count the total including the support items from unmanned programs, and institutional and operational costs, including our estimates for fiscal 1964, amount to something like $8.9 billion. The manned space flight program accounts for approximately $7.3 billion of this amount.

The estimates today, which are of course harder and firmer than they could have been at the beginning, indicate we should be able to go to the Moon, explore it, and return astronauts to the Earth within the decade for $20 billion or less for the hard core program.

However, it should be understood it is just that. It doesn't mean that you can continue on with many explorations of the Moon; it doesn't mean that you set up a base on the Moon; it doesn't mean that you get prepared to go to Mars, or to operate space stations.

It doesn't include the broad complex of things I personally feel certain the United States should do in space.

Mr. FULTON of Pennsylvania. So your estimate on the manned lunar landing that you made when NASA began the program, 2 years ago, you now say is justified, and you have every reason to advise this committee and the American people that the program will be concluded within those cost estimates?

Mr. HOLMES. Yes.

Mr. FULTON of Pennsylvania. You have spoken of the possiblity it might cost less. What eventualities might make the manned lunar landing program cost less, and within that area of reference, would it be less?

Mr. HOLMES. Less than the $20 billion? So close to it we can't see the difference. I couldn't estimate how much less. Our present figures, within the accuracies of estimating, do point remarkably close to $20 billion.

If it were $22 billion, I would say so. I think it is somewhat of a coincidence that the estimates were quite so good. Clearly they were made with considerable sagacity.

Mr. FULTON of Pennsylvania. It was originally $35 to $40 billion, and then came down to $20 billion. I am glad to see it hasn't been going up.

Could you give us an estimate on the amount we will be asked to authorize for the manned lunar landing program from 1963 on? Suppose this were June 30, 1963. My further qualification of the question is that you leave out the outside programs that are ancillary

and are not necessary, or might be side issues to the Moon flight. I think we should have definitely on the record what NASA can see ahead, Mr. Holmes. Will you take the $20 billion and make a subtraction and give me that result, as of a particular date, June 30, 1963? I would appreciate it.

Mr. HOLMES. I will be glad to. For the hard core program it would be about $16 billion from the end of fiscal year 1963 on. I have arrived at that figure by taking the expenditures through 1963 and subtracting them from $20 billion.

In 1964 we are asking in the Office of Manned Space Flight for roughly $3.7 billion—$3,758,179,000.

Mr. FULTON of Pennsylvania. And your approximate figure for 1965 or 1966?

Mr. HOLMES. I think for 1965 and 1966 the total request will run probably around $4 billion. But implicit in that would be more than just going to the Moon and back. Of course it doesn't make much sense just to go to the Moon and back and do no scientific exploration, and so forth.

If you separated it, it would be less than that for the hard core. In other words, that $4 billion figure would include such things as logistic vehicle support needed to explore, but not to just go and return. The hard core figure alone I would have to supply for the record.

Mr. FULTON of Pennsylvania. If you could give us a general estimate, so we can see what we are going to do budgetwise and how to fit it into the budget, I would appreciate it. But as you come then into 1968 and 1969, what balance remains? You seem to have put it all into 1964, 1965, and 1966, and 1967.

Mr. HOLMES. But I haven't told you yet when we are going to land on the Moon. I think the President or Mr. Webb has to do that, if anyone does. The goal is sometime this decade. If we get into detailed discussion of the runout costs for the last few years, then we are into the discussion of when we land on the Moon.

Mr. FULTON of Pennsylvania. This committee should be able to anticipate the major portion to be expended for the basic Moon flight for the coming years, 1964, 1965, 1966, and so on. From your testimony, it seems evenly distributed over that period. There is no peak year, is there?

Mr. HOLMES. For the very hard-core program—not considering such things as logistic support—fiscal years 1964 and 1965 will probably be higher than fiscal years 1966 and 1967. When you add the things other than the hard core there really is no peak year.

It is difficult to separate them. Suppose we do, as we are studying now, proceed with a logistics vehicle. This would let you put a cache of materials and supplies on the lunar surface, which would mean a better capability of exploring the lunar surface.

At the same time, however, an added safety factor would be supplied to the original mission. Therefore, should you include the logistic vehicle in the hard core or not?

I am not today. But I think in future years we might tend more in that direction.

Mr. FULTON of Pennsylvania. On your colloquy with Mr. Daddario, Mr. Gurney, and Mr. Riehlman, I think you should make it plain in the record that this is the tight budget. On these contrac-

tors' estimates which may be lower when actually negotiated, do you have there a marginal factor in the budget that you are relying on which could be called money not absolutely necessary, but only needed in certain eventualities? I think you ought to make that explicitly clear.

Mr. HOLMES. Yes. I spend a good part of my day trying to see that the job is managed within the budget. If we do not manage within the budget the only alternative is to slow down. We have no duplicate hardware. We have no duplicate paths to follow.

It is not like a crash military program—which I have run—where money is secondary to time. Here money dictates the performance.

Mr. FULTON of Pennsylvania. Your budget estimates and figures as to various programs as well as to line items are based on your personal experience and judgment and not on contractors' figures as outside possibilities or probabilities?

Mr. HOLMES. Yes. Contractors' figures are an element, as Mr. Gurney pointed out We start with that. But——

Mr. FULTON of Pennsylvania. You make your judgment on those.

Mr. HOLMES. It is just one element of the total figures we present to Congress.

Mr. FULTON of Pennsylvania. Would you say these figures could be cut substantially for manned space flight?

Mr. HOLMES. Not unless we want to slow down the schedule.

Mr. FULTON of Pennsylvania. Any substantial cut would then lengthen the time in our race with Russia and in our program to have the United States preeminent in space?

Mr. HOLMES. I agree with that, with every word.

Mr. TEAGUE. Mr. Waggonner.

Mr. WAGGONNER. No questions.

Mr. TEAGUE. Mr. Chairman?

Chairman MILLER. I am perfectly content to listen to this very interesting discussion.

Mr. TEAGUE. Mr. Bell?

Mr. BELL. I would like to ask a question of Mr. Holmes that is a little different from the particular colloquy that has been going on here.

I would like to ask Mr. Holmes about the procurement program as far as the NASA is concerned. As you undoubtedly know, Mr. Siepert and Mr. Brackett were before our committee 2 days ago. I asked them about the possibility of a better coordination with the Department of Defense in the procurement of materials, in the building of facilities, and even in the handling of personnel. It is my feeling that there is a potential saving in this area. I could be wrong; however, indications seemed to point to my being right. I asked them to send to us a report as to the exact differences in the procurement of contracts or materials that exist between the Department of Defense and NASA,

Of course, we know one feature that is different in NASA than in DOD—the patent situation. But I believe Mr. Siepert said there were several other differences in procurement. He has not yet sent the material, and he didn't say what they were. Do you happen to know what those areas of difference would be?

Mr. HOLMES. No, Mr. Bell; I do not. We have, as probably Mr. Siepert testified, various active coordination channels between

the Department of Defense and NASA in order to try wherever applicable to use the same techniques in procurement.

Sometimes they are not really applicable to both agencies, but in most cases they are. The specific differences in practice, over and above this question of patents which you mentioned, I could not here list for you. I do know, however, the coordination has been increasing at a very substantial rate.

I think in this Gemini planning group we are trying something that is not just procurement but relates to it. Here we are saying, "This is an item being produced by American industry and procured for the Government. Why must there be two items, one for the Air Force and one for NASA?"

Gemini is a program managed by NASA. But Mr. Webb and Mr. McNamara, as you know, made this agreement through which Gemini can hopefully be used to fulfill the needs and functions of both agencies.

Mr. BELL. As you know, Mr. Holmes, the military has a much longer background in procurement than NASA does.

Mr. HOLMES. Yes.

Mr. BELL. To what extent could you at times give certain procurement jobs to the military to perhaps lessen the cost? To what extent, for example, could NASA use existing facilities that the military have? Could you take a part of these, or work out an arrangement in which you use their facilities, rather than adding on, or building a new building?

Mr. HOLMES. We can do this to a considerable extent, and we do so. In Mercury we use an Air Force range and the recovery fleet is supplied by the DOD.

In the area of equipment we have used the Department of Defense launch vehicles wherever possible. We used the Atlas for Mercury, and will use the Titan II for Gemini. We are asking the military to procure these for us, we are not going directly to the contractor. They use their contractors, buy the vehicles for us, and we work with them closely. Department of Defense also assists us in launching, and in the recovery of the astronauts.

Where we use contractors that are primarily Department of Defense contractors, we do not move in and set up a whole new Government team to manage that contractor. In quality control, inspection, and other areas which require thousands of people, we use the Department of Defense wherever we can.

It is only when we work in a new plant or area where the Department of Defense has not worked that we set up a NASA system. Then, if the Department of Defense comes into that plant, they use what NASA has set up.

I do think that the last year has shown great advances toward minimizing inefficiencies and maximizing the effectiveness of this Department of Defense-NASA cooperation.

Mr. BELL. I certainly concur that major steps in this direction have been made, but I think we can do even more.

Chairman MILLER. Would the gentleman yield?

Mr. BELL. Yes.

Chairman MILLER. I believe it was about 14 years ago that the three services were consolidated. You are talking about this interchange between agencies, Mr. Bell. Only last week I saw where General Shoup issued an order that the Marines were to wear black

shoes like the Navy, instead of brown shoes. So it has taken 14 years to come that far.

I presume that, looking around the table, Mr. Riehlman and Mr. Teague are the only ones that recall the chamber of horrors that Mr. Hébert set up over in the Armed Services Committee room. We brought in all of the common items that had different specifications in the three services. The definitions of common nails were different. It has taken 14 years, and it is still not complete. So be a little patient with NASA and DOD.

Mr. TEAGUE. Has your program slipped, Mr. Holmes, because of a shortage of money in the last year?

Mr. HOLMES. The reason I am weighing this is that I can not really answer without giving you some explanation. If one assumed—which is probably a correct assumption—that the program was not definitized enough a year ago to have a really definitive schedule, then the answer is "No."

However, it is true that the original rates on which we were going, could not be maintained without a supplemental. It being our decision not to request a supplemental, we have had to revise those dates.

What happened was that we defined a program with a time schedule compatible to the money authorized. I think that is really different from a slippage.

Mr. TEAGUE. Could you comment on the planning as it affects the budget? What are we going to do with these tremendous facilities we are building, beyond 1970?

Mr. HOLMES. If we talk of Cape Canaveral, and this is my personal opinion, I believe this Nation will be very actively engaged in space, particularly in manned space. We will be engaged in the further exploration of near space and of space as far out as the Moon, and perhaps the planets. We will be so actively engaged with manned space stations, and the complete utilization of space, that I believe the Merritt Island area will be fully used and thought of as a spaceport. In fact, it probably will not be big enough, and another launching area will be established.

As far as the facility at Houston is concerned, it is my considered opinion this is a great national asset that is being established. I think it will be a center for gathering together engineers and scientists to develop the techniques, as well as the equipments, for operating in space environments, in space itself, and on hostile surfaces, such as the surface of the Moon.

I think it is already obvious what a tremendous asset Marshall Space Flight Center is to the country. There we have a group of people, as well as the facilities, to produce these very large boosters necessary to have a space program at all.

I have restricted my answer to the three major facilities for the Office of Manned Space Flight. Of course it could be extended to what we have done to build the competence of industry and to produce the kind of equipment necessary to make this country first in its conquest of space, as well as to the facilities at other centers and elsewhere in Government?

Mr. TEAGUE. Mr. Roudebush?

Mr. ROUDEBUSH. I would like to continue the chairman's question. What are we doing to use facilities that are already constructed? Take the Mercury Control Center, for example, what is NASA

going to do with the extensive, and, I might add expensive, electronic equipment that it contains? What about the launch pads that were constructed for rockets that we are not going to use in the future? Have we already planned to use this hardware we will have in our inventory?

Mr. HOLMES. We plan to use the Mercury Control Center, after the termination of the Mercury program, for our early Gemini program. As soon as the mission control center is operational at Houston we will transfer the control to that location. The Mercury Control Center will then be useful as a tracking and telemetry station similar to others in the Mercury chain.

As far as the launch pads used today, they are military pads, both Atlas and Titan. So the future use of those would have to be looked at by the military. I have no doubt as one grows and progresses in any system, there will be obsolete facilities and equipment which will be discarded. But to the maximum extent possible we are trying to save dollars by utilizing these facilities as long as possible.

Mr. LOW. In connection with the launch stands, Mr. Chairman, I might add, as you know that Atlas pad 14 has been used for the Mercury flights to date. After the completion of the Mercury program it will be converted to an Atlas-Agena pad, to launch the Agena target.

Similarly the Titan pad 19 was initially a Titan I pad, and is now being converted to a Titan II pad, and its utility extended in this manner.

Mr. GURNEY. Would the gentleman yield?

Mr. ROUDEBUSH. Yes.

Mr. TEAGUE. Mr. Gurney, unless this will not wait until after lunch, might we recess for lunch and take it up then?

Mr. GURNEY. Certainly.

Mr. TEAGUE. We will recess, and reconvene at 1:30 p.m.

(Whereupon, at 12 noon the subcommittee recessed, to reconvene at 1:30 p.m.)

AFTERNOON SESSION

(The subcommittee reconvened at 1:30 p.m.)

Mr. TEAGUE. The committee will come to order.

I believe when we left off at noon Mr. Bell had a question.

Was it you, Mr. Bell?

Mr. BELL. Yes.

Getting back to this question of duplication again, I note that NASA has a number of specific projects that perhaps could be coordinated with DOD. For example, NASA has wind tunnels that you are using in one of the space facilities; Marshall or Ames, I believe, was one of them.

Mr. HOLMES. And Langley.

Mr. BELL. Yes; that is true. What effort is being made to coordinate this with the Air Force? They have several wind tunnels; one, I believe, is at Arnold Air Force Base in Tullahoma, Tenn., and there are several others. Is there any way to coordinate that effort so that it is not necessary to build an additional wind tunnel?

Mr. HOLMES. I would like Mr. Low to address some remarks on this matter. He has been concerned with this for the last 2 years.

Mr. LOW. There has been complete coordination between the military services and NASA, and before that between NACA and the

military services, on what tunnels are needed, what ones are available, and what new speed ranges or temperature ranges, and so forth, are needed.

The construction effort between the military and NASA has been coordinated, and there are now books available spelling out the capabilities of each wind tunnel in the country.

For example, in any one of the manned space programs we know we must cover a range of speeds, a range of altitudes, and a range of temperatures, in the wind tunnel tests. The spacecraft are tested in many tunnels, at our own facilities, and at the Tullahoma facilities you have mentioned. We have used the Air Force facilities in all three programs, manned space projects.

Mr. BELL. The facilities at both Ames and Tullahoma are NASA facilities?

Mr. LOW. The facilities at Ames are NASA facilities; the facilities at Tullahoma are Air Force facilities.

Mr. BELL. Does NASA have any duplication here?

Mr. LOW. No exact duplication. There may be overlap in speed range, or temperature range, and so forth. You need an overlap, because you have to test over a range of speeds. There may be an overlap of sizes, but most are of different size.

Mr. BELL. Going to another subject for a moment, I note that in the field of tracking and telemetry that NASA, the Air Force, the DOD, the Signal Corps, and the National Security Agency are all quite active. Isn't there an opportunity for coordination in this area?

Mr. LOW. I could best answer by discussing the Mercury tracking network, which has about 17 stations in it. Nine of these are Department of Defense stations, which are used by the Department of Defense for other purposes as well as providing tracking and data acquisition for Mercury flights during Mercury missions. NASA has five stations operating in the Mercury network. The two additional stations are operated by the Australian Government. The total Mercury network then consists of NASA stations, Department of Defense stations, and Australian stations, all working together as an integrated network.

Mr. BELL. And you are using the DOD facilities, as well as yours?

Mr. LOW. Wherever the capability exists we use it.

Mr. BELL. You have made the decision to move the Mercury Control Center from Cape Canaveral, Fla., to the Manned Space Flight Center in Houston; is that correct?

Mr. LOW. That is correct?

Mr. BELL. What happens to the Mercury Control Center at Cape Canaveral?

Mr. LOW. It will be used for the initial Gemini missions, during which no rendezvous will be performed.

For the Gemini rendezvous missions the Center at Cape Canaveral had only a small part of the capability needed. When in 1964 we start controlling missions from Houston, the Cape Canaveral Control Center will act essentially as a downrange tracking station. The antennas at Cape Canaveral will receive data, and there will be flight controllers in the facility at Cape Canaveral taking data as the spacecraft passed over Cape Canaveral.

Mr. BELL. Then you feel, despite the fact that you are going to build a whole new network of tracking stations for advanced space

programs, that the Center at Cape Canaveral will still be used. The old Mercury Control Center is going to operate as a kind of supplemental tracking station?

Mr. Low. That is correct.

Mr. Bell. But not getting into the deep-space tracking?

Mr. Low. That is right, it will be one of the elements feeding information into the Control Center at Houston.

Mr. Bell. The Center at Houston will control the operation?

Mr. Low. All manned space flights after 1964 will be controlled from Houston.

Mr. Bell. And the Mercury Control Center at Cape Canaveral will be a standby, really?

Mr. Low. In the current Mercury network, for instance, we have a Control Center at Cape Canaveral, we have stations at Bermuda, Canary Islands, Africa, and so on. Each station is in fact a miniature control center. While the spacecraft passes over Bermuda the flight controllers at Bermuda talk to the astronaut, give him instructions, control the spacecraft. When the Center in Houston is activated the current Control Center at Cape Canaveral will assume a role of one of the stations like Bermuda.

Mr. Gurney. In what way does the mission of the Control Center at Houston differ from the one now at Cape Canaveral? Isn't the Gemini program essentially the same as Mercury, except there are two men in it?

Mr. Low. The Gemini spacecraft itself will have the capability to maneuver in space, which the Mercury does not have. It will have a small propulsion unit, allowing it to change its orbit, while the Mercury spacecraft flew along a fixed orbit once the Atlas burned out. This makes a tremendous difference in the amount of tracking and computing required to control the spacecraft.

Mr. Gurney. Couldn't that be done by augmenting your capability at Cape Canaveral? Why suddenly shift it to Houston?

Mr. Low. It could have been done by augmenting the capability, but the augmentation would have been many factors larger than the capability of the present Control Center, because in Gemini there will be two spacecraft, the Gemini spacecraft and Agena target vehicle, in orbit at the same time, and both must be controlled simultaneously.

Mr. Bell. On that point of Mr. Gurney's, wouldn't it be true, from the financial standpoint, that if you could just augment and improve the Mercury Control Center at Cape Canaveral, there would be a substantial saving?

Mr. Low. We examined this in detail, Mr. Bell, this point, together with the point of the accessibility of the Control Center to the people who are going to be using it.

Now, on the first question, as I mentioned the present Cape Canaveral Control Center has only such a minor portion of the total capability necessary that the augmentation really would have meant starting over at Cape Canaveral.

In addition to that, if you now consider the people who must control the mission, also the technical people who must work on a day-by-day basis on the spacecraft design, on the development of the spacecraft, on the astronaut training, all of which is concentrated in Houston, then it turns out the most suitable place for this Control Center is in Houston, with the additional capability.

To give you an example, during the first year of Mercury flights—this was 1961—the flight control team headed by Chris Kraft, which was based at Langley Field, where at that time the Manned Spacecraft Center was located, this team spent, I think, 186 days at Cape Canaveral. Their time was spent there in not only conducting the mission, because we had only Shepard's and Grissom's flights that year, and two unmanned flights, but time must be spent in continuous practice of the missions.

As the missions become of longer duration, up to 2 weeks in Gemini and also in Apollo, these people must spend part of almost every day in the Control Center. The rest of the day they work with the astronauts in training, simulation, and other things, all of which are operated in Houston. It would have been impossible to operate a Control Center more than 1,000 miles away from the place where the daily work is going on.

Mr. GURNEY. Cape Canaveral may have been a better place to have put it in the first instance, then. I am speaking of the entire complex.

Mr. BELL. When you analyze the fact—excuse me, Mr. Gurney—that the Cape Canaveral operation covered 6 hours of flight time, it may seem small when compared to what we are talking of doing, but nevertheless that represents quite a substantial investment. It seems to me that rather than setting up a whole new operation somewhere else, it could be tied together in one package, regardless of the little inconvenience it might cause.

Mr. HOLMES. Our analysis convinced us that the change needed for Apollo was so great there was no possibility of being able to add on to, or adapt the present Control Center. We needed a new one, and as rapidly as you could put that into use, you could achieve economies by using it for Gemini.

We couldn't get it early enough to use for the earlier Gemini flights, nor were they as complex as the later ones.

There were considerable advantages to putting a new center at Houston, once we decided we needed a new one. The development team is at Houston. This team will put in countless hours working with the basic development of the hardware, as well as simulations, test runs, and so forth.

We considered the cape, among other places. There was very little logic to putting it at the cape. The actual launching, after all, is just a few minutes out of a total control time running into weeks. The Houston site was more logical than any other place in the country. We felt we would achieve the greatest economy of dollars and, perhaps more important, the greatest economy of scientific capability by locating at Houston.

Mr. TEAGUE. Any other questions concerning the general budget request, gentlemen?

Mr. DADDARIO. I have one question. In reference to Mr. Bell's last series of questions, Mr. Holmes, wasn't there considerable thought given to having this Control Center in Cape Canaveral, in the first instance, and then there came a change of thinking in favor of placing it in Houston?

Mr. HOLMES. No, sir, not to my knowledge. Canaveral was merely considered, as were many other places in the country.

But within the role I played in it, and I think I was informed of each step, Houston was more seriously considered than any other location from the very start.

Mr. FULTON of Pennsylvania. I have a question, Mr. Chairman.

Mr. TEAGUE. Mr. Fulton.

Mr. FULTON of Pennsylvania. What part did the Space Council have in making up this budget request?

Mr. HOLMES. The National Space Council?

Mr. FULTON of Pennsylvania. Yes.

Mr. HOLMES. Other than the general purview that they have of the overall space program, and the fact that Mr. Webb is a member, none.

Mr. FULTON of Pennsylvania. Outside of seeing the policy recommendations, there was no review by the Space Council as such?

Mr. HOLMES. I think probably Mr. Webb is better qualified to answer that, but I believe that is right.

Mr. FULTON of Pennsylvania. The Office of the President's Scientific Adviser has no jurisdiction or cognizance in this field, is that correct?

Mr. HOLMES. They maintain a close technical familiarity with the program, but as far as the budget or its construction, I did not note their participation.

Mr. FULTON of Pennsylvania. There has been no jurisdictional dispute between NASA and the military services has there, as to who should budget for these various programs in fiscal year 1964?

Mr. HOLMES. No dispute to my knowledge.

Mr. FULTON of Pennsylvania. So you have good liaison and coordination among the various people from NASA and the Air Force working on this $5.7 billion space program?

Mr. HOLMES. I believe the relationship between the Administrator and Secretary of Defense is very good. There is also the AACB, where we meet with Department of Defense officials, and various ad hoc groups. Our relationships with General Ritland, General Schriever, and with Dr. McMillan, are very close, and I think the communication is very good. This is also true of course, in the Gemini planning group.

Mr. FULTON of Pennsylvania. At the Department of Defense level, do you have a correlation with them as well?

Mr. HOLMES. Yes, primarily with Harold Brown, his office, and particularly with John Rubel and Dr. Kavanau.

Mr. FULTON of Pennsylvania. Will you give us their titles as you go along? Of course, we know them, but give us the title.

Mr. HOLMES. Yes. Dr. Harold Brown, Director of Defense Research and Engineering; Mr. John Rubel, Assistant Secretary of Defense for Research and Engineering; and Dr. Larry Kavanau, Special Assistant for Space to Dr. Brown.

Mr. TEAGUE. Anything else that you people would like to say on the general budget?

Mr. BELL. May I ask one more question? Where do the tracking stations appear in the budget? For example, where will Grand Turk show up in the budget? Will that be the in Air Force or the NASA budget?

Mr. HOLMES. In the Air Force. The part that shows up for NASA's budget is in the Office of Tracking and Data Acquisition.

Mr. TEAGUE. Mr. Yeager.

Mr. YEAGER. I believe you mentioned that there was thought of asking for a supplemental authorization late last year in the neighborhood of $400 million, and that NASA decided not to do it. It has been my understanding that the reason for this deficit was because of the low estimates on the part of contractors in their proposals. Was this the case? If so, is it likely to reoccur in connection with the 1964 budget?

Mr. HOLMES. I think there were probably two major elements in the fact that we had less money than we felt we needed for the program we were outlining at that time.

One is just what you have mentioned, contractor estimates were optimistic and it turned out that when the contracts were definitized they were definitized at higher levels than their proposals.

The second was that we had not really established what the program was to be. Once having established that, together with getting the cost estimates from the contractors, we arrived at what were figures that would have exceeded our total authorized dollars if we had continued at that spending rate.

I think the answer is "Yes," that was a significant part of it. The other part was that the program itself had not been put together.

Mr. YEAGER. Is this a continuing risk in the current budget, that the proposals may have been low?

Mr. HOLMES. I think to nowhere near as great an extent. I think we know a great deal more about the program. The contractors themselves were in a difficult position when they proposed them. They had a limited time, they proposed competitively. They know more now about the program, what they are spending.

There is also the element of cost overrun, I think it is a much smaller factor in the 1964 budget than in 1963.

Mr. TEAGUE. Mr. Gurney?

Mr. GURNEY. Let's ask about one specific item. One of the greatest items of expense posed in this whole program is the construction of this enormous tower at Cape Canaveral. How much are you going to spend on that in this coming fiscal year?

Mr. TEAGUE. Don't you want to wait until we get into the line items, Mr. Gurney? We will get specifically to that individual item.

Mr. GURNEY. Yes, I suppose so, if Mr. Holmes is going to be here.

Mr. TEAGUE. He will be here.

I would like to say to the new members of the committee that last year this subcommittee went very carefully into the question of duplication. If you are interested in a particular point, I think you will find it in last year's hearings. I think we went into every possible area of duplication that we could find.

If you will open your backup books to volume II, "Research and Development," and turn to "Manned Spacecraft Systems," and then in the thin book, if you would turn to "Manned Spacecraft Systems," we will start on the individual programs.

Do you want to go into the first paragraph, "Objectives," Mr. Holmes, or do you want to start with the first amount of money?

Mr. HOLMES. I think since we have gone through the summary of resources we can go to the first amount.

I would like Mr. Low to do this. He is prepared to go through item by item.

Mr. TEAGUE. Very well. If any member has a question on an item, don't hesitate to ask a question. Mr. Low, will you please start.

Mr. LOW. Mr. Chairman, the category "Manned Spacecraft Systems" is one of several major categories in the manned space flight program. It specifically includes spacecraft support, research and technology, which I will cover in detail in a few moments. It included in last year the Mercury and Mercury 1-day programs, which were not included for fiscal year 1964. It includes the Gemini program, Gemini spacecraft and Gemini launch vehicles, and includes also the Apollo spacecraft program. The Apollo launch vehicles are funded in another category, the "Launch vehicles and propulsion" category.

In addition to the research and development program we have included the operational costs of the mission control center that we have just discussed.

Mr. TEAGUE. Mr. Low, go back to Mercury. What is the $3,342,000? Is that what NASA used last year? It is not what we authorized last year.

Mr. LOW. In last year's budget book, Mr. Teague, there was a total for Project Mercury which was somewhat higher because it included in a lump sum the research and development costs, the cost for the operation of Project Mercury, and it also included what we call the institutional support associated with Project Mercury.

In last year's budget book we discussed these two numbers together, though in one area in one section of the book they were broken out. You authorized for Project Mercury last year $3½ million.

Our current best estimate is a requirement for $3.342 million, which is just within $158,000 of what you authorized for Project Mercury.

Mr. YEAGER. Were these direct R. & D. costs?

Mr. LOW. Direct R. & D. costs.

Mr. HOLMES. Mr. Chairman, I think all the way through last year's budget we found it somewhat confusing to have the institutional operating costs—cost of the Government people, Government facilities—somewhat arbitrarily prorated into the R. & D. program. So in this budget book they are set out separately.

I think it is a lot easier to discuss. I believe in your discussion at Houston on a recent visit some of those people were confused about the Mercury costs because they had forgotten there was this rather large chunk associated with Mercury which was an institutional cost.

Mr. TEAGUE. Do we have anything to compare the figures with last year's?

Mr. HOLMES. We could compare the overall institutional and overall operations figures, and also compare what we got with what we spent.

Mr. TEAGUE. Last year in considering Mercury we talked of a completely different figure from what you have here. If that is true all the way through the books, we have nothing to compare on the figures this year with last year.

Mr. LOW. Mr. Chairman, in last year's budget book we did have a breakout of the direct R. & D. costs, and they were a part of last year's record, though the number we discussed in more detail than this one portion was the total R. & D. plus the institutional support.

There was a summary table in the front of the book that gave the sum of $3½ million for R. & D. for Project Mercury.

Mr. TEAGUE. Take the $17,957,000 for the 1-day mission, is that the figure we worked on last year for this 1-day mission?

Mr. LOW. No, sir. None of the figures here are the figures that were given last year except for the summary table that I just mentioned.

There have been reprograming actions within the program, also, since last year.

Mr. HOLMES. We did find this confusing. I think last year we indicated, and if I had my books for last year we would find written in the margin the R. & D. costs for each item.

Mr. TEAGUE. The staff has furnished a figure of the fiscal year 1963 budget as presented in 1962 for the 1-day mission of $12,180,000. Then the fiscal year 1963 budget as currently replanned, $30,129,000, giving a reprograming of about 153 percent.

Now, it seems to me it is going to be very difficult for the committee to have any understanding of what you are talking about unless we have some figures as a basis to start from.

Mr. HOLMES. I think we can give you a breakdown, Mr. Chairman, of what the R. & D. portion was of each one of these programs for fiscal 1963.

Mr. TEAGUE. I don't know whether I am the only member of the committee who is confused or not, but take for example, Gemini, $232,838,000. The figure I have that we worked with last year was 203,200,000, so that is a case where it is more than the figure that I have for last year.

Mr. HOLMES. The only way I know to make it clear is to separate from the dollars in last year's budget books the institutional and operating expenses from the R. & D. programs. Then we can make a comparison which may make this clear.

Mr. TEAGUE. Let's proceed a little and see how we come out. Mr. Yeager?

Mr. YEAGER. Mr. Holmes, could you indicate the areas where NASA did reallocate funds as we take up the various major categories such as Mercury, Gemini, Apollo, so on? Could you indicate there where reprograming took place and what happened?

Mr. HOLMES. In each area in addition to discussing the fiscal 1964 request, you want us to discuss fiscal 1963, and our performance?

Mr. YEAGER. I think so, as far as reprograming is concerned.

Mr. TEAGUE. We would like a picture in this hearing of the money you asked for last year, what you got, what you did with it, what you are asking for this year.

Mr. FULTON of Pennsylvania. Mr. Chairman.

Mr. TEAGUE. Mr. Fulton.

Mr. FULTON of Pennsylvania. It might help if at one point you gave us a list of the reprograming for the fiscal year 1964 money that has already taken place, and that is in prospect for the remainder of the current fiscal year up to June 30, and have it put in the record. That might help.

Mr. HOLMES. We could do that. I have in front of me each of our programs, what has been completed to date and what the uncommitted balance is. But the figures we deal with are R. & D. figures.

I am not dealing here with institutional operating costs. That is why I couldn't talk directly to the figures in the old blue book. I could by tabulating it.

Mr. FULTON of Pennsylvania. Those of us who are very interested certainly came to the point in Houston where nobody at the meeting, either NASA or the Representatives of Congress who were there, knew just where the starting point or base was so that we could find the differences between us. I think there should be a statement put in the record so that we have a basis on which to start. We need to get the same starting point.

Mr. HOLMES. We have figures for research and development and construction of facilities. Above that you authorize the money to NASA to pay salaries and run the institutions at the centers. These are separate. But if one does what we did last year in the budget, and takes those total costs—my salary, all the other salaries—and prorates them against the programs, you come up with something one can't relate to R. & D. cost alone. Thus we must separate those from the fiscal year 1963 figures if we are to compare what we spent last year versus what we were authorized.

Mr. FULTON of Pennsylvania. But these are NASA figures or various elements of figures. We must have some point where, on the basis of the figures you have previously given this committee, we can make a comparison as the chairman suggested.

The foundation for the figures we have has been supplied to us by NASA. But certainly someone should go back and make a correlation as the Chairman suggests, both as to the figures and as to the programs, so that at one point in time on a certain date we again have the same starting point. You must go back and pick that up from the figures you have already given us.

Mr. HOLMES. We can readily do that. We are not prepared to do it today, because I was prepared to discuss fiscal 1964. But it is a very simple thing for us to do, and we will be glad to.

Mr. TEAGUE. You have given us a set of fiscal year 1964 backup books, and in these books you also show fiscal year 1963; however, we have never seen the fiscal year 1963 figures before.

Mr. LOW. Mr. Chairman, the figures we show in the 1963 column did appear in last year's budget book, in a summary table, I believe.

Mr. LILLY. That is right in, the front part of the "blue book" used last year there was a summary table showing for fiscal 1961, 1962, and 1963 the component parts, direct R. & D., personnel, institutional estimates. What was shown throughout the balance of the book was the total figure which included the institutional and operating costs.

Mr. HOLMES. I must say, I don't think they were given in detail. They were by totals, and they couldn't go through the book and compare item by item.

Mr. LILLY. That is correct?

Mr. TEAGUE. Suppose we adjourn the meeting and talk this over, and take it up next week? I don't see how we can intelligently discuss this budget unless we have something to compare it with, and here we have figures that we have never seen before.

Mr. FULTON of Pennsylvania. I agree with the chairman.

Mr. TEAGUE. I had hoped that after our visit to Houston, someone on the staff would have talked to you about this, and you would be prepared to discuss it.

Mr. HOLMES. Mr. Chairman, I think we are not prepared to break last year's budget down now so to show R. & D. and institutional costs

separately as is done in the fiscal year 1964 budget. We can very easily be prepared to do that subsequently and to discuss our expenditures and commitments to date.

Mr. TEAGUE. Do any members of the committee have any comment?

Mr. FUQUA. I think you are right, Mr. Chairman. I wasn't on the committee last year, but I would like to know what they asked for last year, what they got, and what they spent. I think it might simplify it a lot.

Mr. TEAGUE. Any other comments?

Mr. HOLMES. What we do have here, Mr. Chairman, is the total R. & D. cost for any element for fiscal 1963. We also have commitments and obligations against it. But these figures will not be the same as those that appeared in the "Blue Book" because of the institutional cost problem.

Mr. FULTON of Pennsylvania. But, you see, we are talking about plan of organization. You used a plan of organization and presentation for 1963, and have changed the plan of organization for 1964. Granted that you have a summary that tallied all these figures and collated them together—nevertheless, as the chairman says, it becomes an impossible job for us to go through item by item.

Unless we have them set up so that we can make a comparison of 1963 budget to the 1964 budget, we are not in a position to identify any changes that have occurred. We had suggested that, as the chairman said, at Houston.

Mr. HOLMES. I have a suggestion by which we could proceed. We do have here the research and development figures for each of the line items for 1963. Take Mercury, for example. We could state what that figure was; we could state what we have spent to date. The thing it will not do is agree with the figure you have from the "Blue Book."

But we could state this figure, as a matter of record. Then we could come in tomorrow or the next day with a list that shows what the R. & D. was, and the institutional costs. So I don't think anything would be lost in the review.

Mr. TEAGUE. Suppose we just wait, and start over again.

Mr. HOLMES. All right, Mr. Chairman.

Mr. FULTON of Pennsylvania. Unless we have the bookkeeping done for us so that we can judge from 1963 to 1964 by the various items as we go along, it would become a job for our staff of some degree of intricacy, even though they are given to us all at once. Is that not so, may I ask, Mr. Yeager?

Mr. YEAGER. It would be a considerable job—a considerable job.

Mr. TEAGUE. I just don't see how we could go to the floor and intelligently discuss these figures and justify them unless we have this breakdown.

Mr. HOLMES. All right.

Mr. TEAGUE. The committee will be adjourned to next Monday at 10 o'clock.

(Whereupon, at 2:15 p.m. the subcommittee adjourned, to reconvene at 10 a.m., Monday, April 1, 1963.)

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1964 NASA AUTHORIZATION

MONDAY, APRIL 1, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON MANNED SPACE FLIGHT,
Washington, D.C.

The subcommittee met, pursuant to adjournment, in room 214–B, at 10 a.m., Hon. Olin E. Teague (chairman of the subcommittee) presiding.

Mr. TEAGUE. The committee will come to order.

We have with us this morning Mr. Norman V. Petersen, Director of the Air Force Flight Test Center at Edwards Air Force Base, Calif. Mr. Petersen played a very prominent part while working for one of the companies that worked on the rendezvous technique.

Mr. Petersen, we are very pleased that you would come in and give the committee the benefit of your thinking as far as rendezvous is concerned. You have a prepared statement. I will let you go ahead with that.

Without objection, I would like to put Mr. Petersen's biography in the record.

(The biographical sketch of Mr. Petersen is as follows:)

BIOGRAPHY OF NORMAN V. PETERSEN

Mr. Norman V. Petersen is Technical Director, Air Force Flight Test Center, Edwards Air Force Base, Calif. He was born in West Branch, Iowa, on April 9, 1921, and educated in the public schools of the State of Iowa.

He served in the field artillery during World War II and received a B.S. in mechanical engineering (1949) and an M.S. (1950), both from the State University of Iowa. He subsequently worked as a research engineer with Midwest Research Institute, and in 1952 joined Sperry Gyroscope Co., participating in preliminary design studies of ground- and air-launched missile systems, research analysis of orbital flight mechanics, and conceptual design of manned space vehicles. In 1958, he became research staff engineer at Lockheed Missile and Space Division, Palo Alto, Calif., and from 1959 to May 1962 was chief, astro sciences group, at the Norair Division of Northrop Corp., Hawthorne, Calif. During the latter assignment, the referenced report on Earth-orbital operations was prepared. Mr. Petersen's engineering experience has primarily been devoted to preliminary design and advanced concept studies with major emphasis given to space technology and the astronautical sciences.

Mr. Petersen has authored or coauthored 25 technical papers on various engineering subjects concerning space flight, with a major portion of these directly relating to the topic area of rendezvous, assembly in space, and Earth-orbital operations.

During the past 10 years, Mr. Petersen has devoted considerable effort toward the establishment of an effective professional scientific and engineering community in the field of astronautics. He is a member of the American Institute of Aeronautics and Astronautics, Aerospace Medical Association, and fellow of the American Association for Advancement of Science, and the American Astronautical Society. Mr. Petersen assisted as founding member, past president, 1955–57,

and has served continuously as member of the board of directors of the American Astronautical Society since formation in 1953. He additionally served as first editor of the Astronautical Sciences Review, first editor of the proceedings of the American Astronautical Society and served as national program chairman for a number of national scientific and engineering symposia. Mr. Petersen organized the first professional technical symposium held in the United States on the subject of rendezvous in 1958.

In 1955 and 1956, Mr. Petersen served as a U.S. delegate to the Fifth and Sixth International Astronautical Federation Congresses in Copenhagen and Rome.

He was joint recipient of the Samuel M. Burka Award, the Institute of Navigation, 1959.

In September 1946, he was married to the former Bonita M. Crees of Atalissa, Iowa. They have two children, U. Brian, 14, and T. Douglas, 12. They reside at 5370 Sage Avenue, Edwards, Calif.

Mr. TEAGUE. Go right ahead, Mr. Petersen.

STATEMENT OF NORMAN V. PETERSEN, TECHNICAL DIRECTOR, AIR FORCE FLIGHT TEST CENTER, EDWARDS AIR FORCE BASE, CALIF.

Mr. PETERSEN. Mr. Chairman and members of the committee, I appreciate the opportunity to participate in your committee's review and discussion concerning the subject of earth-orbital rendezvous operations. I wish to clearly indicate that the basis for my discussion, and comments in answer to specific questions, primarily stems from engineering studies performed prior to joining the Air Force Flight Test Center. Specific reference is made to a technical report authored in 1961 summarizing technical considerations of the earth-orbital rendezvous, assembly, and launch route for lunar operations. This report entitled "Orbital Assembly and Launch for Lunar Operations," was written by me and published in Aerospace Engineering, Institute of Aerospace Sciences, volume 21, No. 8, August 1962.

Mr. TEAGUE. Mr. Petersen, if there is no objection from any member of the committee, we will put your technical paper in the record at this point. I think most of the members have seen it, but I think it should be made a part of the record.

(The material referred to is as follows:)

Orbital Assembly and Launch for Lunar Operations

Norman V. Petersen, MIAS

Northrop Corporation, Norair Division

DEVELOPMENT OF AN orbital assembly and launch capacity for the national space program is recognized as the most vital element in the United States' plan for lunar and interplanetary exploration. The capacity for rendezvous, assembly, checkout and launch from orbit provides an immediate and permanent solution to booster payload limitations, broadens the achievable space mission window, and permits the vital utilization of man to the limits of his ability to provide in space the capacity for decision making, the ability to perform secondary (orbital) checkout, the dexterity to yield improved reliability through orbital maintenance, repair and modification and the flexibility to broaden vehicle maneuverability performance limits. The purpose of this report is to discuss some of the general requirements for orbital assembly and launch for lunar missions, to present specific design and performance characteristics for an orbital rendezvous base system, to demonstrate the potential value of rendezvous compatible orbits thus giving improved surface-to-orbit launch logistics and to present a brief appraisal of the Soviet Union's orbital assembly and launch potential.

The author acknowledges the many engineering contributions made to the study outlined in this paper by associate members of the Astro Sciences Group of the Norair Division.

Best Route to the Moon: Orbital Assembly and Launch

Only a brief period of time has passed since serious announcements were made indicating that first priority was to go for the development of the "rendezvous route to the moon." This decision provided the capability for implementing our "lever into space" as shown in Fig. 1. This "lever into space" concept for orbital assembly and launch operations can be employed to accomplish the goals of manned exploration of the moon and planets beyond, provided we have a strong "fulcrum" from which to act. Effectively, the fulcrum in space is the orbital rendezvous base for assembly, checkout and launch operations for lunar and deep-space missions. When the United States space effort includes this fulcrum in space, we can initiate many new missions with a considerable improvement in launch logistics.

General mission requirements for an earth-orbital assembly and launch system to accomplish manned lunar operations are presented. A concept for development, general system characteristics, and operational use of a proposed orbital launch pad for rendezvous, assembly, check-out and launch of mannad lunar flyby, orbiting and landing vehicles are discussed. Particular emphasis is given to utilization of rendezvous compatible orbits and stationkeeping for improved surface-to-orbit launch logistics. The "best route to the moon," employing a proposed Space Canaveral facility as a low-altitude orbital assembly and launch adjunct to Cape Canaveral, will significantly increase the United States' capacity for lunar and interplanetary exploration.

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This writer believes that our conquest of space can more soundly be built through use of an earth-orbital launch base—i.e., a "Space Canaveral" facility as a low-altitude orbital assembly and launch adjunct to Cape Canaveral. Present booster payload limitations are considered inadequate to reach with confidence the moon or planets, land man on their surfaces and return him to earth. We can, however, attain the moon with manned landings, employing the Saturn C-1 or C-3 class boosters, provided these boosters are utilized as surface-to-orbit logistic transports to build and supply a minimum orbital launch base with subsequent assembly, checkout, and launch of special lunar craft. The Saturn class boosters using rendezvous techniques envisioned at present will permit assembly in orbit of the required launch base and mission vehicles. Best engineering estimates require about two to ten Saturn shots to build this minimum base. An additional three to ten Saturn vehicles will boost the specially designed spacecraft modules to the orbital base for assembly and launching to the moon. No other mode of transport to the moon can compare favorably, considering reliability, operational simplicity, early operational availability, and in no way can be compared considering growth potential.

Engineering techniques and devices to accomplish orbital rendezvous, coupling, assembly, resupply, and fueling of satellites in space have been studied to a considerable degree. Extensive research and development remains, however, to be accomplished before full utilization of this new dimension for space operations can be made. Potential utility of an orbital launch base is shown on Fig. 2. In addition to the primary objective of providing an assembly point and launch pad for the diverse space missions, possible side advantages include the use of base appendages for experimental research laboratories, and as a continuous launch base for reentry testing.

The growth of the United States' and Soviet Union's orbital payload capability[1] during the last 4 years is plotted on Fig. 3. A stair-step progression has occurred with a marked difference in capability indicated. Maximum operational orbital payload capability presently for the U.S. is approximately 5,500 lb using the Atlas–Agena, whereas for the U.S.S.R. it is announced as over 14,000 lb. Operational availability of Atlas–Centaur, Titan, and Saturn class boosters will give significant improvements. Saturn C-3/C-4 vehicles are estimated to give payloads of 100,000 lb to 200,000 lb in the 1964–66 time period. This capacity for space payloads (in light of that required for lunar and interplanetary missions) is still markedly insufficient. A significant improvement can result, however, if

Fig. 1. Lever into space.

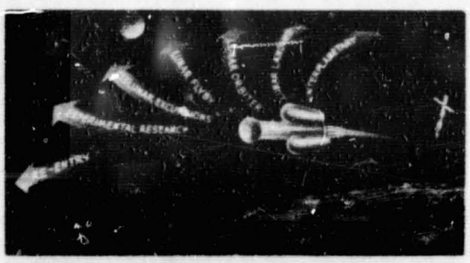

Fig. 2. Orbs space missions.

aggressive orbital assembly and launch operations are programmed into our space efforts. As shown on Fig. 3, orbital launch weights for lunar and near-planet missions are approximately 500,000 lb and 5,000,000 lb, respectively. Using orbital assembly and launch, this required capacity can be available at an earlier time period than by direct launch techniques.

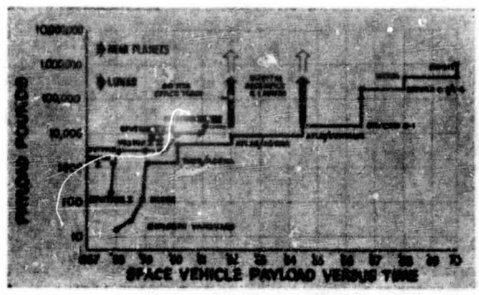

Fig. 3. Vehicle payloads.

In recognizing the potential value of orbital launch operations to our space program, it is of interest to try to determine the Soviet capability to exploit this "springboard to space." Let us first take a look at a published planning chart (1958) of the Soviet rocket, missile and space-travel program[2] as published in a 1960 pamphlet of the Department of the U.S. Army. Fig. 4 illustrates the Soviet Union's planning as of 1958 immediately following launchings of Sputnik III having a payload of 2,925 lb. At the present time, the Soviets have progressed across this chart of space objectives including the temporary manned satellites (Vostok I and II) and the lunar impact probe (Lunik II). Plans for implementation of a manned satellite base and a moon base are shown next on their agenda and closely coupled conceivably employing assembly and launch operations. In February 1960 and again recently, articles in the press have quoted Premier Khrushchev's speeches about the Soviet efforts in development of their so-called "60-ton space train." According to our best estimates, a 60-ton payload is sufficient to perform the lunar flyby and orbital missions but is approximately a factor of 2-4 times

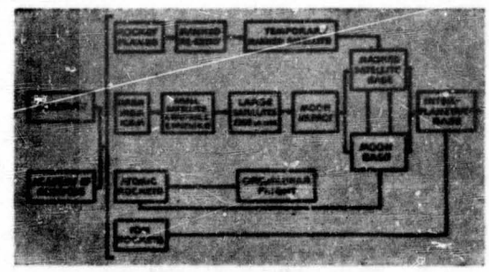

Fig. 4. Soviet rocket missile and space travel program—1958.

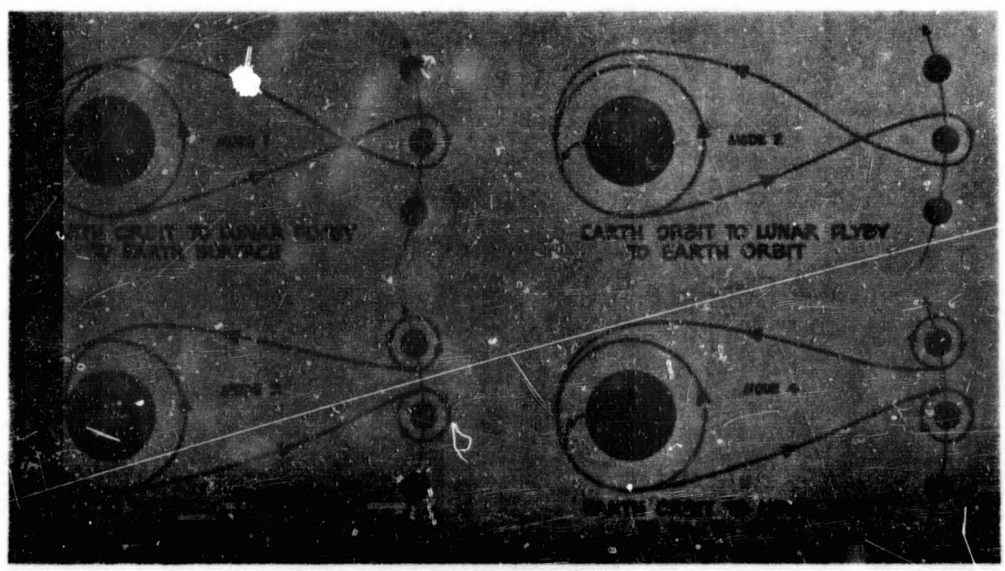

Fig. 5. Earth-lunar trajectory profiles.

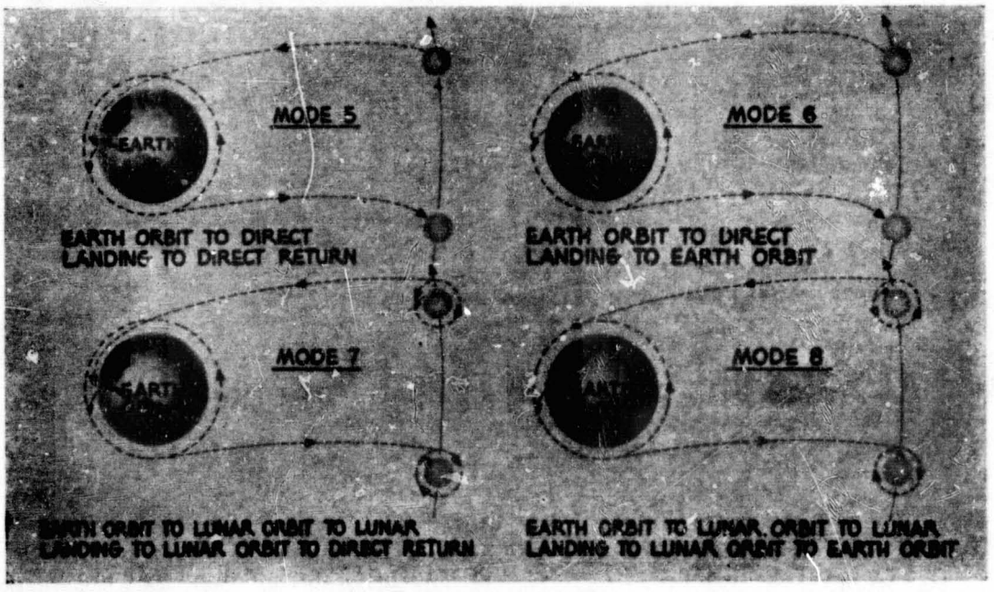

Fig. 6. Lunar landing and return modes.

too low to achieve the lunar landing task. Based on the U.S.S.R.'s announced Venus probe payload capability of 14,000 lb to earth orbit, their 60-ton "space train" would require about nine rendezvous in space to give this assembled payload. Recent booster tests in the Pacific Ocean during September and October of 1961 have had the announced purpose of developing larger boosters. It is surmised that

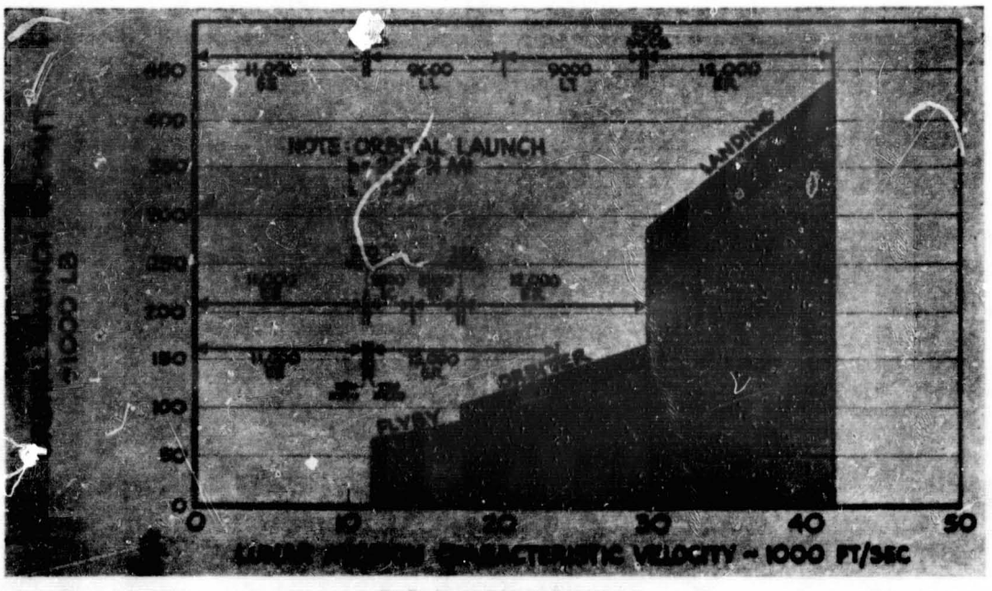

Fig. 7. Lunar mission requirements.

the nine rendezvous may therefore be reduced.

The payload comparison of Fig. 3 shows an approximate 2-yr lag in capability. Recent Soviet booster tests may increase this to 3 years, although NASA's announced plans for Mercury II using Atlas–Agena and Titan may somewhat counter this separation. Production time on available boosters can be far more easily compressed than development time.

In considering the Soviet potential for going in the direction of orbital operations, let us review some of their announced milestones having a direct bearing on requirements to effect rendezvous, assembly and launch in space as shown by Table 1. Additional equipment and operational systems for certain supporting areas that are mandatory in order to provide the Soviets with an orbital operations capability are noted.

Table 1, in summary, suggests that at present a capacity for rendezvous may exist and that manned lunar landings may well occur as early as 1963.

Table 1. U.S.S.R. Orbital Assembly Potential

Simultaneous launch pad operation	Feb. 1961
Orbital launch from parking orbits	Feb. 1961
14,000-lb payloads	Feb. 1961
Launch on time capability	Sept. 1961
Precision guidance capability	Sept. 1961
?-lb payloads	Sept. 1961
+	
Vostok I-II liquid-fueled de-orbiting propulsion	?
+	
Rendezvous radar/Guidance/Coupling	
=	
Orbital assembly capability	1961–62
Therefore: Manned lunar landing	1963

Routes to the Moon

In considering flight to the moon, it is believed that the several earth–moon transport modes may be classified by the following six operational approaches: direct ascent, earth-orbit rendezvous, in-transit rendezvous, lunar-orbit rendezvous, earth-orbit/lunar-orbit rendezvous, and lunar surface rendezvous. Each of these approaches have special merit, although my discussion primarily will concern the second approach—earth-orbit rendezvous. It is believed that this route to the moon has the greatest pay-off for lunar as well as interplanetary missions inasmuch as the total effort of transport to the moon and return is approximately equally divided about the earth-orbit launch base. The total energy, the tasks to be accomplished and the order of complexity for the surface-to-orbit boost phase is reasonably well matched with those occurring during and following orbital launch.

It is recognized, however, that future development of nuclear propulsion will probably encourage the use of special-purpose shuttle vehicles for operation between earth-orbits and lunar-orbits with lower transport costs.

Lunar Mission Energy Requirements

Many factors must be considered in attempting a selection of an optimum approach in developing an orbital assembly and launch base. Principal factors that must be recognized and evaluated include:

(1) Booster payload capacity and launch rate.

(2) Surface-to-orbit booster launch restrictions.

(3) Orbital launch criteria.

(4) Lunar trajectory profiles and energy requirements.

(5) Space environment and hazards.

(6) Mission vehicle configuration and weight criteria.

(7) Propulsion system and auxiliary power criteria.

(8) Life support and crew requirements.

(9) Orbital checkout requirements and system reliability.

(10) Flight test and evaluation.

(11) Production capacity and cost scheduling.

Synthesis of these primary factors, plus many secondary items, must be achieved in the process of arriving at an optimum orbital assembly and launch logistic system. Only a portion of these system criteria are reviewed in this paper.

In order to design and size an orbital launch system, it is necessary to synthesize a vast number of design equations involving numerous performance variables and constraints in the eleven areas shown. Suffice it to say, a general weight equation must be developed for each vehicle module or element utilized

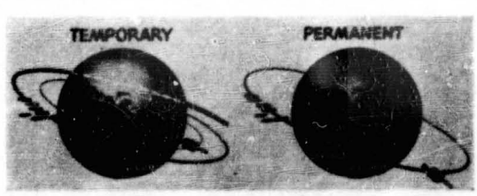

Fig. 8. Orbital assembly and launch systems. *(Left)* Orbital-parking. *(Right)* Rendezvous-compatible.

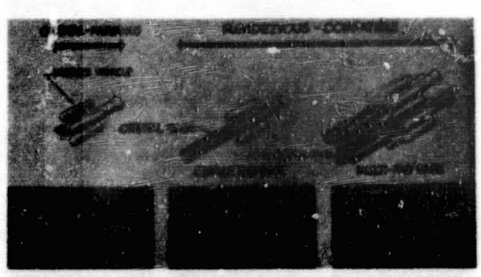

Fig. 9. Orbital assembly and launch concept. Lower inset panels (a) *left*, (b) *center*, and (c) *right*.

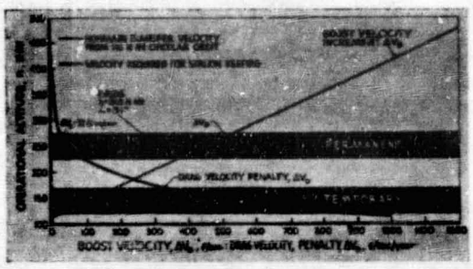

Fig. 10. Operational altitude, air drag, and boost velocity criteria.

in the entire orbital launch system in order to establish the overall system weight and energy requirement. This was performed for a special set of design characteristics for the Northrop engineering study[8] on orbital assembly and launch. Several different earth–lunar flight trajectories were considered; namely, the flyby (Modes 1 and 2), orbiting (Modes 3 and 4), and landing (Modes 5-8) missions with two lunar–earth return approach modes. These are illustrated by Figs. 5 and 6. Fig. 5 shows both lunar flyby as well as lunar orbital trajectories with Modes 1 and 3 depicting direct atmospheric reentry whereas Modes 2 and 4 show return to the orbital launch base. Launch from the orbital base with a coast trajectory to a lunar-orbit followed by descent to the surface as shown by Mode 8 probably is the most versatile approach for earth–lunar operations. Initially, the lunar-orbit phase would be employed only to give improved landing site selection, but eventual availability of nuclear boosters would permit shuttle operations between earth and lunar orbiting bases.

Although the lunar–earth return trajectory direct to the earth-orbit launch base has several significant advantages, time did not permit developing detailed system requirements. Two advantages considered are first the possibility for use of the previously discussed special shuttle vehicles and second that of reducing the return vehicle's atmospheric reentry heat loading since only a ΔV of about 10,000 fps need be considered.

The relationship of orbital launch weight to characteristic velocity for the three lunar missions are presented in Fig. 7. Orbital launch weight is plotted vs the required characteristic velocity. The left-hand side of each mission shows the launch weight for an aerodynamic reentry whereas the right-hand side pertains to a powered reentry. Considering the landing mission, the minimum orbital launch weight is 290,000 lb and requires 30,000 ft per sec characteristic velocity. The velocity increments for the several segments of the mission are earth-orbit escape of 11,000 fps, midcourse-correction-out of 250 fps, lunar-orbit-capture of 3,000 fps, lunar landing of 6,000 fps, lunar-take-off of 9,000 fps, and midcourse-correction-back of 250 fps. The powered reentry mode with 12,000 fps capability increases the orbital launch weight from 290,000 lb to 440,000 lb, an increase of 51 percent. The shaded area illustrates the additional launch weight imposed by radiation shielding. In this

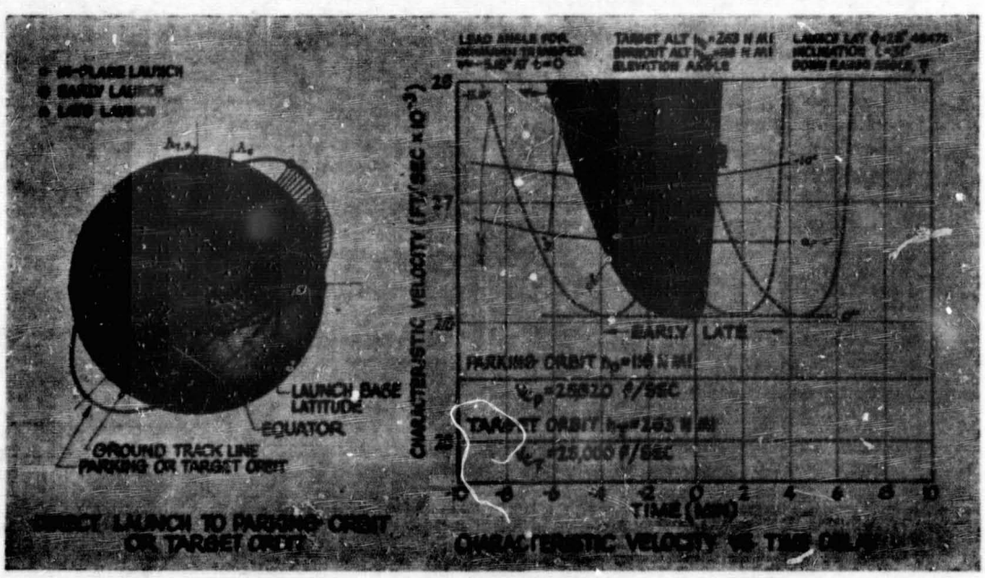

Fig. 11. Direct launch to RCO.

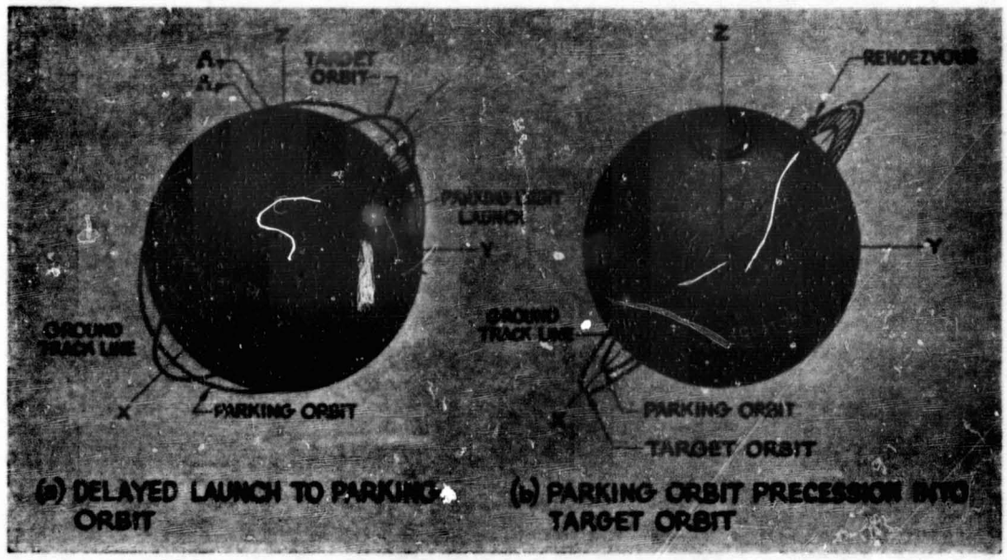

Fig. 12. Delayed launch to RCO.

case, approximately 6,000 lb of water and aluminum shielding serves as a "storm cellar" for Class 3 solar flares, and Van Allen radiation protection. Increasing crew size, mission duration and propulsion performance markedly add to orbital launch weight. However, the use of standardized modules and assembly in space provide the great advantage of flexibility to re-configure the vehicle to provide for changes in crew size and duration. These changes can readily be made through orbital assembly and launch but cannot be made for the direct launch mode to the moon.

Total energy requirements for both orbital launch and direct launch ascents are exactly the same. The basic comparison and determination of performance advantages between orbital launch and direct launch can only be resolved by considering first operational dates, reliability and growth potential. Consideration of these criteria results in a distinct advantage for the orbital launch technique.

Orbital Assembly and Launch Systems

Generally speaking, two basic approaches exist for implementation of an orbital assembly and launch capability. These are defined as either *orbital-parking* or as *rendezvous-compatible* assembly and launch approaches.

Orbital-parking assembly and launch system is an operational procedure that involves placing successive payloads (using direct launches) to the desired orbit, or employing a parking orbit with subsequent injection to the assembly orbit followed by assembly during the natural air-drag decay phase to the orbital launch position.

Rendezvous-compatible assembly and launch system considers similarly a direct launch to a rendezvous compatible orbit (RCO), or use of a parking orbit with subsequent injection to the same RCO, with continuous station keeping of the independent vehicle modules or base on the RCO throughout the life of the base.

Fig. 8 illustrates these two basic operational approaches. Principal advantages and disadvantages are shown in Table 2. Development of a rendezvous-compatible assembly and launch system provides growth potential such as illustrated by Fig. 9. Initial development of an interim launch base comprised of a checkout and life support module employing the rendezvous compatible orbit concept can serve as a single launch pad for mission vehicle assembly, checkout and launch. This approach is recommended in preference to the orbital parking approach. Continuous manned operation by an

Table 2. Significant Features for Orbital-Decay and Rendezvous-Compatible Assembly and Launch Systems

Orbital-Decay	Rendezvous-Compatible
Stationkeeping not required	Rendezvous compatible
Checkout facility replacement	Greater launch opportunities
Fixed assembly time restriction	Permanent facility maintained
Nonconservative initial development	Assembly and checkout time flexibility
Improved booster economics	Launch time selection
	Greater rescue opportunity
	Orbital launch simplification

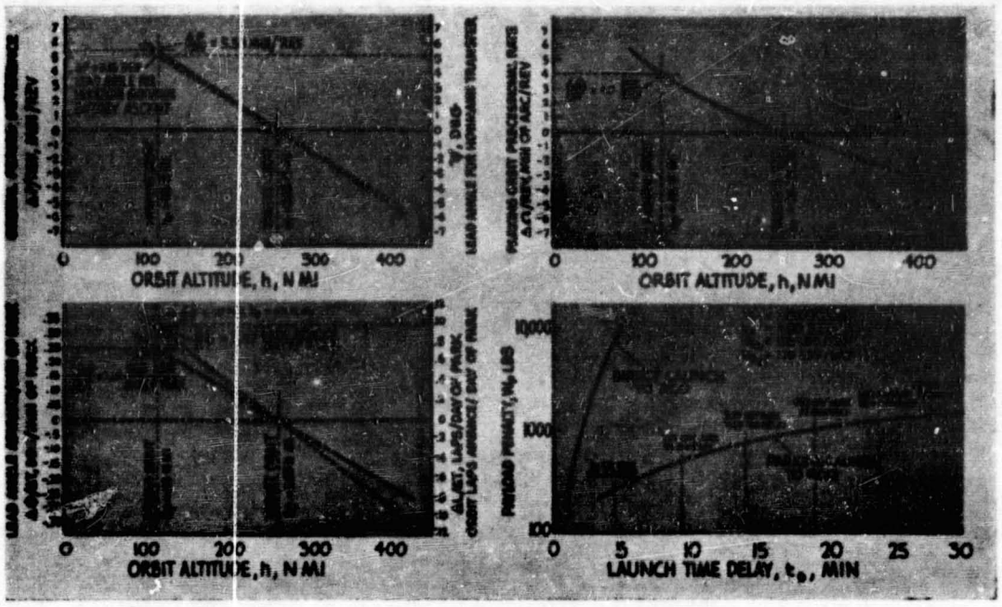

Fig. 13. Parking orbit launch characteristics.

assembly and launch complement is considered desirable. Eventual progression to a permanent launch complex is shown in Fig. 9's inset (c). Multipad as well as orbital tracking facilities may be the course of development.

Launch Restrictions

Surface-to-Orbit Launch Restrictions for Rendezvous

Major launch facilities and tracking ranges now exist at Cape Canaveral (Atlantic Missile Range, AMR) and at Vandenberg Air Force Base (Pacific Missile Range, PMR). These launch ranges, with some restrictions, now provide capacity for easterly as well as westerly launch trajectories. AMR restrictions, because of booster hazards, permit launch azimuths from 46° (Northeast) to 114° (Southeast). Tracking facilities further restrict launch azimuths to about 70° (Northeast) to 110° (Southeast). PMR restrictions allow launch azimuths ranging from about 170° (Southeast) to about 350° (Northeast). In addition to the economic advantage of using low-altitude orbits for assembly, launch azimuths giving as large a component of earth spin (low-orbit plane inclinations) as possible are desirable. However, the orbiting base must not be at too low an altitude so that high drag penalties result. In order further to improve logistics, the booster launch trajectory is programed to result in injection into a rendezvous compatible orbit, thus giving maximum opportunities for launch, rescue, and recovery.

Consideration of such factors as launch azimuth restrictions, rendezvous compatibility, air drag, booster requirements, and radiation shielding penalties results in establishing the best operational altitude and inclination for orbital assembly and launch logistics to the moon. Fig. 10 illustrates only two of these parameters—booster velocity increments for injection to variable altitudes above the 116 nm reference circular orbit, and drag velocity increment for orbit maintenance due to air drag. Here the drag velocity increment is the velocity requirement to maintain a module in orbit having a 100 lb per ft^2 area loading for a period of one yr. Thus, for a 263 nm orbit the interorbital transfer velocity increment ΔV_B is about 520 fps and the drag increment ΔV_D is about 32 fps per year. A further factor is that of determining the best rendezvous compatible orbit, as influenced by the additional constraint of synchronism for earth-orbit launch and lunar-arrival at a specified lunar phase.

Surface-to-Orbit Launch Time Delay Considerations

The most serious problem to development of an orbital assembly and launch capability is recognized as that of "launch-on-time." Delays in launch cause increasingly severe velocity penalties and subsequent payload degradation in accomplishing ascent to, and rendezvous with, the target satellite base. Launch delays cause increasing velocity penalties because of plane angle change that occurs as the launch base passes through and beyond the target launch base orbit plane and as a result of in-

creasingly large injection and adaptation velocity components for ascent and rendezvous with the target satellite on the RCO. The plane change velocity penalty develops for direct ascents to a RCO as well as for the parking orbit (sometimes referred to as orbit phasing) ascent if the parking orbit is established in the plane of the target orbit.

In considering these launch restrictions, the conclusion is drawn that a compromised ascent-to-rendezvous trajectory program is the best solution if launch delays exceed from 3 to 4 min. Direct ascents should be employed if the velocity penalties, or small launch windows can be accepted. However, use of the extended parking orbit technique will give zero payload penalties with considerably larger launch window limits. Other launch techniques for rendezvous operations have been presented by Houbolt,[4] Bird and Thomas,[5] and Straly.[6]

The first two reports demonstrate that, for the condition of small angular differences between launch base latitude and target satellite orbit inclination, the payload penalties for rendezvous will be small. The payload penalty effects associated with launch-pad delays are not as sensitive to delay time, although the practical launch window would be less than 5 min. However, for the condition of a relatively large angular difference between the launch-base latitude and target satellite orbit inclination (Cape Canaveral launch base at 28.5° and an RCO constrained target orbit of about 35° to give multiple recovery opportunities at existing air bases—i.e., Edwards AFB), for example 6.5°, the payload penalty becomes excessively large.

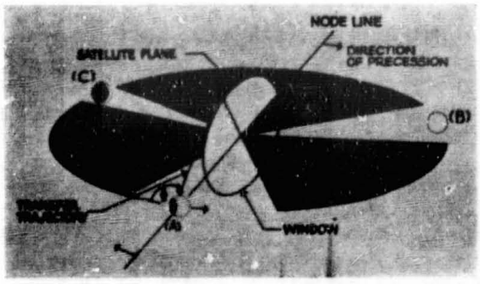

Fig. 14. Escape window display.

The third report effectively extends the technique of Houbolt and Bird by providing booster maneuverability during ascent and the use of parking orbits to minimize payload penalty and increase launch window limits. However, Straly's orbit phasing technique is restricted practically to small angular differences between the launch base and target satellite orbit, and for this condition, launch window limits are of the order of an orbital period.

The extended parking orbit technique outlined in this paper provides a launch procedure having a zero payload penalty and a practical launch window to an RCO constrained target satellite of up to 30 min. The following paragraphs compare payload penalty and window limits of the direct launch technique with the extended parking orbit technique. No attempt is made to compare these two techniques with those of Houbolt, Bird and Straly. It is believed, however, that within the launch window limits of up to 20-30 min that the extended parking orbit approach is superior.

Fig. 11 illustrates the direct launch case.[7] Here the target satellite is shown on an inclined rendezvous compatible orbit. Analysis was performed to determine the effect of launch time delays[4] for rendezvous with a target satellite. Total characteristic velocity was determined for early, in-plane and late launches to the RCO. The characteristic velocity V_{ch} is plotted on the right-hand figure. Solid lines are for the conditions of varying target positions, or lead angle, with respect to the launch base at time zero. For example, the solid line illustrates the variation of V_{ch} as a function of time for a lead angle of $\psi = -5.18°$ providing a Hohmann transfer at $t = 0$. A 6.2 min early launch to the target on a rendezvous compatible orbit requires about 28,000 fps or about 1,970 fps in excess of a Hohman transfer for the case of a zero time delay. A one-min late launch similarly requires about 1,970 fps excess over a Hohmann transfer. Although the launch base is rotating into and beyond the target orbit plane as a function of time, the actual plane change angles involved are small as shown. The major velocity penalty arises from the large elevation angles at the injection point and at target adaptation. The 3.2 min launch window line illustrates the maximum delay time for a velocity penalty of 260 fps just matching that for the Hohmann adaptation increment at $t = 0$. The 4.2 min launch window requires a characteristic velocity increment twice that for Hohmann adaptation, or 520 fps. Thus, it is concluded that direct launches to either a target satellite on a rendezvous compatible orbit or to a parking orbit in the same plane as the target is a costly oper-

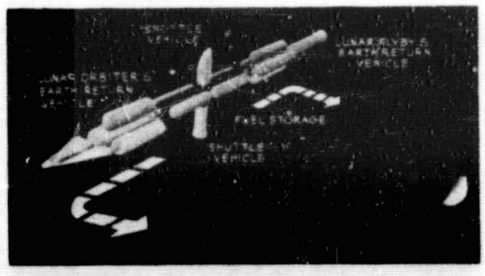

Fig. 15. Orbital rendezvous base system.

Fig. 16. Launch sequence.

ation with regard to payload penalty and is too restrictive with regard to launch window time.

Shown on Fig. 12 is the approach whereby a parking orbit, having the same inclination as the target, is used to minimize the total characteristic velocity for rendezvous. The target orbit is shown at an altitude of 263 nm with a parking orbit of 116 nm. Because of the difference in precessional rates of the target and parking orbits, an in-plane condition will occur after a given interval as shown on the right-hand side of this figure. The time interval to wipe out the original out-of-plane angle can be related to the delay time occurring at the launch pad. The relationships existing between the target and parking orbits are shown on Fig. 13 normalized with respect to the target orbit. The objective is to synchronize the precessional rate difference with that of the relative target and parking satellite positions.

The upper right-hand graph of Fig. 13 indicates the parking orbit precessional rate increase normalized with respect to the target at an altitude h_t of 263 nm. For a parking orbit altitude h_p 116 nm the precessional rate difference is 4.0 min of arc per revolution, or approximately 1.0° per day. The period difference and lead angle for a Hohmann transfer normalized with respect to the target is shown in the upper left-hand figure. The period difference is about 5.58 min/rev and the required lead angle is 5.15°. The lead angle advance/min of park and laps advance/day of park is shown on the lower left-hand figure. These rates are about 0.24°/min of park or 0.97 laps/day of park.

One can compare the advantages of the extended parking orbit launch to the direct launch by considering the right-hand lower figure. For example, since the precessional rate difference of 4 min of arc/rev is relatively small, it will require about 53.4 revs, or 3.29 days time, to wipe out a 3.56°

Fig. 17. Assembly sequence.

Fig. 18. Rendezvous-compatible orbit (trace on a mercator projection of an RCO).

launch base angle difference corresponding to a 14.25 min launch delay. Thus, as shown on the graph, a 4.75 min delay means a 1.1 day park; a 9.4 min delay, a 2.17 day park; a 14.25 min delay means a 3.29 day park; etc. The author believes that a 5-day park is about the upper limit that might be accepted operationally without scrubbing the flight to wait for another launch opportunity. With use of rendezvous compatible orbits, a second launch opportunity occurs 3.15 hr later for an RCO with N/m (synchronism ratio, number of satellite revolutions per day) of 15 and small n of 2. Thus if the vehicle cannot be launched precisely at the optimum launch time it may be better to hold for the second opportunity.

The advantage of this "overtime parking" using the extended parking orbit launch approach may be compared with that for direct launch as shown on Fig. 13. A 4.75 min delay (1.1 day park) therefore costs about 242 lb in payload penalty whereas this penalty is nearly 10,000 lb for direct launch, a 50-to-1 advantage. A 28.4 min delay, requiring a 6.59 day park, will have a payload penalty of only 1,450 lb. This is far less than for a direct launch and would be considerably smaller than that for the orbit phasing technique.

The small payload penalty and practical launch window limits for the extended parking orbit launch to a rendezvous compatible orbit fullfills the three major criteria for selection of the best launch technique for rendezvous. These are (1) minimum pay-

load penalty for launch delays, (2) practical launch window, and (3) minimum total launch pad time. Although minimum payload penalty is important, the high direct operating costs of launch base crews during unnecessarily long prelaunch delays must be considered. Utilization of RCO's and the extended parking orbit launch concept will give improved surface-to-orbit launch logistics with the following significant results:

(1) Increased number of launch opportunities (maximum of two per day continuously).

(2) Increased number of rescue and recovery opportunities (greater than two per day continuously to selected recovery sites).

(3) Launch and recovery time periods would be fixed and repetitious, thus simplifying scheduling and reducing operational costs of ground handling crews.

(4) Launch time delays up to about 30 min would still permit optimum in-plane transfers from the launch base to the parking orbit and, hence, to the target orbit with nearly zero payload penalty.

Concerning the extended parking time employed in this concept it is this writer's conclusion that "let's accept the time delays that occur and let the flight crew use the park time for indoctrination, or other useful task assignments, and permit the launch crew to initiate assembly and checkout operations for the next shot."

Orbital Launch Criteria

Two additional factors predominate in the choice of an orbit plane for orbital launch operations aside from the restrictions discussed in the preceding section. These are the number of launch-from-orbit opportunities occurring and the Van Allen Belt trajectory transit time. Although polar orbit inclinations yield minimum exposure to Van Allen radiation, the best compromise is to employ the 28.5° to 50° inclination possibilities from Cape Canaveral as depicted by Fig. 14.

Other criteria that must be evaluated are eclipse time or the day-night cycle to which the satellite is subjected. This factor requires serious consideration from two points—the use of the sun as a power source and as an attitude reference.

Launch from orbit is a function of many variables, both geometric and dynamic. A clear understanding of the three-dimensional geometric relationships of the satellite–earth–moon system is necessary to visualize the problem. Geometry for the earth–lunar transfer orbit and lunar arrival window is shown on Fig. 14. Detailed studies have been performed establishing the many orbital launch requirements to effect an optimum earth–lunar transport system and are available in Refs. 8 and 9. Primary objectives of these detailed trajectory studies have been to (1) define the earth-orbit launch criteria for lunar trajectories, (2) establish the departure trajectory sensitivities to orbital parameters, (3) establish mission and vehicle sensitivities to time and energy requirements, and (4) determine analytical techniques for determining optimum launch conditions.

It is essential that launch from orbit should occur when the resulting transfer trajectory will permit a rendezvous, or intercept, with the moon near the line of nodes. An adjustment must be made in the trajectory central angle or the launch plane angle, or both, in event of a nonoptimum launch time, thus

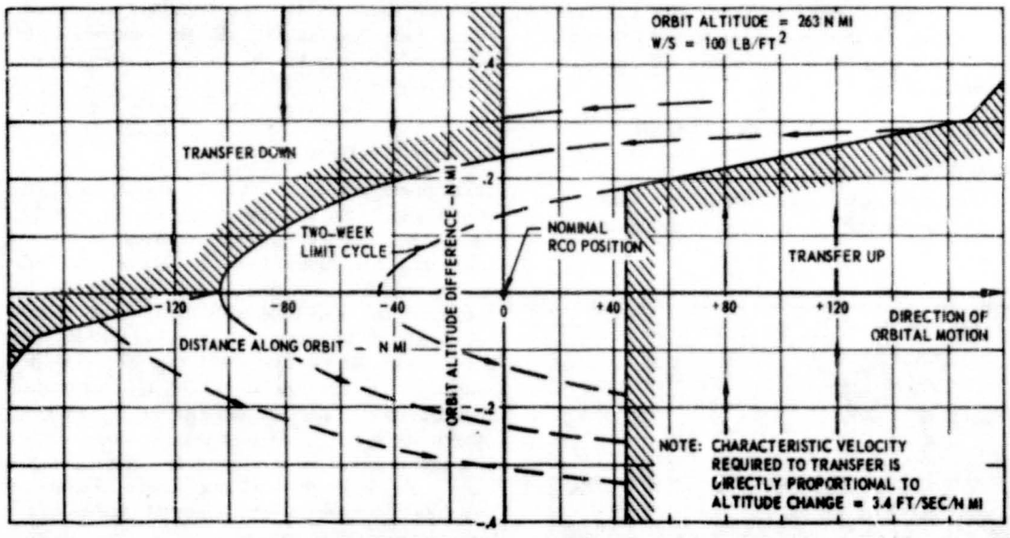

Fig. 19. Limit cycle characteristics for stationkeeping of a rendezvous-compatible orbit.

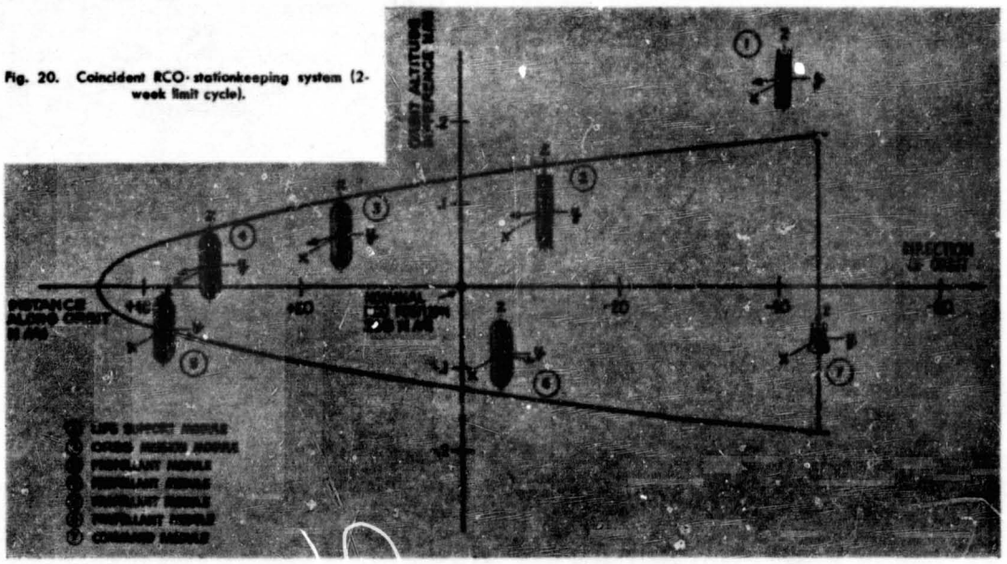

Fig. 20. Coincident RCO-stationkeeping system (2-week limit cycle).

requiring additional energy. The amount of additional propulsion system capability required for the orbit launched vehicles is directly related to the limits established for the "launch or escape window" for the lunar transfer orbit. Because of the precession of the orbital launch base about the earth and the motion of the moon about the earth–moon center of mass, a resulting "launch window" occurs approximately every 10 days. Precise width and frequency of this "launch window" varies markedly with time. Number of launch opportunities (satellite revolutions per launch window) varies accordingly. Practical "launch window" widths or durations of from one to two days, or 15 to 30 Revs will exist with reasonable requirements for additional propulsion energy.

Orbital Rendezvous Base System Concept

Orbital Base Development

The natural course of events in establishing an orbital base for earth–lunar logistics should proceed from an elementary manned space station to the full launch base facility required for sustained orbital launch operations. The elementary manned space station, as the first phase, would serve to develop and demonstrate operational procedures and to establish design requirements for future major subsystems such as rendezvous guidance, control, and computer equipment, mechanical and fluid coupling devices, checkout equipment air locks and extravehicular mobility devices, communication and electronic techniques, etc. At present, first flight tests are planned for this first phase using advanced Mercury multiman maneuverable space capsules. Advanced orbital base development will be constrained to similar vehicle modules anticipated for the Project Apollo program.

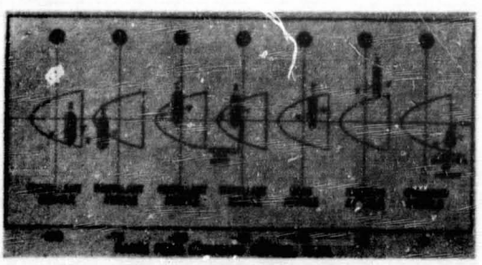

Fig. 21. Offset RCO stationkeeping system (1-week limit cycle).

Key Operational Phases

The principal phases for the operational use of an orbital launch involve rendezvous, assembly, checkout, and launch. Various approaches may be taken, however, in development of the orbital base and mission vehicles. The design of the orbital launch base must be compatible with the operational requirements of the specific missions assigned to the base. It should be recognized that the concept approaches available are very closely coupled to the available booster size and launch rate for surface-to-orbit logistics. Upon first consideration of the problems involved in developing an orbital launch base, one is confronted with a variety of system techniques and operational modes that may be integrated into a working complex.

The objectives of the design study on which this

paper is based were to establish the design concepts and characteristics for a disciplined orbital rendezvous, assembly and launch system illustrated by Fig. 15. This design study,[3] referred to as "An Orbital Rendezvous Base System" (ORBS), provides the foundation for development of an economical earth-moon logistics system. The concept is based on employing standardized modules for command and control, life support and propulsion with each placed into orbit by Saturn-class boosters and subsequently assembled to form a launch base for a variety of space missions. Standardized modules have been configured, and are launched from the AMR and injected into a low-altitude rendezvous compatible orbit of about 263 nm with an inclination of 32°. Other specific altitude and inclination combinations uniquely required for orbital rendezvous compatibility and lunar phase synchronism exist and will be discussed in later sections of this paper.

Each of the modules, employed in the ORBS concept for the lunar missions, are injected into orbit and constrained by an on-board guidance system to maintain a precise attitude reference to the orbit plane and local vertical. The five to seven unmanned modules in the proposed concept are constrained to precisely the same orbit but spaced at about 10-mile intervals along the orbit. This technique for injection of the unmanned modules is employed due to a probable maximum booster launch rate schedule for 1965-66 of one shot per week. With this launch rate, it will require 5 weeks to inject the first six manned modules into orbit. Immediately following injection of the last unmanned module and following a brief orbit smoothing phase, the manned command module may be launched. Following injection of the manned command module, assembly of the mission vehicle and base commences. A rendezvous transfer guidance system maneuvers each module from their station-keeping positions toward the command module. An automatic or manual control system is employed for the terminal maneuvering and coupling to the command module. Upon subsequent checkout of the mission vehicle the base module is uncoupled and the vehicle is maneuvered downrange a safe distance, perhaps a mile, and launched on its trajectory to the moon. Primary consideration was given to crew safety with a 30-day duty cycle established for the crew. Thus, for the assembly period and a 14-day lunar mission (under reasonably optimistic conditions) the crew is in space for a total of about 20–25 days. Total single mission time from first launch to final reentry requires about 60 days.

Some of the specific advantages envisioned for orbital launch operations employing techniques similar to those developed in this paper include:

(1) Increased launch opportunities from orbital base.

(2) Permits assembly of mission scaled vehicles.

(3) Provides configuration flexibility.

(4) Assures early capability for lunar/planetary operations.

(5) Reduces reliability restrictions through mission staging.

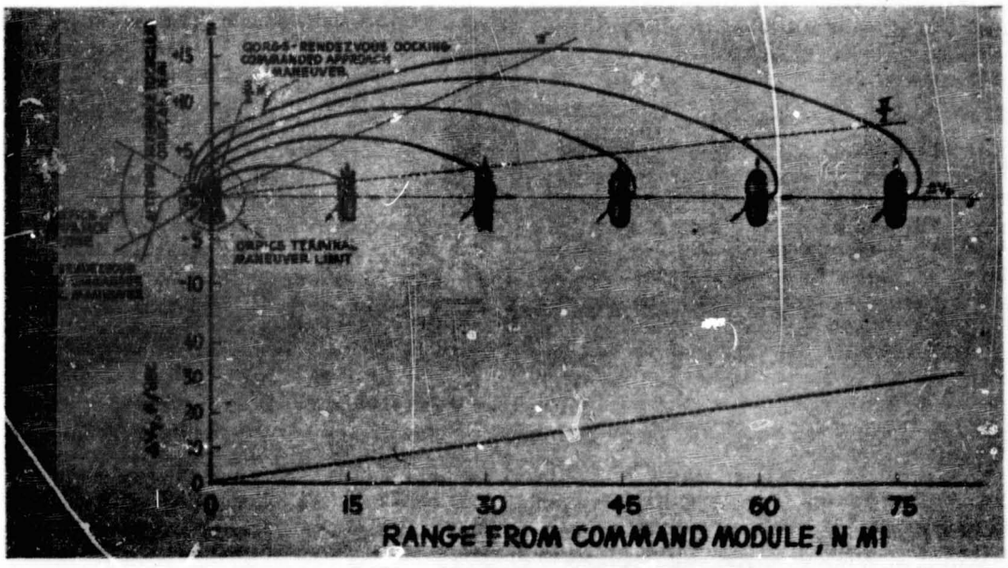

Fig. 22. Relative motion during rendezvous (Offset RCO with iso-orbital initial condition).

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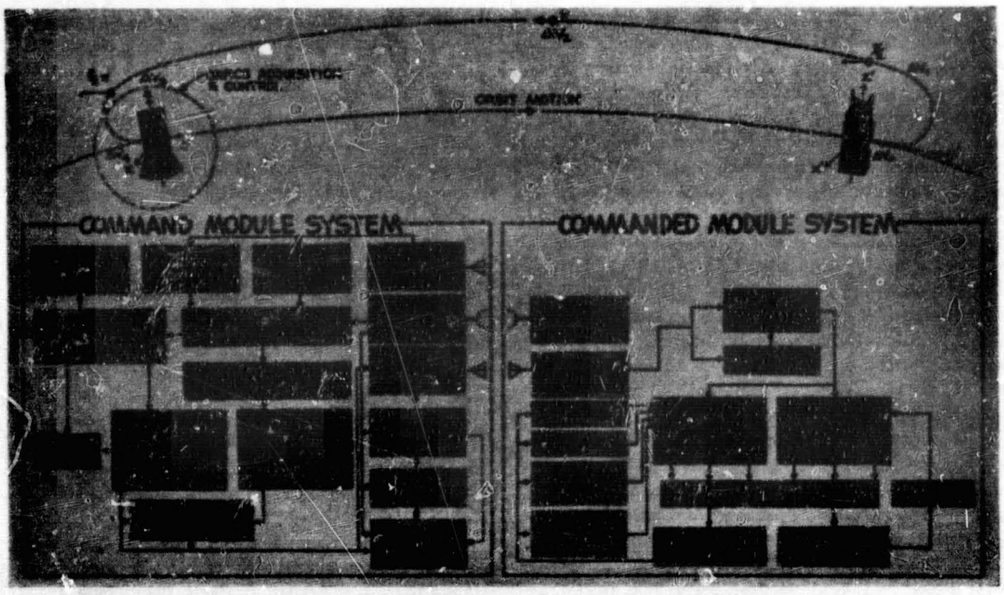

Fig. 23. Rendezvous-transfer maneuver control system, block diagram.

Launch and Assembly Sequence

Launch and assembly sequence is depicted on Figs. 16 and 17. As shown by Fig. 16, the life support module is launched first, base mission module second, the four propellant modules in turn and the manned module last. The assembly sequence is shown on Fig. 17 wherein each module is assembled in turn to the command module, thus minimizing the energy requirements for rendezvous. Inserts 5 and 6 illustrate the decoupling from the launch base and maneuvering of the mission vehicle down range prior to launch.

Orbital Rendezvous Techniques

In order to provide periodic resupply of the orbital launch base and increase the number of launch, deorbiting and rescue opportunities from Cape Canaveral launch pads, we have selected a particular orbit having a special altitude and inclination and termed a "rendezvous compatible orbit" (RCO).[10] This rendezvous compatible orbit provides synchronism of its position-on-orbit and the launch pad at Cape Canaveral. The RCO selected has characteristics of 263 nm in altitude and 32° inclination with the equator. Thus, the orbit ground trace is as shown on Fig. 18 for a synchronous or rendezvous compatible orbit.

Because of the one-week launch rate from Cape Canaveral a "stacking" concept for the unmanned modules is employed until the manned command module is launched. A limit cycle technique, illustrated by Fig. 19, has been proposed as a method for providing continuous maintenance of the assembly and launch base on a rendezvous compatible orbit. Two approaches for this stacking phase are shown in Figs. 20 and 21 and are referred to as coincident and offset stationkeeping systems.[11] Fig. 20 shows the coincident stationkeeping technique with the seven modules constrained to a 2-week limit cycle or period of circulation about the nominal aim point on the orbit. As drag decays the altitude of each over a 2-week period, a small velocity impulse of about one fps elevates the module up to a slightly higher altitude and the limit cycle continues. Here the vertical motion may be extremely small, about ± 0.2 nm, whereas the horizontal excursion is ± 44 nm.

Although collision probability is small over a 7-week period, a preferred technique may be that shown on Fig. 20. Here each module follows a one-week stationkeeping limit cycle. During these stationkeeping phases, each module is constrained to maintain a particular attitude reference to the local vertical and orbit plane. This is accomplished by a horizon scanner and yaw gyro respectively.

Following injection of the manned command module, the rendezvous transfer maneuver of each module is executed. Relative motion of each module is depicted in Fig. 22. Each module responds to guidance signals or commands from the command module as determined by range, range rate and angular information from the command modules radar, infrared tracker, and computer. The terminal approach to the command module is prin-

cipally along the orbit and may be likened to the landing approach of an airliner to its runway. Although vehicles in orbit have extremely high absolute velocities referenced to the earth's surface—viz., 18,000 mph for low-altitude orbits—it is the relative motion between satellites that concerns us here. If we have two satellites on nearly the same orbit this relative velocity between them will be small. If the satellites are on precisely the same circular orbit, their relative velocity is indeed zero. Satellites placed like a string of beads in space and constrained to nearly identical orbits thus may have maximum relative velocities of about 10 to 20 fps. Subsequent rendezvous maneuvers will increase this relative motion to probably a maximum of 50 to 100 fps. The terminal rendezvous maneuver should be as simple to perform as that of driving and parking a car. Certainly it should be easier to perform than the present rendezvous and coupling of fighter aircraft to a tanker coping with both night time and rough weather conditions. It is believed that manned rendezvous in space can be performed as a matter of routine and with high precision and reliability. Division of equipment responsibility is depicted by Fig. 23. As shown, the command module determines the relative position and motion of the commanded module, computes the command signal, and transmits these to the target module. The responding module receives these signals and activates the appropriate attitude or translational jet to move the module to the command module using a quasi-optimal rendezvous guidance system.[12]

An alternative automatic guidance system has been considered for the terminal phase and is shown in Fig. 24 designated ORPICS[13] (Orbital Rendezvous Positioning, Indexing, and Coupling System). The ORPICS system reduces the terminal approach velocities and positioning displacements of the approaching module to zero. Fig. 25 shows the terminal approach trajectory.

The boost, coast and homing phases for manned ascent to the orbital base is expected to be similar to present Project Mercury flight operations, but modified to include rendezvous maneuvers resulting in docking and coupling to the target base. Ref. 14 presents a detailed system concept for rendezvous and docking.

Vehicle Design

The engineering approach in designing the vehicles employed in this orbital rendezvous base system utilizes the modular concept established for the NASA APOLLO manned lunar project. However, the special requirements for orbital assembly necessitated new design techniques. Airlocks provide access between all mission and base modules. Final mechanical, electrical and fuel coupling between modules, following assembly positioning, is performed by the crew from the module interior. Malfunctioned modules may be jettisoned to permit assembly of a replacement module. The base module contains auxiliary power and life support equipment to sustain the entire base and mission vehicle during assembly and checkout. Life sup-

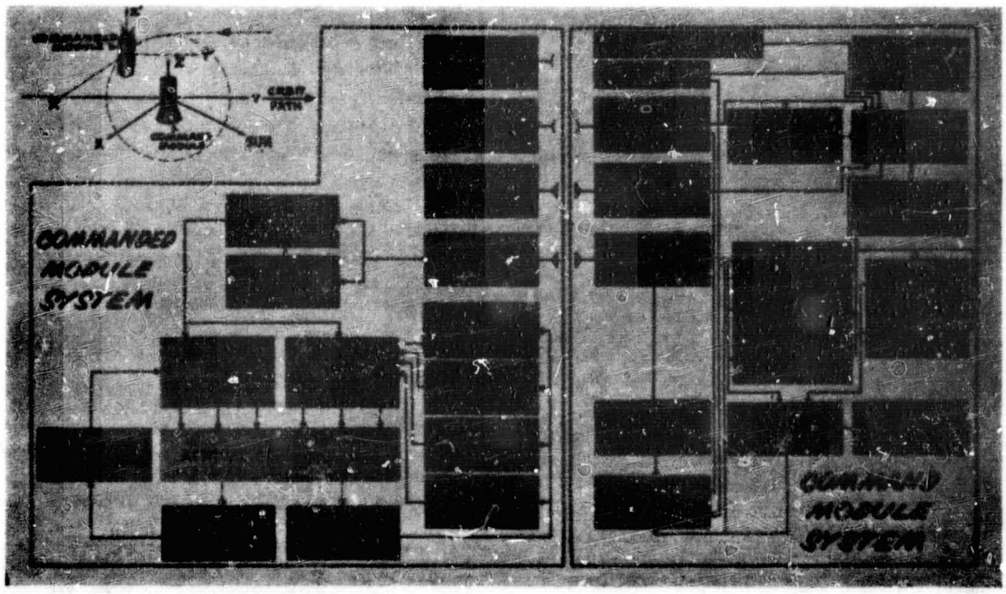

Fig. 24. Rendezvous- ‘ing maneuver control system, block diagram.

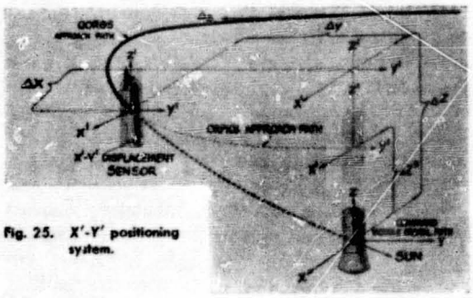

Fig. 25. X'-Y' positioning system.

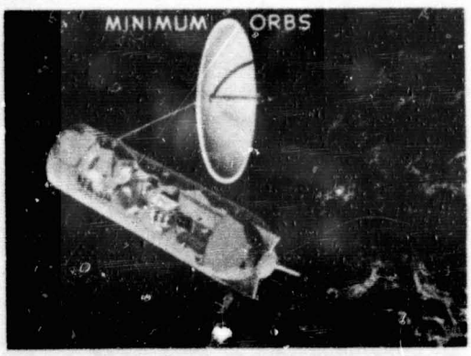

Fig. 26. Base module cutaway.

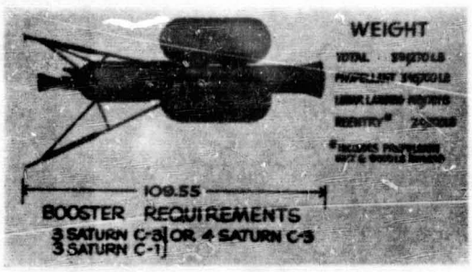

Fig. 27. Lunar landing vehicle, powered re-entry.

port systems are based on an open cycle system eliminating water recovery due to the abundance of water contained within the radiation shield.

Internal arrangements of the ORBS base module is shown by the cut-away illustration of Fig. 26. Auxiliary power is provided by a 15-kw solar dynamic electric system erected in space by inflatable structures. Fig. 27 illustrates the lunar landing configuration. Boosters required for this mission are three C-1 Saturns plus three C-3's or four C-3's. Orbital launch weight ranges up to 440,000 lb. A single propulsion engine of 200,000-lb thrust using liquid oxygen-hydrogen provides orbital boost, lunar landing, and lunar escape thrust. Thrust acceleration ranges from one-half to about four g's.

Concept Summary and Conclusion

Concept advantages for this orbital launch base are briefly summarized as follows:

(1) Economic operation from rendezvous compatible orbits.

(2) Greater launch flexibility from orbital base.

(3) Permits assembly of mission scaled vehicles.

(4) Provides checkout and launch under controlled environment.

(5) Provides configuration flexibility.

(6) Permits shuttle operation between earth-moon.

(7) Assures early capability for lunar/planetary operations.

(8) Provides mission mending capability.

(9) Reduces reliability restrictions through mission staging.

It is the author's conclusion that our decision to go to the moon via the orbital assembly and launch route will greatly influence our capacity to expand our space potential. Orbital assembly and launch will provide greater economy, flexibility, reliability and saving of time than direct ascents to the moon using larger boosters. Consideration should be given to long-range planning concerning integration of lunar operations with development of earth-orbital assembly and launch facilities for planetary missions. It is believed essential that the following operational factors be recognized to give improved logistics to the moon and planets:

- Crew-return-rate should be less than crew-departure-rate.
- Regenerative capability essential for lunar operations.
- Lunar base development should establish foundation for planetary exploration.
- Earth-moon combined operational support required for earth-orbital launch base for planetary missions.

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Mr. PETERSEN. This engineering study illustrates the general mission requirements for an Earth-orbital assembly and launch system to accomplish manned lunar operations based on design information available at the time of the study. A concept for development, general system characteristics, and operational use of a proposed orbital launch pad for rendezvous, assembly, checkout and launch of manned lunar flyby, orbiting and landing vehicles is discussed.

Mr. FULTON of Pennsylvania. You may have advanced your thinking on some of the problems in the interval since you wrote the paper. At any point on which you have changed your mind or brought anything up to date, would you make that interlineation right at that point in the technical report?

Mr. PETERSEN. I have personally been pursuing, with a number of other people at various times, certain elements that were presented in the paper. Since I joined the Air Force I have not been working specifically on the problem. I have not come to any other conclusions than what are presented in the paper.

Mr. FULTON of Pennsylvania. It is up to date, then?

Mr. PETERSEN. I consider it so.

Particular emphasis is given to utilization of rendezvous compatible orbits and stationkeeping for improved surface-to-orbit launch logistics. It was concluded that the best route to the Moon, employing a proposed space Canaveral facility as a low-altitude orbital assembly and launch adjunct to Cape Canaveral, would significantly increase the United States' capacity for Earth-orbital, lunar, and interplanetary exploration.

The referenced report summarizes results of a company-funded study initiated in August 1960. This company-funded study on Earth-orbital rendezvous, assembly, and launch for lunar operations was initiated simultaneously with the August 1960 bidders conference and subsequent award in October 1960 by the NASA of three parallel study contracts to industry to investigate direct launch systems to the Moon. The specific objective of this study was to establish system requirements for an Earth-lunar logistic transport system based on development of an Earth-orbital rendezvous, assembly, and launch system.

The study recognized the several basic modes of transport to the Moon to include the following:

(1) Direct launch (Earth surface launch and direct transit to the Moon);

(2) Earth-orbital rendezvous (Earth-orbital rendezvous, assembly, and launch with direct transit to the Moon or descent from lunar orbit).

Mr. TEAGUE. On each of these, would you talk about the launch vehicle a little? Would No. 1 require the Nova?

Mr. PETERSEN. Well, a larger vehicle, yes, or the present system with some modification——

Mr. TEAGUE. Could No. 2 be done with a number of Atlases?

Mr. PETERSEN. No, not Atlases, but with slightly larger vehicles. The larger the better, the fewer the rendezvous, though I don't think the number of rendezvous is particularly a disadvantage.

(3) Modified direct launch/lunar orbit excursion and return rendezvous (Earth surface launch and direct transit to lunar orbit with descent to lunar surface and subsequent rendezvous to lunar orbit).

(Present NASA concept employs this technique.) This third mode is what I call the modified direct launch (MDL) with lunar orbit excursion and return rendezvous, a combination approach. This third mode should be identified as a modified direct launch to the Moon, and it is, I think, improper to identify it as lunar orbit rendezvous in the same sense as Earth orbit rendezvous.

(4) Lunar orbit rendezvous (direct launch to lunar orbit, rendezvous, assembly, and descent to surface).

This employs earth surface launch of two or more vehicles with direct transit to the lunar surface orbit with subsequent assembly and descent to the lunar surface.

Mr. TEAGUE. What is the difference between No. 3 and No. 4?

Mr. PETERSEN. I would identify lunar orbital rendezvous as the technique employing assembly in a lunar orbit to achieve a mission. The present system to the Moon is effectively a modified direct launch to the Moon and does not employ orbital assembly, and consequently should be properly identified as a modified direct launch, MDL, approach.

Mr. FULTON of Pennsylvania. Why do you use a smaller vehicle if it is really a modified direct ascent to the Moon?

Mr. PETERSON. I have a few comments that will bear on this later on. Primarily, the vehicle may be smaller for the modified direct launch only if the excursion module descending to the lunar surface encompasses less payload and backup systems than those selected for Earth orbit rendezvous.

Mr. TEAGUE. If we ask questions that you are going to cover later on, just say so.

Mr. PETERSON. All right.

(5) Lunar surface rendezvous (direct launch to lunar surface with lunar surface assembly and launch).

(6) Earth-orbital rendezvous/lunar-orbital rendezvous (general concept employing rendezvous, assembly, and launch operations in both Earth orbit and lunar orbit).

Each of these primary modes of Earth-lunar transport have special merit though primary emphasis was given to the Earth-orbital rendezvous mode. It was believed that this route to the Moon had the greatest payoff for lunar as well as interplanetary missions, but further would provide a useful foundation for expanded Earth-orbital civil and military space programs. Completion of any single program or mission, lunar or interplanetary, using the Earth-orbital assembly and launch base as a "fulcrum" or "springboard," would accrue a stronger space foundation or capacity in the form of technology, orbital operations experience, as well as facilities in space to serve as an operational catalyst for future programs.

Mr. TEAGUE. Are you saying that EOR has a much greater growth potential than LOR?

Mr. PETERSEN. Yes; I think it has a strong bearing on all our programs in space. Many of these will rely on Earth-orbital operations; we have plans to build navigational satellites, weather satellites, and many other scientific laboratories that will require a considerable amount of manned operation in space, and I think an adequate orbital launch facility could best serve this operational purpose in space.

It was recognized that the total effort of transport to the Moon and return is approximately equally divided about the earth orbit

launch base. The total energy, the tasks to be accomplished, and the order of complexity for the surface-to-orbit boost phase is reasonably well matched with those occurring following orbital assembly and launch. It was further recognized that the development of specialized modules for propulsion, command or flight control, life support and auxiliary equipment, as building blocks for assembly in space, provided the desired qualities of flexibility and growth potential. It is these two areas that are considered the key criteria in identifying the advantages of Earth-orbital rendezvous. Earth-orbital rendezvous is considered to have far more growth potential and flexibility than can be achieved by any launch system. The ability to significantly increase production capacity in a far shorter time period rather than the continual initiation of new R. & D. programs for larger boosters was accepted as a necessary objective. It was further recognized that future development of nuclear propulsion would encourage the use of special-purpose shuttle vehicles for operation between both Earth- and lunar-orbital assembly and launch bases with lower transport costs.

Generally, the concept of orbital rendezvous operations considers the sequential rendezvous of multiple satellite vehicles and is construed to include succeeding phases of docking, coupling, assembly, checkout, and launch toward completion of more complex, specialized missions. The utilization of these orbital operations permits the full benefit of rendezvous to be attained in execution of larger space missions by assembly techniques in space. Considering these six modes of transport, only modes (2), (4), (5), and (6) employ multiple launches and subsequent rendezvous and assembly for execution of larger missions in space.

General conclusions established by the referenced engineering study were as follows:

(1) The capacity for rendezvous, assembly, checkout, and launch from Earth orbit provides an immediate and permanent solution to booster payload limitations;

(2) Broadens the achievable space mission window; and

(3) Permits the vital utilization of man to the limits of his ability to provide in space the capacity for decisionmaking, the ability to perform secondary (orbital) checkout, the dexterity to yield improved reliability through orbital maintenance, repair, and modification, and the flexibility to broaden vehicle maneuverability performance limits.

Specific advantages to be gained through development of a capability for rendezvous and assembly and the implementation of an orbital launch base were identified as follows:

(1) Permits assembly of mission-scaled vehicles (negates booster payload limitations by assembly in space of appropriately sized vehicle to match mission requirements; provides mission flexibility and growth potential; provides positive means to offset payload growth during development rather than through elimination of redundancies and backup equipment as occurs for direct launch systems); in addition to what I have here, I wish to emphasize that we can build mission-scaled vehicles. For example 2 years down a program or project route, if someone concludes that he would like to have a four- or five- or six-man crew we can add on propulsion modules to provide this flexibility. In the present system the only way you can go—the only direction you can go is to back off from a three-man

crew to a two-man crew and throw overboard redundancies and backups.

(2) Provides configuration flexibility (offsets launch and aerodynamic drag restrictions and provides improved configurations for auxiliary power and nuclear propulsion systems).

You don't have to live with the specific articulated arms that can be folded inside the nose cone. One can refigure the system, employ certain APU panels or structure after you have exited from the atmosphere and therefore avoid the confinement of the aerodynamic shroud on the vehicle.

(3) Provides secondary (orbital) checkout and launch (reduces reliability restrictions through mission staging; provides stabilized or controlled environment for checkout and launch);

(4) Provides mission-mending capability (permits possible return to orbit and subsequent rendezvous for certain abort conditions of lunar and interplanetary vehicles exhibiting malfunctions during escape maneuvers, thus salvaging key elements of large mission vehicles);

(5) Provides improved launch logistics through use of rendezvous compatible orbits (RCO's)—I may refer to these by the abbreviation "RCO's" a time or two—and station keeping (the operational procedure of employing rendezvous compatible orbits, RCO's, to provide a "milk run" synchronism of the orbiting assembly and launch base yields two optimum, in-plane, launch opportunities per day, for rendezvous with zero-payload penalty; the RCO synchronous orbit simultaneously yields two optimum, in-plane, recovery opportunities per day from orbit to a preselected landing site; the RCO synchronous orbit further provides two optimum, in-plane opportunities per day for both rendezvous or recovery-type rescue or retrieve missions; offsets payload penalties associated with launch operations to randomly orbited target satellite stations).

Mr. RIEHLMAN. Would you just explain that a little more?

Mr. TEAGUE. Why don't you go a little slower?

Mr. PETERSEN. A rendezvous compatible orbit is just a class of orbit that can be employed in space to give milk run synchronization with the launch station. There are many problems, associated with improved logistics, to Earth orbit, such as delays on the launch pad, so on, since we have a vehicle in orbit around the Earth, and the Earth spinning beneath it. We can by using stationkeeping capability on board the vehicle in orbit constrain it to a fixed orbit so that the ground track line over the surface of the Earth repeats itself. If we select the altitude and inclination just right and have stationkeeping on board the station in space we can drive it or constrain it, at very low cost, to repeat its ground track line over the face of the Earth. Stationkeeping is the ability to make minute maneuvers in space, to restrict a satellite to a fixed selected orbit. We can maintain or constrain the vehicle to follow the same orbital path in space so that twice a day there is an optimum in-plane launch opportunity. We can constrain the vehicle in space by stationkeeping, by using small rockets on board, fired periodically on perhaps a 2-week limit cycle, and drive the satellite into the desired orbit so that once a day it will have a north going path right over the cape and two revs or three revs later it will have a southgoing path over the launch base. Thus, we can improve our launching capability, so that our logistics to space

can be obtained at a very low cost per pound of payload in orbit. To constrain a vehicle on the order of, say, the Apollo command module, support module, and other modules that might be attached to it, it would cost about 30 feet per second per year in characteristic velocity to provide this stationkeeping capability.

We all know it takes about 25,000 feet per second to constrain a vehicle in an orbit around the earth. We have need for only 30 feet per second, roughly a thousandth of that, to periodically adjust the orbit to give this rendezvous compatibility with the launch base resulting in two optimum inplane launch opportunities per day. Twice a day we can expect to have milk run synchronism of the base in space with the Cape Canaveral launch base. It is essential to have the target space station at some desired central angle position with respect to the center of the Earth and the Earth-surface launch base, so that when you launch from the launch pad the ascending vehicle will arrive in space together with the target space station.

If you use stationkeeping you can drive or constrain the station in space to follow this rendezvous compatible orbit trace. Primarily the successive velocity impulses employed on a 2-week limit cycle are simply used to offset the aerodynamic drag occurring on the target station and to reelevate the station to its original altitude. Say we select an inclination of 35° and altitude of 264 nautical miles. We would use little impulses every 2 or 3 weeks to elevate or reelevate the station a mile or two in orbit to offset the altitude dissipated by air drag. Thus we can constrain it month after month to give this repeatability, repeating the ground track line over the surface of the Earth day after day, to give us this rendezvous and recovery compatibility with the launch and recovery sites.

If we don't use this technique we have random orbits. All the 100 satellites we have placed in space now are on random orbits and to achieve rendezvous with these vehicles may pose severe payload penalties. It is very rare they ever pass through the original injection point, which is necessary in order to give a new minimum energy path to effect rendezvous with them. The use of random orbits generally may result in a high payload penalty associated with the rendezvousing vehicles. Alternatively you may have to wait perhaps 3 weeks or 6 months; or perhaps never would you have a truly optimum access to the target satellite. The stationkeeping system required can be provided at low cost to the vehicle system and it is essential to providing a low-cost logistics system to low-altitude orbits.

Mr. TEAGUE. Mr. Roudebush.

Mr. ROUDEBUSH. Wouldn't this require a technical knowledge and excellence that we have not presently attained?

Mr. PETERSEN. We have not demonstrated stationkeeping to date. But we are building stationkeeping techniques into the 24-hour satellites. I believe we presently have all the information, guidance equipment, and propulsion capability to do this now.

Mr. ROUDEBUSH. This would require repeated starting and stopping by radio direction?

Mr. PETERSEN. Yes, if the station were unmanned, though generally I am referring to a manned station.

Mr. ROUDEBUSH. Do we have that technical knowledge?

Mr. PETERSEN. Yes.

Mr. ROUDEBUSH. We can bring satellites into the precise orbit we want now?

Mr. PETERSEN. Very nearly for unmanned systems—yes. Manned systems could more easily be adjusted very precisely to the desired orbit.

Mr. BELL. Do you mean the second vehicle can be launched at exactly the precise time desired?

Mr. PETERSEN. There is no assurance that one can do this but there are several solutions in event you cannot. Certainly the launch time delays on the launch pad greatly influence the payload penalties. Even a minute's delay on the launch pad increases the payload penalty severely.

Mr. BELL. Even when we launch one today we have the long countdowns, and there is also a question of whether the launch will be at the precise time or not.

Mr. PETERSEN. That is very true.

Mr. BELL. Until we conquer that, aren't we in trouble on the exact meeting in orbit?

Mr. PETERSEN. Yes, sir. This can only be solved by experience, more launches and improved reliability, and the use of perhaps the best solution, that of a backup vehicle. It might even take two backup vehicles to provide this launch window capability.

Mr. FULTON of Pennsylvania. Could I give you a glowing example of almost rendezvous in space. The Soviets had a perigee of 111 miles on one vehicle and 112 on the other, and apogees of 163 to 166 miles, within 2 or 3 miles of each other. So the Russians were able to do it a day or so later.

Mr. BELL. But they had a precise time when that second vehicle was going to be launched, apparently.

Mr. FULTON of Pennsylvania. We are talking about whether such a system is possible.

Mr. BELL. It is possible, but we have not achieved it yet.

Mr. FULTON of Pennsylvania. To be able to come within 1 mile in height and 2 miles in orbital path on an orbital plane similar to another satellite is a tremendous accomplishment. Don't you think so?

Mr. PETERSEN. I agree. Vostok 3 and 4, apparently from what I have seen in the press, came very close to achieving rendezvous. They may have, as far as I know, even completed rendezvous, docking, coupling, and uncoupling, on the unobservable side of their orbit, then establishing a drift rate of about 24 miles per hour, as was reported, I believe.

Mr. TEAGUE. Mr. Daddario.

Mr. DADDARIO. This ability you say we are developing to have a fixed orbit, of which we can keep track and take a sight on, and then to be able to launch another vehicle for a rendezvous, seems to me the one way of doing it. But isn't NASA doing anything else to launch a vehicle, track it, in even random orbit, and then adjust the orbit of the rendezvous vehicle to catch up?

Mr. PETERSON. Sure.

Mr. DADDARIO. What are the problems attendant to that?

Mr. PETERSEN. Minimum payload penalties result if the target vehicle in space is at a specific position on its orbit relative to the launch base. The only way one can obtain this is to use this station-keeping capability to drive it in to this constraint. If you don't have this compatibility with the launch base you can certainly back off and accept whatever out-of-plane angles occur, whatever noncorrect

central angle exists. You might have to sit on a parking orbit half a day, a day, or a longer time, to improve the conditions for subsequent injection to the target station. But it is not a complex system to provide this station keeping. We can't get to the Moon and impact on a certain spot without a similar very precise propulsion capability and guidance system. It doesn't require anything new to be added to the system.

Mr. DADDARIO. One of the elements I read in your report is that through the Earth-orbital capability we would develop a wider space program. It seems to me, it would have military implications to be able to go and inspect a satellite in space which could be put up by another country and would not be put into this same kind of fixed orbital station-keeping capacity. A part of our effort ought to be directed toward the ability to send a satellite into space to have this rendezvous capacity to catch up with a vehicle, rendezvous in orbit, inspect it, and neutralize it, if it becomes necessary. This would seem to be a proper objective within the limitations of our capability to widen our program for security purposes.

Mr. PETERSEN. I agree military applications, certain of them, such as inspection of satellites, demand and require a higher degree of maneuverability to cope with non-coplaner or uncooperative targets than we need for civil or military R. & D. programs aimed at just developing an Earth-orbital capability.

Our civil program and most of our military research and development programs in space, the logistics ought to employ the most efficient launch procedures possible—there is no point in thinking we can hide, nor should we try to hide, these R. & D. vehicles in space. Certainly for the research and development military programs that have been proposed, there is little point in hiding these in space. In fact, I don't think you can, certainly not on low-altitude orbits. And on the civil side we ought to develop a minimum low-cost operation technique to permit the subsequent rendezvous of these vehicles, and it should be done on the minimum cost basis.

I think it can only be done by having a rendezvous and recovery compatible orbit operation. The launching of vehicles on random orbits is appropriate for single missions by themselves. You do not need station keeping for single orbit missions. But for repeated rendezvous with space laboratories in space, or assembly of launch pads in space for other missions, that requires mutliple rendezvous, we should use the lowest cost system, with the lowest payload penalties, to do it. Certainly there are military missions where you would never use rendezvous or recovery compatible orbits, at all.

Mr. TEAGUE. Mr. Bell.

Mr. BELL. Mr. Petersen, is the general principle involved in rendezvous that after you get the first vehicle in orbit to keep it on a fairly constant orbit, and when the second vehicle is launched, to have it catch up by a continuing widening of orbit to the point where the vehicles come together? Is that the general principle?

Mr. PETERSEN. You are getting at the use of parking orbits for the subsequent injection of a vehicle to a target satellite. Because of launch time delays there is a need to place the ascending vehicle on a parking orbit to relieve the payload penalties of final rendezvous with the vehicle. Because of launch time delays you go to a parking orbit and wait there because of the period difference between the two,

to permit a lower energy ascent to the target, in the same orbit; thus the parking orbit is really used only to provide a favorable angular relationship with the target, and this could vary in time depending on the launch time delay. A parking orbit may be used for launch to a target satellite on a random orbit as well as those employing station keeping to provide rendezvous compatible orbits.

Mr. FULTON of Pennsylvania. Do you recommend the immediate planning and construction of a space platform by the United States so that we can have in orbit a permanent installation, or permanent installations, which might be space laboratories, space viewing depots, and even give space mechanical assistance on mating capsules, repairing, and even recovering capsules that go into random orbit?

Mr. PETERSEN. Right. I feel strongly that a good Earth orbital capability for manned operation, of 260 nautical miles or in that general area, is very vital to all of our programs involving man in space, whether to provide operational support to him for our civil programs as well as military——

Mr. FULTON of Pennsylvania. We have no recommendation in the authorization, as you know, for such a platform. But you would recommend it?

Mr. PETERSEN. I do, strongly.

Mr. TEAGUE. I think we ought to continue your statement, Mr. Petersen, and please go slowly through those sentences and make it as clear as you can.

Mr. PETERSEN. I will try to.

Mr. TEAGUE. They are rather complicated.

Mr. PETERSEN. Well, the sixth item encourages development of the "building block," or vehicle module, approach for design of large space mission systems. Orbital rendezvous concept thus yields lower production costs, higher reliability, and greater payload delivered to orbit for mission application at any given instant of time; significant consequence afforded by the orbital rendezvous or "building block" approach is the more rapid transition of technical personnel to the application and use of the payloads delivered to space—it is the application and use of the manned and unmanned payloads delivered to space that provides the greater payoffs of space technology and science; launch boosters serve primarily as a means to an end, that of transport of valuable payloads for its specific mission.

We are still pursuing the approach of building a new booster vehicle, including the extensive research and development efforts for every new mission that is coming along. We are not building, at all, "propulsion system building blocks" that can be used across the board—well, there are a few exceptions. But on the propulsive side we are not developing propulsive system building blocks in the form of engine modules or fuel modules that can be assembled in orbit and operated to give us a booster amplifier, in essence, to perform bigger missions.

Mr. TEAGUE. Are you saying we are building the house from the top?

Mr. PETERSEN. Well, we are not obtaining or including the growth potential and flexibility in our space program that you can obtain from the "building block" approach as far as propulsion systems or life support modules, and so forth, are concerned.

Mr. ROUDEBUSH. Would you say our program is overly specialized? We are building, in other words, special vehicles for a special purpose without a broad base?

Mr. PETERSEN. All of them so far are with that in mind. We have very fine objectives and in may ways, I think, an extremely good space program. But we are not including the two characteristics, growth potential and flexibility, on the design end of these systems as strongly as we ought to. We are not getting the growth potential and flexibility that we can accrue from Earth-orbital operations.

Without these "propulsive system building blocks" and other building block modules, I think in a way we may well get beat at the game we are supposed to play the best, that of large production runs. The sooner we fix on a given booster with a larger production run, improved reliability and lower cost will result. Faster transition of engineering and technical talent to the payloads will result and this is where the real value or payoff from our space program will come, not booster technology. Certainly some comes from that, but the ability to apply the greater effort of the Nation to the payloads, where the real scientific benefits will come from—and not from the booster end. The sooner we go into a larger production run on boosters the greater the reliability and lower cost. We ought to improve our boosters, certainly, but we should fix and obtain higher production runs on perhaps standardized boosters.

Mr. TEAGUE. Mr. Daddario.

Mr. DADDARIO. I read testimony that Secretary McNamara gave to one of the appropriations subcommittees the other day, in which he referred to the Titan III as this kind of booster, that it would be the "building block" on which the future payloads would be delivered. Is this what you are talking about, too?

Mr. PETERSEN. I am not referring to a given specific booster, though it is identified as a standard launch booster, but that is not the specific point I have in mind.

Mr. DADDARIO. That is just the point. How does your statement either agree with or differ from Secretary McNamara's presentation on the use of the Titan III as a potential standardized booster?

Mr. PETERSEN. Well, I am sure the Titan III can be used as a standard booster; every one of our boosters can be used as standard boosters. I don't know what I can add to this, except that I would recognize the Titan III as a standard booster and it could be used and exploited right now.

Mr. DADDARIO. I don't say you might agree that the Titan III would be the standardized booster, but is that what you are talking about, getting a booster manufactured in such a way as to take advantage of our productive capacities and getting a standardized vehicle to develop our space system?

Mr. PETERSEN. Sure. Either the Saturn or Titan III could be used as standard launch boosters. Maybe I am not understanding you.

Mr. DADDARIO. I am trying to find out from you if, in this particular instance, when we are talking of "building blocks," you and Secretary McNamara are talking of the same thing, or if you are referring to "building blocks" actually in the payload?

Mr. PETERSEN. I am talking of "building blocks" on the propulsion end, that will serve the ends of assembly in space. I think perhaps maybe the term "standard launch booster" generally is used in the

military and civil programs, standard launch boosters with many applications, that can be launched for high-altitude probes generally, or single-mission objectives, and as such have a variety of payloads and so forth. But I am talking here of use for assembly in space, and going from there. Neither the Titan III or Saturn C–1 are being designed in this light. They are not building blocks in this light.

Mr. DADDARIO. That is the answer to my question.

Mr. PETERSEN. It is not considered practical to summarize the specific design details of the referenced orbital rendezvous study. Certain conclusions of the study could, at the time it was prepared, only be identified in a qualitative sense. However, the above-listed specific conclusions or advantages identify key operational procedures essential to the development of an economic space logistics system.

Major factors, or system requirements, that seriously affect development of an orbital launch base, as well as other space vehicle systems involving rendezvous and lunar or interplanetary landings, are not to be discounted as simple problems to be solved though techniques exist to counter or offset all of these factors. These major factors that must be considered are those of launch time delays and the related payload penalties; rendezvous, docking, and coupling with the target station or soft landing at a preselected point in space; propellant handling and storage in space and related propulsion system checkout; mechanical and electrical assembly and associated checkout and maintenance; factors of attitude control, long-term guidance and navigation and need for onboard computing and data processing; and long-term radiation protection.

Launch time delays and the serious effect of payload penalties can be solved by improved reliability; may be offset by multiple launch pads and the necessary backup vehicles to meet launch window limits; or may be relieved by use of rendezvous compatible orbits due to the increased number of optimum launch opportunities, as many as two per day, the use of maneuverable ascent launch vehicles, and the use of parking orbits.

Terminal rendezvous, docking, and coupling in space will be practically resolved by increased reliance on the pilot-in-the-loop, coupled with redundant automatic guidance systems, and simplified through use of stationkeeping constraints on the target satellite station.

Pilot-in-the-loop is the integration of the pilot into the command of the vehicle to literally drive it as we maneuver any vehicle. Generally the pilots in the vehicles so far, either the civil or military, do not have the pilot tied into the loop from liftoff at the launch pad.

Mr. FULTON of Pennsylvania. Do you orbit by pilot-in-the-loop?

Mr. PETERSEN. No, by the guidance system, and control circuitry. The vehicles so far, the Mercury vehicles and even the Dyna-Soar X–20, have the pilot-in-the-loop only to a degree. In the automatic guidance system of Mercury for example, the pilot does not have primary guidance responsibility. Presently he is in during the ascent phase only in the abort side, has the prerogative of pushing an abort button, but doesn't steer the vehicle all the way. Many people working on the X–20 have concluded the pilot can provide considerable safety and perform better if placed fully in the guidance loop all the way from liftoff into orbit.

Mr. TEAGUE. Mr. Bell.

Mr. BELL. Concerning this checkout system, and the necessity for precise timing in the launch of the second vehicle, Dr. Seamans indicated that the Saturn V would be checked out in a seperate enclosure 2 or 3 miles from the launch pad and that after checked, it would be brought to the launch pad in an upright position for final checkout and firing.

Would this improve the accuracy and preciseness of the timing?

Mr. PETERSEN. Surely, these would be essential in using—in enclosures such as are in the plan at the cape, to provide initial checkout in the vertical attitude, then moving these out for final checkout at the launch pad.

Mr. BELL. NASA has only one vertical enclosure for a checkout; doesn't it?

Mr. PETERSEN. There is room for a number of vehicles, as I recall it.

Mr. BELL. It is my understanding that the Russians move their vehicles directly to the pad for launching. The checkout is made inside an enclosure ahead of time, and, strangely enough, I understand they lay it down and check it out. Is that correct?

Mr. PETERSEN. I have heard some of the same information——

Mr. BELL. In other words, the launch vehicle doesn't have to be in a vertical position?

Mr. PETERSEN. They don't have to be. Certainly big vehicle systems and the Saturn C–1, C–5, will be much taller than any that the Russians apparently may have checked out to date and perhaps it wouldn't be very practical to do it horizontally. You could do it, but I don't think there would be many advantages. The larger the vehicles become the advantage would be to use the system that is being followed by NASA presently. It certainly gets complicated when you have as many as nearly 10 stages to check out, whether horizontal or vertical. The present Apollo system employes 10 major operational phases to perform its mission.

Mr. BELL. I understand that in Gemini, NASA will have to do a lot of checkout outside of the vehicle. Is that correct?

Mr. PETERSEN. There would be a need for doing this, certainly. If there are access ports on the launch pad—on the Gemini they don't have this enclosure, so the vehicle is effectively assembled on the pad and fired from there.

Mr. BELL. I see.

Mr. PETERSEN. Propellant handling in space may initially be simplified to only involve individual propellant modules wherein each module serves as a separate propellant "building block" element of the required vehicle propulsion system. Use of propellant modules eliminates the problems of direct pumping, or propellant transfer, under the zero gravity environment. The propulsion system building blocks would normally consist of a liquid rocket engine plus the associated fuel and oxidizer tanks with means to attach or assemble these modules into the required cluster size.

Onboard, self-contained guidance and control system requirements for Earth-orbital rendezvous are essentially identical to those established for soft lunar landing at a preselected site, thus no new technical problems arise. Similarly, other factors, those of assembly in space and radiation effects, are not unique to Earth-orbital rendezvous or in operational use of an orbital launch base.

An important consideration to be recognized in employing the orbital rendezvous and assembly concept is the opportunity to gain the significant economic benefits accruing from reliability improvements as reflected by larger production runs of a given booster system.

It is believed important that the orbital launch base be established with a practical orbital inclination of at least 35° to provide adequate land recovery opportunities from space to existing and available recovery areas within the United States. Further, that the orbital altitude be selected appropriately in relation to the inclination, namely, about 264 nautical miles to assure maintenance of the rendezvous and recovery compatible orbit concept.

Going back a little more to the concept of rendezvous compatible orbits, we could identify these in a way more broadly as rendezvous, rescue and recovery compatible orbits. Having this constraint of the station in space we can select the altitude and inclination also to provide two optimum in-plane recovery opportunities to a landing site. One obtains an increased number of inplane launch opportunities to rendezvous, an increased number of inplane recovery opportunities, plus additional optimum inplane opportunities for rendezvous and recovery because of rescue and retrieve requirements. You cannot have these additional rendezvous, rescue or recovery opportunities with a random constraint, or random launching of vehicles.

The importance of implementing an Earth-orbital rendezvous, assembly, and launch system is very evident by observing the historical plot of proven booster payload capability as a function of time. A stair step progression has occurred for both the United States and for the U.S.S.R. since 1957. Our maximum payload capability of about 5,500 pounds was established in 1960 by the Atlas-Agena and remains to this date. A further improvement in this stair step advance will not be available to the United States until 1964–65, at which time the Saturn I and Titan III will provide between 20,000 and 30,000 pounds to Earth orbit. The U.S.S.R. payload capability, as announced by the U.S.S.R., jumped to 14,000 pounds in 1961 and subsequent estimates have ranged as high as about 17,000 pounds in 1962. Considering the orbital launch weight required for manned lunar landings, which are estimated to range from 250,000 pounds to about 450,000 pounds, depending on crew size, and so forth, the U.S.S.R. would require about 10 to 15 rendezvous operations. It is quite probable that the required number of rendezvous operations will decrease as newer booster systems are established by the U.S.S.R.

Very nearly the required tonnage for a single manned lunar flyby mission was evidently launched successfully to Earth orbit, or space, during the past year when 12 Cosmos satellites, 2 Vostoks vehicles and 1 Mars probe were launched. The recent near-rendezvous of the Vostok III and IV vehicles, in August 1962, demonstrated many of the essential capabilities necessary to the development of an Earth-orbital launch base. Though apparently failing to attempt or effect the final closure, or docking and coupling, with the Vostok III vehicle, the launch of the Vostok IV illustrated at least three key aspects essential to Earth-orbital operations. These are a reasonably small launch time delay, either rapid erection and checkout of subsequent vehicle on single launch pad or availability of auxiliary launch pad, and sufficient onboard guidance and maneuver capa-

bility for terminal adaptation or injection near a target satellite. The initial orbital characteristics of Vostok III and IV, with an announced separation of about 3 or 4 miles and only a small variation in inclination and orbital velocity, would have required but small velocity increments to effect the docking or closure maneuver. Therefore, it may be concluded that if major emphasis were given by the Russians to a single lunar mission, using Earth-orbital rendezvous, they would have the ability to accomplish this at the present time.

Our ability to close the gap in capability for accomplishing large space missions is believed to rest primarily upon the implementation of an orbital assembly and launch base. Earth-orbital, manned, scientific laboratories in space are important; however, the development of an orbital assembly and launch base in space is at least as vital to our space program. In order of necessity, I believe the orbital assembly and launch base is of prime importance because of its inherent value to all of our space operations, whether it is scientific laboratories, other civil or military Earth-orbital missions or support operations, or lunar or interplanetary programs.

An important parallelism may be drawn concerning our need for an orbital assembly and launch base and the parallel need for our large seaports in support of oceangoing traffic. As our seaports serve to integrate the small cargoes of trains, trucks, buses, cars, and coastal ships, so also will our spaceports serve to promote space traffic by integration or assembly of individually launched payloads.

I have recently compiled a bibliography of the scientific and engineering contributions to the open literature, as well as company or governmental agency sponsored reports, specifically dealing with the subject of rendezvous and Earth-orbital operations. This bibliography consists of nearly 1,000 technical papers with approximately 2,000 individual authors with pertinent contributions made by an estimated additional 5,000 or more supporting personnel. So considerable effort has been and is devoted to the area of orbital operations. That is, rendezvous and Earth-orbital operations.

The present status of engineering projects and technologies directly related to an Earth-orbital operational assembly and launch base is sufficiently well founded to justify initiation of a major U.S. space program for its development. Perhaps a solution, as illustrated by the newly formed U.S. Satellite Communications Corp., is to establish a new U.S. Space Port Corp., supported by the U.S. Government in part and by private industry and the U.S. public. This orbital facility would serve to promote space research and space operations by industry, other agencies of the Government and provide an orbital launch service to the free world countries desiring an active participation in space development.

Mr. TEAGUE. Are there any further questions?

Mr. FULTON of Pennsylvania. Would this U.S. space port be in addition to the present Apollo program, or could it be made part of that program?

Mr. PETERSEN. I think it ought to be part of an overlying structure to support our whole space operation, military and civilian.

Mr. FULTON of Pennsylvania. Looking at the cost of it, would it be an entirely new cost, or could part of the cost be paid by what NASA is presently doing on the Apollo program?

Mr. PETERSEN. I presume that with the present fixed program or direction of effort underway that there would certainly be required modification to achieve a good assembly capability in space.

Mr. FULTON of Pennsylvania. How much extra would this cost be if it were added to the Apollo program?

Mr. PETERSEN. I could not come up with a figure now.

Mr. FULTON of Pennsylvania. How much time would it take to get this kind of a space platform?

Mr. PETERSEN. I think we could begin to do this on a more rigorous basis with the present system. But to truly exploit and provide an orbital launch capability you have to provide building block support systems and building blocks to go along with this, to have total system capability.

Mr. FULTON of Pennsylvania. NASA could do the space platform program, though, with the present booster equipment, without going to the Apollo-type C–5 Saturns, couldn't it?

Mr. PETERSEN. Well, sure, the Gemini system with Titan II and Titan III could provide a pretty good start with the Earth orbital operation. The Saturn C–1 and Titan III, certainly, would provide a pretty good initiation point to develop an Earth orbital operation.

Mr. FULTON of Pennsylvania. Were you consulted on the decision to use the Earth orbital or lunar orbital approach on the Apollo program?

Mr. PETERSEN. I wasn't consulted directly. While I was with the Northrop Corp. we pursued this study and had contact with many of the technical groups in NASA, certainly.

Mr. WAGGONNER. Would the gentlemen yield?

Mr. FULTON of Pennsylvania. Certainly.

Mr. WAGGONNER. To your knowledge, was the Air Force consulted as to the relative merits of lunar orbit versus Earth orbit with respect to which would give the military the greatest advantage?

Mr. PETERSEN. I suppose it was, but I am not aware of it. I only joined the Air Force as a civilian less than a year ago. I can't answer that directly.

Mr. TEAGUE. Mr. Petersen, it is true that NASA gave out study contracts, including yours, to study the various approaches to accomplishing the manned lunar landing. After those studies were completed, NASA consulted with DOD, the Space Council, and with the President's Advisory Committee. So through DOD, the needs of the Air Force were considered; however, perhaps they were not consulted directly, I don't know. In any case, Mr. Petersen was not with the Air Force at that time.

Mr. PETERSEN. The study we performed was relatively small, supported only by company funds, and it was not one of the three winning contractors that performed those three direct studies to the Moon in 1960 and 1961.

Mr. TEAGUE. I might say that we have in the record of March 19, 1963, the statement submitted by Dr. Welsh, the Executive Secretary of the Space Council, who said that in his opinion "LOR" was a proper decision. I think you were at Houston, Mr. Waggonner, when the astronauts said they voted for LOR.

Mr. FULTON of Pennsylvania. Could we have your comment on the relative merits of Earth orbital rendezvous and lunar orbital rendezvous insofar as it applies to the Apollo program? Could you evaluate that?

Mr. PETERSEN. First, we should identify the two as Earth orbital rendezvous and modified direct launch to the Moon, parenthetically with lunar rendezvous, if you like.

Mr. FULTON of Pennsylvania. But you mean the same as the customarily used "LOR"?

Mr. PETERSEN. Yes. I think all of our future programs, whether they are communications satellites or other low altitude satellites, can benefit by a manned, low altitude assembly base in orbit and can be used to perform maintenance, repair, and modification of them, support laboratories in space, and assemble vehicles for interplanetary missions. All these can benefit by having a low altitude logistics system, or assembly base, for support.

Mr. FULTON of Pennsylvania. You spoke of the three major methods: direct ascent, Earth orbital rendezvous, and lunar orbital rendezvous, or modified direct ascent, as you call it. Would you comment on the decision whereby the United States had tentatively set its course on Earth orbital rendezvous, then in midpassage, around the latter part of last summer, changed its direction, and adopted the policy of lunar orbital rendezvous for the lunar landing program?

Mr. TEAGUE. Mr. Fulton, I read the technical paper by Mr. Petersen, and he was the only person that I could find who has really written the story of rendezvous. I don't think he should be asked to comment on a decision made by people who are now above him. He came here to discuss rendezvous, and I would hope we will not put him in the position of approving or disapproving what a superior command has done. I think to put him in that position is unfair to him.

Mr. FULTON of Pennsylvania. I would accept that.

But I would say: Would you then comment on your recommendations, on which is the best mode, leaving out what the decision was. What is your final recommendation on the mode most likely to succeed, and the mode most likely to get a return on abort; and the cheapest mode; and the shortest time mode as well as the most efficient?

Mr. TEAGUE. Mr. Fulton, I think you are asking the same question. I think Mr. Petersen's presentation speaks for itself.

Mr. FULTON of Pennsylvania. Well, the presentation has various aspects that lean toward a decision. When you get recommendations that point in one direction, you would like to know what his conclusion is.

Mr. PETERSEN. Let me make just a comment.

Mr. FULTON of Pennsylvania. I don't want to put you on the spot.

Mr. PETERSEN. I appreciate that. I have many friends on both sides of this argument. Some things have no concrete, absolute answer, they depend on many attenuating or related circumstances.

I think in the long run we are not interested in just landing a single crew on the Moon, but really interested in a reasonably necessarily long-term study of the Moon scientifically to consider its applications and unique characteristics as applied to what we are involved in here on the Earth. And we cannot achieve this by a single landing on the Moon. In the long run I am sure we are interested in a sustained program until we finally conclude that we have milked the Moon of all its scientific value and applications and don't

want to pursue it further. A sustained activity lasting 15 to 30 years should be planned as a minimal lunar program.

Mr. FULTON of Pennsylvania. I look at your position as a change in emphasis, rather than one which calls a decision right or wrong. So in that area of reference I think you could comment.

The second point is: In looking at the Moon flight, you are really saying that you want it to have a constructive effect on later space exploration programs by the United States, rather than as a single flight, which, when it is over, ends the Moon program without maximum lasting benefits.

Mr. PETERSEN. I think our approach should be on the side of growth potential and flexibility and that those two parameters shoud be the strongest or heaviest-weighted in making a decision.

Mr. FULTON of Pennsylvania. In that context, you then recommend Earth orbital rendezvous for future space programs so that we can use not only the gain from a particular program but also a space platform or space port for future launches?

Mr. PETERSEN. That is right. Yes.

Mr. TEAGUE. Any other questions?

Mr. Bell.

Mr. BELL. Mr. Daddario, do you want to go first?

Mr. DADDARIO. Go ahead, Mr. Bell.

Mr. BELL. Mr. Petersen, I note that you have built up a considerable scientific bibliography to which you refer in your statement. Where is this material? Is it all in one place, or has it been printed?

Mr. PETERSEN. I have been assembling this for sometime. It is not in a published form yet. But I anticipate having it in a form which would be printed, just to give a complete listing or nearly complete listing of the effort supporting the general subject area.

Mr. BELL. When you have completed this what are you going to do with it?

Mr. PETERSEN. Well, it would only be made available to anyone technically interested, or who wants to use it for the pertinent references in the various subject areas. I have only done it to kind of maintain an inventory of effort along these directions. Many other people do it also.

Mr. BELL. It is certainly going to be a wonderful thing for people to refer to. I would think possibly the most logical filing spot might be the ASTIA area?

Mr. PETERSEN. That is correct.

Mr. FULTON of Pennsylvania. Mr. Chairman.

Mr. TEAGUE. Mr. Fulton.

Mr. FULTON of Pennsylvania. Mr. Petersen, could you supply us with your bibliography of the technical papers you have prepared or had published in this field, both your own as well as in conjunction with someone else as coauthor, so we could add that to your biography?

Mr. PETERSEN. Yes, I will forward this list. I won't have the special bibliography availably for just a little while. It includes a number of in-hcuse reports by various companies, and I have to clear it with these to make sure they are in agreement to including a listing of some of these internal reports I have had access to.

Mr. FULTON of Pennsylvania. I think it would be well worth while to have it collected for students and research people.

(The information requested is as follows:)

TECHNICAL PUBLICATIONS AUTHORED BY NORMAN V. PETERSEN

"Lifetimes of Earth Satellites From New Circularity," presented to Fifth International Astronautical Federation Congress, Copenhagen, Denmark, August 1955.

"General Characteristics of Satellite Vehicles," Journal of Astronautics, volume 2, Nos. 2 and 3, 1955.

"Conquest of Space," Sperryscope, No. 3, 1955, Iowa Transit, volume 60, No. 4, 1956.

"Earth Satellites—Some Characteristics and Problems," Sperry Engineering Review, volume 9, No. 2, 1956.

"Lifetimes of Earth Satellites in Near-Circular and Elliptic Orbits," Jet Propulsion, volume 26, No. 5, 1956.

"Factors Affecting the Lifetime of Earth Satellites," Aero Digest, volume 73, No. 1, 1956.

"Summary of Proposed Methods for Determining Satellite Lifetimes," proceedings of the Seventh International Astronautical Congress, Rome Italy, September 1956.

"Project Skyball—A Proposed Primary Satellite Trainer for Space Flight Operations," proceedings of the American Astronautical Society, fourth annual meeting, January 1958.

"Rescue and Retrieve Space Missions," proceedings of the Second International Symposium on the Physics and Medicine of the Atmosphere and Space, November 1958, School of Aviation Medicine, USAF Air University, Randolph Field, Tex.

"Satellite Rendezvous Operations," proceedings of the American Astronautical Society, fifth annual meeting, December 1958.

"Rendezvous in Space—Effects of Launch Conditions," Aero/Space Engineering, (summary article), May 1960, volume 19, No. 5, N. V. Petersen and R. S. Swanson.

"Rendezvous in Space—Effects of Launch Conditions," IAS Proceedings, Manned Space Stations, May 1960, N. V. Petersen and R. S. Swanson.

"Satellite Rendezvous Navigational Requirements," Journal of the Institute of Navigation, autumn 1959, volume 6, No. 7, N. V. Petersen, L. Pode, and L. Hoover.

"Rendezvous Compatible Orbits," Astronautical Science Review, October–December 1959, N. V. Petersen and R. S. Swanson.

"The Influence of Launch Conditions on the Friendly Rendezvous of Astrovehicles," proceedings of the American Astronautical Society—Second western national meeting, August 1959.

"Satellite Rendezvous Guidance Concept," proceedings of the American Astronautical Society—Sixth annual meeting, January 1960, N. V. Petersen, R. S. Swanson, and L. Hoover, Western Aviation, April 1960.

"Lunar Landing Simulator," presented, Institute of Aeronautical Sciences, national summer meeting, Los Angeles, June 1959.

"Stationkeeping of Satellites in Rendezvous Compatible Orbits," August 1961, American Rocket Society Preprint 1954–61, N. V. Petersen, R. S. Swanson, and P. W. Soule; Progress in Astronautics and Rocketry, volume 8, 1962, Academis Press.

"Earth-Lunar Logistics Employing Orbital Assembly and Launch," Space Logistics, John Wiley & Sons, Inc., 1961, N. V. Petersen, H. Reich, and R. S. Swanson.

"Orbital Assembly and Launch for Lunar Operations," Institute of the Aerospace Sciences, annual meeting, New York, N.Y., January 22–24, 1962, IAS paper No. 62–81; Aerospace Engineering, volume 21, No. 8, August 1962.

"Rendezvous, Docking and Transfer," lectures in Aerospace Medicine, School of Aerospace Medicine, Brooks Air Force Base, Tex., February 6, 1963; Proceedings of the Lectures in Aerospace Medicine (to be published).

Mr. TEAGUE. Mr. Daddario?

Mr. DADDARIO. Could you give us a job description of your position as technical director, Mr. Petersen?

Mr. TEAGUE. What we are interested in are the technical programs you are working on now for the Air Force.

Mr. PETERSEN. I report to Gen. Irving L. Branch, Commander of the Air Force Flight Test Center, which operates as 1 of the major 14 elements of General Schriever's Air Force Systems Command, having 7 divisions and 7 centers. We have the task of performing the air-

craft as well as space flight testing, where this is primarily to do what is called category 2 flight testing of these vehicles, which includes the whole spectrum of aircraft vehicles, a few of the Army and Navy programs that the Air Force works with. This is to obtain the performance characteristics, stability, and control characteristics of these vehicles and assist in obtaining a better production vehicle for use by the military.

I assist in a general technical way. I am, in effect, staffed to General Branch, and as such, aid him in a technical way across all the programs that we have. I don't become directly involved with many of them.

We have some 176 projects presently going on at the Flight Test Center, and, actually, even though—I am not trying to imply anything, but actually the workload at the Flight Test Center is even larger now than it has been for the past few years, and this primarily stems from a few new aircraft that are coming, a great many iterations of the same vehicle, like the B–52–H is from a long family of B–52's, and the last test program on the B–52 is about completed.

Col. Harold Norton is in charge of the rocket research laboratories and reports directly to General Demler at Bolling. Colonel Norton's rocket research laboratory is 1 of some 20 tenants on the Test Center and the Air Force Flight Test Center is the host organization. Our procurement people at the Flight Test Center provide a supporting service to the rocket research laboratories in the award of their research contracts, and so forth.

Mr. DADDARIO. Does Dyna-Soar fit in there?

Mr. PETERSEN. Right; the planned flight test program for the X–20 will be somewhat similar to that for the X–15. The X–20 will be carried aloft on a B–52, which is presently at Wichita being modified to carry the Dyna-Soar. The airdrop flight test program will be performed at Edwards, in about 1965.

Mr. DADDARIO. To get into a somewhat different area for a moment, last year Dr. Baker, of Bell Telephone Laboratory, testified before our committee that there was a split in the Technical and Scientific Committee concerning how we should be developing our space program to get more out of it. There was some question as to whether or not we were doing enough in order to protect and maintain the security of this Nation. Do I read a similar fear in your mind about this program? You state that we can get to the Moon either by the method chosen or by some of these other methods, but that you say that we ought to be doing more. Is your desire to do more motivated by the idea that we should do more for security purposes?

Mr. PETERSEN. I think both on the civil side as well as the military side that at any instance of time we would have the stronger foundation for space programing if we had a good Earth-orbital operational capability, and this certainly will provide a much stronger support to the military.

If the decision is that we pursue this military space role or direction then a good Earth-orbital capability will support that most effectively.

Mr. DADDARIO. Will we not have this capability as a result of the decision to go to the Moon through the modified lunar orbital techniques?

Mr. PETERSEN. There are many payoffs for many programs that we initiate. Every program has some payoff. There will be many

technological benefits derived from the current program, across the board. But just having technology and knowledge is not enough, there is a long time in implementing these. Pursuing space research and technology is important. You can't expect to have an off-the-shelf systems capability available at any instant of time. It takes at least 5 years or more to develop any practical vehicle. Just developing technology is only part of it.

Mr. DADDARIO. That is because it is not being developed specifically to perform definite missions? Is that a proper conclusion?

Mr. PETERSEN. Militarywise we are not in a position to do much operationally in space at the present time. Before we can, I think, even do very much on the civil side, and certainly on the military side, we need a good applied R. & D. program using manned laboratories in space; and these are going to have to be operated for a considerable length of time before you can truly develop good operational capabilities in space. Most operational military space systems certainly will generally be constrained to random orbits, and possess an excess maneuverability, and so on. But for some time, we need a good R. & D. capability in space if we are going to get around to doing anything operationally. This R. & D. phase by the military can best be performed by employing a low-altitude complex of orbital laboratories using rendezvous compatible orbits for better logistics.

Mr. DADDARIO. It will have a great deal of technical fallout, then, but may not necessarily fit some of the programs which the military feel may be necessary. Is that what you are driving at?

Mr. PETERSEN. I assume you are speaking in reference to our lunar program, yes.

Mr. TEAGUE. Mr. Petersen, is this a fair question: If we had not set the manned lunar landing as a national objective, do you believe, looking at an orderly way of developing our space program, that our emphasis would now be on EOR or LOR?

Mr. PETERSEN. If we didn't have a specific mission to go to the Moon, a hoped-for target date, we probably wouldn't have any orbital assembly and launch system under development; we would probably be pursuing the scientific satellite area, perhaps still not with emphasis on the launch capability.

The desire for an orbital launch capability stems only from wanting to do other Earth-orbital missions or lunar or interplanetary missions or laboratory missions. I think the first step is to have an orbital assembly and launch capacity. The launch capacity can be used for other Earth-orbital missions as well.

Mr. WAGGONNER. Mr. Petersen, I think what the chairman really meant was that if we didn't attach time as a significant factor to the lunar landing program, would we pursue it from the Earth-orbital rendezvous method, or the lunar orbit rendezvous method?

Mr. TEAGUE. Yes. In other words, is EOR going to be the workhorse of the space program in the future?

Mr. PETERSEN. I feel it is an essential part of the program. We are always booster limited.

I think the objective of going to the Moon is a real fine one. We also have an objective of going for manned missions to Mars and Venus, and we are forever limited with—faced with booster limitations.

Mr. WAGGONNER. Do you feel from a purely military standpoint, there is much more that could be done a lot quicker with EOR than with LOR?

Mr. PETERSEN. Sure. Yes.
Mr. TEAGUE. Any other questions?
Mr. RIEHLMAN. Mr. Chairman.
Mr. TEAGUE. Mr. Riehlman.
Mr. RIEHLMAN. It would be fair to deduce from what you said that had NASA chosen EOR as the method of getting to the Moon, that NASA would have had greater cooperation and interest from the military. As you said today, military application, in the future, at least as you see it, is going to be attached to the EOR program?
Mr. PETERSEN. I think it is a fine and wonderful thing that we have a civil program distinct from the military. I think there are certainly areas in which the two can cooperate in many ways. Some of this cooperation already exists, but not to a very strong degree. It is not that they don't want to, it is just that the mechanism is not set up. We have a good civil program, generally.
Mr. RIEHLMAN. I agree with you on that. But I am also looking to the future with respect to the cooperation NASA is going to get from the military and the interest it is going to get from the military on the elimination of overlapping or duplicative activities in these fields.
Mr. PETERSEN. I don't think in the military we have a mission as far as the Moon is concerned. I think we might keep an eye peeled to the Moon militarily. But I think there is such a giant frontier in Earth-orbital space, for the military, to consume all the energy that the military could put in this direction if this were the decision.
Mr. RIEHLMAN. What I am trying to say is, this is where the concentration of interest is going to be on the part of the military.
Mr. PETERSEN. Right.
Mr. RIEHLMAN. Had it chosen EOR, NASA would have not only had the support of the military in connection with the military's interest in the EOR program, but could have also advanced its program to go to the Moon.
Mr. PETERSEN. Right. Personally, I would much rather pursue peaceful pursuits. If we elect to have a military space capability I think the Earth-orbital mode of mission operation is the first one we should be concerned about.
Mr. RIEHLMAN. I agree with you 100 percent. We are all concerned about the peaceful applications of space. But we just cannot forget the fact that there is certainly a great possibility that the military is going to be just as vitally interested in this program as NASA is. If for nothing else, than just for the psychological advantage of putting a man on the Moon, without knowing exactly what the advantages will be, or what we are going to gain from that type of venture.
Mr. FULTON of Pennsylvania. Would you yield?
Mr. RIEHLMAN. Yes, sir.
Mr. FULTON of Pennsylvania. One comment which you made has always concerned me, particularly when I have heard it from witness after witness from the DOD. That is your statement that "If we"—meaning the United States—"elect to have a military space capability." That kind of comment always leaves me up in the air, up in space. The reason is that you don't say you have decided one way or the other, but that you are uncertain.
Now, at some point in time, or some point in space, or atmosphere, the DOD and the Air Force must come up with a decision as to

whether they have a military defense or security function in the strategic area of space. In my opinion that decision should have been made many years ago, back in 1954 or 1955.

Mr. TEAGUE. I would say to you gentlemen, that you are going to get a good chance to ask questions on that, soon. But Mr. Petersen is not the man to answer it.

Mr. FULTON of Pennsylvania. But did Mr. Petersen actually mean it when he said, "If we elect to have a military mission in space?"

Mr. PETERSEN. First off, you have to try to identify the military threats that exist, then try to mechanize the weapons systems to cope with these. And I don't feel one can identify the threat very clearly or precisely, or even mechanize the system precisely to cope with that threat.

Mr. FULTON of Pennsylvania. At this point in time, then, there is both National Aeronautics and Space Administration's interest in Earth-orbital rendezvous, as well as a military Air Force's interest in Earth-orbital rendezvous procedures?

Mr. TEAGUE. The military would be lacking in their responsibility if they didn't look at everything happening in this world as far as the defense of this country is concerned.

Mr. PETERSEN. Certainly the military is given the mission of providing defensive, and in some ways offensive, capabilities, and space is just one more place of doing things. One can develop backup retaliatory capabilities to provide a certain potential deterrent. Space is just another area for developing systems and defenses.

Mr. FULTON of Pennsylvania. I will ask the reporter to read my question.

Mr. TEAGUE. The Chair will rule that the question will be left as it is, and we will hear Mr. Fuqua's question.

Mr. FUQUA. I may fall on the same ruling.

You mentioned the "building block" approach of our space system. Then, in probable future exploratory trips to Mars, say, or some of the other planets, the lunar-orbital rendezvous will have no practical effect and we may have to then go back to Earth-orbital rendezvous for a trip to something like Mars?

Mr. PETERSEN. I would think so, though certainly a C–5 vehicle is only 3,000 tons and only about the size of a small destroyer. It is still not very big as far as ocean vessels we build. We could build 10,000 tonners, perhaps big enough vehicles to do the single mission to Mars in one vehicle. But I think we can easier capitalize on having more tonnage delivered to Earth-orbital space faster by going to the assembly route, and far quicker and cheaper.

Mr. FUQUA. And this would have more long-range effects, for example, to Mars and Venus?

Mr. PETERSEN. It is a booster or payload amplifier, assembly in space is, and we can use at any instant in time available techniques, available systems, and if properly configured and designed these can give you flexibility and growth potential that you cannot attain any other way. It is a launch system amplifier, literally, in letting you do missions that weren't on the books originally.

Mr. TEAGUE. Mr. Roudebush.

Mr. ROUDEBUSH. Mr. Petersen, you made certain observations on the dual launchings recently performed by the Russians, and mentioned their capability of putting a 17,000-pound vehicle in orbit. Approximately what thrust would that require?

Mr. PETERSEN. It would depend on the efficiency of the propulsion system.

Mr. ROUDEBUSH. Well, approximately.

Mr. PETERSEN. Well, C–I Saturn is going to deliver somewhere between 20,000 and 30,000 pounds, and it will have 1,500,000 pounds, so you would have—well, on the assumption that it has the same propulsive efficiency, same propellant system as the C–I, it would be perhaps on the order of 1 million pounds.

Mr. ROUDEBUSH. One other question. Concerning station keeping or controlling the orbits, would you say that on the basis of the experiments performed by the Russians, that they are developing an excellence on this stationkeeping technique? Would you say they are ahead of us on that capability at the present time?

Mr. PETERSEN. So far I have seen no definite statements that subsequent maneuvering in space was performed to make it clear to us in the United States, the free world, that they actually rendezvoused and docked and coupled the two Vostok vehicles. On the basis that they did not, on the basis of what I have seen to date, there were no subsequent maneuvers performed other than perhaps of an attitude nature, no translational maneuvering to change the separation rate or drifting rate, which continued at perhaps 25 miles an hour. There was some position difference between them, shortly after but apparently not very much. Apparently this remained about constant. I have no direct information other than what I have read in the open literature.

Mr. ROUDEBUSH. The reason I ask this series of questions I think is obvious. If the Russians are directing their efforts toward developing the Earth-orbital rendezvous technique rather than perhaps a direct ascent or lunar orbit rendezvous technique, this may imply something.

Mr. PETERSEN. I think their total space program, what we have seen to date, is much narrower than ours. On booster capability they are ahead of us. As far as demonstrating three of the vital characteristics to providing assembly capability in space, of having a reasonably short time delay, and ability to get the second vehicle off at the right time, the ability to guide it approximately into the vicinity of the target, and the ability to check out, erect, and check out a second vehicle quickly, these are essential ingredients of having an assembly capability. If we use rendezvous compatible orbits you can identify the launch time very precisely, establish a precise schedule for the launch crews, and in addition you can have the two launch opportunities per day. One or two backup vehicles can assure a vehicle ready at the right time.

If the station is on random orbits you can have certain window limitations, rather broad; if you use parking orbits you can even expand it, provided—and the payload penalties are not particularly large—providing the inclination of the target station is about the same as the launch space. If you steepen up the inclination the payload penalties increase.

Mr. ROUDEBUSH. The evidence of the Soviet experiments then more or less tends to point toward Earth-orbital rendezvous, rather than lunar, is that correct?

Mr. PETERSEN. I would certainly concur with that, that everything they have done to date supports a capacity for orbital assembly in

space, and I am just hazarding a guess that this is perhaps the route they may take.

Mr. ROUDEBUSH. We are all guessing, of course but going on the evidence, I would certainly agree that it indicates they are thinking about assembly in low Earth orbit and rendezvous.

Mr. PETERSEN. Having multiple launch pads, quick erection and checkout, short launch time delays, are vital to an orbital assembly capability.

Mr. DADDARIO. Then you wouldn't be surprised, from what you say, if the Russians were to go to the Moon tomorrow?

Mr. PETERSEN. No, I think we can anticipate seeing a string of payloads in space that will be tied together, rendezvoused, coupled; maybe the first attempts will be just a flyby, lunar excursion, but——

Mr. BELL. Would the gentleman yield on this point?

Mr. DADDARIO. Yes.

Mr. BELL. If the Russians have been only able to get 17,000 pounds into space as far as their booster capability is concerned, they will have had to have considerably stepped up their booster capability to go to the Moon tomorrow, wouldn't they?

Mr. PETERSEN. I don't know. They launched 12 Cosmos series satellites and 2 Vostoks and a Mars vehicle in 1962. The total tonnage of this delivered to Earth orbit is on the order of about between 150,000 and 200,000 pounds.

Mr. BELL. Oh, is that right? I thought their Vostoks were in the neighborhood of 20,000 pounds.

Mr. PETERSEN. 10,000-something, I believe, sir.

Mr. TEAGUE. He is talking about total tonnage.

Mr. PETERSEN. Total tonnage.

Mr. BELL. In other words, you have to be able to boost 250,000 to 400,000 pounds, as you are saying?

Mr. PETERSEN. That is right, 250,000 to 400,000 pounds from Earth orbit depending on the crew size, flight path, duration time, stay time, backups, redundancies, whatever you want to design into it. If you want a minimal system, then it is on the lower side.

Mr. BELL. But at any one single time they have not come close to it, have they?

Mr. PETERSEN. Oh, no, no.

Mr. BELL. That is what would have to be done, isn't it?

Mr. DADDARIO. As I understand it, you are talking about putting up these payloads and putting them together——

Mr. PETERSEN. On a daily basis, launching of 10 or 15 satellites, or on a weekly basis, depending on the environmental system on board, does not appear unreasonable. They have already demonstrated ability to fire two vehicles from the same launch pad in 24 hours, apparently, and conceivably they could do this 10 days in a row.

Mr. DADDARIO. And that would do the trick?

Mr. PETERSEN. At least for a flyby mission, it would be ample.

Mr. FULTON of Pennsylvania. If the Russians put this "Toonerville Trolley" train together in Earth rendezvous in the near future, the U.S. space program might be sitting on the launch pad with a Pullman or Cadillac type assembly, and the Soviets would be 6 years ahead.

Mr. PETERSEN. Possibly.

Mr. TEAGUE. Any further questions? Mr. Yeager?

Mr. YEAGER. Mr. Chairman, I have a number of questions which I would like to submit for the record for Mr. Petersen to answer, if I may.

Mr. TEAGUE. Without objection, it is so ordered. Mr. Petersen, would you please answer these questions for the record?

Mr. PETERSEN. Yes, sir; I will be glad to.

(The information requested is as follows:)

EARTH AND LUNAR RENDEZVOUS TECHNIQUES

1(*a*). Question. What are the unique characteristics of the direct flight mode?

Answer. The direct flight mode defines the operational approach for ascent to the Moon using a single vehicle to accomplish the entire mission from the Earth-surface launch pad to final touchdown on the lunar surface. Generally, the direct flight mode also implies the further restriction that the payload landed on the Moon is of sufficient size, permitting launching, and followed by a direct return flight to the Earth.

1(*b*). Question. What are the advantages of the direct flight mode?

Answer. Perhaps the primary advantage for the direct flight mode is that this approach may provide the minimum total flight time or travel time from Earth-surface launch to touchdown on the Moon.

1(*c*). Question. What are the disadvantages of the direct flight mode?

Answer. Primary disadvantages are (1) the initial gross weight on the Earth-surface launch pad is a maximum for a given delivered payload; (2) the system lacks growth potential and flexibility in that once the first, second, and subsequent boost stage sizes are fixed and development initiated, the payload size is similarly restricted and cannot be increased if desired at a later date; (3) all stages must be checked out on the launch pad for the full mission; (4) maximum reliability probably would be attained only after an extended time period, since total number of vehicles per unit payload delivered to the Moon would be smaller than if the Earth-orbital rendezvous approach were followed since this may be accomplished with somewhat smaller surface-to-orbit boosters having a larger total production.

2(*a*). Question. What are the unique characteristics of the EOR mode?

Answer. The principal unique characteristics include the following: (1) booster limitations are negated by employing rendezvous and assembly in Earth orbit; (2) maximum growth potential exists since mission-scaled vehicles can be assembled in orbit to match any desired current or future mission objective; (3) provides configuration flexibility since the assembled modules in space can be reconfigured as desired since aerodynamic forces need not be considered; (4) provides opportunity for secondary (orbital) checkout and launch, thus reducing reliability restrictions through mission staging; (5) provides mission-mending capability (permits possible return to orbit and subsequent rendezvous for certain abort conditions of lunar and interplanetary vehicles exhibiting malfunctions during escape maneuvers, thus salvaging key elements of large mission vehicles); (6) provides improved launch logistics through use of rendezvous compatible orbits, RCO's, and station keeping (this is an operational procedure of employing a special class of orbits termed "rendezvous compatible orbits," RCO's, to provide a "milk run" synchronism of the orbiting assembly and launch base yielding two optimum, in-plane, launch opportunities per day, for rendezvous with zero-payload penalty; the RCO synchronous orbit simultaneously yields two optimum, in-plane, recovery opportunities per day from orbit to a preselected landing site; the RCO synchronous orbit further provides two optimum, in-plane opportunities per day for both rendezvous or recovery-type rescue or retrieve missions; and, offsets payload penalties associated with launch operations to randomly orbited target satellite stations; and (7) encourages development of the "building block," or vehicle module approach for design of large space mission systems (orbital rendezvous concept thus yields lower production costs, higher reliability and greater payload delivered to orbit for mission application at any given instant of time; significant consequence afforded by the orbital rendezvous or "building block" approach is the more rapid transition of technical personnel to the application and use of the manned and unmanned payloads delivered to space that will provide the greater payoff of space technology and science; launch boosters serve primarily as a means to an end, that of transport of the valuable payloads for its specific mission).

2(*b*). Question. What are the major advantages of the EOR mode?

Answer. Major advantages for the EOR mode are generally summarized in part 2(a) of this question.

2(*c*). Question. What are the significant disadvantages?

Answer. No major disadvantages can be identified, with the exception that a reasonable booster capability for delivery of payloads to Earth orbit should exist so as not to require an excessive number of rendezvous.

3(*a*). Question. What are the unique characteristics of the LOR [1] mode?

Answer. The unique characteristics of the LOR (MDL) mode are as follows: (1) A direct ascent is made by a single vehicle from the Earth-surface launch base with a direct transit to the Moon, or via a brief parking phase on a parking orbit to adjust for launch delays; (2) lunar orbit capture occurs with the vehicle constrained to a low-altitude orbit followed by descent to the surface by an onboard lunar excursion module. Subsequent launch occurs with the excursion module and escape propulsion stage in lunar orbit; (3) after rendezvous and coupling is accomplished, crew transfer completed, excursion module is hence jettisoned and an escape maneuver from lunar orbit is executed; Earth return transit occurs with necessary midcourse corrections followed by reentry and recovery of crew on board the command module; (4) this mode of transport to the Moon is best identified as a "modified direct launch" since a single vehicle is employed for complete mission with only an excursion away from and return to the basic vehicle in a lunar orbit.

3(*b*). Question. What the the major advantages of LOR as compared to EOR?

Answer. No major advantages of the LOR (MDL) mode over EOR are anticipated.

3(*c*). Question. What are the significant disadvantages of LOR?

Answer. Primary disadvantages of the LOR mode are as follows: (1) Payload limitation of present Saturn V vehicle restricts redundancies and backup systems with attendant higher risks involved; (2) lacks growth potential available through assembly in Earth orbit, lunar orbit or at lunar surface; (3) possibility of abort action such as to result in subsequent adaptation into Earth orbit and salvage of major "building blocks" for reuse on later flight not realizable since Apollo vehicle not designed for assembly in orbit; (4) growth potential and flexibility of LOR (MDC) not available since single vehicle employed throughout major portion of flight.

4(*a*). Question. What should be the mode selection criteria?

Answer. I believe the two primary criteria which should be considered are g rowth potential and flexibility. Here, I define growth potential as that quality about our space logistics system which will provide a capability for negating the problem of booster payload limitation. Use of the first available practical booster systems, for example the Saturn C–1 and Titan III and initiating a large production capacity for these boosters, will lead to improvements in reliability together with reduced costs. Further, development of "propulsion system modules or building blocks," plus other "life support" or equipment modules as "building blocks" for assembly in space following rendezvous, will lead to similar gains in reliability and lowered production costs. The inherent quality of flexibility as a significant selection criteria for determining best logistic system to employ should be recognized. Consideration of these two selection criteria should be heavily weighted because of the overall effect on nearly all of our space programs, including Earth orbital operations as well as lunar and interplanetary missions. Further, recognition of the value of these two criteria is further identified when evaluating or comparing the possible potential value of the EOR mode and the LOR (MDL) mode to the U.S. military organization.

5(*a*). Question. Which mode is the most attractive from a mission success and safety standpoint?

Answer. The EOR mode is the most attractive in considering the aspects of mission success and safety. This is true for two major reasons: (1) a positive growth potential provides the opportunity to increase booster capacity, or size in orbit, by assembly of additional propulsion modules to account for gradual growth of the payload during development (both the direct flight mode and modified direct flight mode lack this potential of compensating for payload growth—only alternative with these two modes is to reduce mission duration, reduce redundancies or backup subsystems or to reduce crew size, etc.); (2) the EOR mode pro-

[1] LOR (lunar orbit rendezvous) is recognized as the designation for the present NASA Apollo flight mode to the Moon; however, since the present mode effectively employs a single vehicle for the lunar mission with an excursion to the lunar surface followed by launch and rendezvous with the initial vehicle in lunar orbit, and further does not employ assembly in space, is identified as a modified direct launch (MDL) mode. Reference, therefore, will be made throughout these comments to the LOR (MDL) mode.

vides additional safety procedures over and above those provided by the modified direct launch mode or any other mode (these include (i) a mission-mending capability by permitting a possible return to orbit and subsequent rendezvous for certain abort conditions, (ii) provides secondary, or orbital, checkout following boost to orbit and prior to launch from orbit).

6(*a*). Question. What operations in LOR and EOR mission profiles are the most critical from a mission success/safety standpoint?

Answer. It is difficult to identify specific operations for either LOR (MDL) or EOR which are the most critical from a mission success/safety standpoint. Perhaps primary propulsion for descent to the lunar surfaces, as well as the subsequent launch for both EOR and LOR (MDL) may actually be the most critical. Abort modes for Earth escape and possible rescue from the lunar orbit phase, in event of malfunction, provide some attenuation of risk. Resupply of standard Apollo crews on the lunar surface due to malfunctions developing following landing may readily be handled by subsequent supply craft or cached prior to the manned flight.

7(*a*). Question. What should be done to minimize the potential hazard problems of LOR?

Answer. A considerable number of approaches may be pursued to minimize potential hazard problems of LOR (MDL). Improvements in reliability, reduction of equipment weight where possible, and improvements in propulsion performance are, of course, important. Use of logistic vehicles to land supplies at the lunar site prior to and following the manned landing; use of a backup landing craft placed on the surface of the Moon prior to the manned flight; use of a backup command module placed in orbit about the Moon prior to the manned flight; and, the use of three backup Apollo vehicles complete with the exception of employing only two-man crews to permit subsequent rescue of the stranded Apollo crews in lunar orbit or on the lunar surface. Consideration of these solutions illustrates the value of employing EOR to provide initially larger lunar vehicle systems incorporating the necessary redundancies and backup equipment to minimize potential risks for the first lunar mission. Perhaps the best solution would be to combine the best parts of the LOR (MDL) mode with the growth potential and flexibility of the EOR mode. Thus, EOR could provide the ability to assemble the lunar mission vehicle of such payload size as to incorporate the desired redundancies and to best cope with inherent payload growth and propulsion system inefficiencies. Thus, the EOR mode would permit matching the desired payload size with the expected mission requirement. The present LOR (MDL) mode to the Moon is believed perfectly feasible if performance of the launch booster and subsequent propulsion systems do not dictate extensive elimination of redundancies and backup equipment. The present Saturn C–5 booster is considered restrictive in this light.

8(*a*). Question. Which mode offers the best possibility for early mission accomplishment?

Answer. If both LOR (MDL) and EOR modes were initiated at the same date, it is my conclusion that the EOR mode would offer the best possibility for early mission accomplishment. Even with the present headstart that the LOR (MDL) mode has, the writer believes rapid implementation of the EOR mode is essential to provide the Nation with an unquestioned ability to attain the Moon and explore it in detail. A single landing, if completed at an early date, may satisfy national prestige but our scientific curiosity of the Moon will not be satisfied without an extensive, efficient Earth-Moon transport system.

9(*a*). Question. Using one or two Saturn V's as the case may be, which mode provides the greatest payload weight growth margin?

Answer. Two Saturn V's, using the EOR mode, with properly designed upper stages and modules, should show considerable payload weight growth margin over a single Saturn V using the LOR (MDL) mode.

10(*a*). Question. In addition to getting to the Moon and back, what other advantages accrue from use of the LOR technique?

Answer. No specific advantages can accrue from use of the LOR (MDL) technique that would not evolve as a matter of development of the EOR mode.

11(*a*). Question. Why is a two-man landing system with a third man in lunar orbit preferable to a three-man landing system?

Answer. A two-man landing system with a third man in lunar orbit is preferable to a three-man landing system only if (1) the LOR (MDL) lunar orbit descent and rendezvous system is employed; (2) the command module requires manning during the lunar excursion module descent to improve the subsequent rendezvous operation; or (3) further reduction of redundancies and backup equipment to

provide payload space for extra crew member appears excessive, thus jeopardizing mission success probability. An alternative approach, faced with the payload limitations of the Saturn V booster, would be consideration of a one-man descent to the lunar surface, thus permitting improvements in safety through provision for greater backup systems.

11(*b*). Question. Or a one-man landing system?

Answer. A one-man landing system probably would give greater safety and higher probability of success, based on the single Saturn V LOR (MDL) payload limitations. Sufficient landing aids can be provided the single pilot to execute the landing and subsequent rendezvous. Additional propellant, life support gear, and maintenance and repair equipment for use by the single crewman are considered far more important than the extra crew member.

12(*a*). Question. What factors govern propulsion system selection—cryogenic versus storable?

Answer. The following factors govern the selection of cryogenic or storable propellants for primary propulsion systems: (1) for a fixed payload the specific impulse Isp dictates the booster stage size; (2) payload penalty tradeoffs associated with providing cryogenic storage capability and resulting boiloff versus increased structure requirements for lower specific impulse storable propellants; (3) ground handling considerations, and others.

13(*a*). Question. Is mission accomplishment using the LOR technique dependent on Earth-based tracking stations?

Answer. Early stages of the Earth orbital boost and subsequent escape boost and midcourse correction phases may be dependent on Earth-based tracking stations. Subsequent tracking of the Apollo command module while in lunar orbit and during descent and following rendezvous operation cannot be effectively aided by Earth-based tracking stations.

14(*a*). Question. What if the Russians go EOR? Should this affect our planning as to method?

Answer. If the U.S.S.R. elects to pursue the EOR mode, I believe a U.S. decision to give emphasis to the Earth orbital mode should be made primarily on the basis of military significance. I believe our decision to give emphasis to the EOR mode for our civil space program, in light of a Russian decision in favor of EOR, should be made on merit of the system to provide a stronger foundation for our overall space program, and this decision should be weighed in support of the system possessing growth potential and flexibility.

15(*a*). Question. How significant is the fact that LOR has no Earth abort capability like EOR?

Answer. No comment.

16(*a*). Question. What method provides the best payload margin to cope with the solar flare problem?

Answer. The EOR mode provides the growth potential through assembly in orbit of the necessary orbit launch weight to provide for sufficient radiation protection to cope with class 3 solar flares. The additional payload capability of EOR permits increasing the radiation shielding to the level desired yet accepting a minimal hazard during a given flight. Solar flare activity is anticipated to be at a maximum during the latter part of this decade and is expected to coincide with our first launching attempts to the Moon. EOR can provide the growth potential to best cope with the problem of radiation.

17(*a*). Question. Do you know of any specific payload of around 17,000 pounds which the Russians are presumed to have launched?

Answer. I am not aware of a specific payload of 17,000 pounds for any particular Russian vehicle. My reference to this value in an earlier question stems from a casual reference which cannot be verified at this time.

18(*a*). Question. Will a station-keeping ability be built into either the Gemini or Apollo programs so far as you are aware?

Answer. I do not believe a station-keeping system to give rendezvous and recovery compatible orbits is being considered for either the Gemini or Apollo programs. This was discussed with the Gemini project manager though no interest was shown in the concept at the time.

19(*a*). Question. Do you concur that the LOR method offers advantages from the standpoint of speed and economy over the EOR?

Answer. No; I do not concur that the LOR (MDL) mode offers speed or economy advantages over the EOR approach. I feel that the single vehicle approach to the Moon using the modified direct launch mode, as now in process, entails a higher risk venture than EOR and lacks the necessary growth potential in event these risks require circumventing by redesign or additional safety backups.

20(*a*). Question. Where would the advantage lie from the standpoint of safety?

Answer. The advantage must rest with the EOR mode since the possibility of significantly increasing the assembled payload to the necessary orbital launch weight as dictated by safety exists. Propulsion capacity can be assembled in orbit to match precisely the orbital launch weight requirement.

21(*a*). Question. Should redundancy be built into the Apollo landing module so far as propulsion is concerned?

Answer. The payload penalty incurred by providing a twin engine configuration with one engine as a redundant, or backup, propulsion system is not considered excessive. The weight required to provide a redundant thrust chamber and associated propellant feed lines and pumping system is not considered excessive for the lunar landing and subsequent rendezvous operation. A continuous thrust descent from the deorbit position to touchdown using a low thrust level, but throttleable, liquid engine system with only a single ignition would be perhaps a preferred approach. Payload penalty for a continuous thrust descent from a nominal 25-mile lunar orbit is not appreciable and costs only a few percent in excess of that for a two-impulse landing approach.

22(*a*). Question. Is the module technique being observed or ignored in our present Apollo program?

Answer. The module, or "building block," technique is presently being ignored in the Apollo program insofar as developing a capability for assembly in space. Independent modules are of course being constructed primarily because of the need for a separate command module to simplify problem of reentry, a separate lunar excursion module to reduce landed weight as dictated by Saturn V payload limitations, and a distinct propulsion module for lunar capture and escape. No specific program has been identified thus far with the objective of developing "building blocks" or modules having unit capacity with the expressed purpose of assembling these in space to meet the desired total capacity for a given mission. Of special value would be propulsion modules, life support modules, auxiliary equipment modules, and possibly laboratory modules, each with a specified capacity and capability for assembly in space. Multiple units of each of these four distinct module designs when assembled would provide the total system requirement for the specified mission thus providing an enduring growth potential for undertaking new missions in the future.

Mr. TEAGUE. Mr. Petersen, we appreciate your coming in, and thank you very much. This committee is adjourned.

(Whereupon, at 11:30 a.m., the subcommittee adjourned to reconvene at the call of the Chair.)

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1964 NASA AUTHORIZATION

TUESDAY, APRIL 2, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON MANNED SPACE FLIGHT,
Washington, D.C.

The subcommittee met, pursuant to adjournment, in room 356, Cannon Building, at 10 a.m., Hon. Emilio Q. Daddario presiding.

Mr. DADDARIO. The meeting will come to order.

Mr. Holmes, you plan to present to the committee, I understand, certain adjustments of the NASA budget figures. Would you proceed, please.

STATEMENT OF D. BRAINERD HOLMES, DEPUTY ASSOCIATE ADMINISTRATOR AND DIRECTOR, OFFICE OF MANNED SPACE FLIGHT, NASA, ACCOMPANIED BY WILLIAM E. LILLY, DIRECTOR, PROGRAM REVIEW AND RESOURCES MANAGEMENT, AND GEORGE LOW, DEPUTY DIRECTOR FOR PROGRAMS

Mr. HOLMES. Yes, Mr. Chairman. As you recall during the last hearing there was some difficulty in reconciling the breakdowns in our fiscal year 1963 and fiscal year 1964 budget books.

Mr. FULTON of Pennsylvania. When there has been an event such as the Soviet Moon shot, could we hear a comment by Mr. Holmes on that?

Mr. DADDARIO. I had thought we would get our business out of the way. However, since the request has been made, if you have some comment to make on the general situation concerning the Soviet shot, the committee would be pleased to hear it.

Mr. HOLMES. Yes, Mr. Chairman. I don't have a great deal of information on the shot. It is my understanding they have injected to the Moon a spacecraft of something over 3,000 pounds. Since the Russians have indicated for some time their intention to go to the Moon in a manned vehicle, it doesn't surprise us that they are continuing the unmanned phase of their lunar program.

We have known that they have the capability to launch and inject 3,000 pounds. We are going to have to wait for the Soviet Union to tell us more about today's shot. It could be a lunar hard-lander, a lunar soft-lander or a lunar orbiter. Our Surveyor project is a soft-lander, unmanned program.

I hope that the Soviet Union will release any information that is obtained from this lunar shot. If the mission is successful, the data will be helpful.

Mr. DADDARIO. What size is our Ranger program?

Mr. HOLMES. I don't have the exact figure. It is approximately 700 pounds. It is limited, of course, by the capability of the Atlas-Agena, which is used to launch Ranger.

Mr. GURNEY. What it says here, is that it is 300 pounds.

Mr. HOLMES. It could be 300 pounds, but that figure sounds light.

Mr. DADDARIO. Since there is a difference in the figure, I think it might be well to adjust the record.

Mr. HOLMES. I believe that the Ranger 5, for instance, weighed about 760 pounds at injection. This weight included a 328-pound spacecraft system.

Mr. DADDARIO. Just in the event there is a difference we should know.

Mr. HOLMES. We will furnish it, if the figure I just mentioned is not correct.

Mr. DADDARIO. Any further questions, Mr. Fulton?

Mr. FULTON of Pennsylvania. This shot has been described as a Moon station. Would that indicate it might be a lunar orbiter vehicle?

Mr. HOLMES. If the Soviet semantics were the same as ours, I would think that it would be a lunar orbiter or soft-landing vehicle. I can't see how they could call it a Moon station if the impact were hard.

Mr. FULTON of Pennsylvania. I understand indirectly that Willy Ley says that this is probably a photographic mission launched from Earth orbit and with the possibility it might be an unmanned lunar station. Would it be possible the Soviets might have equipment that would provide continuous television reception of the Moon's surface and relay it to Earth?

Mr. HOLMES. It is possible with that weight that one could design a slow-scan-rate television. The scan rate would necessarily have to be low compared to our commercial television. My statements are personal estimates, Congressman Fulton.

Mr. FULTON of Pennsylvania. The question comes up as to our selecting the lunar orbital method, and directly sending the spacecraft into lunar orbit by Saturn V. We will be 6 years behind the Russians if they take this other approach. For example, in the last year they have launched 13 cosmic rockets. They have also launched four Vostoks. To get the man to the Moon it will take 225,000 to 250,000 pounds payload.

I understand from their announcements that the Soviets have increased their payload capacity this year from about 12,000 or 14,000 pounds to around 17,000 pounds. Just by adding the weight of the 13 cosmic rockets plus 4 Vostoks, you will see there may be over 200,000 pounds possibly in orbit.

If the Russians have the capability of putting up a space platform and making a rendezvous, might we not be left sitting at a station while they are making the Toonerville Trolley train they are talking about and going off to the Moon within a year or two? Why isn't that possible?

Mr. HOLMES. I don't think that the Russians have demonstrated the tremendous proficiency in space operation that is required to rendezvous 10 or 15 or even 20 packages in Earth orbit. Further, if one were to rendezvous or join together many packages in Earth orbit, it is not unreasonable to assume that some of them would not function properly.

In my opinion it is not logical to assume that Russia can go to the Moon using a launch vehicle with a payload capacity of 14,000 to 15,000 pounds in a 100-mile Earth orbit. I think they will require a considerably larger and more powerful vehicle before they are able to send men to the Moon. This is my personal opinion.

Mr. FULTON of Pennsylvania. When is our Gemini flight?

Mr. HOLMES. The first Gemini flight—an unmanned, suborbital flight— is scheduled for the end of the year.

Mr. FULTON of Pennsylvania. It will be November or December before NASA makes the next step forward by having two-man flight in the manned flight program?

Mr. HOLMES. Yes, sir.

Mr. FULTON of Pennsylvania. Are photographic or impact missions within this year's schedule?

Mr. HOLMES. It is my understanding that the next Ranger shot is scheduled at the end of this year, just before the end of this year.

Mr. FULTON of Pennsylvania. Is the money that NASA has been receiving adequate, or are you still slipping as you were earlier in this fiscal year because of funds?

Mr. HOLMES. As you know——

Mr. FULTON of Pennsylvania. Is the program slipping, or is it making good progress?

Mr. HOLMES. We are proceeding according to a definitized schedule, which was established after careful consideration of program goals and available resources. This is not a slippage in the strict sense of the word.

Mr. FULTON of Pennsylvania. We did have a slippage, but it was a decision much above you and me.

Mr. HOLMES. It is a fact that the program is presently limited by money, or structured within available funds. On the other hand, I don't think that is too surprising, considering the sums involved. It is not a leisurely program. It is a very demanding program. It is not going as fast as it could if more money were spent on it.

Mr. FULTON of Pennsylvania. Leaving out a crash program, and putting in the factor of efficiency and economy, could you do better on the Moon program if you had more money?

Mr. HOLMES. Yes.

Mr. FULTON of Pennsylvania. I don't want to press you, but would you amplify that? This is the feeling I have. I want to have the United States paramount in space. I feel that the nation which has the first maneuverable space vehicles in earth orbit that carry nuclear weapons will have a tremendous advantage which could destroy any city, in my judgment, within 15 minutes.

If an adverse nation gives us a demonstration, as we had from Japan in World War II, that they are capable of destroying our cities, what is going to happen? It concerns me. The Department of Defense will not say there is a defense mission in space.

I feel an urgency for a military capability in space. Unless NASA does the necessary groundwork in research so that we will have this capability if we later decide we need military assistance, then we are in trouble. Is NASA going fast enough, in your judgment?

Mr. HOLMES. In my judgment we are going at a reasonable and proper pace. I do not pretend to have an understanding of the military application in space. I have not been working in, or studying

that particular area. I think that the question of military applications of space technology is up to the Department of Defense.

As far as our lunar program is concerned, including Gemini, for man's greater conquest in space, I think that we are going at a reasonable rate.

Mr. FULTON of Pennsylvania. Is NASA's pace set as if it were a race with the Soviets to get to the Moon first? Is NASA on that basis now?

Mr. HOLMES. I don't know how to run a race, other than at full throttle. We are not going at full throttle because we don't have the funds. However, we are going at a reasonable pace.

Mr. RIEHLMAN. Is NASA going at such a pace to achieve our goal with the funds available?

Mr. HOLMES. Yes, sir. Our program is geared to achieving our objectives within the resources available.

Mr. DADDARIO. Since the subject has been opened, I think it is important to keep this in proper perspective. We are considering the NASA budget request for next year. It is important that we deliberate on this as objectively as we possibly can. Does this Russian shot come as any surprise to NASA?

Mr. HOLMES. No. I think it does not. Of course, I can't say that I knew it was going to come this week, or last week. Their announced intention is to go to the Moon and their demonstrated capabilities in space should make us believe that they would be launching unmanned lunar shots.

Mr. DADDARIO. NASA has an estimate of the Soviet's capabilities, and in keeping with that estimate, NASA has established a program which you say has a reasonable rate to it.

Mr. HOLMES. That is correct.

Mr. DADDARIO. You say that the only way to go ahead to achieve a success in a race is at full throttle, and NASA is not going at full throttle. Has this been taken into consideration in view of the Russian capability?

Mr. HOLMES. What I meant to say, is that the only way I know to win a race, if you are talking only about a race, is to go at full throttle. I am talking in terms of arriving first. However, being ahead in the first lap in a race is not necessarily the key to winning the overall race. I think that one must draw that distinction to be fair.

We are running a reasonable program—a program that doesn't completely disrupt the Nation's economy by draining the resources of both industry and academic institutions, or doesn't interfere more than I think is necessary with other scientific programs. Whether or not we get there first, we will make this country much stronger in our conquest of space.

I don't call that losing the race in the broadest sense. Therefore, my use of the phrase "full throttle" meant that if the significant point is merely to arrive there first, and if this country determined that this was the only objective—which would be an unwise and limited view—more money would be required.

Mr. DADDARIO. The objective is the objective of obtaining a final goal in space and doing it in a way which you feel accomplishes——

Mr. HOLMES. I think that it would be foolish to squander funds on an all-out program. I think it would be unnecessary to lose lives

just to get there first. I believe that it is necessary to run a sound program, based on careful planning and long-term objectives.

If Russia wants to run a different program, that is up to them.

Mr. DADDARIO. Then we are pacing our program within the capabilities of this Nation, rather than acting and reacting to what Russians do?

Mr. HOLMES. That is my opinion.

Mr. DADDARIO. When you said we are approaching this national objective, which the President established, at a reasonable rate, you also mean by that, I imagine, a reasonable rate which has been quite a gigantic one. The increase in the size of the budget does encompass in it certain managerial problems to build the facilities, to gather together the scientific personnel, and to spend these funds in the most efficient way possible.

Mr. HOLMES. Absolutely. We are involved in a tremendous effort. We are requesting a manned space flight budget of about $10 million a day, which is definitely a large program.

Mr. DADDARIO. Do you feel it is a program which does credit to the Nation, and which in the final analysis, will put us in the position where we will not have anything to fear from the capabilities of other nations?

Mr. HOLMES. Based on my knowledge of other nations' development of their programs, I would answer affirmatively. I think we must recognize that in our budget, since it is, however, fund limited, that any reduction of funds means a slowing down of the program. I would be less than honest if I didn't say that.

I should add, to clarify my point, that the present level of funding is a sound rate in my opinion.

Mr. DADDARIO. If we were to radically increase the funds, would it have a proportionate effect on the advance of our space program?

Mr. HOLMES. It would increase the speed at which we are going, yes.

Mr. DADDARIO. Do you feel this is necessary at this time?

Mr. HOLMES. No, I do not. I don't think that a radical increase in funds is desirable at this time.

Mr. DADDARIO. Neither necessary nor desirable?

Mr. HOLMES. That is correct. In my opinion it is neither necessary nor desirable.

Mr. RIEHLMAN. I would like to go back to the basic program that this Nation is trying to accomplish. We have set the goal of landing a man on the Moon within this decade. The budget that you have presented to us is in keeping with that goal, am I correct?

Mr. HOLMES. That is exactly correct.

Mr. RIEHLMAN. If we provide the funds that were requested in this budget, there should not be any slippage in the program, and we would accomplish the manned lunar landing within this decade. Concerning the other remarks made today, we have not accepted, as I understand it, this program as a crash program. Am I correct in that?

Mr. HOLMES. That is correct. It is not a crash program, and it was not planned as a crash program.

Mr. RIEHLMAN. We are not at this moment anticipating to change our program into a crash program?

Mr. HOLMES. That is correct.

Mr. RIEHLMAN. With that as a basis, then no matter what Russia intends to do, or what its accomplishments may be within the next 2

or 3 years, we are going to keep on with what I hope is a steady, constructive program. I hope this approach will be more effective and more productive than to spend a lot of extra money in haste and waste to compete with Russia when we don't know what they are doing, or what they will accomplish.

Mr. HOLMES. I agree with what you said, Mr. Riehlman. I rather object to the thought of racing with Russia, just to arrive on the Moon first.

I don't think that one should object to racing with Russia in order to increase our proficiency and knowledge as to our space program.

Mr. RIEHLMAN. If we come to the realization that there is a great military potential in space, we will have the fundamental background that will be of use to the military.

Mr. ROUDEBUSH. It appears to me that there is a great degree of unnecessary hysteria in a portion of our population every time the Russians achieve a successful launch. Is there anything about the Soviet Moon shot that would cause us to reevaluate our program?

Mr. HOLMES. With the very limited information that I have available at this time, my answer is "No." There is nothing that I know of to cause us to re-evaluate our program.

Mr. ROUDEBUSH. Does this limited information you have, Mr. Holmes, indicate any new or advanced booster or technology on the part of the Russians?

Mr. HOLMES. No; it does not.

Mr. ROUDEBUSH. This could be achieved with the standard booster that the Russians have been using the last several years?

Mr. HOLMES. That is correct.

Mr. ROUDEBUSH. Is there any technical advantage indicated by the type of satellite which the Russians launched?

Mr. HOLMES. I don't know enough about the craft to say. I would have to know more about what is in that payload to be able to answer your question more specifically.

Mr. ROUDEBUSH. We know that the initial boosters which they have perfected would loft a payload of something over 3,000 pounds to the Moon.

Mr. HOLMES. Yes.

Mr. ROUDEBUSH. Thank you, Mr. Chairman.

Mr. DADDARIO. Any further questions?

Mr. CASEY. Mr. Holmes, the Soviets' Sputnik I, of course, motivated the U.S. program. We were kind of loafing along at that time, were we not?

Mr. HOLMES. We did not have much of a space program at that time.

Mr. CASEY. We had just started, so to speak, and Russia had about a 4-year jump on us, if I recall correctly.

Based on the progress that has been made since that time, we have closed some of this gap, have we not?

Mr. HOLMES. I believe we have. In fact, I believe we have taken the leadership in many areas of space technology.

Mr. CASEY. We have taken the leadership insofar as technical advances and results obtained by our exploration as compared to what the Russians have obtained in the way of productive satellites.

Mr. HOLMES. The Russians have neither a meteorological satellite nor a communications satellite.

Mr. CASEY. We are achieving for ourselves tangible, practical results rather than something for display purposes, isn't that correct?

Mr. HOLMES. I certainly believe it is correct that we are achieving many goals in our program that strengthen the Nation.

Mr. CASEY. That would be the communications satellites and all the other advancements in the peaceful use of outer space?

Mr. HOLMES. Yes.

Mr. CASEY. The fact that the Soviets have a payload headed for the Moon doesn't necessarily mean that they have made any leapfrog in their technogical capability, does it?

Mr. HOLMES. No. The fact that they have the payload on its way to the Moon doesn't. I think they have demonstrated a great capability in their space program. I would hesitate to judge just what has been accomplished with this probe until we know more about what is included in the payload.

Mr. CASEY. I am sure you couldn't do that. If the United States maintains the same pace that we have been maintaining insofar as the peaceful uses of outer space are concerned, is it not possible that even though the Russians might be the first to land a package on the Moon, we could still very well be the first to land a more productive and beneficial package, could we not?

Mr. HOLMES. Yes, we could.

Mr. CASEY. When the United States does make this shot to the Moon, we will have many productive scientific experiments on board, is that correct?

Mr. HOLMES. That is correct. I believe we are running a very sound program. In my experience, I have never seen a sound program or sound business that was triggered only by what the other side was doing.

Mr. CASEY. It hasn't been our objective to put a satellite in orbit that has no productive capacity?

Mr. HOLMES. That has never been our objective.

Mr. CASEY. Our objective, when we do send men to the Moon, will be to obtain productive results that will repay us for the money and labor expended getting them there?

Mr. HOLMES. Precisely.

Mr. CASEY. Thank you.

Mr. WAGGONNER. Mr. Holmes, the goal of this Nation to land a man on the Moon within this decade is one which has been accepted by some people as being a sound and worthy project, and one which has been criticized by others.

Should this goal be changed and the time delayed? Can you enumerate what the ill effects would be of a voluntary slowdown in the schedule to land a man on the Moon and return, in this decade? That is, other than the psychological effect a slowdown might have as to the charge that the United States is not meeting the challenge to keep its goal. What would be the ill effects of a voluntary slowdown in this time schedule?

Mr. HOLMES. My opinion, Mr. Waggonner, is that we are going at somewhat of an optimum rate. I think that a slower program would be less efficient. I think that it would hurt the present space program of the United States if we did slow it down by reducing the funds. Just as I feel fairly strongly it is not necessary at the present time to increase the funds in order to speed it up. I do think that it would

be undesirable to slow it down. A program manager has to determine the way men pull together and the rate at which they work. The optimum rate isn't working around the clock every day. By the same token, the optimum rate isn't working 3 days a week either.

I am sure from my experience of over a decade of running programs that it would not be wise to conduct a manned lunar landing program at a much slower rate than we have established. I think in the long run it would cost us more, and we would gain a lot less from it.

Mr. WAGGONNER. Geared to the present temper as we are, if we slow it down you feel it would definitely make the overall program cost more money, rather than less money?

Mr. HOLMES. I do think that, yes.

Mr. WAGGONNER. What other sacrifices would we make? Are we going to make any sacrifices, or would we sacrifice national security and the military uses of space by slowing this program down? Do we know enough about the Soviet military space program to fear, in our own minds at least, that we would be risking national security by slowing this program down?

Mr. HOLMES. I don't know. I think Mr. McNamara or representatives from the Defense Department should answer that question. I think their demonstrated interest in our Gemini program makes us believe that it is worthwhile for them to have this knowledge.

My knowledge of the military applications in space is limited to such an extent that I think I shouldn't comment on it.

Further, I don't have this responsibility, and I think others should comment.

Mr. WAGGONNER. Certainly your knowledge of the possible military applications of space should not be limited. Do you foresee a great military advantage or use in space as a result of what you know this program to be at this point?

Mr. HOLMES. I would feel very badly to see another country demonstrate a capability in space operations that dwarfed the capabilities of this Nation. The economic and military effects would lead to nothing good for us.

Mr. WAGGONNER. Both you and the Department of Defense believe that there is nothing in our decision to use the lunar orbit rendezvous approach that would weaken the knowledge that this Nation would gain for security purposes by use of the Earth orbit rendezvous approach.

Mr. HOLMES. I think this could be demonstrated by the fact that we will practice and develop the lunar orbital rendezvous technique in Earth orbit. We will learn how to perform rendezvous operations in our present program. The thing we want to do is to develop a large tanker of liquid oxygen that would rendezvous and transfer its payload of liquid oxygen to another vehicle. I think I can state definitely that NASA is confident that the lunar orbit rendezvous approach will provide high proficiency in manned space operations.

Mr. WAGGONNER. Did NASA consult with DOD before making this decision?

Mr. HOLMES. Yes.

Mr. WAGGONNER. DOD feels that they will sacrifice nothing by the LOR approach?

Mr. HOLMES. That is correct—based on discussions we have had and those between Mr. Webb and Mr. McNamara.

Mr. GURNEY. What progress are we making in regard to a space platform? Are we doing a continuing study in that field, and do we have any date as a goal when we are going to move in that field?

Mr. HOLMES. Yes; we are. I think one must recognize, as I know you do, that Apollo itself is a space platform in a sense. It can carry three astronauts for 2 weeks. We can probably extend that period.

Space platforms are being studied by the Manned Spacecraft Center at Houston. These studies include considerations incident to changing personnel and the resupply of food and necessities, using the Gemini vehicle. In addition, the Air Force has done studies on launching a space vehicle with Titan III.

Mr. GURNEY. Do you have any idea when NASA intends to do that?

Mr. HOLMES. We have informal unapproved programs. We have authorized study programs now which will continue in fiscal year 1964. Then we will make recommendations. I have almost day-to-day discussions with my superiors as to when we should go ahead with space stations.

The NASA/DOD agreement which Mr. Webb and Mr. McNamara signed, provided that neither party would proceed in an uncoordinated effort.

Specifically, however, we have no approved date as to when we will have operational space stations.

Mr. GURNEY. This is a material goal on which you are constantly working?

Mr. HOLMES. Yes, it is.

Mr. DADDARIO. Are there any other questions?

We have had important testimony here this morning.

Mr. FULTON of Pennsylvania. NASA was not able to track the Soviet satellite until it was out of its parking orbit and on the way to the Moon, is that correct?

Mr. HOLMES. From our Mercury tracking that is probably correct.

Mr. FULTON of Pennsylvania. There is no tracking being done by the Mercury stations on this particular shot?

Mr. HOLMES. I think that is correct. The Mercury network is not tracking this Russian shot.

Mr. FULTON of Pennsylvania. Should NASA expand the Mercury network to have the capability to track these Russian satellites?

Mr. HOLMES. I don't think so. I think we have capabilities for tracking these satellites which are probably sufficient.

Mr. FULTON of Pennsylvania. Does this shot by the Soviets, Moon IV, raise in your mind any question as to their method of approaching their man flight to the Moon? Does this indicate that the Russians are using the Earth orbital rendezvous approach with the gathering together in earth orbit of various equipment and capsules?

Mr. HOLMES. No, I don't think it does. As far as I know, the Russian shot this morning did not involve rendezvous in Earth orbit. One would expect them to launch the payload from Earth orbit.

Mr. FULTON of Pennsylvania. On this type of flight with a 3,500-pound payload, would we have about the same program? That is, put the capsule in parking orbit and launch toward the Moon from the parking orbit.

Mr. HOLMES. It is very likely that we would, yes.

Mr. FULTON of Pennsylvania. Do we have that capability now?

Mr. HOLMES. We have that capability right now.

Mr. FULTON of Pennsylvania. We can launch 3,500 pounds with the Atlas so the feat would be no problem.

Mr. HOLMES. No. We can send approximately 700 pounds to the Moon with the current capability of the Atlas-Agena.

Mr. FULTON of Pennsylvania. The Russians are still ahead of us in this particular field?

Mr. HOLMES. Do you mean in terms of payload injection to the Moon only?

Mr. FULTON of Pennsylvania. Should we restudy the decision as to direct ascent, Earth orbit rendezvous, or lunar orbit rendezvous approach before NASA goes ahead and builds the large Saturn rockets and some of the largest buildings in the world to house them?

Mr. HOLMES. No, sir. In my opinion I see no reason to reopen the mode decision. We devoted over 1 million man-hours to comparisons of the potential techniques for manned lunar landing. It would be very inefficient to conduct more studies unless there was evidence to indicate that we were wrong in our decision.

Mr. FULTON of Pennsylvania. You would see no saving in our U.S. space program at the present time if we turned to the Earth orbit rendezvous approach which the Russians may be using?

Mr. HOLMES. Quite the contrary. I would see a need for considerably more funds to be expended to maintain the same schedule and to adapt to the requirements of Earth rendezvous.

Mr. FULTON of Pennsylvania. You made a request for more money in fiscal year 1964, and it was actually cut by the Bureau of the Budget. When you say this is the optimum speed possible for the U.S. space program, you, of course, qualify it by saying that this is the optimum speed possible under the budgetary restrictions that have been imposed.

Mr. HOLMES. I was restricting myself to the manned space program. Our manned program request was not reduced by the Bureau of the Budget.

Mr. FULTON of Pennsylvania. You are getting the exact amount you have requested, and these are the same figures that were submitted to this committee?

Mr. HOLMES. Yes, that is correct.

Mr. FULTON of Pennsylvania. That is all.

Mr. TEAGUE (presiding). We will proceed, then, with the business scheduled for this morning.

Mr. HOLMES. Yes, Mr. Chairman.

As you will recall, at my last appearance as a witness before this subcommittee there was some difficulty in reconciling the figures which we had included in our fiscal 1963 budget book for research and development and the figures which we have included under the fiscal year 1963 column in our fiscal year 1964 budget book.

The difficulty in reconciliation was due to the fact that in fiscal year 1963 we had included both institutional support and personnel service expenses as a part of the total for each program.

In the fiscal year 1964 budget book we have broken those expenses out separately from the totals of each program element. I would like to read, Mr. Chairman, a prepared statement which, I think, gives a succinct explanation of these divisions.

As was mentioned during our last appearance before this subcommittee last week, NASA's budget presentation was changed in

format between the fiscal year 1963 "blue book" and the fiscal year 1964 "yellow book."

This morning we would like to present a comparison between the funds requested in the fiscal year 1963 hearings with our actual fiscal year 1963 operating plan, as presented in connection with the fiscal year 1964 budgetary request. For this purpose, we have prepared the attached tables.

(The tables referred to are as follows:)

OFFICE OF MANNED SPACE FLIGHT

TABLE I.—*Comparison of fiscal year 1963 budget with fiscal year 1963 column of fiscal year 1964 budget*

[Dollars in thousands]

	A—Fiscal year 1963 budget book			B—Fiscal year 1963 column of fiscal year 1964 budget book			Changes to fiscal year 1963 research and development
	Total	Institutional and personnel	Research and development	Total	Institutional and personnel	Research and development	(Difference, cols. 3 and 6)
	(1)	(2)	(3)	(4)	(5)	(6)	
Total, Office of Manned Space Flight	$1,849,092	$211,539	$1,637,553	$1,737,020	$192,442	$1,544,578	−$122,975
Manned spacecraft systems:							
Spacecraft supporting technology	11,764	2,464	9,300	12,223	4,123	8,100	−1,200
Mercury	13,259	9,759	3,500	3,785	443	3,342	−158
1-day mission	12,180	8,880	3,300	30,929	12,972	17,957	+14,657
Gemini	203,200	13,000	190,200	246,447	13,609	232,838	+42,638
Apollo	617,164	37,031	580,133	462,812	27,028	435,784	−144,349
Mission Control Center	0	0	0	10,500	0	10,500	+10,500
Subtotal	857,567	71,134	786,433	766,696	58,175	708,521	−77,912
Launch vehicle and propulsion systems:							
Launch vehicle supporting technology	31,690	11,630	20,060	18,513	1,763	8,800	−11,260
Propulsion supporting technology	21,682	3,242	18,440			7,950	−10,490
Launch operations supporting technology	3,223	46	3,177	3,501	501	3,000	−177
Saturn I	225,837	78,337	147,500	257,946	67,236	190,710	+43,210
Saturn IB	0	0	0	22,758	4,008	18,750	+18,750
Saturn V	335,172	20,729	314,443	368,365	39,765	328,600	+14,157
M–1 engine	55,316	5,316	50,000	36,229	1,229	35,000	−15,000
H–1 engine	5,176	676	4,500	5,838	578	5,260	+760
RL–10 engine	18,224	224	18,000	33,574	929	32,645	+14,645
F–1 engine	55,316	5,316	50,000	52,080	1,280	50,800	+800
J–2 engine	38,732	3,732	35,000	45,748	1,206	44,542	+9,542
Range support	18,263	1,263	17,000	8,257	257	8,000	−9,000
Nova	163,574	8,574	155,000	0	0	0	−155,000
Subtotal	972,205	139,085	833,120	852,809	118,752	734,057	−99,063
Space medicine	19,320	1,320	18,000	10,811	3,811	7,000	−11,000
Integration and checkout	0	0	0	41,834	3,334	38,500	+38,500
Systems engineering	0	0	0	34,870	8,370	26,500	+26,500

TABLE II.—*Conversion, fiscal year 1963 budget and project listing used in fiscal year 1964 budget estimates*

Page A2-1 fiscal year 1963 budget book					Section A from table 1			
Project	Total	Institutional	Personnel	Research and development	Project	Total	Institutional and personnel	Research and development
Mercury	$13,259,000	$4,880,170	$4,878,830	$3,500,000	Mercury	$13,259,000	$9,759,000	$3,500,000
		$9,759,000						
Advanced manned space flight	863,628,000	27,442,823	35,252,177	800,933,000		(863,628,000)	(62,695,000)	(800,933,000)
		62,695,000			Spacecraft supporting technology	11,764,000	2,464,000	9,300,000
					1-day mission	12,180,000	8,880,000	3,300,000
					Gemini	203,200,000	13,000,000	190,200,000
					Apollo	617,164,000	37,031,000	580,133,000
					Mission Control Center	0	0	0
					Space medicine	19,320,000	1,320,000	18,000,000
Saturn C-1	249,237,000	33,001,367	46,235,633	170,000,000		(249,237,000)	(79,237,000)	(170,000,000)
		79,237,000			Saturn I	225,837,000	78,337,000	147,500,000
					H-1 engine	5,176,000	676,000	4,500,000
					RL-10 engine	18,224,000	224,000	18,000,000
Advanced Saturn	335,172,000	10,694,076	10,034,924	314,443,000	Saturn V	335,172,000	20,729,000	314,443,000
		20,729,000						
Nova	163,574,000	5,763,536	2,810,464	155,000,000	Nova	163,574,000	8,574,000	155,000,000
		8,574,000						
Launch vehicle technology	31,690,000	4,728,341	6,901,659	20,060,000	Launch vehicle supporting technology.	31,690,000	11,630,000	20,060,000
		11,630,000						
Launch operation development	21,486,000	637,994	671,006	20,177,000		(21,486,000)	(1,309,000)	(20,177,000)
		1,309,000			Launch operations supporting technology.	3,223,000	46,000	3,177,000
					Range support	18,263,000	1,263,000	17,000,000
Liquid propulsion	163,102,000	6,271,339	9,409,661	147,421,000		(163,102,000)	(15,681,000)	(147,421,000)
		15,681,000			M-1 engine	55,316,000	5,316,000	50,000,000
					F-1 engine	55,316,000	5,316,000	50,000,000
					J-2 engine	38,732,000	3,732,000	35,000,000
					Propulsion supporting technology (liquid).	13,738,000	1,317,000	12,421,000
Solid propulsion	7,944,000	990,846	934,154	6,019,000	Propulsion supporting technology (solid).	7,944,000	1,925,000	6,019,000
		1,925,000						

In table I we have listed both the funds requested in fiscal year 1963, and the fiscal year 1963 columns of the fiscal year 1964 budget book. Note that we have presented three columns for each of these estimates.

One of these columns labeled "I. & P.," includes all funding for "Institutional support and personnel services." Institutional support relates to the operation of our physical plant; personnel services encompasses all costs supporting the salaries and expenses of NASA personnel.

The second column is headed "R. & D." This category includes all funds directly related to our programs, and consists primarily of the effort of our contractors.

The third column headed "Total," is the sum of the I. & P. and R. & D. columns.

During the fiscal year 1963 hearings we presented all three numbers (R. & D., I. & P., and Total) only in an overall, summary fashion, but presented only the "Total" column in detail.

This method of presentation, we found, was less desirable because the "I. & P." column is not too meaningful when considered in terms of individual line items. The nature of our programs makes it impossible to assign operating expenses to each project in a coherent fashion; hence, these operating expenses are prorated to each line for accounting purposes only, but have no significance unless they are considered in terms of total operating expenses for all of NASA.

For this reason, we have returned, for the fiscal year 1964 budget presentation, to a detailed listing of the R. & D. funding. In our fiscal year 1964 authorization requests we plan to justify these R. & D. funds in detail, but will discuss the I. & P. funding only in terms of the totals required for the program.

We should also note that the combination and titles of projects presented in our fiscal year 1964 budgetary estimates differ from those presented in fiscal year 1963. These differences stem from a desire to present a more complete picture of the program, as it has evolved during the past year, than we were able to do in the justification of the fiscal year 1963 budget.

In table II we have made a comparison of this year's breakdown with last year's breakdown.

From this table we can see that the split between I. & P. and R. & D. funding, as presented in table I, is identical to the information presented on page a–2–1 of the fiscal year 1963 NASA budget estimate "blue book".

The last column in table I represents the reprograming actions, in terms of the R. & D. budget, that have taken place since last year's authorization.

At the time we submitted the fiscal year 1963 budgetary estimates, many of our contractors had not yet been selected. Also, at that time, alternative mission modes were still under consideration. By the summer of 1963, most of the remaining contractors were on board, and a firm decision had been made to use the lunar orbit rendezvous mode for the Apollo project. Soon thereafter, an overall restructuring of the program schedule became necessary, in order to balance the time of availability of all elements of the program within the available funding.

All of these factors combined to require extensive reprograming actions, in order to assure the earliest possible achievement of a manned lunar landing within the total resources available for this program.

I can either answer questions, Mr. Chairman, relative to the tables or I can go further into detail to correlate the figures in the tables with our budget books and then discuss the reprograming actions which have taken place. It is my understanding that you wish to review them.

Mr. TEAGUE. Yes; would you proceed? We might have some questions as you go along.

Mr. HOLMES. If we examine table I and look at the third column heading A, we will see the figures for research and development which were included in our "Blue Book"—our fiscal year 1963 budget book.

If we look at column 6 under heading B, we will see the research and development figures included in the fiscal year 1963 column of the fiscal year 1964 budget book.

If we look at the last column there is a difference between the two R. & D. columns. The difference represents the reprograming from our fiscal year 1963 request. We therefore see that there is a reduction of $122,975,000 from our fiscal year 1963 request. This sum is made up of the various figures in the last column of table I.

Before justifying these changes between our actual operating plan or expenditure plan for 1963 versus that requested, I think that referring to table II will support our contention that the split between institutional operational expenses and R. & D. are accurate.

If we look at the total figure, which is the first column of figures on table II, we will find that it agrees exactly with the total shown in the fiscal year 1963 budget book. I can refer to the fiscal year 1963 budget book, since the committee may not have it available here.

As an example Mercury is $13,259,000. Mr. Chairman, I am referring to the "Blue Book" the fiscal year 1963 budget book.

Mr. TEAGUE. We don't have that.

Mr. HOLMES. If we look at that first total column, we find that it agrees exactly with the fiscal year 1963 budget book, both in total and in the split between institutional and personnel expenses and R. & D. What I am aiming at is bringing it back to the R. & D. figures alone so that we have a basis of comparison with the 1964 budget book.

The R. & D. column in totals, and broken down in a different fashion in the 1964 fiscal book, is shown in the fourth column on table II. We see $3.5 million for Mercury. Now we have arrived at the R. & D. figures in the fiscal year 1963 budget book minus the institutional and personnel figures.

The first thing to do for comparison is to reorient those R. & D. figures from the project titles shown in fiscal year 1963 to the much more precise project titles shown in the fiscal year 1964 budget book.

If we go across for Mercury, we show R. & D. of $3½ million.

If we follow down the table, we will see that this figure checks out. Therefore, we can look at the right-hand side or section A of table II and compare the figures directly with the R. & D. figures which appeared in the fiscal 1963 budget. In addition, we can compare the titles with what we are including in the fiscal year 1963 column of our fiscal year 1964 budget book.

Mr. TEAGUE. Mr. Yeager?

Mr. YEAGER. Could you go down in table I in the final column which shows the main changes that have been made in R. & D. in

your reallocation for the 1963 money and indicate what happened, or why these changes were necessary?

Mr. HOLMES. Yes, we certainly can. Up to this point I have been justifying the fact that the last column in table I is indeed an accurate comparison between what we requested for the fiscal year 1963 authorization and what we show in the fiscal year 1964 budget book as our fiscal 1963 operating plan. If that is acceptable, I can go down this column and talk to these figures.

Mr. TEAGUE. You may proceed.

Mr. HOLMES. One will note a decrease in spacecraft supporting technology of $1.2 million. The decrease is somewhat academic. This decrease resulted from the transfer of certain tasks, which did not relate to current flight projects, to NASA's Office of Advanced Research and Technology.

The next item is Mercury where our present operating plan in that fiscal year 1963 book shows almost exactly the same figure requested. The difference is only $158,000.

The next item is One-Day Mission. Here we had increased requirements over and above——

Mr. FULTON of Pennsylvania. Could I stop you? I believe you mean $158,000?

Mr. HOLMES. We requested $3½ million for Mercury. We are spending $3.34 million. The only deviation is $158,000. In the last column we see $158; if we multiply that by 1,000, we have $158,000.

The next item is the One-Day Mission. Our estimate was not very precise, as you can see. We requested $3.3 million. We have in our fiscal year 1963 operating plan $17.957 million. There are several reasons for this increase. First, our cost estimates for production of modified Mercury spacecraft for the One-Day Mission and its backups were too low. The increase was in the order of $2 million. Secondly, our estimate for recovery operations was far too low. That requirement increased by approximately $2 million. Our flight operations increased by $800,000.

The total remaining increment of about $9 million was in the launch vehicle area. Two elements contributed to this increase, One was an increased Atlas booster cost of about $3½ million and the other was partial deferment of Atlas requirements for some $5½ million.

Those totals add up to this $14 million.

Mr. FULTON of Pennsylvania. What was the Atlas booster amount?

Mr. HOLMES. We use the Atlas D booster. The Air Force changed their weapon booster in quite considerable detail. That with the reevaluation gave us a larger bill than we anticipated.

Mr. DADDARIO. Was the reevaluation a result of the change in the booster or a change in General Dynamics' estimate?

Mr. HOLMES. It was a change in the General Dynamics' estimate. It was coincident with a lower production rate for the Atlas D, which would normally raise their cost. All in all my statement on the One-Day Mission estimates in the fiscal year 1963 budget book were not very good.

Mr. DADDARIO. Are these General Dynamics estimates?

Mr. HOLMES. General Dynamics increase was $3.6 million.

Mr. FULTON of Pennsylvania. How did NASA decide that it was reasonable and correct?

Mr. HOLMES. Our Manned Spacecraft Center people reviewed it very carefully with the Air Force who in turn reviewed it with the

contractor. It is my understanding they had joint meetings in that review.

Mr. FULTON of Pennsylvania. What gross profit did that give to General Dynamics?

Mr. HOLMES. I don't have it.

Mr. TEAGUE. Will you supply that for the record, please?

Mr. HOLMES. I will attempt to. We will try to, Mr. Chairman.

Mr. FULTON of Pennsylvania. Did General Dynamics get in touch with you about revising your previous contract after the fact occurred, or was it done ahead of time?

Mr. HOLMES. I believe it was done ahead of the time. I will check that for the record.

(The information requested is as follows:)

The $3.6 million increase in the Atlas booster cost was a billing from the Air Force Space Systems Division (AFSSD). It covered additional negotiated costs per Atlas launch vehicle from several contractors, including General Dynamics Astronautics (GD/A), North American Aviation/Rocketdyne Division, General Electric, and Aerospace. Of the $3.6 million increase, approximately $1 million is for launch services due to program stretchout and $2.6 million is for added booster cost. The General Dynamics Astronautics share is approximately $1.9 million. The exact fee on this amount cannot be determined until the end of the contract because General Dynamics Astronautics has several incentive-type contracts. If the average GD/A fee of 7 percent is applied, the gross profit on $1.9 million would be approximately $133,000.

Any change to the Mercury program space system development plan, which represents our contract with the Air Force, is brought about by management direction from the Air Force based on rescheduling, contract reviews, changes in scope, negotiation, and amendments to contracts. No direct contact between NASA and GD/A is made on contractual matters.

Mr. HOLMES. In the Gemini program, we reprogramed to increase the estimate by $42.6 million. This increase is identified primarily with an increase of $49.9 million in spacecraft. The fiscal 1963 congressional budget request was made at the suggestion of the contractor. The increase reflects McDonnell's 6 months of actual experience in 1963. In this area the contractor had been optimistic about what he could build a spacecraft for, only having very preliminary information about its design.

It appears the contractor's optimism was not warranted, at least in terms of the dollars involved. In addition to the spacecraft adjustment, the requirement for Gemini launch vehicles increased. In other words, in order to have this booster available in time, the Titan II production schedule was stepped up.

Mr. DADDARIO. You have said that McDonnell Aircraft Corp. underestimated their cost in providing the Gemini capsule. It is our understanding they were given this contract without any compeitition whatsoever because of the great experience that they had developed in the Mercury program. How do you reconcile that with the fact that they underestimated the cost to such a considerable degree?

Mr. WAGGONNER. It would appear that there was no basis for the award.

Mr. HOLMES. I think that the answer lies within the basic philosophy of the Gemini program. In order to get data as soon as possible, there was only one company which could give us the fastest possible application of experience—both in developing spacecraft and in working with NASA in that capacity. That was McDonnell Aircraft Corp., which, of course, developed and produced the Mercury spacecraft for NASA.

Mr. DADDARIO. You don't mean by that, regardless of cost?

Mr. HOLMES. No.

Mr. DADDARIO. It would seem that there is that element included.

Mr. HOLMES. I don't think so. Because, indeed, although it is a fact that McDonnell's underestimated this, we are talking about an underestimate here in total which includes the Titan II cost of 22 percent. Let me see if I have a breakdown. It is somewhat larger than 22 percent. Still, it was an undefined program. There is no doubt in my mind if we had gone to CCPF award that their estimates would have gone up more than McDonnell because they would have known less about it. The history of such bids is very poor.

Mr. DADDARIO. I would agree with that reasoning, if it did go to another contractor. I still can't reconcile in my own mind that it should justify an increase to a contractor who was chosen because of special qualification based on longtime experience.

Mr. HOLMES. We have, as you know, in cost-plus-fixed-fee contracting; we have no recourse except to pay his cost or terminating him. We don't think the way the program has developed that they were negligent in giving us what we believe was their best estimate of the cost.

Mr. GURNEY. Where did the cost get out of line?

Mr. LOW. In the McDonnell contract, for the spacecraft, the cost for those portions of the spacecraft produced directly by McDonnell have not changed significantly since we presented our 1963 budget requests. However, within the Gemini spacecraft there are a number of subsystems that were not used in Mercury.

For example, we are going to use in Gemini a fairly new guidance and navigation system. Such a system did not exist in Mercury. Most of the underestimates that Mr. Holmes has addressed himself to is in the area of the subcontracts to McDonnell and not to McDonnell's in-house efforts.

Mr. GURNEY. Did McDonnell get bids or estimates from their subcontractors?

Mr. LOW. McDonnell has bids from their subcontractors today. They did not have them at the time the 1963 budget was submitted. They had estimates from their own people.

Mr. WAGGONNER. You say now, that as a result of some of these new component systems, such as guidance, that we have changed the design and requirements of the Gemini capsule since the original contract?

Mr. HOLMES. No, I wouldn't say that.

Mr. LOW. What I inferred was that those systems in the Gemini spacecraft, which are different from the Mercury system were most difficult to estimate a year ago. These systems were planned for Gemini last year. Those estimates were new and were not as good as the systems previously used for Mercury.

Mr. WAGGONNER. Who is supplying this new guidance system?

Mr. LOW. The guidance computer is provided by IBM, the platform by Minneapolis-Honeywell.

Mr. WAGGONNER. Does IBM have the guidance system contract with Grumman for the Apollo program?

Mr. LOW. No, sir. The guidance system for the Apollo program is being developed by the MIT with industrial support contracts. The guidance techniques are similar but because of the different

mission requirement for Gemini and Apollo, it is impossible to use identical guidance equipments.

Mr. WAGGONNER. You are saying then that these estimates, subcontractor estimates which McDonnell themselves do not provide, the error is there and not in the capsule itself?

Mr. LOW. The majority of the difference is in subcontractor cost and not in McDonnell's direct cost.

Mr. HOLMES. We have to be a bit careful. The responsible party is McDonnell. It is not the subcontractor's responsibility. It is McDonnell's responsibility to the Government to both give us the right cost from the subcontractors and to review them and control them. And, indeed, we have, as far as information from these subcontractors of their preliminary estimates on the information transmitted to us from McDonnell. I don't want to in any way infer that it is not the primary responsibility of McDonnell.

Mr. WAGGONNER. Does McDonnell have a certain amount of leeway in selecting its subcontractors?

Mr. HOLMES. Yes, it does.

Mr. FULTON of Pennsylvania. How did you make up your original estimates when you computed what this capsule would cost? Somebody has made an error. Either McDonnell made an error when it asked the subcontractors for the prices, after having bid, or else NASA made them when the preliminary estimates were submitted to the Congress on the budget. There were errors made. The question is not whether they are blameworthy errors, but how did the errors occur?

Mr. HOLMES. I think the errors were twofold. The primary responsibility was NASA's, in underestimating Gemini's cost requirements for fiscal 1963. The secondary error, in terms of responsibility, was McDonnell's, since we depend upon them, not totally but to some extent, for these estimates. We were, of course, just initiating the Gemini program at the time. You can't actually estimate. I regret it is always up instead of down.

Mr. FULTON of Pennsylvania. That has been the case on the Mercury program. The preliminary estimates were much lower than the final cost. Now that you have given us the final estimate on the Mercury program for 1964, that brings up the question of how firm the figures were on which you have based your budget requests.

During the authorization hearings, you say you need all the money requested, and you give us a certain estimate. Later we find that there were large amounts of reprograming and the final figures are admittedly different. Is it necessary for us to have the basic or prime contractor show us his subcontractor's estimates before we go ahead and talk about a NASA contract? On this particular setup, obviously the original contract figures mean little. If this practice is established, it would mean that the contractor simply bids any old figure and can come later and get a contract revision.

I think we should know what was originally estimated by NASA for these subcontracts, and then what the actual fact was.

Mr. HOLMES. I agree with that, Mr. Fulton.

Mr. FULTON of Pennsylvania. Then the question would be on the requested change of the contract figure by the prime contractor, how much was requested by McDonnell when they came in and needed a change, and likewise, how much of this is needed by the subcontractors, and how much was allowed.

Mr. DADDARIO (presiding). Could you supply that for the record?

Mr. HOLMES. I will supply what part of it I can. It appears to me that when we have a program of this size initiated the way it was in fiscal 1963 and have a total reprograming and 10 and 12 percent that is pretty good performance. It is my opinion that the details of that, as long as that total is reasonably good, should be delegated to the people who are managing the program.

Mr. DADDARIO. These are statements we want to get from you. I do think they are reasonable questions which quickly come to mind when any contractor is in the enviable position of being chosen above all his competitors by reason of his having a built-in competence which has been brought about by Government expense in the first instance.

I think it has to be justified when there is a change, even though it might be a reasonable one.

Mr. HOLMES. Yes, sir. We will be glad to furnish any definitive information that we can.

(The information requested is as follows:)

The estimated program costs for the major subsystems in the Gemini spacecraft are about $49.9 million over the original estimates made at the time of project approval in December 1961. These original estimates made in December 1961 by NASA and McDonnell were based on minimum changes from Mercury technology and served as the basis for the fiscal year 1963 budget submission. As detailed specifications for subsystems performance were developed to accomplish the Gemini mission objectives, realistic cost estimates, not previously available, were obtained from subcontractors. The first of these subcontractor cost estimates were obtained by McDonnell in April 1962 and revealed significantly higher estimates than were originally used. For example:

(*a*) In data transmission, it became necessary to change from a Mercury-type system to a pulse code modulation (PCM) system because of increased data transmission requirements, and the need to reduce weight and electrical power. The Gemini data transmission system will be directly applicable to Apollo.

(*b*) Other subsystems have a similar history. The rendezvous radar was originally planned to be similar to ones used by the Bomarc missile, but it was found necessary to design an interferometer type radar for low weight, small volume, and to provide the highest reliability possible.

(*c*) The environmental control system was originally planned as two Mercury-type systems, but as the detail specifications became definitive it was apparent that the Mercury ECS was inadequate and, although extensive use of Mercury design techniques were utilized, major modifications were required

Mr. DADDARIO. Mr. Riehlman?

Mr. RIEHLMAN. I think that just about answers my question. Certainly you have some working sheets or some information as to the need for these additional transfers to McDonnell in your files, Mr. Holmes.

Mr. HOLMES. We do have information. However, the supporting figures preceded the award to McDonnell. The figures are our own internal budgetary estimates, based on informal discussions with McDonnell. I can't go back that far and submit a record. We will be glad to give any definitive explanation we have.

Mr. FULTON of Pennsylvania. I should think you would have your original budget estimates.

Mr. RIEHLMAN. As I understand it, the $190 million originally requested was NASA's estimate and apparently not that of McDonnell. Am I correct?

Mr. LOW. That was not based on a formal estimate by McDonnell. It was based on informal duscussions with McDonnell. This is a Government figure.

Mr. RIEHLMAN. At what point did McDonnell come in and say to you "this isn't a sufficient amount to carry out this contract. We have to have X million more." When did that happen?

Mr. LOW. May I give some of the history of this contract?

The Gemini contract was approved within NASA in December 1961. Our estimated costs at that time were based on informal discussions with McDonnell. Between January and April of 1962 the contractor and NASA together worked on a formal set of specifications for the Gemini program and it wasn't until April 1962 that we received a formal cost proposal from our contractor, McDonnell.

Mr. RIEHLMAN. Was it at that time that you arrived at the decision that they would have to have $42 million more?

Mr. LOW. No, sir, because this was the basis for our initial negotiations with McDonnell. Later on, our technical people used this for the final contract with McDonnell.

Mr. RIEHLMAN. When was that consummated?

Mr. LOW. This week.

Mr. HOLMES. I suppose a couple of months for the cost basis——

Mr. RIEHLMAN. When was the decision to transfer funds made?

Mr. LOW. I would have to get the exact date for the record. It was probably in November of last year.

(The information requested is as follows:)

The increase of $42.6 million in the Project Gemini estimate was the net result of an increase of $49.9 million in the McDonnell spacecraft contract and changes in several other elements of the project. The increased McDonnell estimate was approved in the financial operating plan for Manned Spacecraft Center in November 1962.

Mr. RIEHLMAN. You made the decision in NASA to transfer this before you had a firm contract with McDonnell?

Mr. LOW. Yes, sir. Our negotiations had progressed to the point where we knew what the final estimate was going to be. We were very close. This was a reprograming within NASA.

Mr. HOLMES. We tried in this fiscal 1963 column in the fiscal 1964 budget book—the "Yellow Book"—to give you our best guess. This is done 6 months before the end of the fiscal year. We must look out or we will give you a completely unreasonable figure.

Mr. WAGGONNER. Mr. Holmes, has the recent agreement with DOD with regard to the Gemini program added to this increase?

Mr. HOLMES. No, sir.

Mr. GURNEY. In last year's figures what did you use, the budget figures for fiscal year 1963?

Mr. LOW. We used our informal discussions with McDonnell and the best estimates we could use in NASA.

Mr. GURNEY. We are talking about December.

Mr. LOW. We are talking about November and December of 1961.

Mr. GURNEY. In April 1962, did you find then there was going to be a considerable difference between your preliminary estimates and the figures in April?

Mr. LOW. We had the first indications at that time. These were the preliminary figures. This was the first cost proposal submitted by McDonnell. It had not yet been analyzed in April by our own people.

Mr. GURNEY. It was obvious then that the preliminary figures were not correct? Was this brought to the attention of the committee?

Mr. HOLMES. It was obvious they were not correct, and I think it was not brought to the attention of the committee.

Mr. CASEY. Mr. Holmes, on this total of $232.8 million, you break that down in the yellow book as to individual items. That includes launch vehicles and flights, covering crew and everything, doesn't it?

Mr. HOLMES. That is the total; yes, sir.

Mr. CASEY. What part does McDonnell have of that total?

Mr. LOW. It is the line item for spacecraft, I believe, that is $153,900,000. Most of that is for the McDonnell contract. It includes also the amount for the paraglider development.

Mr. CASEY. Where is paraglider included? Is that under the "other" column?

Mr. LOW. No, sir. It is included in the spacecraft line item.

Mr. CASEY. What does the "other" column include?

Mr. LOW. The "other" column includes minor subcontractors and spare parts.

Mr. CASEY. Where is your McDonnell figure? Is McDonnell participating in those three line items, adapter and so forth?

Mr. LOW. Yes sir. I am sorry, I was looking in volume I and not volume V.

Mr. CASEY. Volume V, page 5, you have a total broken down.

Mr. HOLMES. I have volume II. Our justification is in volume II.

Mr. CASEY. Look at page 5 of that book, under the Gemini spacecraft.

Mr. HOLMES. Yes.

Mr. CASEY. You have the line items there giving the total spacecraft cost for fiscal year 1963 of $153.9 million, right?

Mr. HOLMES. Right.

Mr. CASEY. Of those line items, how much of this is McDonnell contract? In other words, what do they participate in? Do they participate in the reentry module?

Mr. LOW. Yes, sir, and the adapter module and some of the items included in "other."

Mr. CASEY. This $42.6 million that was increased, is that in these three items?

Mr. LOW. Yes, sir.

Mr. CASEY. What was the total contract with McDonnell?

Mr. LOW. The total contract with McDonnell is for $456 million.

Mr. CASEY. That was started during fiscal 1963, is that correct?

Mr. LOW. It was started in fiscal 1962.

Mr. GURNEY. You finalized it just last fall.

Mr. HOLMES. We started McDonnell working in December of 1961.

Mr. CASEY. Do you anticipate any increases in the future on this?

Mr. HOLMES. I would like to be able to say that it is going to stop.

Mr. CASEY. It is only 10 percent so far.

Mr. HOLMES. The Gemini spacecraft estimate increased about 20 percent, for the reasons that I mentioned before.

Mr. CASEY. The contract was for $456 million. You have also added $42.6 million. They have missed at almost 10 percent, is that right?

Mr. HOLMES. The $42 million, which is an approximate figure, is included in this $456 million contract. The present contract that

we are signing with McDonnell covers the cost involved for the total Gemini effort.

Mr. CASEY. This contract was made before you signed the contract?

Mr. HOLMES. Yes, sir.

Mr. GURNEY. Do you have anything in the fiscal year 1964 budget comparable to the McDonnell situation, where you have figures that are based on informal conversations or informal estimates with contractors?

Mr. HOLMES. Yes, sir, I think we do.

Mr. GURNEY. Are they substantial? Can you give us the approximate amounts that are involved, either in dollars or in a percentage?

Mr. HOLMES. Where there was a competitive bid and proposal, we have the figures that were proposed by the contractor. Where it is negotiated, it is very hard to provide firm figures, since they can be classed as working papers.

Mr. GURNEY. Could we have the figures in the record which are comparable to the McDonnell situation, figures based on informal conversations with the contractor before a formal contract is arrived at?

Mr. DADDARIO. I would suggest that we take those up as we go along. We will get that testimony as we go through the budget request.

Mr. GURNEY. That is agreeable provided that we don't lose sight of it.

Mr. DADDARIO. Mr. Yeager has something to enter in the record.

Mr. YEAGER. I would like permission to incorporate at the proper point in the record the two tables that were supplied today.

Mr. DADDARIO. The tables will be so entered.

This committee is adjourned until Thursday morning at 10 o'clock.

(Whereupon, at 12:15 p.m., the subcommittee adjourned, to reconvene at 10 a.m., Thursday, April 4, 1963.)

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1964 NASA AUTHORIZATION

THURSDAY, APRIL 4, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON MANNED SPACE FLIGHT,
Washington, D.C.

The subcommittee met, pursuant to adjournment, in room 356, Cannon Building, at 10 a.m., Hon. Emilio Q. Daddario presiding.

Mr. DADDARIO. The committee will come to order.

Mr. Holmes, before we proceed, I noticed in the morning paper that a new Advisory Board has been established for the Manned Spacecraft Center. The Chairman is Mr. Kelly of Bell Telephone Co. This is the first I recall hearing of this; I wonder if you might give the committee an explanation.

STATEMENT OF D. BRAINERD HOLMES, DEPUTY ASSOCIATE ADMINISTRATOR AND DIRECTOR, OFFICE OF MANNED SPACE FLIGHT, NASA, ACCOMPANIED BY WILIAM E. LILLY, DIRECTOR, PROGRAM REVIEW AND RESOURCES MANAGEMENT, AND GEORGE M. LOW, DEPUTY DIRECTOR (PROGRAMS)

Mr. HOLMES. I will be glad to. For the last approximately 16 months Dr. Kelly, who is, as you know, retired chairman of the board of Bell Telephone Laboratories and now consults with many companies, has been giving his time to NASA as consultant to Mr. Webb. Dr. Kelly spends at least a day a month with me. He serves in an advisory capacity, using his great background and experience in systems engineering and development programs.

Another individual whom I consider outstanding and a skilled person is Dr. Hector Skifter. He has also been working with me personally as a consultant over this period of time. I have known Dr. Skifter for many years. He is chairman of the board of the Airborne Instruments Laboratory and has for many years unselfishly given his time to serve the Government. He had served on many committees. For instance, he worked with Dr. York as one of the key people to analyze electronics circuits for the defense of the country, including major weapons systems such as Zeus. Dr. Skifter has also headed numerous committees. He served as the first president and chairman of the board of the Research Analysis Corp., an R. & D. organization formed by the Army.

I thought it would be very helpful if these two individuals, in addition to two or three other people of comparable experience, could look at our entire manned space flight program and give us the benefit of their thinking. I did not anticipate these men would judge

detailed designs. However, I was convinced that their space program experience and their findings would enable them to contribute valuable advice on manned space flight organization and management, and even the overall systems approach.

Mr. Webb agreed and felt that it would be useful for this advisory group to cover an even broader area, including procurement practices and other activities. Mr. Webb officially appointed the Manned Space Flight Management Advisory Committee. In addition to Dr. Kelly and Dr. Skifter, the members are: Gen. James McCormack, retired from the Air Force, who was formerly the head of research and development for the Air Force and is now vice president of the Massachusetts Institute of Technology; Dr. Hendrick W. Bode, a member of the board of Bellcomm and a world-renowned mathematician, whose work on feedback theory and analysis in electronics amplification is perhaps the most important book written on that subject; and Dr. Arthur E. Raymond, a retired senior vice president of Douglas Aircraft, who has for some time been a consultant to Mr. Webb on overall NASA organization and has been kind enough to give me some of his time. The five-member Committee represents a number of industrial groups and offers an intimate knowledge of NASA and its functions.

Mr. DADDARIO. It is, then, as I understand from you, a permanent committee?

Mr. HOLMES. It was set up to dissolve unless extended, at the end of fiscal year 1964. It is my hope and intention to have it function as a permanent advisory committee, which might meet, say, every 6 months or so.

Mr. DADDARIO. Are they paid as consultants or on a salaried level?

Mr. HOLMES. As consultants, though several of them don't accept any payment.

Mr. DADDARIO. How do they fit into the scheme of things, considering the management assistance you will get from Bellcomm and General Electric? There are so many management advisers in the program at the moment that it is somewhat confusing.

Mr. HOLMES. Yes; however, there is only one management advisory group, and this is this group, who advise me personally. Presumably the Manned Space Flight Management Advisory Committee will also discuss the subject with Mr. Webb, Dr. Seamans, and Dr. Dryden. They are acting in strictly a consulting capacity. This week is their first meeting. I personally participated in planning their itinerary and agenda. They met with us all day Monday, then went to the Marshall Space Flight Center on Tuesday, and visited the Manned Spacecraft Center on Wednesday. Today they are at the Launch Operations Center. Tomorrow the Committee will return to summarize their findings and discuss it with us.

Mr. DADDARIO. This Committee then is to be of specific assistance to you?

Mr. HOLMES. Yes, sir.

Mr. DADDARIO. When did the idea occur that you should have a Committee for that purpose?

Mr. HOLMES. I suggested it to Dr. Kelly over a year ago. He felt it was a little early at that point to make a firm decision. Several months ago I indicated to Dr. Kelly again that I thought it would be a valuable approach, and he took the necessary action. He dis-

cussed the idea with Mr. Webb, as I did. The necessary action to select the membership was then taken.

Mr. DADDARIO. Will they confine themselves to consulting with you in this advisory capacity, or will they also be available individually as consultants to other people within the program?

Mr. HOLMES. Three of the five members are consultants to NASA on an individual basis. Dr. Skifter is a consultant to me. Dr. Kelly and Dr. Raymond are consultants to Mr. Webb. They will continue to do that as individuals, but will meet to advise us on the manned space flight program from time to time, as appears appropriate.

The Manned Space Flight Advisory Committee fulfills a function distinct from Bellcomm and GE, which are working, line operations to support our effort. GE and Bellcomm are not personal advisers to me in any sense of the word. The Bellcomm people are highly technical people who provide systems engineering support to Dr. Joseph Shea, my Deputy Director for Systems. Bellcomm carries out task assignments. General Electric works for Mr. Sloan, Director of Integration and checkout, and with the centers in developing an entirely integrated checkout plan. The Manned Space Flight Management Advisory Committee is the only advisory group that I have. Bellcomm and GE are line organizations.

Does that clarify it at all?

Mr. DADDARIO. Somewhat. It clarifies it insofar as the formation of the committee is concerned. It still leaves some question in my mind insofar as General Electric and Bellcomm are concerned. I have discussed this with Mr. Teague, and we will look into it later.

Do you have any further information on the Russian Moon shot that might be of assistance to us?

Mr. HOLMES. No, I do not, except to confirm our earlier information that about 3,100 pounds were injected toward the Moon, and further that our Ranger injection weight is about 700 pounds. I think we had some question about those things.

Mr. DADDARIO. You have no information as to the nature of the experimental equipment on board?

Mr. HOLMES. No, sir. We suspect it is either a lunar orbiter or lunar soft-lander, probably the latter. This hasn't been announced, and I suspect it wouldn't until it works satisfactorily. I even suspect if it crashes on the Moon it will be announced as a hard lander.

Mr. DADDARIO. Which would be your considered opinion on those two observations?

Mr. HOLMES. It would be my opinion that it would be a lunar soft-lander to telemeter data back to Earth as our Surveyor would.

Mr. DADDARIO. Telemeter back what kind of information?

Mr. HOLMES. Probably something about the surface. Our Surveyor, for instance, would be taking small core borings and telemetering back data on lunar surface characteristics. Whether the Soviets have done this I don't know. It would be logical for them to use a soft-lander for such a mission.

Mr. DADDARIO. Since it is larger than our Surveyor, does that give the Russians greater capacity to do more experimentation in this kind of soft landing than we would be capable of doing?

Mr. HOLMES. Yes, assuming equal proficiency in packaging and miniaturization. It would be comparable to our Surveyor, which has an injection weight of approximately 2,100 pounds. Certainly every

pound is very important and, if used with equal efficiencies, their 3,000 pound vehicle could do quite a bit more than a 2,100 pound injection vehicle.

Mr. DADDARIO. Is there any suggestion that the Russians will make some of this information available to us? I believe you have suggested this in your past testimony.

Mr. HOLMES. It is my opinion that the Russians will release information if it serves their purposes, whether for international propaganda or some other end. They have not made any information available to us unless it was useful to them, in my opinion.

Mr. DADDARIO. This has been their performance in the past, in your opinion?

Mr. HOLMES. Yes.

Mr. YEAGER. Do you attach significance to the report in the press that this time the Soviets had not announced any frequencies, so that not even Jodrell Bank was tracking it?

Mr. HOLMES. This morning's Times reported a frequency of 185 megacycles, I believe, but that is my total knowledge of it.

Mr. ROUDEBUSH. Did we get any useful information at all when we landed the Ranger package?

Mr. HOLMES. No, sir. It destroyed itself landing on the back side of the Moon.

Mr. ROUDEBUSH. Prior to the time it impacted on the Moon, we received no information whatever?

Mr. HOLMES. I believe we received no novel information.

Mr. ROUDEBUSH. Why has NASA dropped the Prospector program?

Mr. HOLMES. I think primarily because Prospector, which would have been larger, and crawled around the Moon, and also perhaps would have been a logistics supply vehicle, doesn't really have a place in the scheme of things between a successful Surveyor program and our first manned lunar landing, using a lunar excursion module. Putting a payload on the Moon, as a cache of supplies, would take over at least part of the early thoughts of what Prospector might do.

Mr. ROUDEBUSH. Will Surveyor have any mobility?

Mr. HOLMES. None as such, though there will be moving parts, to take core samples. The first maneuverability by our present thinking would be the astronauts. If we go ahead with a logistic system we plan to send support equipment to let them move around on the surface of the Moon.

Mr. ROUDEBUSH. We might get atypical rather than typical response from the Surveyor, couldn't we?

Mr. HOLMES. You could obtain atypical responses from Surveyor or any unmanned vehicle. We will attempt to correlate our surface measurements with photographic measurements. We hope that this approach will give us the necessary information on the characteristics of the manned lunar landing site.

Mr. ROUDEBUSH. That is all.

Mr. DADDARIO. Is it possible that this was a manned lunar flight?

Mr. HOLMES. No, sir. We don't believe so. As you know, we are going with what we think is the minimum reasonable payload to take three men—90,000 pounds. Even if the crew is reduced to 1 man, the reduction doesn't yield a ratio of 30 to 1. We don't believe the Russians' 3,000-pound payload could possibly take a man to the moon and bring him back.

Mr. DADDARIO. Is it possible they could have experiments using live animals on this?

Mr. HOLMES. It is possible.

Mr. DADDARIO. Would it be likely, in consideration of the value it might be?

Mr. HOLMES. No; we think it is unlikely. We are not planning to send animals. We are trying to obtain other data.

Mr. DADDARIO. Mr. Fulton.

Mr. FULTON of Pennsylvania. There was a comment by Soviet Defense Minister Rodion Malinovsky, on the Russian cosmonauts, in which he said: "Let our foes note what technology and what militancy are in the possession of the Soviet power."

My question is: Does this particular vehicle have any relation to scientific research? Do you see any overtones in this particular shot that might have any relevance to the comment by Malinovsky?

Mr. HOLMES. Replying to you from a vast ignorance of the details of the payload, I would answer "No," with one important qualification. Whenever one puts a payload into Earth orbit and then injects it farther into space one learns more about how to operate in space. Technology and operational skills increase.

Mr. FULTON of Pennsylvania. So in the cislunar area between the Earth and the Moon the Soviets are making substantial progress which can be said to either equal or exceed ours in the scientific fields? Then with our lack of information, we are unable to tell what operations these scientific discoveries might be put to?

Mr. HOLMES. Yes, sir.

Mr. FULTON of Pennsylvania. So we can really make no evaluation, from the information we have, on the peaceful scientific uses, or military uses, of this Russian lunar probe.

Mr. HOLMES. We can only make the general evaluation, to which I alluded, unless we know more about it.

Mr. FULTON of Pennsylvania. I smiled when you said we should credit them with a capability equal to ours with respect to the payload. Shouldn't we credit them with a little better than our capabilities, in order to be sure?

Mr. HOLMES. I guess maybe we should, though I thought I was being generous.

Mr. DADDARIO. Fine. Now to return to the business at hand. We left off on the tables that you had prepared for us, Mr. Holmes. We were discussing the Gemini program, as I recall.

Mr. HOLMES. Yes, sir. With your permission, I have a statement I would like to read, which continues with the other figures.

Mr. DADDARIO. Mr. Yeager?

Mr. YEAGER. Were you going to leave Gemini now?

Mr. HOLMES. Yes. I was going to. I will return to a question on Gemini if you have one.

Mr. YEAGER. All right.

Mr. HOLMES. My general observation is this: Despite the increase of $42.6 million in the cost of Gemini, the total cost of the Apollo program was reduced by $144.3 million. The point is that despite the very early developmental nature of the program and despite the changes which required funds to be reoriented for the program, the total development cost of the Apollo hardware changed only some $33 million out of total request of $1.149 billion, or about 3 percent. We

won't do better than that with any program in the developmental stage. I say this not really supporting NASA, but in a joint way, with the committee. I think as far as hardware development, despite these changes we are applying funds to the development of equipment for that Moon program about the way the committee felt we would do, with the one exception of the Nova funds that we indicated might be put aside since we wouldn't be going with all of these missions at once.

Mr. DADDARIO. Mr. Yeager.

Mr. YEAGER. I have a couple of questions on the Gemini program.

Mr. DADDARIO. Do you wish to proceed further with your prepared statement, or should we let Mr. Yeager ask his questions on the Gemini program?

Mr. HOLMES. I think it would be fine for him to ask his questions now.

Mr. YEAGER. Was the $42.6 million increase in the Gemini program all involved with the McDonnell contract, or was a part of it for something else?

Mr. HOLMES. Actually the McDonnell variation was larger than $45.6 million, which represents the net change. The adjustment on the Gemini spacecraft was approximately $49.9 million. Titan II, which increased because of Air Force dollar requirements to meet an accelerated production schedule, was up about $12.3 million.

However, other factors offset these increases. Operations decreased by about $8 million. Atlas-Agena requirements decreased by about $9.7 million. Supporting development went down by approximately $1.9 million. The net result of these adjustments is the $42.6 million.

Mr. YEAGER. The NASA release on the new Gemini program does not indicate a time limit on the McDonnell contract, but specifies only what services are to be purchased with the money. Is there a time limit on this new Gemini contract with McDonnell?

Mr. HOLMES. Yes, there is a very definite schedule requirement for delivery of spacecraft, both for testing and flight missions.

Mr. YEAGER. I am looking for a terminal date.

Mr. HOLMES. Mr. Low, do you have a delivery date?

Mr. LOW. Delivery of the last spacecraft is at the end of calendar year 1965.

Mr. HOLMES. The end of calendar 1965 is our last scheduled launch for Gemini. Since we hold the contractor responsible until the spacecraft is flown, the contract would certainly run through that time.

Mr. YEAGER. One other question. According to the news release, McDonnell has approximately 1,500 subcontractors or suppliers involved with Mercury and Gemini. Do you have a breakdown as to what percentage of this new contract will be let to subcontractors?

Mr. LOW. Mr. Yeager, that is a[ ]oximately 55 percent.

Mr. GURNEY. Mr. Chairman.

Mr. DADDARIO. Mr. Gurney.

Mr. GURNEY. In your initial summary on page 1, for fiscal year 1964, you don't have anything about the 1-day mission. However, in the small book, on page 5, there is a reference back to page 26 in the big book, which shows $208,000 for this 1-day mission. Why does this not appear in the summary on page 1? And, where is this $208,000 in the summary which appears on page 1?

Mr. HOLMES. I didn't think we were carrying any costs for the 1-day mission in fiscal year 1964.

Mr. Low. In the big book, page RDO 1–26, the $208,000 appears. These are personnel costs for the people still carried in fiscal 1964 for the final data reduction from the last 1-day Mercury mission flight.

Mr. Gurney. Your figures on page 1 are R. & D. facilities; is that right?

Mr. Low. The figures on page 1 in the supplemental book?

Mr. Gurney. No, the big book. I thought the figures on page 1 of the big book were a capsule rundown.

Mr. Low. Those figures are R. & D. costs except for the last two line items, personnel costs and operations of installation, $27 million and $42 million, on page 1, Mr. Gurney.

Mr. Gurney. Then the 26th item of $208,000 is included—

Mr. Low. Included in the 42 and 47.

Mr. Gurney. In the paper this morning there was a news article, apparently a NASA release, which indicated that there may be another Mercury mission that might go for 3 days. A cost figure was mentioned of $1 million. I realize this has been discussed before, and you have made a decision on it, but where is the $1 million going to come from?

Mr. Holmes. That figure is presently budgeted in our Mercury program for fiscal year 1963. At the recommendation of my staff and the Manned Spacecraft Center, about 3 months ago I authorized expenditure of $1 million—between now and the Cooper flight—on the backup spacecraft. This was to study and accommodate changes in the life support system and control system. It seemed a reasonable expenditure for several reasons. First, it did increase our knowledge of these areas that we could apply in Gemini. Secondly, we did have a backup spacecraft that we were not changing. Thirdly, it appeared as time went on and if the Cooper flight was very successful, we wouldn't be shut off from going further if the people studying and wanting to know more about weightlessness thought that before, even, we could go with Gemini, we should go further.

Mr. Gurney. The money, the $1 million, is coming from fiscal year 1963?

Mr. Holmes. The $1 million to do the work is coming from fiscal year 1963. If we decided to do the mission it would take reprograming action and would cost considerably more than the $1 million.

Mr. Gurney. How much money does NASA have left in this program for fiscal year 1963 that has not or will not be expended, as nearly as you can judge?

Mr. Holmes. Do you have that figure, Mr. Lilly?

Mr. Lilly. I am able to give you the financial status as of the end of February 1963, Mr. Gurney. On the 1-day mission there was an uncommitted balance of $4.4 million, and in the Mercury program there was an uncommitted balance of $147,000.

Mr. Gurney. How much of this do you expect to expend in the additional flight?

Mr. Holmes. We expect to spend all of this amount, Mr. Gurney.

Mr. Daddario. Mr. Waggonner.

Mr. Waggonner. Mr. Holmes, you spoke of this next Mercury shot possibly being our last shot, I would like to think that it will be. However, should we experience our first failure with the next Mercury, what planning has been made toward further Mercury shots?

Mr. HOLMES. We do have two backup spacecraft; one active, which I referred to in my discussion with Mr. Gurney and one in bonded storage. We also have the necessary boosters for these spacecraft. The backup is scheduled in September should we fail to accomplish our objectives in May with Major Cooper's mission.

Mr. WAGGONNER. If we have a slippage until September, what does that do to the Gemini schedule, and how does it affect the Apollo schedule?

Mr. HOLMES. It would impose a greater burden on the people who would be involved in Gemini operational planning. However, I don't believe that it would cause a slippage in the Gemini or Apollo schedule.

The other effect is more unknown. If this longer flight of 1½ days does not reveal adverse reactions to prolonged weightlessness, there is no effect. If, however, we encounter great problems from the weightlessness, the impact could be serious as you know, one of the reasons that we are conducting the 1-day mission is to increase our knowledge of the effects of prolonged weightlessness.

Mr. WAGGONNER. One thing the Russians said after their last spectacular when they launched Vostoks III and IV was something about the possible problem of calcium and bone deficiencies due to extended time and space. On the first day of the posture hearings, Mr. Webb made a statement concerning the possible effect of prolonged weightlessness. I don't think he meant to cast any doubt on the effect this problem would have on our future probes, but does NASA know anything which leads us to believe that man cannot stand extended periods in space?

Mr. HOLMES. I think the direct answer that I might be qualified to give would be, "No," we don't have any information on this point. There is some concern that muscle tone might be affected as a result of extended periods of weightlessness. However, I think when Dr. Roadman comes up to testify on his budget you may get a better answer than I am capable to give you.

Mr. GURNEY. Mr. Chairman.

Mr. DADDARIO. Yes.

Mr. GURNEY. I take it, from this discussion of the Mercury program, there is a definite possibility that you may do a 3-day mission, at least you are thinking of it?

Mr. HOLMES. There is a possibility, with a much less than 50-50 chance. A 3-day mission has not been approved either by my office or by my superiors.

Mr. GURNEY. Do you have any figure in mind what this will cost?

Mr. HOLMES. I will ask Mr. Low to answer that, please.

Mr. LOW. The cost in fiscal year 1964 for such a mission would be about $8 million. This doesn't appear in our budget at this time.

Mr. GURNEY. That was the question I was going to ask. I gathered from the previous conversation that if that was necessary, there would be a reprograming. Now my question is: Where would you take the $8 million from to do this shot?

Mr. HOLMES. I can't really answer. It would be my personal, final decision, after recommendations, that it come out of the manned space flight budget. Our program is dynamic and it is my responsibility to achieve a proper balance. As critical needs arise, it may prove necessary to transfer money from one part of the program to another. So if it seemed important enough, we would take money

away from some part of Apollo or Gemini, and it would slow up that much of an increment. But if the total program would have a greater chance of success of being done earlier, we would make the decision and would report these facts to you.

Mr. GURNEY. I understand this. My question is to find out how NASA plans for reprograming. Certainly there must be some sort of planning for an item as large as $8 million.

Mr. HOLMES. There is no planning for this item now. The reason is that I don't think we are going to conduct a 3-day mission. We have enough budget problems right now with a difficulty here, a difficulty there, taking money from one program, putting it into another, all with these very high-volume spending rates related to problems and to schedules. We don't have this money any place in our thinking.

Mr. GURNEY. Then it is fair to say that, at least on this item, when the reprograming is accomplished, the decision will be made at that time where to take the money from, is that correct?

Mr. HOLMES. Yes, sir.

Mr. GURNEY. Is that generally true of most of the reprograming that has been done in the past, and will be in the future?

Mr. HOLMES. Yes, sir. As soon as we have a program that we expect to approve, we analyze then how we would fund it. Then we carry the proposal forward to the Associate Administrator of NASA, Dr. Seamans, with my recommendation that this is what we do. Sometimes I have asked for money from other parts of NASA. So far I have not been successful.

Mr. DADDARIO. If it will affect the schedule, you can ask Congress for a supplemental appropriation.

If a failure in Mercury will not slow down the Gemini or Apollo programs, can we assume that the elimination of the Mercury shots wouldn't slow down the Apollo and Gemini programs either?

Mr. HOLMES. I don't think that is correct, by reason of my earlier answer to the counsel, Mr. Yeager. If everything goes well—if all the data come back well and confirm that there is no deleterious effect on the physical capabilities of the astronaut, the answer would be "Yes." But we are probably going to find out information that we don't have. If our findings have a great impact on design, the sooner we know the better. If we went directly to Gemini, we would obtain this data much later, which would cause delays and increased expense.

Mr. DADDARIO. Your qualification is, then, in the area involving the bioastronautical significance of the next Mercury flight, is that it?

Mr. HOLMES. Yes, in addition to increasing our knowledge about the physiological and psychological effects of prolonged weightlessness, we expect to obtain data from experiments in the space environment, such as how well a trailing balloon and the horizon can be seen. The results may have an impact on design from the standpoint of rendezvous or the horizon sensor or for setting the inertial platform.

Mr. WAGGONNER. One reason you say that there won't be any effect on the Apollo program is that we now have reached the point where, as we phase out one program and move into another, we have a greater shadow zone, and have the ability to work with more than one program successfully?

Mr. HOLMES. Yes. It would put more of a strain on us, but we believe we could handle it.

Mr. DADDARIO. Will you proceed with your statement?

Mr. HOLMES. Yes, sir.

Mr. Chairman, members of the subcommittee, during our appearance before this subcommittee earlier in the week, we were in the process of discussing the changes that have taken place in the programing of our fiscal year 1963 "Research and development" funds since our program was presented to you last year.

With your permission, Mr. Chairman, I propose to continue this discussion, starting with the Apollo line item which reflects a decrease of $144,349,000 from the estimate presented to you last year. The selection of the lunar orbit rendezvous mode resulted in the elimination of the lunar landing module which alone had been estimated to require approximately $115 million in fiscal year 1963.

You will recall that the lunar landing module was a stage to let you deboost the entire spacecraft to very slow speeds and land the spacecraft on the lunar surface.

The mode selection also reduced the number of Saturn I operational launch vehicles required. These two items accounted for the major reductions to the project. These decreases were offset, of course, to some extent by the new requirements for the lunar excursion module and the guidance and navigation system for this module, as well as some increased requirements for command module guidance and navigation.

The remaining item of change in the manned spacecraft systems area is a new requirement for the Mission Control Center. This item was not presented to you last year. As we have previously discussed, it was our original intent to control the early Gemini rendezvous flights from Cape Canaveral by providing modifications to the Mercury Control Center. However, the extensive modifications required, along with operational benefits to be gained from using the same center for both Gemini and Apollo flights, brought about our decision to advance the planned construction of the Mission Control Center at Houston from fiscal year 1964 to fiscal year 1963 to accommodate the Gemini rendezvous flights. This new requirement resulted in an increase to our plan of $10,500,000 in fiscal year 1963. As you know, this control center in Houston will be used for the Gemini rendezvous, Apollo, and subsequent manned flights.

Moving now to the "Launch vehicle and propulsion systems" area, the first three items are concerned with "Supporting technology for vehicles," "Propulsion," and "Launch operations." The reductions shown for these items total $21.9 million for the first three items under "Launch vehicles and propulsion systems."

There are two principal reasons for this reduction. The first reason is related to NASA presentation format. Unlike fiscal year 1964, the fiscal year 1963 budget structure did not identify supporting technology with individual program offices.

Even in the justification of the engines for our boosters, this was presented before another committee. That structure was revised as the NASA classifications were clarified.

Approximately $13 million of the apparent reduction to "Manned space flight" was for technology tasks under the cognizance of other NASA program offices. The balance of the reduction in these programs was simply the result of program priority decisions required to live within the funds available to the Office of Manned Space Flight.

The $13 million originally intended for the Office of Manned Space Flight was still spent on advanced technology.

The Saturn I development project reflects an increase of $43,210,000. It was originally intended that the Marshall Space Flight Center, using in-house effort, would produce all the developmental S–I stages. Because of the necessity for MSFC personnel to give increased attention to the Saturn V development as well as the Saturn I–B, we subsequently decided to have Chrysler build two of the Saturn I first stages. This change resulted in an increased R. & D. contract cost in fiscal year 1963. In addition, developmental problems on the S–IV stage required a more vigorous program to forestall schedule slippages. To solve some of the problems which have become apparent as a result of the S–IV developmental effort, hardware modifications involving ambient helium pressurization and additional helium heater testing to maintain liquid oxygen pressure were initiated. In order to pressurize the tanks, particularly the hydrogen tank in the S–IV stage, to force the fuel into the engines, we have helium gas in bottles, under pressure, that we release at the bottom of the tank. It forces the hydrogen out. If the helium is immersed in the liquid hydrogen, it is very cold, and it doesn't take much volume. It must be put through a helium heater before it goes in to be used to pressurize the tank. The helium heater is similar to a gas burner; it uses the fuel we are using for the booster, and should, apparently, be fairly simple. We have been studying the heater and it is working now. We bottled the helium in larger tanks, and did not have to use the cryogenic temperatures.

Provision has also been made for additional flight and ground instrumentation, and the S–IV reliability program has been increased. Costs for operational engines increased, as did the costs of guidance and instrument units. Additional costs also occurred in ground support equipment requirements for the Saturn I and in the redesign of electrical components for SA–8 and subsequent Saturn I vehicles.

As a result of the lunar orbital rendezvous decision and the reconfiguration of the original spacecraft to include a lunar excursion module, a vehicle with increased booster capability was necessary to test the heavier Apollo spacecraft and conduct rendezvous exercises. It would be heavier because it would have the bug in it in addition to the other equipment. The Saturn I–B development, therefore, became a new program requirement costing $18,750,000 in fiscal year 1963.

The Saturn I–B vehicle will be capable of placing 32,000 pounds in low Earth orbit. This payload is about one and a half times the payload capacity of the Saturn I, which is 22,000 pounds. The Saturn I–B vehicle will also advance the flight testing of the S–IVB stage by 14 months. This flight experience will assist in assuring successful Saturn V flights and in maintaining the current Saturn V launch schedule.

What I am saying here is that in addition to getting the increased payload capacity of some 45 percent to let us conduct Earth orbital missions with the Appollo spacecraft, we also have earlier experience on the third stage that will be used for the Moon rocket. If we had a diagram that showed the Saturn I–B, and beside that the Saturn V the part from the S–IVB stage up would be identical—the "bug" service module-command module. S–IVB will be the last stage of

both the Saturn I–B and the Saturn V Moon rocket. On top of the S–IVB stage will be the lunar excursion module, the service module, and the command module, in that order. We will not be able to fully fuel the service module for Earth orbital missions because the payload capacity of the Saturn I–B will not be enough.

Mr. FULTON of Pennsylvania. You came up with a new program, the Saturn I–B. Was the Saturn I–B absolutely necessary?

Mr. HOLMES. In our opinion it is necessary for both an economical and safe approach to manned lunar landing.

Mr. FULTON of Pennsylvania. So you are saving money in the whole Saturn program by going into the Saturn I–B vehicle, rather than adding that much more money onto the total Saturn program?

Mr. HOLMES. In my opinion that is the case, for several reasons I think that the Saturn I–B will give us much greater confidence for the reasons I have outlined. The Saturn I–B will give us a greater payload capacity and will permit Earth orbital missions of the S–IVB stage and the Apollo spacecraft configuration that is going to the Moon. It will definitely advance the accomplishment of the manned lunar landing mission.

Mr. FULTON of Pennsylvania. Do you have any backup for the Saturn I–B?

Mr. HOLMES. Another type of vehicle?

Mr. FULTON of Pennsylvania. No; just another Saturn I–B as a backup.

Mr. HOLMES. Yes, we will have Saturn I–B's for developmental and operational flight missions.

Mr. FULTON of Pennsylvania. Has that meant more expense to have the additional backup that you might not use?

Mr. HOLMES. No, sir. Instead of jumping directly from the Saturn I to the Saturn V, we will make dual use of the S–IVB stage. We have reduced the number of operational vehicles required for Saturn I flights, at least for the manned flight program. We will move into production of the Saturn I–B at the earliest possible time. The first stage is essentially the same for Saturn I and Saturn I–B.

Mr. FULTON of Pennsylvania. How much are you saving by stopping the Saturn I program sooner than you had expected to?

Mr. HOLMES. I would have to get you that figure. It will be the operational costs of a Saturn I vehicle, which would be equivalent to the operational flights of the Saturn I–B's, of which we have seven or eight.

Mr. DADDARIO. Can we get that for the record?

Mr. HOLMES. Yes, sir.

(The information requested is as follows:)

Four operational vehicles were eliminated from the Saturn I program as a result of the decision to adopt the lunar-orbital rendezvous technique for the initial manned lunar landing and return. These vehicles would have cost an estimated $150 to $160 million.

Mr. DADDARIO. Thank you.

Mr. HOLMES. The reflected increase of $14,157,000 for the Saturn V development is a net change of only 4.5 percent. Considering the size and complexity of this project and its early stage of development, we consider a change of this magnitude well within the normal bounds of estimates.

Mr. FULTON of Pennsylvania. Is the 4.5 percent the original estimate or later estimate?

Mr. HOLMES. The net change represents 4½ percent of the original estimate shown in the table 1, $314 million for R. & D. We are saying the $14.1 million increase divided by the original estimate of $314.445 million is 4½ percent.

Mr. GURNEY. Mr. Chairman.

Mr. DADDARIO. Yes, Mr. Gurney.

Mr. GURNEY. Do you have illustrations of the various parts of the Apollo launch vehicles? I am sure this would be very helpful for the new members. It is difficult to put the various stages of the Saturn's in their proper perspective.

Mr. HOLMES. I understand, having been through that problem myself. The names have evolved historically, and they are not always very logical.

Mr. DADDARIO. Will you supply that for the committee?

Mr. HOLMES. Yes, sir.

(The illustration requested is on following page, fig. 140).

The decrease of $15 million on the M–1 engine is a direct result of the LOR decision. The choice of lunar-orbit rendezvous as the initial lunar landing mission mode resulted in a concurrent decision to defer development of the Nova vehicle. Original configurations of Nova included the use of M–1 engines in the upper stages. Deferral of Nova development lowered the priority of the M–1 development and allowed time to modify the engine design to produce a more technically advanced engine. The redesign phase has delayed a requirement for some hardware fabrication and testing.

The importance of going ahead with engine development of this type is related directly to the leadtime necessary to develop such engines, which runs around 7 years. Unless development is initiated at an early point, we find ourselves well behind when we want to build a booster stage.

Mr. DADDARIO. That could be properly classified as falling under a Nova caption, development of this M–1 engine?

Mr. HOLMES. Yes, sir; as long as we treat Nova just as we are.

Mr. DADDARIO. Mr. Yeager?

Mr. YEAGER. That answers the question I had.

Mr. HOLMES. The increase of $760,000 on the H–1 engine project results from development problems occurring during the year. One of these is combustion chamber tube cracking, which appears as a problem at the thrust level of 188,000 pounds and which was not apparent in the 165,000-pound thrust level used in early Saturn development flights.

Our present H–1 engines have 165,000 pounds of thrust. The combustion chamber tubes are small tubes that are immediately adjacent to each other all around the inside of the thrust chamber, and are used to cool the chamber. We pump the kerosene through the tubes, down and back, and they cool the flared skirt of the engine. The tube cracking necessitated further R. & D. work to provide a material less subject to the cracking phenomenon. The other major problem centered in certain high-speed turbopump bearings which, on occasion, showed signs of abnormal wear.

In the fiscal year 1963 budget, RL–10 engine development funding was included in two projects—this has to do with the reorientation of the budget, following the reorganization of NASA—Saturn I ($18,000) and Centaur ($10,240). The fiscal year 1964 budget reflects the

APOLLO SPACECRAFT & SATURN LAUNCH VEHICLE CONFIGURATIONS

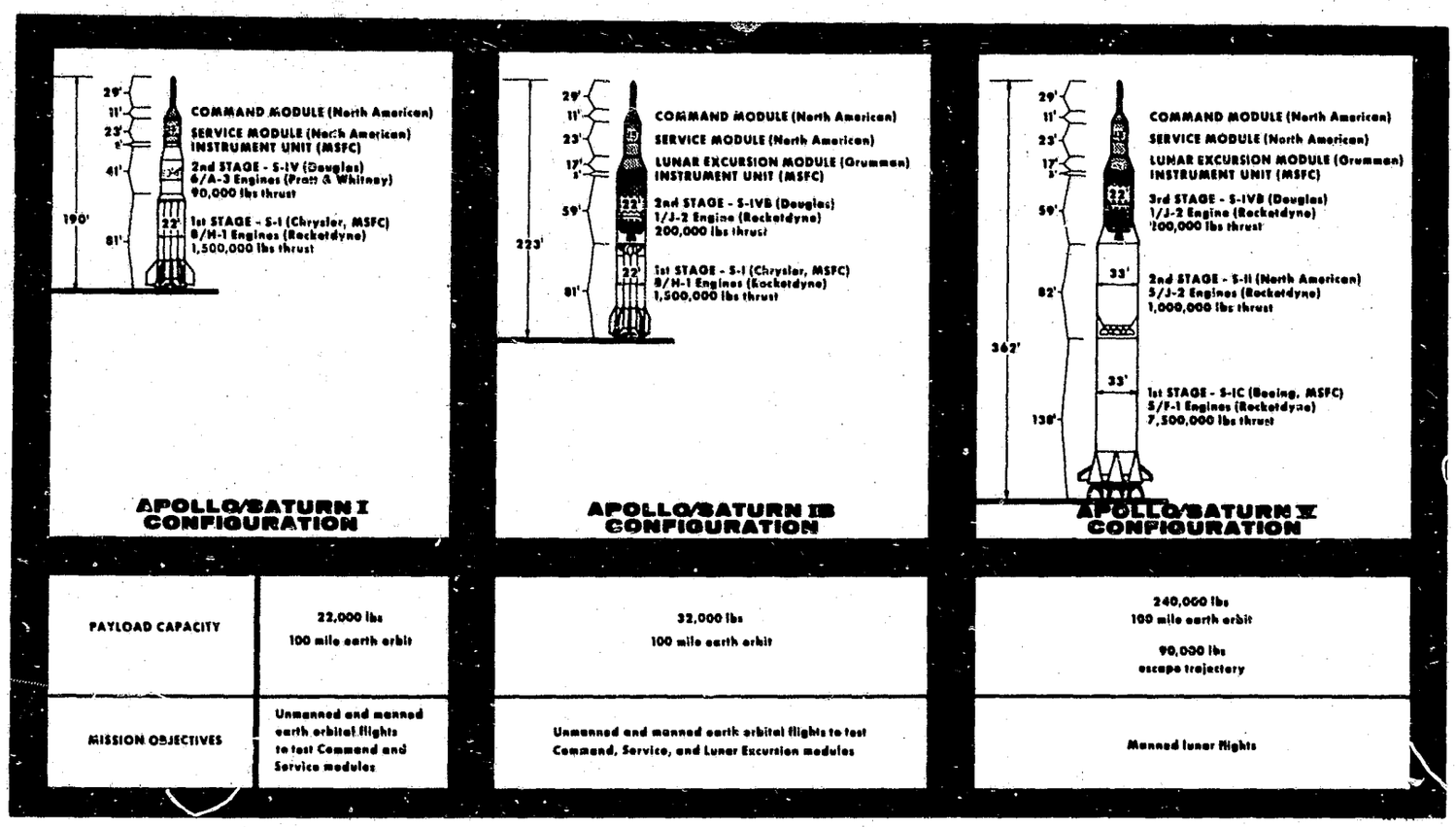

FIGURE 140

RL–10 as a separate OMSF project. This project includes the funding previously identified with both Saturn I and Centaur. Therefore, the real difference in manned space flight was slightly more than $4 million rather than the $14.6 million indicated for the total project. In addition to the originally planned total budget for RL–10, a throttling version of this engine was initiated in fiscal year 1963. A feasibility demonstration of this variable thrust on an RL–10 will be completed by the first quarter of fiscal year 1964.

The fiscal year 1963 budget estimate of $50 million for the F–1 engine development was prepared with the anticipated need to overcome certain technical problems especially in the areas of combustion stability and pump performance. As indicated, the change in estimate of $800,000 is 1.6 percent.

There is a larger increase, $9,542,000, indicated for the J–2 engine development. This change is directly attributable to the decision on the Saturn I–B vehicle. A single J–2 engine is used to propel the Saturn IV–B stage, developing 200,000 pounds of thrust. The Saturn IV–B smaller stage used on the Saturn I has six RL–10 engines, each developing 90,000 pounds of thrust.

Subsequent to the submission of the fiscal year 1963 budget a decision was made to develop the Saturn I–B vehicle as a test bed for Saturn V components and to provide the necessary payload capacity to test the Apollo spacecraft, including the lunar excursion module. This decision required an advance of 4 months in delivery of J–2 engines for use in the second stage of the Saturn I–B, and a requirement to increase the firing duration of the engine from 250 to 500 seconds.

Switching to the Saturn I–B means that we buy fewer operational Saturn I's. However, we have to develop and buy the Saturn I–B and start procuring the long leadtime items for the Saturn IV–B stage, which has very little additional development cost and comes under the Saturn V development as its third stage.

In the project for range support the phasing of support requirements in the Merritt Island launch area at Cape Canaveral has undergone a more gradual buildup than originally anticipated. The longer phasing of this requirement has allowed us to reduce our fiscal year 1963 funding by $9 million.

As we have discussed previously, the decision to eliminate direct flight as the primary mode for accomplishing the initial manned lunar landing and return was made subsequent to the submission of the fiscal year 1963 budget. The LOR decision, therefore, permitted elimination of the initiation of Nova development and the reduction of $155 million in fiscal year 1963.

In the space medicine project the reduction of $11 million results from the transfer to the Office of Advanced Research and Technology of tasks which did not directly relate to current manned space flight projects.

The last two changes are for "Integration and checkout" and "Systems engineering." At the time the fiscal year 1963 budget request was prepared and submitted to Congress, fund requirements were not separately identified for these extremely important functions. Funds have been reprogramed from items throughout the fiscal year 1963 budget. The integration and checkout effort, estimated at $38,500,000, is being directed, as you know, toward the objectives of

insuring that the major system elements of the Apollo project are designed, developed, and tested to fit together mechanically, electrically, and functionally for systems assembly and compatibility during operations. The systems engineering effort, costing $26,500,000 in fiscal year 1963, is providing centralized and coordinated systems responsibility for the manned lunar landing program and for the study of advanced mission concepts. The funding of all studies leading toward mission mode decision came out of that $26 million.

Mr. FUQUA. Mr. Chairman.

Mr. DADDARIO. Mr. Fuqua.

Mr. FUQUA. Mr. Holmes, on $38.5 million that you have for the integration and checkout, is that for the General Electric contract?

Mr. HOLMES. Yes, sir.

Mr. FUQUA. This is the work they are doing?

Mr. HOLMES. The largest part of that $38.5 million goes to fund the GE contract; isn't that right?

Mr. LILLY. That is correct.

Mr. WAGGONER. General Electric will actually receive about $25 million?

Mr. LILLY. Yes, sir; in fiscal year 1963 close to $30 million will be used to fund the GE contract.

The other approximately $5 to $6 million is for specific work in the integration and checkout area executed by the Marshall Space Flight Center and the Manned Spacecraft Center.

Mr. HOLMES. We can get the exact figure for the record if you would like it.

Mr. DADDARIO. But that is only part of the GE program. Isn't General Electric receiving more money on NASA contracts than this $38 million?

Mr. HOLMES. Not for fiscal 1963, Mr. Daddario. The General Electric Co. as far as the Office of Manned Space Flight is concerned, not including vendors, only has this business in fiscal 1963. General Electric is working on other projects, such as Nimbus, for NASA.

Mr. DADDARIO. Besides what?

Mr. HOLMES. Other than manned programs.

Mr. FULTON of Pennsylvania. You say fund requirements are not separately identified for these extremely important functions. Don't you really mean that there were no fund requirements put into the fiscal year 1963 budget? NASA has reprogramed funds from throughout the fiscal year 1963 budget, for this purpose.

Mr. HOLMES. That is what we really mean. With the reorganization of NASA, new people with new ideas came. My idea was to have a systems engineering organization and an integration and checkout organization that weren't included in the fiscal year 1963 budget.

In summary, this review of programing changes to our originally presented fiscal year 1963 estimates has involved discussion of individual changes. The total change, however, resulted in net decreases to Spacecraft Systems. Obviously we would prefer all our estimates to be precise. However, considering the size and complexity of this total program and the degree of program and schedule definition required during the past year, we do not consider these deviations to be abnormal.

Mr. DADDARIO. Mr. Holmes, when you decided that the Mission Control Center for Gemini would be changed from Cape Canaveral

to Houston, this decision was contrary to what you advised this committee you would do. It is my understanding that when we inquired into this some time ago, we were told that it would not be a function of the Houston operation to have a mission control capacity. Now, was this a change in your concept of what Houston was to accomplish, or was this a part of your original objective?

Mr. HOLMES. As I understand it, our original objective as part of Houston's charter has been not only spacecraft development, but flight missions, which meant the operational control of flight missions. There was a question as to where we would locate the Mission Control Center. To the best of my knowledge, we had always intended to have the Manned Spacecraft Center responsible for operating the Mission Control Center.

Mr. LOW. That is right.

Mr. FULTON of Pennsylvania. I thought it was going to be put at Cape Canaveral.

Mr. LOW. Last year we listed the Mission Control Center under various locations because we had not completed our studies as to the best place to locate. The two principal contenders were Canaveral and Houston.

Mr. DADDARIO. Despite the fact that the charter, as Mr. Holmes spelled out, gives you the right to put it in Houston, the fact is that we were advised it would be at Canaveral, not Houston, and that Houston would be confined to the development aspects of the program.

Mr. HOLMES. I think it is accurate to say that I was not a party to advising you that.

Mr. DADDARIO. No, you were not.

Mr. HOLMES. Assignment of flight mission operations to any center but the Manned Spacecraft Center is foreign to what our plans were. All I can say is that I regret any confusion that arose. The reason for moving, as we said, from Canaveral to Houston is that only a small portion of these flights, a relatively few minutes out of many, many days, takes place at Canaveral. It is tremendously important to have the people who run the Mission Control Center close to the people who are responsible for spacecraft development.

Mr. DADDARIO. This is why I inquire into it. Because this committee, not having the technical competence of NASA, came to the conclusion that the sensible place for the Mission Control Center would be in Houston. We were advised by NASA that this was not feasible, that and Cape Canaveral was the place where it should be. As I recall, rather than to speak for the other members of the committee, funds were requested so that it would be placed in Cape Canaveral. The change came after this. Not that I object to the change, but this raises a question as to our making inquiry, and then being advised that the inquiries we make are not logical or sensible. Later we find that NASA decided to do what we suggested in the past. It puts a crimp in the idea that much of this information that NASA gives us should be taken on faith alone.

Mr. HOLMES. Certainly it sounds as if in this case the committee was wiser than the adviser.

Mr. FULTON of Pennsylvania. We had the same assurances on Nova. We were advised that Nova couldn't be cut and that if we went ahead and did it, it would ruin the program. Then we find later that the whole program was deleted.

Mr. HOLMES. I think last year my testimony clearly stated we didn't know how we were going to the Moon. As soon as we made the lunar-orbital rendezvous decision we did have another special hearing and indicated what we were doing. I think we tried very hard not to mislead the committee that we were allwise and knew what our mission was going to be, and this included the Nova consideration.

Mr. DADDARIO. I think if your testimony was to be documented it would bear out what you have just said. But it does not change Mr. Fulton's position that on the basis of information which we had been given, Nova was a very important part of the program, and that it would be disastrous not to authorize funds for it. This is the basis on which we began our original budget hearings, and we did in fact authorize the funds.

Mr. HOLMES. Yes, sir; and if we had selected direct ascent all these statements would have been true.

Mr. DADDARIO. I bring that up because it bears on the question. I think you should caution some of those people who run your centers about giving us such strong information which later on you and others have to substantiate.

Mr. HOLMES. I agree.

Mr. FULTON of Pennsylvania. We must justify on the floor that we have been over these very programs, and we, in effect, certify that, from our experience and judgment and looking after the taxpayer's money, these programs are necessary.

What occurred last year occurred not only on Nova, but on Mercury as well. We were going to reduce the programs, but NASA informed us that they were necessary, so we eased up a little bit. Then a year later we find that everything we said could have been done was in fact done, including setting up the Mission Control Center in Houston. It does make a rather peculiar situation when we again look at NASA's budget request. We have to go to the floor of the House and again say, based on our responsibility and integrity we feel that this recommended amount is absolutely necessary, and that it can't be cut. That presents us with a problem—as you know, there is quite a move for budget cutting at this time. Especially when, if I may quote Mr. Riehlman, it turned into "quite a battle" last year, even with this subcommittee. I wanted to go further and cut more Nova money, and I hesitated because I didn't want to hurt your program.

Mr. DADDARIO. I think that is a statement for the record, and no reply is necessary.

On page 4 of your statement you talked about granting Chrysler the contract to build two of the Saturn I first stages. What procedure was used in granting them that contract? Was there any competitive aspect to it? Were any other companies advised they could submit a proposal?

Mr. HOLMES. The contract for the production of the S–1 stage was run competitively. Chrysler was awarded the contract. Initially we planned to have the Marshall Space Flight Center assemble and produce, in-house, stages No. 1 through 10. Subsequently it appeared to be wiser, from the standpoint of efficiency and getting industry onboard to produce this equipment earlier, to have Chrysler produce stages 8 and 10. In addition, this adjustment gave the Marshall Space Flight Center the opportunity to concentrate on Saturn IB and Saturn V development.

Mr. DADDARIO. You adjusted the responsibilities of the Marshall Center and Chrysler.

Mr. HOLMES. Yes. It was not an increase in the scope of the contract.

Mr. DADDARIO. It was an adjustment of the funds, then, to fund each of these sections?

Mr. HOLMES. Yes, between 2 calendar years.

Mr. DADDARIO. Mr. Waggonner.

Mr. WAGGONNER. You say the Marshall Space Flight Center had the in-house capability to produce the S–1 stage, but having devoted more of their time to the S–5 and the S–4B, I believe, they contracted two of the S–1's to Chryser? For the record, can you supply the production costs at Marshall with their in-house capability for producing stages 7 and 9 of these vehicles as compared with Chrysler's cost to produce stages 8 and 10? Which cost the most money?

Mr. HOLMES. Yes, we will attempt to do that. The difficult part is in separating the engineering and development that applies to all of the stages.

(The information referred to is as follows:)

There is no practical method of comparing in-house costs at MSFC with Chrysler's costs for a variety of reasons. The S–I stages in question are the first to be built by the contractor. Also, no two developmental stages are exactly alike, since the mission requirements differ and a continuing process of test and refinement is followed. MSFC in-house activities are essentially of the level of effort covering several NASA projects. As a result, many of the associated costs are not readily identifiable with a specific stage or vehicle.

Mr. DADDARIO. You may not want to get into this, and I can take it up when General Roadman comes before the committee but if you do know I would like to hear from you. What has happened in the space medical area, which you refer to on page 9, to the agreement that Mr. Rubel and Dr. Dryden referred to when they appeared before this committee last year? They said we would receive a copy within 2 or 3 weeks after the hearings of the committee terminated.

Mr. HOLMES. I would like to get you that information or have Dr. Roadman present it. I could only give it in a very sketchy fashion. On the basis of the NASA/DOD agreement, we are using their facilities such as Brooks Air Force Base, to the extent that the Air Force and Department of Defense felt they could supply our needs. However, as far as the specific answers of what dollars and what percentage of the program are being done in DOD facilities and NASA facilities are concerned, I would like to provide for the record, or have Dr. Roadman testify on the details.

Mr. DADDARIO. Let's wait until General Roadman appears before the committee. We can decide at that time whether we need additional information.

Can you touch on the reasons why the space medicine project was reduced by transferring its tasks to the Office of Advance Research and Technology?

Mr. HOLMES. Yes. In the space medicine budget we had included items that were really bioastronautics in the purer sense. This situation was partly due to organization. As you know, before November 1, 1961, we had, under Dr. Roadman, the space medicine that included bioastronautics, as well as the space medicine for man. After the reorganization there were certain fiscal years 1963 budget items that fell more properly into the Office of Advanced Research

and Technology. We did not actually decrease the total. We merely reoriented to the proper organizational entity those parts for which they had charter responsibility.

Mr. DADDARIO. You say you didn't in fact reduce the program. Do you mean that you reduced just that line item, but that an increase will be reflected somewhere else?

Mr. HOLMES. Yes. The reduction of $11 million in our space medicine was really an increase to Dr. Bisplinghoff's or Dr. Newell's office. The amount is still being spent on bioastronautics.

Mr. WAGGONNER. You mean that it was just transferred to another program office, rather than doing it yourself?

Mr. HOLMES. The $11 million were taken out of our budget and put into another program office's budget because they had cognizance.

Mr. DADDARIO. This is really just a readjustment within NASA itself, and not money paid outside to NASA?

Mr. HOLMES. That is correct.

Mr. DADDARIO. Mr. Fulton?

Mr. FULTON of Pennsylvania. I would like to have this put in the record. You have commented in your statement this morning on the transfers that have been made. Could you give us that in diagrammatic form, for the record, so we could see where it comes from, and where it goes to?

Mr. HOLMES. Yes, sir.

(The information referred to is as follows:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Summary of fiscal year 1963 reprograming actions, affecting manned space flight projects—Research, development, and operations (direct)

[In thousands of dollars]

	Fiscal year 1963 budget book	Fiscal year 1963 column of fiscal year 1964 budget book	Changes to fiscal year 1963
Total—Office of Manned Space Flight	1,637,553	1,514,578	−122,975
Manned spacecraft systems:			
Spacecraft supporting technology	9,300	8,100	−1,200
Mercury	3,500	3,342	−158
1-Day Mission	3,300	17,957	+14,657
Gemini	190,200	232,838	+42,638
Apollo	580,133	435,784	−144,349
Mission Control Center	0	10,500	+10,500
Subtotal	786,433	708,521	−77,912
Launch vehicle and propulsion systems:			
Launch vehicle supporting technology	20,060	8,800	−11,260
Propulsion supporting technology	18,440	7,950	−10,490
Launch operations supply technology	3,177	3,000	−177
Saturn I	147,500	190,710	+43,210
Saturn I–B	0	18,750	+18,750
Saturn V	314,443	328,600	+14,157
M–1 engine	50,000	35,000	−15,000
H–1 engine	4,500	5,260	+760
RL–10 engine	18,000	32,645	+14,645
F–1 engine	50,000	50,800	+800
J–2 engine	35,000	44,542	+9,542
Range support	17,000	8,000	−9,000
Nova	155,000	0	−155,000
Subtotal	833,120	734,057	−99,063
Space medicine	18,000	7,000	−11,000
Integration and checkout	0	38,500	+38,500
Systems engineering	0	26,500	+26,500

Mr. DADDARIO. Mr. Yeager?

Mr. YEAGER. We have not discussed columns 2 and 5, which involve institutional support and personnel costs. These two items have involved a total reduction within your office of approximately $35 million. Would you explain how this came about and who was responsible for it? Was this money over which you had control or not? We are talking about the totals now, personnel and institutional?

Mr. HOLMES. Yes. It is not money for which I have responsibility. It is money that is primarily dictated by the ceilings for NASA personnel, established in the executive offices and approved by Congress. The institutional expenses are budgeted NASA-wide. The I. & P. dollars associated herein in totals are purely arbitrary. They represent that part of the total personnel and institutional cost prorated to manned space flight. I don't budget or control these funds, I budget and control manpower at the three centers in Houston, Huntsville, and Cape Canaveral and manpower within my own office. I operate within ceilings or limits established by the Associate Administrator's Office. Perhaps Mr. Lilly could give you more detail on that, Mr. Yeager, if you want it.

Mr. YEAGER. Do you have anything to add, Mr. Lilly?

Mr. LILLY. Very little. I think that to compare the two estimates, one must put in perspective and recognize where we were last year in terms of appropriation structure. Fiscal year 1963 was the first year in which we combined the "Salaries and expenses" appropriation with the R.D. & O. appropriation. This reorientation was done quite late in the year. Assignment of "Salaries and expenses" costs, while moving from two different appropriations structures, was done in a purely statistical way. This year we have just a few months of operational experience under this combined appropriation.

As Mr. Holmes said, the control of these funds is under the Associate Administrator's office and is assigned on the basis of personnel ceilings for all the centers and the program offices within NASA headquarters. These funds must be prorated to the individual projects for presentation in the combined appropriation. I believe that your figure, however, is the difference between the $211 million total and $192 million. The $19 million difference bears some relationship to the decrease in the direct R. & D. cost.

Mr. YEAGER. You are including in the $192 million, though, the new items such as "Integration and checkout" and "Systems analysis"?

Mr. LILLY. That is correct.

Mr. YEAGER. The J-23 engine is being developed by Rocketdyne; is that correct?

Mr. HOLMES. Yes.

Mr. YEAGER And the M-1 by Aerojet?

Mr HOLMES. Yes.

Mr. YEAGER. Is there a considerable difference in the concept between those two, or is M-1 merely a scaled-up version of the J-2? Or do you know yet?

Mr. HOLMES. It was our initial thinking that the M-1 would be a scaled-up version of the J-2. But going from 200,000 pounds of thrust up to 1.2 million pounds is really quite a different engineering feat, which requires different techniques. In anticipation of a more sophisticated Nova vehicle, we are asking the contractor, Aerojet, to not go quite as fast, and look at a more sophisticated engine.

Mr. YEAGER. You don't at the present time have a specific vehicle in mind for the M–1 engine?

Mr. HOLMES. That is correct.

Mr. DADDARIO. Mr. Holmes, you had previously referred in your testimony to new programs you had submitted to the Bureau of the Budget this year. Could you list those new programs for the record?

Mr. HOLMES. Yes, we certainly can.

Mr. DADDARIO. And supply the pertinent information to us?

Mr. HOLMES. Yes. I am not sure exactly what you are referring to, Mr. Chairman.

Mr. DADDARIO. Sometime back, you said in your original dealings with the Bureau of the Budget you submitted the old programs and also the new programs, as I recall the testimony.

Mr. HOLMES. We do have under study now new programs which we plan to submit to the Associate Administrator, for approval. I don't recall my statement about submitting new programs to the Bureau of the Budget.

Mr. DADDARIO. I may be a little hazy about that. But I do recall some testimony from you involving new programs.

Mr. HOLMES. Yes, my office is studying new projects, which will be submitted to the Associate Administrator's office. I could certainly provide you with the list of what we have under consideration.

Mr. DADDARIO. They are not reflected in this budget?

Mr. HOLMES. No, sir.

Mr. DADDARIO. Are there any new programs reflected in this budget?

Mr. LILLY. We have requested in the systems' fiscal year 1964 budget, as indicated, small amounts of money for study of such advanced projects. However, we have not budgeted for any development work on new projects, such as the lunar logistics system.

Mr. DADDARIO. Could you provide for the committee the list of the new programs now reflected in the budget, and also list for us those new programs presently under consideration which will be soon submitted to the Associate Administrator of NASA?

Mr. HOLMES. Yes, sir.

Mr. DADDARIO. Mr. Fulton has one further request.

Mr. FULTON of Pennsylvania. I have been very interested in the space platform program, and have previously asked that we be given information on that. Could we have that and the amount of money budgeted for it now, and the amount proposed for the next few years. Is that all right, Mr. Chairman?

Mr. DADDARIO. Yes.

(The information referred to is as follows:)

The fiscal year 1964 budget does not contain any new project starts for the Office of Manned Space Flight. In view of possible initiation of new projects in future years, however, a comprehensive program is underway to study projects which would support or extend our presently authorized program. This advanced study program totals $29.1 million in fiscal year 1964, and is included under the systems line item (vol. II, RDO 5–1) and the launch vehicle supporting technology and launch operations supporting technology line items (vol. II, RDO 2–1).

Although this study effort represents an appreciable funding level, it is a small percentage of the funding level which would be required for any one of the projects if approved for development. These studies provide a sound engineering basis on which to judge the feasibility of future missions and provide the necessary technical and cost data required for making necessary program decisions.

The advanced study program includes efforts in the following areas:

Lunar logistic system, $6 million

This system may be required to provide logistics support to the manned lunar landing program.

Lunar systems, $3 million

These studies are directed toward extending the capability for lunar exploration beyond that provided by Apollo and the possible lunar logistics system. The program potential of lunar bases is included.

Space station systems, $4 million

Small orbiting laboratories, larger stations and staging bases, and related resupply concepts are being examined not only in terms of technical feasibility, but also in terms of the supporting roles they may provide for the total manned space flight program.

Planetary mission systems, $2 million

Studies in this area are exploratory in nature, aimed at defining possible missions in relation to the predicted technology of manned space flight.

Advanced vehicle systems, $10.4 million

These studies are specifically concerned with new launch vehicle concepts which may be required in support of the future missions. Included herein is $5 million for studies related to Nova-class vehicles.

Launch facilities systems, $1.4 million

Potential new launch concepts are under study and are directly related to the advanced vehicle studies.

General program support, $2.3 million

These are studies that relate to more than one of the categories described above, and include advanced studies of a more general nature.

As a logical followon to studies in these areas, the Office of Manned Space Flight is recommending new development programs for the lunar logistic system, an early manned space station and a multipurpose cryogenic space stage. Funds for this development work are not included in the fiscal year 1964 estimate.

Mr. FULTON of Pennsylvania. The other thing is, on the Nova there has been some design and engineering for the facilities that we had questioned. My question is: What has happened to that money? Would you submit that for the record later?

(The information requested is as follows:)

The selection of the lunar orbit rendezvous technique for the initial manned lunar landing resulted in a deferral of Nova development. The present study effort to define future requirements for Nova-type class vehicles includes analysis of the related facilities requirements. These studies will investigate structural concepts for test stands and general support facilities required for a Nova-type vehicle test program. The balance of the authorized Nova facility funds has been authorized for other projects using established reprograming procedures.

Mr. FULTON of Pennsylvania. Then, you were giving us a statement this morning of the program for the fiscal year 1963 research and development funds in connection with the manned space flight programs. I would like to have a calendar of the budget given to us, with the chairman's permission, and a later statement. That would be a calendar of obligations. If it could be done by month or by quarter, I think that would be satisfactory. As well as a calendar of your cashbox disbursements which you expect to have in fiscal 1964.

Mr. DADDARIO. Would you look into this, and advise the committee of the feasibility of putting that together? At that time we can take it up with Mr. Fulton and decide in what form we would like to have it for the record. It sounds like quite an operation.

Mr. FULTON of Pennsylvania. As a matter of fact, I would like to get a comparison of your fiscal year 1963 obligation budget and your

cashbox disbursement budget with what you plan to do for fiscal year 1964.

(The information requested is as follows:)

The actual and estimated expenditures for the National Aeronautics and Space Administration for fiscal year 1962, 1963, and 1964 appear as follows in "The Budget of the United States Government, Fiscal Year Ending June 30, 1964," page 394:

TABLE G.—*Expenditures of the National Aeronautics and Space Administration for research and development*

[In millions of dollars]

	Conduct of research and development			Research and development facilities		
	1962 actual	1963 estimate	1964 estimate	1962 actual	1963 estimate	1964 estimate
Manned space flight	467.2	1,105	2,313	80.2	271	400
Space applications	60.6	82	123			1
Unmanned investigation in space	323.2	421	557	14.2	20	36
Space research and technology	183.2	249	400	13.0	32	75
Aircraft technology	28.0	41	43		1	3
Supporting operations	80.6	152	205	6.9	26	44
Total, National Aeronautics and Space Administration	1,142.8	2,050	3,641	114.3	350	559

The forecast of expenditures is made at the appropriation level through the statistical analysis of past performance by major appropriation segments, i.e., personnel costs, operation of installations, and major elements of the research and development program. This method has proved more accurate than forecasting the cash disbursements for each project at the end of a given point in time.

The chart shown below reflects the fiscal year 1963 and fiscal year 1964 obligation plans for the Office of Manned Space Flight.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

OFFICE OF MANNED SPACE FLIGHT

Fiscal year 1963 and fiscal year 1964 obligation plans as of Apr. 15, 1963

[In thousands of dollars]

Project	Fiscal year 1963 obligation plan				
	1st quarter	2d quarter	3d quarter	4th quarter	Total
Total, OMSF	240,079	352,743	627,597	294,159	1,514,578
Manned spacecraft systems	155,687	132,784	259,227	160,323	708,521
Launch vehicle and propulsion systems	80,992	200,482	349,179	103,404	734,057
Space medicine	1,151	2,272	1,477	2,100	7,000
Integration and checkout	250	7,550	13,024	17,576	38,500
Systems engineering	1,999	9,555	4,690	10,256	26,500
	Fiscal year 1964 obligation plan				
Total, OMSF	899,288	975,719	686,657	370,136	2,931,800
Manned spacecraft systems	435,019	513,916	351,776	255,889	1,556,600
Launch vehicle and propulsion systems	394,508	387,356	300,762	85,814	1,168,500
Space medicine	3,841	3,357	4,659	4,343	16,700
Integration and checkout	56,610	58,140	18,360	19,890	153,000
Systems engineering	9,250	12,950	11,100	3,700	37,000

Mr. DADDARIO. Mr. Waggonner.

Mr. WAGGONNER. Did I understand you to say kerosene was the cooling medium in the skirt around the H–1 engine?

Mr. HOLMES. Yes, sir. The kerosene is pumped through the tubes back and forth before going into the kerosene dome above the injector. The kerosene is preheated and injected with the liquid oxygen into the thrust chamber, where combustion occurs.

Mr. WAGGONNER. That has made for more uniformity in the ignition in the engine, as well as cooling?

Mr. HOLMES. As well as keeping the skirt from burning out.

Mr. WAGGONNER. As well as keeping the skirt from burning out, it gives you better combustion in the combustion chamber?

Mr. HOLMES. Yes, sir.

Mr. DADDARIO. Any further questions?

If not, this committee will adjourn until 10 o'clock next Monday morning, at which time this committee will go into executive session.

(Whereupon, at 11:40 a.m., the subcommittee adjourned to reconvene at 10 a.m., Monday, April 8, 1963.)

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1964 NASA AUTHORIZATION

MONDAY, APRIL 8, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON MANNED SPACE FLIGHT,
Washington, D.C.

EXECUTIVE SESSION

(The following testimony of Assistant Secretary of Defense John H. Rubel and Gen. Bernard A. Schriever was taken in executive session because of the classified nature of the material presented. The classified portion of the testimony has subsequently been deleted from the record by the Department of Defense, and the testimony as shown below is unclassified.)

The subcommittee met, pursuant to adjournment, in room 214–B, House Office Building, at 10 a.m., the Honorable Olin E. Teague (chairman) presiding.

Mr. TEAGUE. The committee will come to order. I would like to note for the record that our subcommittee has the honor of having the chairman of the full committee, Mr. Miller, with us today.

Today we will hear from the Honorable John H. Rubel, Assistant Secretary of Defense, and Deputy Director of Defense Research and Engineering, and Gen. Bernard A. Schriever, commander of the Air Force Systems Command.

Mr. Rubel, would you tell us how long you have been with the Department of Defense, and the exact chain of command as far as you are concerned?

(The biography of Mr. Rubel is as follows:)

BIOGRAPHICAL SKETCH OF MR. JOHN H. RUBEL

Mr. John H. Rubel was appointed Deputy Director of Defense Research and Engineering on April 1, 1960. Mr. Rubel had been Assistant Director of Defense Research and Engineering (Strategic Weapons) since May 19, 1959.

Mr. Rubel, who was born in Chicago, April 27, 1920, received his B.S. in electrical engineering with honor from the California Institute of Technology in 1942. Following his graduation he was associated with the General Electric Co. for 3½ years in the GE research laboratories, briefly with Lockheed Aircraft Co., and then joined Hughes Aircraft Co. in 1946.

While with Hughes, Mr. Rubel contributed to the development of one of the earliest successful automatic celestial navigation systems in this country. He also was associated with the development of the Falcon family of missiles. In 1952 he joined the radar laboratories, later renamed the airborne systems laboratories of which he was named director in 1955. It was from this post that Mr. Rubel came to the Defense Department on May 19, 1959.

Mr. Rubel's industrial experience encompassed the field of airborne systems including radar, digital and analog computers, guidance and control systems, communications subsystems, etc.

With the Department of Defense, Mr. Rubel's responsibilities have included research, engineering, and engineering management aspects of long-range strategic strike forces currently in being, under development or contemplated for future

development. He has also been concerned with related matters including operations analysis relating to the design of strategic weapons systems.

As Deputy to the Director of Defense Research and Engineering, Mr. Rubel's responsibilities encompass the entire field of military systems. Mr. Rubel served as Acting Director of Defense Research and Engineering during the several months of Dr. Herbert F. York's recovery from his illness in the summer and fall of 1960. For his service as Deputy Director of Defense Research and Engineering and Acting Director of Defense Research and Engineering, Mr. Rubel received the Secretary of Defense Meritorious Civilian Service Award on January 16, 1961.

On May 11, 1961, the President nominated Mr. Rubel to the Senate to be Assistant Secretary of Defense. Following confirmation by the Senate Mr. Rubel's appointment became effective on May 19, 1961, with the specific duty being Deputy Director, Defense Research and Engineering.

Mr. Rubel is married and has three children. They were residents of Los Angeles, Calif., before moving to Washington, D.C.

STATEMENT OF HON. JOHN H. RUBEL, ASSISTANT SECRETARY OF DEFENSE, AND DEPUTY DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING; ACCOMPANIED BY GEN. BERNARD A. SCHRIEVER, COMMANDER, AIR FORCE SYSTEMS COMMAND

Mr. RUBEL. I would be happy to. I came down to Washington 4 years ago. I am almost celebrating my fourth anniversary this month.

Dr. York, who had been appointed the Director of Defense Research and Engineering a few months before, endeavored to recruit people from industry and other organizations to assist him in carrying out his responsibilities, and I originally came down as Assistant Director of Defense Research and Engineering for Strategic Weapons.

I served in that capacity for just about a year and then became a Deputy Director of Defense Research and Engineering.

About 1 year later, early in 1961, I was made the No. 1 Deputy, the overall Deputy for the office, and subsequently I was nominated by the President as Assistant Secretary of Defense in addition to holding those duties, so that I have been in this position that I hold now for essentially 2 years, really sitting in the chair for almost 3 and in the office for 4 years.

The Director of Defense Research and Engineering, as I am sure you, Mr. Chairman, and the other members of the committee know, has a responsibility by statute to supervise all research and engineering in the Department of Defense.

He has the authority to approve, disapprove, modify, or initiate, programs and projects in the field of research and engineering.

My duties have essentially been those of his No. 2 man during a good deal of this period and as such I have been very much involved, of course, with our space programs as well as the rest of our research and engineering programs.

My responsibilities in that area have been a little special. We set up about 2 years ago an arrangement between Dr. Seamans and his office in the NASA and myself in the Office of the Director of Defense Research and Engineering for creating, and getting our bosses together on, agreements between the two agencies. The great majority of the agreements which have been testified to before this committee are the result, agreements such as that concerning Canaveral for example.

Our agreements on the national launch vehicle program, the Gemini agreement, those things have been worked out largely between

Dr. Seamans and his folks on the one side, and me and others in our office on the other.

And then Dr. Brown, Dr. Dryden, Mr. McNamara or Mr. Gilpatric and Mr. Webb, have finalized these in the form of formal agreements. This I think summarizes, Mr. Chairman, the way in which the testimony is tied together pretty much on these programs.

Mr. TEAGUE. For the benefit of other members of the committee, Mr. Rubel and General Schriever were asked to prepare statements. It is an executive statement and as I understand although neither statement is classified, it may not be discussed outside until released by this committee.

Chairman MILLER. May I say something? I notice Mr. Rubel started by saying that Dr. Herbert York recruited him. Dr. Herbert York is a very persuasive person and we congratulate him for having recruited a person of your caliber. We think you have done a very fine job, Mr. Rubel.

Mr. RUBEL. Thank you.

Chairman MILLER. We don't want to lose you, even to California.

Mr. RUBEL. Thank you. I appreciate those remarks.

Mr. TEAGUE. Mr. Rubel, would you start with your statement.

Mr. RUBEL. Mr. Chairman and members of the committee, it is my understanding that the committee is interested in the responsibilities and programs of the Department of Defense in the field of military space.

I am here today to discuss this important subject because of the desire that this committee has expressed to acquire a better understanding of the nature and scope of these responsibilities and of this program.

I also shall point out that the very important part that space programs play in our overall research and development effort. It has been a growing effort. At present the Air Force is responsible for nearly all of it. Under Air Force leadership it has evolved over a long period of years, has grown rapidly especially in recent years, and has assumed a correspondingly greater importance. By that I mean a greater importance in the context of our overall Defense Department research and engineering activity.

In fact, in fiscal year 1963, it accounts for almost one-fourth of the R.D.T. & E. budget in the Defense Department and about 40 percent of the Air Force research and development budget.

It will be useful to place this effort and assignment of responsibility "in context" by outlining the historical evolution of space activities in the Department of Defense. You recall the situation in 1958, shortly after Sputnik I, when we had virtually no experience to go on.

The Army conducted a program with Explorer satellites. The Navy had Project Vanguard. The Air Force initiated a study of satellite applications under Project 117L. It was then that the Advanced Research Project Agency (ARPA) was formed, with congressional approval, to provide leadership at the Office of the Secretary of Defense level and to bring about a consolidation of these efforts in space.

In July 1958, Congress established the National Aeronautics and Space Administration and the Space Council to provide national leadership and to insure that scientific and civilian applications of space would be given appropriate support. At that time a number

of projects and facilities were transferred from ARPA to the National Aeronautics and Space Administration.

These included certain space programs for satellite applications in fields such as meteorology, the development of certain launch vehicles which have primary application to space exploration, such as Saturn and Centaur, as well as important Department of Defense facilities and personnel which included the nucleus of the Marshall Space Flight center and the Jet Propulsion Laboratory.

In this split off we retained in the Department of Defense those projects which we considered vital from a military standpoint. These included our programs for satellite inspection, early warning, communications, navigation and certain others.

In September 1959, Secretary McElroy directed that the responsibility for conduct for space projects would be transferred from ARPA to the appropriate Military Departments, in accordance with certain orderly criteria and schedules. The responsibility for the development, production and launch of space boosters and the necessary systems integration incident thereto was assigned to the Department of the Air Force except for such research and development as might be conducted by the ARPA.

By the end of 1960, the Vela Hotel program for detection of nuclear explosions in space was the only major space program remaining ARPA. I should add it is the only space program remaining in ARPA—it is not the only one, but it is the only major one.

The present administration continued the consolidation of responsibilities for space activities in the Department of the Air Force. In March 1961, Secretary McNamara issued a directive which stated that research, development, tests, and engineering of Department of Defense space development programs or projects which are approved hereafter, will be the responsibility of the Department of the Air Force.

It also provided that each military department and Department of Defense agency is authorized to conduct preliminary research to develop new types of technology to perform its assigned functions.

When, in the fall of last year, the Department of Defense effort on communications satellite was reoriented, the responsibility for the development of the satellite portion of the system was assigned to the Air Force. The Army retained its role as the developer of the ground terminal equipment.

I have mentioned that communication satellite because that was really the last one on which we had a somewhat interlocking arrangement for responsibilities which was altered by the new directives issued by the Secretary in regard to that program.

I hope this short résumé will indicate clearly and amply that the evolution of responsibilities for the Department of Defense space program has become steadily clearer and better defined with the passage of time.

The Air Force has altered its internal organization to match the growing needs of these space efforts. There, too, internal to the Air Force, you will find a well-planned and dynamic organization, which is well prepared to discharge its assigned responsibilities.

I am sure General Schriever will testify in more detail to the manner in which the Air Force is facing up to those. I know you are also interested in the scope of our space programs in the Department of

Defense. Many, in fact, nearly all the things we are trying to do now were foreseen in 1957, 1958, when many of these efforts were started, but when technology was much more limiting than now.

Our efforts include systems to use space in the traditional missions in the Department of Defense.

Examples include satellite inspection, early warning, communications, and navigation systems. This represents approximately one-half of our space effort.

I would like to clarify that a little. When I say "traditional missions" I mean to communicate, to provide early warning, to accomplish navigation, to inspect hostile objects. These are examples of traditional missions although it certainly has not been traditional to inspect satellites but it might turn out that would be in the future something that would be important to do. In that sense it falls into the traditional context of military undertaking.

The balance of our effort is not undertaken to meet well-defined military needs but, is aimed at creating a broad base of new technology, devices, and even systems for possible future applications.

Titan III is a good example. Although we believe that it is likely to have important military applications in the future, we are not waiting to define them in great detail before proceeding with the development.

For similar reasons we are requesting $200 million for development in fields specifically related to space undertakings, such as components and bioastronautics. In this way, we hope to insure an ample technical base in which future systems could, if needed, be developed without delay.

Of course, we look to the NASA to conduct the development of hardware and technology required for space exploration and civilian applications. We continually review our efforts and coordinate closely our programs. However, it is the clear responsibility of the Department of Defense to conduct a program of research and development planned to enable us to meet future military requirements.

I know that the Subcommittee on Manned Space Flight has a particular interest in Department of Defense programs in this field. In this connection, I quote from the testimony of Secretary McNamara to the Subcommittee on Department of Defense Appropriations:

> * * * A third category of research and development work sponsored by the Defense Department relates to the development of certain capabilities which would be required were we subsequently to find it necessary to put a man into space in conjunction with some military requirement that might arise in the future. In this connection we have a series of projects underway of which the largest by far is Dyna-Soar; Titan III, also falls into this category even though it will also provide future launch capability for categories 1 and 2.
>
> Here we are dealing with an uncertain military requirement, specifically the need for manned space vehicle operations but a requirement which, if it develops suddenly, cannot be met quickly unless we are today carrying out the development work on large boosters, on space environment systems that will facilitate the existence of a man, and certain other techniques that would allow a man to operate effectively in space and carry out certain assumed military missions.
>
> There is here the real danger that two national programs will develop; one in the Defense Department and one in NASA. It was to avoid the development of two national programs and to insure that only one such program, would be undertaken to meet the needs of the two agencies that Mr. Webb and I joined together in an agreement on the 21st of January. Under its terms we agreed that a joint planning board comprised of representatives of NASA and the Defense Department would be set up to plan the content and coverage of the Gemini program, to insure that the requirements of the Defense Department

for potential operation of a man in space and the requirements of NASA for that same purpose were met by this single program, thereby avoiding the duplication that was implicit, for example in the Air Force request for its own manned space program.

* * * As for the requirement for a manned military operation in space, it is not clear to me that we gain by putting a man in space for military purposes. I do not see the future clearly. It may be that certain of our requirements in space cannot be met without a man there. It may be that in order to inspect properly—

His original wording was "to inspect properly," but he means "properly inspect"—

unidentified satellites we might have to have a man in a U.S. satellite in space. I think it is rather unlikely we would require a man for those purposes, in part because a man greatly complicates the operation in space. You have to put so much in space just to allow a man to exist that it greatly adds to the complexity of the operation. Today it appears to us we can achieve military capabilities in space more quickly without a man than with a man. But as our knowledge of space operations advances this conclusion may prove false and I believe, therefore, we should have boosters with a sufficient capability to put into space satellites that will allow man to operate within them and we should have an understanding of the strains on the man and the extent of his capability in that space environment.

As Secretary McMillan mentioned in his discussion with you last week, Secretary McNamara, in a memorandum for the Secretary of the Air Force, dated February 22, 1962, provided constructive guidance concerning the conduct of a manned military space program.

This was not a departure from previous policy.

It does not represent any change from the policy and guidance we would issue now A copy of this classified memorandum will be furnished to you. I think this outline, in a very general way, covers the approach we are taking in space research and development. I will be very happy, Mr. Chairman, to answer questions of your committee on this subject.

Mr. TEAGUE. Is there any new agreement or new memorandum other than the one of February 22, 1962?

Mr. RUBEL. The only one I know about for sure is one dated the 15th of March 1963. It is a confidential memorandum from Mr. McNamara to the Secretary of the Air Force and it is considerably broader than the one of February 22, but considerably shorter. It states—excuse me, could we go off the record for a moment?

Mr. TEAGUE. Off the record.

(Discussion off the record.)

Mr. TEAGUE. Mr. Rubel, throughout the Secretary's statement there is the connotation that there is a possibility of the military requirement in space, but that this requirement has not been definitized as yet.

Is this said for the benefit of the public or is this really the belief of the Defense Department?

In the first part of the statement, Secretary of Defense McNamara says:

Were we subsequently to find it necessary to put a man into space in conjunction with some military requirement that might arise in the future.

From speaking to other Members of Congress, I think there is no doubt in their minds that there is a military mission in space. However, you say that:

Here we are dealing with an uncertain military requirement specifically with the need for manned space vehicle operation but a requirement if developed suddenly cannot be met quickly.

Again there is that connotation of "well, maybe." This continues throughout your statement. Again you quote Secretary McNamara as saying:

As for requirement for a manned military operation in space, it is not clear to me what we gain by putting a man into space for military purposes.

I have heard testimony from NASA that they would have lost 80 percent of their flights with the X–15 if they had not had a man in them. I also understand that there has been a study conducted by the Navy on one of their missile programs which indicated that they would have saved about 80 percent if they had a man in them.

When one hears this type of thing, I can't see how there can possibly be any doubt that there is a manned military mission in space.

Is what you have been saying for the public, or is this what DOD really believes?

Mr. RUBEL. Mr. Chairman, I think it is what we honestly believe. I don't think this is merely a statement for public consumption at all. In our inner councils when we sit around talking about this, these are the same as words we use with ourselves.

Chairman MILLER. Mr. Teague, I think Mr. Rubel is very sincere when he tells you that.

I am satisfied, as I think he is, that as there are further developments in space, possibly there will be a military mission for a man in space. I don't think one can foresee it at this time, and I think there are many reasons for not being able to pinpoint it. In the first place, we have to learn more about man in space Can men withstand the rigors of space? We will not have the answer to that until he gets out into space. At the present time, I don't think anyone can definitively say that there is a military need for a man in space.

Is that correct, Mr. Rubel?

Mr. RUBEL. Just exactly.

Mr. FULTON of Pennsylvania. Let's put the disagreement on the record as to the chairman's position.

Mr. TEAGUE. I though you mentioned in the office this morning that you thought there was a military mission in space, and that we ought to get on with it.

Chairman MILLER. Certainly you have to get on with it. It is just a question of not duplicating what NASA is doing.

Mr. GURNEY. Mr. Chairman?

Mr. TEAGUE. Mr. Gurney.

Mr. GURNEY. You stated, Mr. Rubel, that you were spending about one-quarter of your research and development budget for space programs. Can you give us some general notion of how you are spending this money?

Mr. RUBEL. Yes, sir; I would be delighted to do that.

(The material referred to is classified.)

Mr. GURNEY. Is your program for fiscal year 1964 approximately the same breakdown, proportionately?

Mr. RUBEL. Yes, sir; it is about the same. We have an increase in 1964—of course, these are funds not yet approved by the Congress but there we go up in vehicle and engine development largely because of a very substantial increase in the Titan III. We go down in

spacecraft and mission projection largely because of a substantial reduction in the Discoverer program.

Mr. GURNEY. Is any of the budget for 1963 or 1964 earmarked for research in manned space military missions?

Mr. RUBEL. We have study efforts that are constantly being undertaken. Most of them now are being done in-house by the Air Force and through the Air Force by the Aerospace Corp., some by contractors, which concern that specifically.

These kinds of studies, I think, are what you probably have in mind. They relate to how you would use a man, for example, in an interceptor or inspection role in space. That is an example and there are many other examples of that kind.

They don't show up as large dollar amounts in any budget but their importance is much greater than the dollar amounts that are allocated to them.

Mr. GURNEY. Would you say this, that in view of the review of the Secretary's statement which Chairman Teague went into, that there is an enthusiastic search going on in the Air Force and in the Department of Defense as to the use of man for military missions in space?

Mr. RUBEL. Yes, sir; I think the answer is "Yes."

Mr. TEAGUE. Mr. Rubel, what does the DOD expect to gain from the Gemini agreement?

Mr. RUBEL. I think the intent of the Gemini agreement is pretty clear and if that intent is carried through then I think we will have a lot to gain. We have, as you know, this joint planning board, the members from the Defense side are General Schriever, Dr. McMillan, and Dr. Kavanau. The object is to set forth the requirements that the Defense Department has for the conduct of manned operations of an experimental and research character, utilizing the Gemini program; to set forth the requirement that the NASA has for conducting experiments using the Gemini program; and then to look at the program itself and ask does the program meet these requirements or doesn't it meet these requirements. Wherever we identify through this joint planning activity, an area or an item which is not met by the actual Gemini project, then we will modify the project so that the requirement will be met.

This is the fundamental objective, from a national standpoint, to lay out all of the requirements that we can legitimately and properly assess against that program and use the program to meet those requirements, and if this board is effective, and if Mr. McNamara and Mr. Webb carry out the intent of that agreement—which they surely intend to do—then what we are going to gain is the use of the Gemini program in the overall national interest on the earliest possible time scale.

Mr. WAGGONNER. Mr. Chairman?

Mr. TEAGUE. Mr. Waggonner.

Mr. WAGGONNER. Mr. Rubel, since this question involves speculation as to the role played by Secretary of Defense McNamara with regard to Gemini and Dyna-Soar programs, if you don't care to comment I will understand. In this morning's newspaper, the Washington Post, Marvin Miles as special reporter to the Washington Post from the Los Angeles Times says:

> Some Washington observers feel McNamara made the Gemini deal quite deliberately so they could mollify Congressmen who feel the Air Force should

play a greater role in space and at the same time dump Dyna-Soar—with an appropriate prelude of deliberation, of course.

Do you care to comment on that statement?

Mr. RUBEL. I would be delighted to comment on that because I was involved in all of the discussions that were a prelude to making the Gemini agreement.

I assisted the Secretary in drafting some of the words in the agreement.

I think I know what his thinking was at that time and certainly what the thinking of the rest of us was at that time, and there was no ulterior motive ever evidenced to me—either express or implied—by anybody who was involved in that.

It was exactly and precisely the sincere desire to insure that the Gemini program would be used in the national interest for national purposes to which Mr. McNamara has already testified repeatedly. I think Mr. Miles' article attributes motives to Mr. McNamara that are without any substance insofar as my personal——

Mr. WAGGONNER. They definitely do not exist?

Mr. RUBEL. Based on my own observation and I sat with Mr. McNamara in meetings prior to, during, and subsequent to the consummation of that Gemini agreement, I believe that they simply do not exist. He was simply sincerely trying to do exactly what he told the Congress he was trying to do, what he told Mr. Webb he was trying to do, and what he asked some of the rest of us to try to help him do in drawing up that agreement.

Mr. TEAGUE. I suggest that the newspaper article be placed in the record with Mr. Rubel's comment. Without objection, it will be placed in the record at this point.

(The newspaper article is as follows:)

[From the Washington Post, Apr. 8, 1963]

McNAMARA IS GUNNING FOR IT—IF DYNA-SOAR GLIDER IS RESCUED, CREDIT LIKELY WILL GO TO NASA

(By Marvin Miles, special to the Washington Post from the Los Angeles Times)

NEWS ANALYSIS

If Dyna-Soar is saved there's a good chance the National Aeronautics and Space Administration will be credited with rescuing the winged space glider.

Secretary of Defense Robert S. McNamara, in his quest to slash duplication, has asked the Air Force to consider cutting back the Dyna-Soar—a request that could be tantamount to an execution order.

NASA, on the other hand, has a thriving interest in the space glider and it is quite possible that this interest may result in some sort of an agreement to keep the project alive.

An official hint of NASA rescue came in a portion of the Defense Secretary's recently released testimony before a House Appropriations Subcommittee:

"As a matter of fact," he told the subcommittee, "representatives of NASA have informed me of their interest in certain of the Dyna-Soar characteristics so there is not a clear case for knocking out Dyna-Soar."

Some Washington observers feel McNamara made the Gemini deal quite deliberately so they could mollify Congressmen who feel the Air Force should play a greater role in space and at the same time dump Dyna-Soar—with an appropriate prelude of deliberation, of course.

Asked directly by a House committeeman if Dyna-Soar is out of the ball game, McNamara replied: "I am not telling you that because I am not prepared to say that at the present time."

Some analysts have expressed the opinion that the Air Force never will get a chance in the Gemini program, that its pilots will be sidetracked in view of McNamara's admitted pessimism about the role of military men in space.

Others don't subscribe to this view, not after McNamara has assured Congress the U.S. Air Force will play a very important role in Gemini. The Secretary is too astute to go that far, for one thing. The Congress wouldn't stand still for it, for another.

Here's the way to figure it:

NASA Administrator James Webb indicated his interest in Dyna-Soar in a recent Washington interview. In the same period McNamara told me it appeared Gemini, the two-man space capsule, could do any military job in low orbit and do it quicker than Dyna-Soar.

NASA is interested in the space glider as a sure research vehicle that could open up the whole area of controlled reentry and conventional landing.

McNamara appears to have little feeling for the research values of Dyna-Soar.

The Secretary's sights remained fixed on the fact that two $800 million-plus programs (Dyna-Soar and Gemini) are similar in nature in that they can launch, orbit, and recover astronauts.

Gemini will be ready well before Dyna-Soar, he reasons, and a NASA–Pentagon agreement has cut the Air Force into Gemini operations. So why continue with Dyna-Soar? The Air Force can learn what it needs to learn about man in space from Gemini.

NASA is dominant in Gemini, but now the Air Force will play an increasingly important role. The Air Force has been dominant in Dyna-Soar, but NASA's research needs in this area should bring about another agreement to keep the project alive.

In other words, it appears McNamara, in his zeal to reduce costs, is maneuvering for Dyna-Soar aid from NASA by threatening to cut the project.

NASA can't afford to fund Dyna-Soar on its own—not with the $20 billion Apollo Moon project on its hands—but if McNamara decides against Dyna-Soar as now programed, it seems possible he and Webb will sit down and work something out.

Mr. TEAGUE. Mr. Riehlman?

Mr. RIEHLMAN. I don't want to rehash some of the things said here but I have been perturbed, Mr. Rubel, as you know, and I think General Schriever knows, about the failure of the Defense Department to even in a modest way say to the public that the DOD has an interest in the space program. But yet underlying all of the statements made today there is an indication that the Defense Department is definitely interested in space. Every indication we have at the present time is that the DOD is going to follow every development made by NASA to eventually come up with a specific program for the Defense Department in space.

We deal with Members of Congress other than the men on this committee, and this committee is going to be faced with the very same charge when we take the NASA authorization bill before the House.

The Appropriations Committee is going into this in some depth too. Yet anything that we can say, or are permitted to say, is sort of a lukewarm approach to this whole program.

Now, my question is this: When are we, as Members of the House of Representatives, going to be able to at least say with some backing from the Defense Department, that the DOD does have some program for a man in space. At least some broad statement that is effective and will carry some weight in the House of Representatives.

Mr. RUBEL. Mr. Riehlman, I think you can say that right now.

Mr. RIEHLMAN. But every time we get into something specific, the Department of Defense says that it does not have a program in that area.

Surely the DOD doesn't have a program to go to the Moon, but certainly underlying your statement there must be some specific ideas as to how you are going to use space.

Mr. RUBEL. Mr. Riehlman, am I correct in thinking that you are referring to man in space as distinct from the nonmanned applications here?

Mr. RIEHLMAN. Yes, sir.

Mr. RUBEL. I think that Chairman Miller stated very well our thinking with respect to the fact that you have to take first steps first. We could not define a mission for a man in space until we had done the very first things necessary to put the man up there and find out what his functional capabilities were, what his functional limitations were, what the relative costs and advantages and disadvantages of having him there are, and so forth, so that the first step in any program, even if we could define with the greatest precision right now exactly what military mission he would perform, the first steps in any program would be to do just exactly what we are doing, to do the bioastronautic work and perform the tests and experiments necessary to get the fellows up there and find out their capabilities.

Mr. TEAGUE. Mr. Rubel, in your February 23 memorandum, just to take one thing, you mention rendezvous with uncooperative satellites. Won't it be necessary to have a man in space to be able to do that?

Mr. RUBEL. Incidentally, I would like to correct the record. We have talked of the February 22 memo and the 23d and it is the 22d, not that it really makes much difference but it happens, at least the copy I have, that it is dated February 22.

Mr. TEAGUE. The one I have is February 23.

Mr. RUBEL. It is? OK, I hope we are talking about the same one.

The one I am talking about is a memorandum signed by Mr. McNamara for the Secretary of the Air Force and the subject is the Air Force manned military space program.

Mine just happens to be dated February 22.

I have noticed that it has come out both ways in the testimony and I wonder how it could be both dates.

When it comes to the business of rendezvousing with a noncooperative satellite, I think I can summarize the views that I have and which I think are views that are largely shared in the Defense Department along the following lines.

Mr. TEAGUE. Show this to Mr. Rubel.

Mr. RUBEL. It is the same one but different dates.

When thinking of this rendezvous identification mission, we are thinking in terms of the possibility of combating a hostile satellite.

I think that is in the foreground of everybody's minds when they start thinking about that mission.

If you ask yourself what do you have to do in order to deal with a hostile object, I think you will go through a series of steps or stages in your thinking that is pretty much the same regardless of what medium that object is in.

Mr. Chairman, it might be worth while if it is agreeable with the committee and with you if I spent about 2 or 3 minutes outlining these steps because I think it may help put this in context.

If you think about the antisubmarine problem, or if you think about the interception of ships on the surface of the ocean, or if you think about aircraft in airspace, or if you think about objects in space, you must think about each of these steps in about the same way.

The first thing you have to do is detect the fact that there is an object there in the first place.

The detection is the No. 1 thing; so that any program aimed at potentially countering a hostile object must start with detection. If you don't know it is there, then you cannot do anything about it.

The second step is tracking: you must be able to track the object, whatever the object may be. Frequently in our discussions of this we find ourselves mixing these two things together, detection and tracking; but it is better if we don't mix them together because there is a lot of difference between simply knowing there is a deer in the forest and tracking that deer, or knowing there is a ship on the surface of the sea and tracking that ship, or knowing there is an aircraft in the airspace and tracking that airplane. The requirements for these functions are quite different, so that tracking is very important. The reason it is so important, of course, is so that you can predict what the future position of the object will be because you are going to have to take your action against that object, if you take any such action, at a future time. Therefore, you must know where the object will be at that future time, and it requires tracking in order to make such a prediction.

A third step that we always associate with this problem of intercepting and, if necessary, destroying hostile objects is what is often called classification, the distinction between a friendly object or a hostile object, or between a friendly object and a neutral object. Classification is important since naturally we don't want to take hostile action against a friendly object or a neutral object.

Now the classification problem is extremely difficult. It is extremely difficult in almost any circumstance.

In the case of ships at sea, we make an effort to rendezvous with unidentified ships if that proves necessary to make some sort of physical identification. I think we are all more or less aware that the problem of classifying objects under the surface of the sea is extremely difficult, much more difficult than classification of objects on the surface.

The same kinds of remarks apply to objects in our airspace. We have elaborate means for detecting intrusions into our airspace, and in order to keep our false alarm rate down; that is in order not to be uncertain about whether we are tracking friendly or neutral or unfriendly objects, we try to identify everything that penetrates our detection and tracking screens.

For this reason, because sometimes our identifications are imperfect, we have, as I am sure the committee is aware, a way of scrambling fighters in order to make a physical visual identification of unidentified aircraft, something which is very practical to do and which enables us to keep the false alarm rate in our air defense screen down to very, very low levels, so that we can always distinguish between a normal situation and a raid situation.

In the case of hostile or potentially hostile objects in space, this classification problem is particularly difficult and it is here that people begin to extend their thinking from the airspace situation and the identification of airplanes performed there by visual observation into space.

Here is where we begin to think of rendezvousing with an uncooperative object, possibly with a man, possibly without, in order to better identify that object—in case we have not identified it before—so that we can tell whether it is neutral or hostile.

Presumably we would know whether it was a friendly one because we would initiate those under conditions that are much more controlled than the initiation of movement in the airspace. That is going to be true for very, very many years.

The fourth step is of course the actual interception itself, the business of placing weapons on hostile objects, whether they be ships, or whether they be submarines, or whether they be aircraft, or whether they might be unfriendly or hostile satellites that comprise some kind of a threat.

Now there are differences among all of these different situations for detection, tracking, classification, and destruction that I have outlined here in this brief résumé. The antisubmarine problem is a lot different than the surface ship problem and that is a lot different than the airspace problem and that is going to be a lot different than the space problem, and I don't think that any of us can say with complete certainty at this stage that a manned interceptor for rendezvousing with uncooperative objects in space is going to turn out to be the answer to the classification problem if that classification problem arises.

We have had a lot of skull sessions on this among ourselves——

Mr. TEAGUE. I think you just made out the best case you could possibly make for a manned military mission.

Mr. RUBEL. Mr. Chairman, I am not trying to make a case for or——

Mr. TEAGUE. You have. What you have just said is going to be my perfect argument from now on for a manned military mission in space.

Mr. RUBEL. I am not trying to make a case for or against, but I am trying to point out that we believe it is necessary and important to take all of the steps necessary in order to commence that development, whether or not it turns out in the future, that it is, in fact, the the right way or the best way or a feasible way even of going about the job. So rendezvous with uncooperative objects and with a man in our satellite is one of the things which I believe we contemplate as a very important phase of our participation in the Gemini project.

Isn't that right, General?

General SCHRIEVER. That is right.

Mr. TEAGUE. Suppose tomorrow it were possible to track a satellite or unidentified objects in space, and suppose further that Mr. Khrushchev told you it might be something like our SLAM program, that it might have a nuclear warhead in it.

What do we do?

Mr. RUBEL. Well, SLAM was a——

Mr. TEAGUE. Just take any object in space that we don't know what it is, but we know it is not one of ours. Do we have any plan for contacting it and destroying it? (The material deleted was classified.)

Isn't it true that you have had research teams that have said that "Slam," which is a supersonic low altitude missile that can carry a warhead, was feasible and you should go ahead with it? Isn't it also possible that Russia has done the same thing?

Mr. RUBEL. Slam is not an orbiting device. It is a long-range, low-altitude, high-speed, air-breathing nuclear powered rocket for very low altitude penetration so it really is not that kind of a device at all.

Mr. RIEHLMAN. I would like to concur that Mr. Rubel made the best possible case for us with respect to a military manned space program. To show you the problems we are going to have with the Appropriations Committee and the other members on this subject, let me read one paragraph from a statement made in the March issue of Data magazine, the Air Force command control, by a very influential member of the Appropriations Committee. He says:

> First, there is the row between the Air Force and NASA over their respective roles in space. All of the public comments to the contrary, this is a problem which is far from solved. Our subcommittee or our committee has not yet begun to review this important subject carefully. When we do, I know that the technical justification or the lack of it for a substantial military role in space will be basic to our study.

This comes from an influential man on the Appropriations Committee. Is there still a great controversy going on between NASA and the Air Force that has not been settled completely as to your respective missions?

Mr. RUBEL. Mr. Riehlman, I would like to ask General Schriever to add his comments to mine; but I would like to say first I don't think so. I don't expect that we are always going to agree with everything that NASA does. I don't expect NASA is going to always agree with everything we do, but I don't think that translates into a basic conflict with respect to missions at all.

Mr. WAGGONNER. The truth of the matter is that there are times you have trouble agreeing among yourselves?

Mr. RUBEL. Sure we do. Even within the family, so I don't think that translates into a basic disagreement with respect to missions.

Perhaps General Schriever is in a better position to testify to that point.

General SCHRIEVER. I don't believe there are any activities that are going on now that could be categorized as controversies. Whenever we have programs that are of the magnitude of the space program and NASA and the Department of Defense, there are bound to be problems arise and we are constantly working on those.

I can say categorically that I do not consider that any controversies exist. I think we have had areas of disagreement and I think that these will always be. I have them plenty in my own command, which is some 65,000 strong and spread all over the United States and the world.

I think that people being people you are bound to have disagreements but I think our mechanism has improved greatly in the last few years to bring about a much more rapid solution of problems when they arise than we had several years ago.

Mr. RIEHLMAN. I am sure both of you will be before the Subcommittee on Appropriations once the NASA authorization is completed, and you may be confronted by this same gentleman that has written this article. We will be asked questions on this same subject as we present the NASA authorization bill to the House of Representatives. Members of this committee will have to be conversant as to whether or not these problems are solved, and this deals specifically, I am sure, with the role or the mission that the Air Force has in space.

Mr. GURNEY. One further question on that. Mr. Rubel, you stated that a large part of your defense efforts on a man in space was in the Dyna-Soar program. Apparently there is some contro-

versy concerning the Dyna-Soar program, or at least so we gather from news media and also other rumblings that we hear, that the program is going to be canceled. The Secretary of Defense, Mr. McNamara, took a trip about a month or so ago down to Texas specifically to investigate this program, and as I recall, the DOD announced that no decision would be made on Dyna-Soar for another 6 months.

Now I don't know anything about the technical aspects of Dyna-Soar, but you have said this is one of the major efforts of the Defense Department in man in space. Why is the DOD so uncertain as to whether they should go ahead with it?

Is not the ability to man a space vehicle at a fairly precise point the next logical step in this program? If the Defense Department does cancel Dyna-Soar, what are you going to do in place of it?

Mr. RUBEL. Well, Mr. Gurney, to answer the first part of your question, why is there this question about the character of the Dyna-Soar program and its continuation, I think the answer to that is that the Dyna-Soar program is a very large program.

Even as presently laid out the plans call for a total expenditure on the order of $800 million.

Our experience with programs of this scope in the past, an experience which certainly might be reproduced in the future, is that frequently initial estimates are on the low side. They have practically never been on the high side. So even if we do not have an overrun, even if we don't have a bigger program when we are through than we thought we would have as we began, we are still talking about a program on the order of a billion dollars.

We don't have very many billion dollar programs in the Defense Department and those that we have we need to review very carefully and frequently to make sure that we are on the right track and that we are husbanding and expending the resources of the American people in their proper interest.

So it is perfectly natural for us to review Dyna-Soar. It has been reviewed many times in the past and it is going to be reviewed many times in the future, I am confident, because this is a process that is simply inherent whenever you are undertaking a major program, and this is a major program.

A second thing that makes Dyna-Soar of particular importance in this regard is that it is a space program of a very advanced character. We would be reviewing this program even if it were not a space program, even if it were not as technically far out as the Dyna-Soar is, even if it had many fewer uncertainties and unknowns from that point of view. But in addition to being a very large program, which we certainly ought to review frequently just because of that, we are confronted with these technical questions, these technical unknowns, these technical risks, these technical objectives, and it is awfully important to ask the extent to which those risks still look like good risks, because we are in a field of very rapidly advancing technology which requires frequent reassessment in order to maintain a good and current picture of whether one's policies and programs are proper. So that is another major reason for looking at Dyna-Soar.

There is a third reason, and that is that we have the Gemini program. When Dyna-Soar was begun we did not have the Gemini program. In fact, until recently we did not have any mechanism

for including the Defense Department, and specifically the Air Force, as an active part of management and the participation in the Gemini program.

Now we are certainly going to have to answer the question to ourselves, and I am confident that Members of Congress are going to ask it too: If you are participating in the Gemini program, why should you be doing the Dyna-Soar program? What is unique about it that requires you to support such a large effort at the same time you have another one going to put man in a near space orbit at very great expense and at a time when we know so little about what is involved in the support of life and the limitations and capabilities of man in space?

We have to be able to answer those questions to our own satisfaction and to yours and the satisfaction of other Members of the Congress.

That is another reason for looking at Dyna-Soar to be sure that there is no unnecessary and unwarranted duplication of effort here.

Mr. GURNEY. But the Gemini program is really no different than the Mercury program except there are two men in the capsule and it orbits for a longer period of time.

As far as the landing aspect is concerned, it is precisely the same, or pretty much the same, as Mercury. It seems to me there is a great deal of difference between Dyna-Soar and Gemini. The whole point, as I understand it, is to be able to land precisely by control of the person within the spacecraft. Isn't that right?

Mr. RUBEL. That is a very important and major feature of the Dyna-Soar. There are others.

Mr. GURNEY. Admittedly you should certainly examine carefully a program that runs into millions of dollars, although the TFX program is several billion.

Mr. RUBEL. Several billion including the procurement.

Mr. GURNEY. Admitting that your basic premise is right that it is expensive and you ought to look into it, and I certainly agree with that, again I get back to the point, What are you doing so far as advancing manned space flight is concerned?

The Dyna-Soar program certainly makes a good deal of sense to many Members in Congress as an advance in manned military space flight. If you say it should be reexamined, you must have reason for reexamining it other than just the money itself which, of course, is extremely important. What are the reasons?

Mr. RUBEL. I think I just cited three reasons.

Mr. GURNEY. One was a dollar reason. Another reason was that science and technology are advancing so fast that it may be obsolete tomorrow. I ask you what advances are there being made to indicate it might be obsolete?

Mr. RUBEL. I think you read more into my statement than I intended you to read into it.

It is a fast-moving field, yes. The technological possibility and limitations constantly become clearer. This is the reason for its reexamination.

I did not mean to suggest that the concept of the Dyna-Soar would necessarily become obsolete in the course of this evolution and that that obsolescence would necessarily be revealed by examination.

That could be a possibility but that was not primarily what I had in mind. I had its utility rather than obsolescence as a primary thought.

Mr. GURNEY. I think that a great many members of this committee and of Congress have the distinct feeling, as the chairman said, that the argument you made in answer to his question about military application in space all leads back to one thing: When you are talking about developing reconnaissance and inspection, you must be thinking in terms of the manned military applications of space.

I cannot imagine that the Russians are not working as fast as they can on this concept of military man in space. Certainly their space program is aimed at putting a man in space as fast as they can.

I don't know whether the other members of the committee know or not. I don't gather from your statement that we are doing anything along this line.

I will go back to just a simple World War II experience. I think it is a fair statement to say that the weapons we fought with in World War II were in many cases vastly inferior to those which were being used against us, the basic kinds of weapons, machineguns and tanks and things like that. So these questions are questions that we are anxious to hear something about because we have had an experience in the past which has not been too satisfactory in some respects.

If we get concrete answers as to what we are doing in space, then I think we might be more reassured. That is all I have.

Mr. FULTON of Pennsylvania. On page 3 of your statement you said:

> A third category of research—

Quoting Secretary McNamara—

> and development work sponsored by the Defense Department relates to the development of certain capabilities which would be required were we subsequently to find it necessary to put a man into space in conjunction with some military requirement that might arise in the future.

My comment is that obviously in the Department of Defense testimony by Secretary McNamara, there has not been up to this time a judgment or decision that it is necessary to put a man into space in conjunction with any military U.S. requirement that might arise in the future. I believe that that is an error in judgment because it brings up the question where does the man become not necessary. Is it the transition between ballistic flight and orbital flight; or is it at a certain height in the atmosphere; or is it when there is no lift at any foreseen speed that a craft could use in the atmosphere.

At which one of those three points is it that a man becomes not necessary in the Department of Defense judgment on activities above the Earth's surface?

Mr. RUBEL. Mr. Fulton, I don't think the Defense Department has made any judgment at all with respect to the necessity or nonnecessity of man.

Mr. FULTON of Pennsylvania. That is my point.

Mr. RUBEL. And because of the uncertainties, it has undertaken an extensive program and one which incidentally is a growing one——

Mr. FULTON of Pennsylvania. You are starting out and saying, "I don't know where the man would fit into a space mission of the military requirement."

I am going just the opposite. I start from the atmosphere and say, "When does the man not become necessary," and gave you three logical points where he might not become necessary. So when does he not become necessary?

Mr. RUBEL. I don't know the answer to that question. I am not sure there is any point.

Mr. FULTON of Pennsylvania. I hope General Schriever says he never becomes not necessary and any machine is operated better with judgment in it.

General SCHRIEVER. I would agree to that; yes, sir.

Mr. FULTON of Pennsylvania. The next point is, suppose a small nation could perfect the payload of an atomic or nuclear bomb since we are coming to the point where the costs are going down and the knowledge is becoming general in the atomic nuclear field.

Under those circumstances, suppose that an adverse nation should place into orbit 100 objects orbiting the Earth at between 8 or 9 miles and 300 miles above the Earth's surface. Then, they announce that each has nuclear payloads, with a capability on reentry, nonmanned, of destroying any city in this country, or in the world for that matter, within 15 minutes. In my judgment that would be the occupying of a strategic area to the exclusion of every other nation or individual in that area, and that would make every Army, Navy, Air Force, Marine Corps in the world useless.

At present we have no means of identifying whether there are the 400 armed nuclear weapons in orbit and the nation might say we will try it, we will let you inspect 5, and we do, and they turn out to have nuclear weapons in them. The question then is what is next. They would immediately say, well, you gave an ultimatum to Japan and destroyed two cities, why shouldn't we do the same thing to you great U.S. people in order to save the world as you thought you were doing in a previous generation. At this point in time I don't know of any way to find out whether a rocket or an orbiting vehicle is armed with nuclear atomic weapons other than inspecting them on the ground before they are put into orbit.

Mr. WAGGONNER. I don't think you could tell if you took a look right now.

Mr. FULTON of Pennsylvania. Under these circumstances, it causes me some concern that we are simply not able to make up our minds as to the method of defense to such a proposition.

For example, to me the Nike-Zeus approach is trying to catch all of the apples falling from the tree when the tree is shaken, and you know one of them is going to hit you on the head. You can't help it, because the Nike-Zeus is not perfect.

In my thinking there should be something done by the Department of Defense along these lines that do not compete nor infringe upon any of NASA's activities in space.

I must say in this regard that as a Republican not in the particular grouping, I agree with the Republican Senator from Arizona on his approach to the emphasis on military capabilities in space as well as the peaceful uses of space.

I would compliment the Air Force for the number of their people who are thinking very broadly along these lines and planning for the future. Likewise, I would compliment the Air Force on the fact that they are looking into these capabilities which, if they are employed,

such as in the example I gave, could result in the complete destruction of this country. Suppose a nation did have a system of orbiting 100 vehicles with ablative materials on the nose cones that would bring them in at tremendous speeds and with the ability to explode them over our cities. They could be exploded over our cities so that the intensity is increased 10 to 15 times, or even 2 or 3 times, the ordinary nuclear atomic explosion. What would you be doing in the Department of Defense?

You see, I am all for a space force. I have been an enthusiast of this and I have been stating this for a good many years. I believe we must be the first nation having vehicles orbiting in space, both manned and unmanned, with nuclear and nonnuclear weapons. The difference in times in a ballistic course which the Department of Defense adheres to, rather than an orbital course, is a tragic failure of imagination.

Could I have just your general comments on those thoughts, sir?

(The reply contained classified material and has been deleted.)

Mr. FULTON of Pennsylvania. Why not have a manned maneuvering orbital vehicle so that a man's judgment can take the place of a system. If you have 5 or 10 of those up, it would certainly be a threat to any country.

Mr. RUBEL. There is no question that a person can look into the crystal ball into the far distant future when one has very large payload capability in space, when one can afford to put a man on board to control complex devices and imagine that such a system could be constructed.

I would be the last one to say that is not so and I am sure General Schriever would agree with that.

I would say we are a long way from that point.

There are many unknowns to be learned before we reach that point and the complexities and expense associated with it are very, very great.

Mr. FULTON of Pennsylvania. I went out to see the X–15 at Edwards Air Force Base, and I was certainly convinced of the mission of a manned vehicle in the upper atmosphere and in space. Thank you very much.

Mr. TEAGUE. Are there any questions?

Mr. WAGGONNER. General Schriever possibly could answer this question.

General, do you know how much money the Air Force has expended on the Dyna-Soar up to this point?

General SCHRIEVER. I would like to furnish it for the record but it has been over $100 million. We have $130.4 million in the 1963 budget. One hundred and twenty-five million dollars is in the President's request for fiscal year 1964. We had a little over $162 million but I would like to be sure it is right. I will supply the numbers for the record.

(The information requested is as follows:)

The funds which have been released to the X–20 program to date are shown as follows:

[In millions of dollars]

	Fiscal year 1958	Fiscal year 1959	Fiscal year 1960	Fiscal year 1961	Fiscal year 1962	Fiscal year 1963
R.D.T. & E. (P–600)	3	5.0	18.7	58	100	130
D.T. & E. (P–119)		24.5				

The funds programed and planned for fiscal year 1964 and 1965 are: R.D.T. & E. (P–600): Fiscal year 1964, 135;[1] fiscal year 1965, 130.

Mr. TEAGUE. Could your staff and ours get together tomorrow and go over this testimony and take the classified material out of it?

General SCHRIEVER. Yes, but we will have to work with the Department of Defense, too. There is quite a bit of what has been covered here today that is classified.

Mr. TEAGUE. Only your statements will be released. Everything else will remain classified until the staff has had a chance to go over it.

General SCHRIEVER. The statements are unclassified.

Mr. YEAGER. Mr. Teague do you want to hold General Schriever's statement until he has an opportunity to testify at a later date?

Mr. TEAGUE. Does it make any difference to you, General?

General SCHRIEVER. Perhaps it might be better to hold the statement until I appear before the committee. If for some reason you would rather do it the other way, I don't have any objection to it.

Colonel ARNOLD. If it please the committee, they require that we not release statements as far as the Air Force is concerned until after the witness has testified.

Mr. TEAGUE. It will not be released.

Mr. YEAGER. Mr. Chairman, I have about seven questions that I would like to submit for the record.

Mr. TEAGUE. I think we have a number of questions that I would like to submit to the Air Force and to the DOD that we have not had a chance to ask this morning.

Mr. WAGGONNER. I could submit mine, too.

Mr. TEAGUE. Let's do it that way. We are going to submit a number of questions to you.

General SCHRIEVER. You plan to have another meeting with my appearing before the committee?

Mr. TEAGUE. Yes.

Mr. Rubel, we are going to adjourn at this point. We have a number of questions that we will give to you for the record. Later we will have our staffs get together, and go over today's hearing and take out the classified material. Only your statement will be released today. Everything else is classified.

[1] The President's budget currently shows $125 million for fiscal year 1964, however, Headquarters, USAF, is supporting the increase to $135 million and it is understood that D.D.R. & E. has indicated they will concur, provided it can be supported by SPP to be submitted approximately May 20, 1963.

QUESTIONS BY THE SUBCOMMITTEE ON MANNED SPACE FLIGHT

Question No. 1. As a general procedure, when DOD makes a decision on a major space project, how are the views of the services brought into the decision-making?

Answer. As a general procedure, when the DOD makes a decision on a major space project, it makes the decision on a specific plan as proposed by a service. Therefore, the service actually supplies the data on which the DOD decision is based. In this decision process, which is one of consultation back and forth between the OSD staff and the service staff, the recommendations of the services are considered.

Question No. 2. Are opposing opinions heard and reviewed? By whom?

Answer. Opposing opinions are heard and reviewed by the OSD staff including those who make the recommendations to the Secretary of Defense. In the case of the D.D.R. & E., either Dr. Brown or myself or both review opposing opinions prior to making our recommendations or decisions.

Question No. 3. Does D.D.R. & E. discuss these projects in detail with those who would have prime responsibility for them?

Answer. Yes.

Question No. 4. The main Air Force space activity now appears to be Gemini; do you have under review any original replacements for Defense space projects which have been canceled in the past?

Answer. The Gemini Program Planning Board has not as yet made its recommendations concerning the extent of Air Force participation in the Gemini program, nor has the Secretary of Defense completed his review of the Dyna-Soar program, therefore, the initial part of the question which contains the statement that the main Air Force activity now appears to be Gemini is in error. For those space projects which have been canceled, there are replacement projects either approved or under review.

Question No. 5. How is basic research stimulated and sponsored in D.D.R. & E.?

Answer. We have in D.D.R. & E. the Deputy Director (research and information systems) and under him there is an Assistant Director (research). They have supervisory responsibility over our basic research. They review the basic research programs of the services and there is considerable cross-fertilization between our staffs and the service staffs. Additionally, other sections of the D.D.R. & E. staff will be involved in research which impinges on their functional area of responsibility.

Question No. 6. Could you summarize DOD's interest in a nuclear propulsion program and indicate the problems connected with a nuclear rocket first stage?

Answer: The DOD is following with great interest and contributing to, where appropriate, the development of a nuclear reactor rocket engine. The present effort, known as Project Rover, is intended to develop a graphite moderated reactor to heat hydrogen which is exhausted through a nozzle. The engine is to be compatible with the Saturn booster. Although the Department of Defense is interested in this development, there have been no military requirements identified. A nuclear engine has the characteristics of large deadweight and, with hydrogen as the propellant, large tankage volume and weight factors. These disadvantages are affected by high specific impulse but only when the velocity imparted by the engine is rather high as in the case for lunar or interplanetary flight. Some military space missions, for the present, appear bounded by the "sphere of interest" within the altitude of 24-hour orbit. The Rover engine does not appear desirable for military missions as we are now able to forecast them. This consideration is somewhat less valid for the case of a small, lightweight, fast reactor engine to be used for in space maneuvering propulsion. Therefore, the Department of Defense is spending a small amount of funds on studies of such reactor application. The AEC is developing a fast metallic reactor which conceivably could have a propulsion application.

The Department of Defense has carried out an exploratory program for several years to investigate the feasibility of using small nuclear explosives to propel a spacecraft (Project Orion). While this approach shows technical promise, the high risk and cost of the development and the uncertain requirement have caused the project to remain in a research or exploratory category.

Essentially, all planning for nuclear rocket engines today involves using the nuclear engine as an upper stage. The problems of safety and launch site contamination make this approach desirable. In addition, the availability of very large chemical engines allows this approach to be practical, as well.

Question No. 7. Are you presently reviewing existing DOD space programs? If so, what specific ones are you studying?

Answer. We are continually reviewing all DOD space programs. Currently, we have been reviewing satellite inspector, Dyna-Soar, communications satellite, and Titan III.

Question No. 8. Do you think that the identification and interception of foreign satellites will require a man in the loop?

Answer. Yes; and we want to determine where in the loop, either in space or on the ground, or both.

Question No. 9. Indications from DOD suggest a tendency to believe that there is duplication between the Gemini and Dyna-Soar programs. Do you think this is so? Since Dyna-Soar seems to involve considerable work in regard to recoverable boosters, single vehicle for takeoff, maneuvers in space, maneuvers for reentry, and aerodynamic landing, how is this a duplication of Gemini? Isn't Dyna-Soar a more natural lead-in to the aerospace plane concept than Gemini?

Answer. You might say that there is a certain amount of duplication in the two programs in that both are going to provide more space flight time for man. However, the Gemini will stay up for days whereas the Dyna-Soar will make only a few orbits. The Dyna-Soar will provide valuable reentry data for lifting body type vehicles whereas Gemini is a ballistic type of reentry vehicle. We are studying both Dyna-Soar and Gemini programs with a view toward coming up with best program or combinations of programs from a national defense viewpoint. The final decision will be based on a consideration of all the factors you have raised in your question plus others.

Question No. 10. When Mr. McNamara speaks of a "combined national space program" does this mean a "single" national space program or something else? (See Feb. 22 memo.)

Answer. I consider that a "combined national space program" means the same thing as a "single national space program." As both the President and the Vice President have said we have one national space program. The two major elements of this program are the portion managed by NASA and the portion managed by the DOD.

Question No. 11. Has the revised development and funding plan for Dyna-Soar been accomplished yet?

Answer. The current development and funding plan for the Dyna-Soar program (systems package program) is dated October 10, 1962. When Mr. McNamara completes his review of this program and makes his decision, the Air Force will require approximately 30 days to prepare a revised plan.

Question No. 12. What if any money made available to Gemini will be based on a consideration of what the Gemini Program Planning Board recommends?

Answer. If, based on an evaluation of this recommendation, it is determined that it would be desirable to place funds on Gemini, we would then look at the DOD space program to determine what funds, if any, could be made available.

Question No. 13. In Secretary McNamara's testimony before the Appropriations Subcommittee in February, he said this:

"NASA is interested in Gemini only to support a manned lunar landing. The Air Force, on the other hand, is concerned about the possible use of man in the same environment, near Earth orbit, for potential military purposes. * * * After the Air Force is acquainted with the extent to which Gemini may add to the Air Force's knowledge of manned flight in space, it may be possible for the Air Force to cut back the Dyna-Soar project substantially."

There seems to be a suggestion here and also in testimony provided to this committee by Dr. McMillan that the Air Force's interest in Gemini may be more comprehensive and possibly will last longer than that of NASA.

If this is the case, do you expect to continue Gemini after NASA's need for the program is completed?

To what extent are you prepared to fund the Gemini program for fiscal 1963 and 1964? Also 1965?

Answer. It would be premature to attempt to answer your question concerning whether we expect to continue Gemini after NASA's need for the program is completed. The Gemini Program Planning Board has only recently started to look at requirements for the Gemini. The point in time when NASA's need for the Gemini program will be completed is still many years ahead. Therefore, it may be some time before DOD planning for that period is completed.

It is also too early to answer your question concerning the extent, if any, that the DOD would be prepared to fund Gemini in fiscal year 1963 and 1964. This decision will be made after the Planning Board has reported.

Question No. 14. Are negotiations now underway with NASA looking toward the development of a manned orbiting space station?

Answer. On March 15, 1963, I wrote to Dr. Seamans, pointing out that both NASA and the Air Force are now studying their need for a manned orbital space station and that I believed that it would be in the national interest if we held discussions to consider the possibility of a joint program. On April 12, Dr. Brown wrote to Mr. Webb again on this subject since we understood NASA was putting RFP's out for a manned orbiting space station. We are awaiting NASA's reply.

Question No. 15. Is any agreement underway with NASA with respect to a Gemini-type agreement involving Dyna-Soar?

Answer. We have considered such an arrangement but no concrete proposal has been made.

QUESTIONS ASKED BY REPRESENTATIVE JOE D. WAGGONNER, JR., SUBCOMMITTEE ON MANNED SPACE FLIGHT

Question No. 1. What is military interest in lasers?

Answer. The laser, as a generator of coherent energy in the ultraviolet, visible, and infrared portion of the electromagnetic spectrum, offers many possibilities for unique military applications. Its limitations, however, should be recognized at the outset. Because of absorption and scattering by the atmosphere, fog, and clouds, lasers will not replace radar for all-weather capability, and because of its line-of-sight characteristics, it will not replace radio for general communications. Nevertheless, because of the very sharply directed and intense beams, the possible military applications include the following: rangefinding, secure communications, target tracking, surveillance, missile guidance, navigation, medical, computer elements, and research instruments.

The rangefinder under development by the Army will probably be the first laser to reach operational status.

Question No. 2. Is Secretary McNamara maneuvering for Dyna-Soar aid from NASA?

Answer. NASA supports the Dyna-Soar program and its technical objectives. However, the DOD is not requesting that NASA share in the cost of the Dyna-Soar program.

Mr. RUBEL. All right, fine. Thank you very much.

Mr. TEAGUE. The hearing is adjourned.

(Whereupon, at 11:55 a.m., the committee was adjourned.)

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1964 NASA AUTHORIZATION

TUESDAY, APRIL 9, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON MANNED SPACE FLIGHT,
Washington, D.C.

The subcommittee met, pursuant to adjournment, in room 356, Old House Office Building, Washington, D.C., at 10 a.m., Hon. Olin E. Teague (chairman) presiding.

Mr. TEAGUE. The committee will come to order.

Mr. Low, where did we leave off?

STATEMENT OF GEORGE M. LOW, DEPUTY DIRECTOR (PROGRAMS), NASA; ACCOMPANIED BY WILLIAM E. LILLY, DIRECTOR, PROGRAM REVIEW AND RESOURCES MANAGEMENT

Mr. Low. Mr. Chairman, during our last session we went through the reconstruction of our 1963 budget and appropriations and we are ready to begin today, with your permission, on the 1964 budget book.

Mr. TEAGUE. That is in volume V, supplemental, and volume II?

Mr. Low. And volume II.

Mr. TEAGUE. Research, development, and operation.

Mr. Low. I would plan to start with page RDO 1–1 in volume II.

Mr. Holmes asked me to express his regrets for being unable to be here this morning. He had to appear before another subcommittee of this committee and therefore was unable to be here.

On page RDO 1–1, we cover manned spacecraft systems which is one of several major breakdowns in the manned space flight program.

Under manned spacecraft systems, we are including this year supporting research and technology, Project Gemini, the Apollo spacecraft project, and the operations of the Mission Control Center.

Our total request for spacecraft systems is $1,556,600.

Mr. FULTON of Pennsylvania. Would you repeat the figure?

Mr. Low. $1,556,600. In addition to that, we are prorating under this category $47,976,000 for personnel costs and $42,865,000 for operation of installations.

Therefore, the total cost for spacecraft systems is $1,647,441,000.

The major breakdowns for the R. & D. direct portion of this number consist of supporting research and technology, $21,100,000. Gemini, $306,300,000; Apollo, $1,207,400,000; and Mission Control Center operations, $21,800,000.

I would first like to discuss the supporting research and technology area which is broken down on page 4 of volume 5 and is discussed on page RDO 1–4 and subsequent pages in volume 2. Under spacecraft

supporting research and technology, we provide for the supporting engineering and development effort for the approved spacecraft projects, that is for Gemini and Apollo, to assure the capability for the rapid development of high performance spacecraft systems.

Significant among items that we budgeted in this category in the past would be items such as the paraglider, which is now being used as a manned landing device for Project Gemini.

Other items in the past included such things as ablation coatings for heat protection on high-speed reentry bodies, and the refinement in the state of the art of a small thrust chamber to improve performance reaction control systems for spacecraft systems.

We include in this category four major breakdowns: materials and structures development and analysis, system development and analysis, flight operational methods and systems, and the fourth is simulation, training, and human factors.

Under the first of these, spacecraft materials and structures, we will include in fiscal 1964 a study involving the detailed analysis of the behavior of Apollo-type structures in high altitude acoustics fields.

Also we will include a study of thermal loads associated with Apollo reentry.

As you know the Apollo spacecraft will enter the atmosphere at about 1½ times the speed of our satellite programs like Mercury or Gemini. With this high-speed reentry, we are faced with a very much higher heat input into the spacecraft and the spacecraft must be protected against this. A great deal of development remains before we can develop a heat shield for the Apollo spacecraft that will assure us of reentry on the way back from the Moon.

Another significant item we will study under supporting research and technology is a search for techniques for transmitting signals during the so-called reentry blackout. As the spacecraft reenters the atmosphere at very high speeds, 17,500 miles an hour for Mercury and Gemini and 25,000 miles an hour for Apollo, a sheath of ionized air engulfs the spacecraft and with present techniques it is impossible to transmit radio signals through this layer. For example, in each one of the flights that we have had to date, Glenn's, Carpenter's, and Schirra's, we were unable to communicate with the spacecraft for about 4 minutes as the spacecraft entered the atmosphere. We are looking under the supporting research and technology for means of achieving the propagation of radio waves through this ionized layer of air.

Also under supporting research and technology we are purchasing component hardware for evaluation as possible backup systems in case the primary systems being pursued by our contractors should fail to function in the developmental program.

Studies in flight operation methods and systems will include the development of emergency operating procedures to be used in spacecraft operations. Under simulation, training and human factors, studies cover the development of visual techniques and hardware for simulation of Apollo missions and evaluation of the performance of humans under stresses of space flight acceleration.

Our total request for supporting research and technology for this fiscal year as I mentioned before, is $21,100,000.

The next major category under spacecraft systems is Project Gemini.

On page RDO 1–5, we have summarized the request for funding for Gemini and broken it down in additional categories. Specifically, for the Gemini spacecraft, which is being produced for NASA by the McDonnell Aircraft Corp., we are requesting $196,200,000.

Mr. TEAGUE. Has there been any discussion as yet with the Air Force about this Gemini program?

Mr. Low. We have recently completed an agreement with the Department of Defense for a cooperative program in Project Gemini in order to allow the Air Force to get the maximum benefit of the things we will learn in Project Gemini. There are no plans at this time for the Air Force to support Project Gemini with additional funds. We have been working very closely with the Air Force actually since the Gemini program started through General Ritland's office. As you know, General Ritland is the deputy commander of the Air Force Systems Command for manned space flight. He has offices in our building and we have direct and close liaison with him.

In addition to that since the Gemini agreement with the Department of Defense was concluded, we have had a team of Air Force officers at the Manned Spacecraft Center in Houston working with our people there to define in detail the nature of Air Force participation in Project Gemini. This definition is not yet complete.

Mr. FULTON of Pennsylvania. Is there the intention that the Air Force will finance and fund part of the Gemini program as an active partner, or will it be where the Air Force is merely an observer and will pay for any modifications that they would like?

Mr. Low. At the present time, Mr. Fulton, the intention is the latter, that the Air Force will act as an observer by direct participation in every phase of the program. It will have people with our Manned Spacecraft Center in Houston working alongside our own engineers in order to get maximum benefit to the Air Force of all of the things that we will learn in Gemini and at the same time in order to give us the maximum benefit of all the Air Force is doing in other programs.

Mr. FULTON of Pennsylvania. Would it be better to integrate the military personnel into the production of the Gemini program or is it better to have them as observers?

Mr. Low. Perhaps when I used the word "observers," it was not the correct term. They will be Air Force officers, but they will be integrated into our Gemini project office in Houston and will be working on a day-by-day basis alongside our engineers, and will in that way participate directly in the program.

Additional categories under Gemini are spacecraft operations for $14.6 million; the launch vehicles for Project Gemini, that includes the Titan II and for this we are requesting $46,900,000 in fiscal year 1964; the Atlas launch vehicle for $15.9 million and an upper stage for the Atlas, the Agena, which will be used as the target vehicle in Gemini rendezvous missions. For Agena development and procurement we are requesting $32 million in fiscal year 1964.

The last line item under Project Gemini is supporting development which includes minor contracts in direct support of the program, for example, the space suits that will be used by the astronauts in Gemini and the food and waste control system for Gemini. For this we are requesting $700,000 in fiscal year 1964.

The total R. & D. direct request then is $306,300,000. The addition of personnel costs and operations of installation costs brings the total request for Gemini to $335,339,000.

Mr. TEAGUE. Mr. Fulton, did you have a question?

Mr. FULTON of Pennsylvania. I had a question on the type of Agena that NASA proposes to use as a rendezvous target vehicle for Gemini. What kind of a vehicle is this Agena and how does it compare with the previous costs for Agena developments? It seems like an expensive vehicle so I think we ought to know why this is different.

Mr. Low. The Agena itself is the standard Agena used as an upper stage in, for example, our Ranger program and in the Mariner program which launched an unmanned spacecraft to Venus.

Mr. FULTON of Pennsylvania. I expect that, but what are you going to put on it that is costing so much?

Mr. Low. I should point out first that under this program we are purchasing eight Agena stages, not just one. We are initially buying the standard Agena vehicle. We are then incorporating into it certain modifications that allow it to be adapted as a target vehicle for rendezvous.

One of these is a capability for multiple restarts. The Agena as it stands today can be restarted only once. For the Gemini mission, where it must perform a number of maneuvers in space before rendezvous, we must have the capability in it to allow it to be restarted either from the ground or from the Gemini spacecraft five or six times.

To do this, we need a modification in the Agena system. In addition to that, we are incorporating in the Agena a radar beacon which will be used to communicate with the radar receiver on the Gemini spacecraft in order to effect the rendezvous maneuver.

Also a flashing light will be incorporated which can be used by the astronauts to obtain or to do a visual rendezvous without the use of the radar and computer system.

These, in essence, are the major modifications, incorporated into the Agena.

Mr. FULTON of Pennsylvania. Could you then give us the number of Atlases as well as Titan II's in this program?

Mr. Low. We are programing 15 Titan II's, 8 Atlases, and 8 Agenas for Gemini.

Mr. FULTON of Pennsylvania. Do these Atlases cost the same price you have been paying for regular boosters?

Mr. Low. The Atlases for the Gemini program will cost slightly less than the Atlases for Project Mercury in that we do not have to incorporate in them an abort sensoring system to trigger the Mercury escape system in case of abort. Since it will be an unmanned vehicle we do not need that.

Mr. FULTON of Pennsylvania. How are you pricing the Titan II individually with the Air Force?

Mr. Low. The Air Force has set up a separate project for the Gemini launch vehicle which is a modified Titan II. For example, the Titan II weapon system is being produced in the Martin Co.'s Denver plant. The Gemini launch vehicle, the Titan II for Gemini, is being produced by the Martin Corp. in Baltimore. The cost associated with this vehicle is entirely separate and we reimburse the Air Force for it.

Mr. FULTON of Pennsylvania. Are you getting the same prices from the Martin Co. that the Air Force is getting on their type of vehicle?

Mr. Low. No, sir; we are paying somewhat more for the Titans for Gemini than the Titan II for weapon system would cost and the reasons for this are several:

First of all, for the manned booster we have a much more severe quality assurance program, what we call a man-rating program. Each part and component is individually traceable and individually inspected to assure the highest possible reliability for the manned booster.

In addition to that, we are——

Mr. FULTON of Pennsylvania. Is that in addition to the General Electric contract?

Mr. LOW. Yes, sir.

In addition to that, we are incorporating in the Titan II a malfunction detection system. This is a system similar to the abort sensing system used in Project Mercury to allow pilot emergency escape maneuvers to be performed in case anything goes wrong with the booster during the launch phase.

These are the additions in the Titan II for Gemini.

Mr. TEAGUE. Have you gone far enough in the paraglider technique that you are convinced that is going to be the system you use?

Mr. LOW. In the initial Gemini flights we will use an 84-foot parachute. This parachute is being developed now for Gemini—in fact its development program has been completed and it is now beginning its qualification test program.

The paraglider is being developed at our flight research center at Edwards Air Force Base under contract to North American Aviation Co., but its developmental program is still in its initial stages and we are not completely convinced that it will be developed in time for the first few Gemini flights. It is a new device and will have many benefits if we can use it and when we can put it into the program, but it is not yet at the stage of development where we can say this is the way we will go early in the program.

Mr. TEAGUE. Why did you go to a completely different escape system in Gemini than you did in Mercury?

Mr. LOW. In Gemini first of all we incorporated the paraglider as one of its major design features and the reason for this was to allow a land landing with no vertical velocity, with a conventional airplane-type land landing and, therefore, allow a landing in a much more conventional system than the Mercury landings.

As a backup to the paraglider however, we felt we would need aircraft-type ejection seats in case the paraglider should malfunction, just as anything might go wrong with a high-speed fighter. We found once we had the ejection seats incorporated and these are needed because of the paragliders I mentioned, that these ejection seats would also allow us to perform the escape maneuvers that we would do with the escape tower in Mercury. This is true in Gemini because we have different propellants than in Mercury or Apollo. We have so-called storable propellants which are not as highly explosive. In the case of a booster malfunction, the fireball would not be quite as big as it would be in either the Atlas or in the Saturn, and therefore our studies indicated the ejection seat would be adequate to get the pilot away from a malfunction.

Since we needed the ejection seats as a backup landing system and they performed the second function of emergency escape, our studies indicated we did not need an escape tower.

Mr. TEAGUE. Mr. Yeager?

Mr. YEAGER. Could you describe the POGO effect of the Titan II, and tell us whether or not this problem is being overcome?

Mr. Low. The so-called POGO effect is a vertical vibration that has been found in almost all of the Titan II weapon system tests to date. I should point out insofar as the weapon system is concerned, this effect is of no concern. It is a vertical vibration of less than 1 g during a certain minor portion of the flight of the booster stage.

However, in a manned flight we cannot tolerate this vibration because the man would not be able to see the spacecraft instrument panel during the period of this vibration. In effect, the instrument panel would vibrate, his face and eyes would also vibrate which would not allow him to clearly read his instruments. Since the abort system in Gemini makes use of displays on the instrument panel, it is absolutely essential that the pilot be able to read his instrument panel at all parts of the flight so we must overcome the POGO problem for our manned flights in Gemini.

We are working closely with the Air Force on this and are confident it will be overcome in the normal Titan II development before we start manning Gemini flight.

Mr. YEAGER. Will this require extra funding?

Mr. LOW. I am not sure yet, Mr. Yeager, whether it will require extra funding or not. Hopefully it will be handled within the normal development program for the booster.

Mr. GURNEY. Why do you need the 15 Titans and 8 Atlases?

Mr. LOW. In our program we have planned for 12 missions and 3 backups. We are therefore buying 12 Gemini flight spacecraft and 15 Titans, because we could reuse 3 of the spacecraft in case we have to fly the backup missions.

As far as the Agena is concerned, we are programing now for 8 rendezvous missions out of the 12 missions.

The remaining manned missions would be long duration missions in which we would not use the Agena so our program is a total of 12 flights with 3 backups, 8 of which will be rendezvous missions and therefore 8 Atlas-Agenas.

Mr. TEAGUE. Do you have to fund all of these this year?

Mr. LOW. All are being partially funded this year.

Mr. TEAGUE. Partially funded?

Mr. LOW. That is right.

Mr. FULTON of Pennsylvania. Could you give us the funding program. How you are doing it and the method?

Mr. LOW. I have with me the programing for fiscal years 1963 and 1964. I don't have the following years' funding with me now.

Mr. FULTON of Pennsylvania. If you could give us the fiscal year 1964 obligation of funds according to time, it would be helpful. As you are working on these various boosters, are you paying for them partly as you go along, starting one after the other? What is your schedule on that for fiscal year 1964?

Mr. LOW. I would have to provide for the record our schedule of funding during fiscal 1964. We are funding both the spacecraft and booster on a partial basis.

For example, in fiscal 1964 we will take delivery on a number of the spacecraft and boosters and these will be fully funded. Those to be delivered in fiscal 1965 will only be partially funded.

(The information requested is as follows:)

The fiscal year 1964 obligation plan for Project Gemini is as follows:

1st quarter	$104, 448, 000
2d quarter	79, 638, 000
3d quarter	73, 206, 000
4th quarter	49, 008, 000
Total	306, 300, 000

Mr. FULTON of Pennsylvania. We should have the leadtime of the construction programs correlated with your operating or flight programs showing us what the leadtime might be.

Mr. LOW. In general terms, the leadtime for Titan II, the Atlas, the Agena, and Gemini spacecraft is from 15 to 19 months, and this is why we have to fund spacecraft and boosters to be delivered during fiscal 1964.

Mr. FULTON of Pennsylvania. You have a 4-month variation in your own estimates when referring to 15 to 19 months leadtime, don't you?

Mr. LOW. I perhaps misstated this. The 15 to 19 months comes about because the leadtime is different for the Titan II, the Atlas, Agena, and Gemini spacecraft, but they all fall within this 15 to 19 months' spread. We have a definite time within that for each one of the elements. Three months should be added to these production times for the total leadtime before launch.

Mr. FULTON of Pennsylvania. On the succeeding flights, other than the first three flights, what effect would it have on the program if there was a delay in the funding?

Mr. LOW. It would undoubtedly and definitely stretch out the program.

It would delay the flights on a day-by-day and month-by-month basis and since the Gemini program is one of the major and significant steps in our Apollo lunar landing programs for many reasons, for pilot training, for the development of hardware, for the development of the operational systems and the ground crews, this then would in turn have an effect on our Apollo program.

Mr. FULTON of Pennsylvania. Suppose the backup money for three flights was given to you in fiscal year 1963. That would not interfere with your current operating plans for 1964, would it?

Mr. LOW. Since I don't have with me the exact schedule of funding, I am not sure whether the backup funding for the three flights, three additional Titan II's is now included in our 1964 budget or whether this was planned for 1965.

Mr. FULTON of Pennsylvania. Could you let us have a statement on that, with the chairman's permission?

Mr. LOW. Yes, sir.

(The information requested is as follows:)

None of the fiscal year 1964 budget request for Project Gemini has been planned for use in procuring the last three Gemini launch vehicles, since the production leadtime is 16 months. These vehicles will be funded in future years.

Mr. FULTON of Pennsylvania. Are these costs estimates, and if estimates, are they your estimates or are they company estimates?

Mr. LOW. In general terms, our costs are based on company estimates and our past experience in running programs like this.

Mr. FULTON of Pennsylvania. The estimates of the company are the basis of your own judgment, and as a matter of act, you do not

have these particular programs and the necessary boosters, hardware and capsules under contract to a great extent, do you?

Mr. Low. I believe, Mr. Fulton, that each element of the Gemini program is now under a definitive contract with our hardware contractors. The Gemini spacecraft contract with McDonnell is a firm definitive contract.

Mr. FULTON of Pennsylvania. That is, it is not a fixed price contract because it has already gone up $42 million from the first estimate that McDonnell gave you?

Mr. Low. It is a cost-plus-fixed-fee contract.

Mr. FULTON of Pennsylvania. When this committee sees the increase of $42 million in such a short time on the McDonnell spacecraft contract, it raises a question in my mind as to whether we will run into more increases as we go along in this McDonnell spacecraft contract. Are we operating on a fixed budget or are we on an escalated budget?

Mr. Low. We are trying to take into account, Mr. Congressman, the types of changes that normally occur in a development program of this nature. We do have our Mercury experience now to back us up.

The increase on Gemini between the money requested in fiscal year 1963 and the money we have now programed in our operating plan occurred at a time before the scope of the Gemini contract was fully defined. I believe the last time we appeared before this committee I went through a history of the Gemini program and the status of that contract at the time the money was requested. We are, I believe, in a very much better position this year in that we do have a definitive contract now with McDonnell Aircraft Corp.

Mr. FULTON of Pennsylvania. My feeling has been that we should get away from chosen instrument contracts. The McDonnell Aircraft Corp. operated well on Mercury in preparing the capsule and it was a fine performance, but when we come to the Gemini, there is no company or no Government agency that has had any experience.

My own feeling is that the contracts are so big that they encourage monopoly in the space business. These contracts should be broken down into their components, and added specifications written by NASA so that you can have a broader base of industry engaged in the NASA programs. Secondly, this will allow smaller companies to compete. Thirdly, the taxpayers will get the advantage of public bid on components that within the space industry are now becoming standard at the level of reliability requirement.

It concerns me this industry is getting so concentrated and that there is not the followup beyond the first level of subcontractors. When you get into further levels down into smaller uniform components, it becomes almost an impossible task for NASA to sit at the top of Mount Everest and follow through many levels of subcontractors to see that an efficient job is being done.

Mr. Low. Mr. Fulton, first of all, I would like to point out that the Gemini contract was awarded to McDonnell on a single-source basis. All of the other contracts that I will discuss this morning in the manned spacecraft systems budget were awarded as a result of industrywide competitive bids.

Now we felt at the time that we let the Gemini contract that we had to go to McDonnell on a single-source basis because of the very striking similarity between Mercury and Gemini.

I have a model behind me of the Gemini spacecraft. As you can see, for example, the external shape is identical to the Mercury. Many of the systems and subsystems are the same as in Mercury. The technology involved in Gemini is an extension of Mercury technology.

Mr. FULTON of Pennsylvania. Once the specifications are written for these particular components and structures, it would seem to me that anybody who is in the space field could come up with the same reliability and supply them to possibly McDonnell on bid or supply them directly to NASA.

Mr. Low. This is being done to a large extent in our subcontract structure. For example, in fiscal year 1964 we are programing $102 million to McDonnell for its inhouse effort and $82 million to the subcontractors. Approximately 40 percent of the total to McDonnell is being spent in industry as a whole among major and minor subcontractors.

Mr. FULTON of Pennsylvania. That is right, but there is not the public advertising and bidding that we have on the usual Government contracts. My point is that the space industry is now an experienced field and the terms of merchantability and guarantees that are needed are very well set.

My criticism, if any, of NASA is not having an inhouse capability to come up with adequate specifications once you have the research and development completed on a major program such as the Mercury capsule, which then, of course, requires modifications for the Gemini.

NASA goes to the many industrial companies and has them put their best engineering talents in preparing proposals and then there is little consideration given to the bid and it is rejected. This is an economic loss. Likewise, it looks to me, from the company point of view as a corporation attorney, that the companies are soon going to get tired of submitting proposals since they put $300,000 or $400,000 or $500,000 or a million dollars into the preliminary design work, without receiving a contract.

Mr. Low. I think. Mr, Fulton, we in NASA recognize the problems you have mentioned. We have in some of our more recent procurements taken steps in the direction that you have suggested to us last year and are suggesting again this year.

For example, in the lunar excursion module competition—this is the module—I have a model of it sitting behind me—for landing on the Moon—this is a contract that was won by the Grumman Aircraft Engineering Corp.

We had in this program better specifications, more detailed specifications than we had a year or so earlier for the Apollo spacecraft. As a result of this, we put out to industry a very detailed work statement, requested the bids to come in in a much shorter time than usual, asked in our request for bids some very specific questions and severely limited the number of pages that industry was allowed to submit to us. In this way we limited the expense by industry in bidding on this. We limited the expense by the Government in evaluating the proposals and all of us are convinced we got a better proposal and a better evaluation than we had in the past.

This is one step that was taken. Another step that was taken along the lines that you have suggested was in the procurement for

the Mission Control Center at Houston. This contract selection was run in two phases.

We first solicited all possible companies in this country, and asked them to tell us their qualifications to bid on a job like this. We asked for these qualifications in a very simple and rudimentary fashion. It only took two or three pages for each of the companies to provide this information to us so the amount of effort by a large number of companies in providing this information was relatively minor. On the basis of this initial information, we then selected those companies which we felt would be most qualified to do the job on the basis of their past experience. Our request for proposal then went out only to that limited number of companies.

Again we followed the same scheme as we had in the lunar excursion module procurement of a definitive specification, a limited number of pages, and responses to specific questions to eliminate the effort by industry in bidding on this.

In both of these cases I mentioned I believe we got a very good contract selection and I have had a lot of comment from industry saying that this is the way one should conduct one's business.

Mr. FULTON of Pennsylvania. I would like to compliment NASA. I made a strong objection on the procurement and the high backing test facilities and now you have, according to your telegram to me, gone over to public bidding on the portions of the facilities that were not technical research and development, so I do compliment you on that.

Mr. RIEHLMAN. Following the outline and procedure that you are suggesting this morning and that NASA is following at the present time, how many companies competed in the bid for the lunar excursion module, and also the contract you just referred to?

Mr. LOW. In the lunar excursion module, I believe there were nine contractors competing.

In this one we cannot run the preselection that I mentioned in connection with the Mission Control Center.

For the lunar excursion module, I believe every major aircraft company in the country bid. I can add all of them into the record, but typically Boeing, Lockheed, Douglas, and Republic. McDonnell and North American did not bid because they felt that they were too heavily engrossed in the early stages of our Gemini and Apollo spacecraft programs so they did not bid on these, but all of the others did.

In the Mission Control Center—and I will have to provide the exact number for the record if you want it, but as I recall in our preselection, there were about 60 companies and about 6 of these were preselected and bid. Again the number may be seven or eight but it was near that number.

Mr. GURNEY. Let me ask another question on these launch vehicles. You said NASA needs 15 Titans. As I understand, you actually have scheduled 12 flights, 8 of which are rendezvous and 4 of which you called long-duration flights?

Mr. LOW. Long-duration missions of up to 2 weeks in orbit.

Mr. GURNEY. When do these take place, initially or after the rendezvous?

Mr. LOW. Our planning is that the long-duration missions would take place initially and the rendezvous missions would be time phased after the long-duration mission.

Mr. GURNEY. Why can't you combine them? For example, why do you need four long-duration flights prior to your eight rendezvous flights? Why can't you combine some of the long-duration flights with the rendezvous flights?

Mr. Low. Mr. Gurney, we will initially have one or two unmanned flights so there will be at most two or three long-duration flights.

Now, in these long-duration flights, we plan to build up in one or two progressive steps to a 1- or 2-week capability in orbit because, after all, the possible biomedical problems associated with the long weightlessness are what we want to study here and we don't feel we can take this in a single step.

But, to specifically answer your question: Why can't we combine them? For the rendezvous mission we must carry in the Gemini spacecraft about 700 pounds of fuels, propellants, to effect the final docking maneuver, the maneuver where the Atlas-Agena target and the Gemini spacecraft finally come together. With this added propellant weight, we cannot get into a sufficiently high orbit to allow for a long-duration mission.

For the rendezvous missions we will be in a lower orbit but in a period of 5 or 6 days in that lower orbit, the friction of the air would slow the spacecraft down and would allow the orbit to decay so we could not stay up for a full 2 weeks. For the long-duration mission, we have to go to a higher orbit with a lighter spacecraft, and, therefore, cannot carry those propellants.

Mr. GURNEY. Why do you think you need four of the long-duration—no, you said you are allowing two?

Mr. Low. Two or three, depending on the number of unmanned flights.

Mr. GURNEY. What is the other one?

Mr. Low. Unmanned flight.

Mr. GURNEY. Is that going to be the first one?

Mr. Low. That will be the first one and possibly the second one might be unmanned.

Mr. GURNEY. Then that will be followed by two or three long-duration flights?

Mr. Low. That is right, and if, for example, in our long-duration flights we find that after a week or so in orbit we have to terminate the mission either for technical difficulties or because preliminary indications of medical problems, then we might have to fly more than two or three long-duration flights.

Mr. GURNEY. Why do you need eight rendezvous flights?

Mr. Low. In developing the rendezvous capability, we must study a number of different possible ways of conducting the rendezvous in order to get the best possible way defined before we do the rendezvous missions in lunar orbit rendezvous in Apollo.

I alluded to some of this before but I think I should be more specific.

For example, we can conduct a rendezvous maneuver in Gemini by purely visual or optical means. In this case there will be a flashing light on the target vehicle. The pilot in the spacecraft will look out of his window and he will rendezvous and fly the spacecraft toward the flashing light and perform the docking. This is one extreme of a purely manual system.

On the opposite end of the spectrum we have a purely automatic system in which we have a radar, computer, and stabilized platform

and, from about 200 or 500 miles out, the spacecraft and the target vehicle lock on to each other by radar and all maneuvers take place automatically from that point on.

We know from our studies on the ground and our simulations that the automatic way is probably the most efficient way of doing it. We would need the least amount of fuel to do it automatically. On the other hand, it is also the most complex way. We need more equipment, and more equipment can fail in this maneuver so it might not be the most reliable way. The completely visual method is the least efficient as far as propellants are concerned, but perhaps the simplest. In between there are many possible combinations of these things.

For example, we could use a radar for determining the distance and the relative velocity between the two without determining the relative angle between the two spacecraft and let the man himself determine the relative angle. We feel we must get actual experience in space flight of a number of these possibilities before we can perform the lunar orbit rendezvous in Apollo.

Mr. GURNEY. Is your spacecraft going to be equipped for both of these maneuvers, the automatic and the manual?

Mr. LOW. Yes, sir.

Mr. GURNEY. They are?

Mr. LOW. Yes, sir.

Mr. GURNEY. Can you do both on the same mission?

Mr. LOW. You cannot do both on the same mission because you can only perform one rendezvous maneuver in any given mission with the amount of propellants available for that particular mission.

Mr. GURNEY. Your automatic mission would use up so much of the propellant that there would not be any left for the manual, is that correct?

Mr. LOW. That is right, because in order to do two missions we would have to go all of the way through a maneuver and then separate and fly the two vehicles apart again for several hundred miles and then come together again. This we cannot do within the propellant limitations of spacecraft.

Mr. GURNEY. How long does it take to manufacture a Gemini spacecraft?

Mr. LOW. The exact number I would have to get for the record if you wanted it, Mr. Gurney. It is somewhat in excess of 15 months for completion of manufacture. An additional 3 months is needed between completion of manufacture and launch.

Mr. GURNEY. For each one?

Mr. LOW. Yes, sir. This includes the manufacture, the testing, the verification of the systems, and the installation of all of the subsystems. It takes approximately 15 months.

Mr. GURNEY. When do you expect to have these delivered to NASA? Have they started manufacture on them yet?

Mr. LOW. Yes, sir.

Mr. GURNEY. When do you expect the first delivery?

Mr. LOW. The first delivery is scheduled for September or October of this year.

Mr. GURNEY. And then you have them scheduled for——

Mr. LOW. For delivery every 2 to 3 months thereafter, depending on the flight schedule.

They will be delivered to Cape Canaveral where they will be checked out for the flights.

Mr. ROUDEBUSH. Mr. Low, I would like to ask about the manned shot you have scheduled in Gemini. Will that be a ballistic flight?

Mr. Low. Yes; it will be a ballistic flight to test the compatability of the Gemini spacecraft with the Titan II booster and, in addition, to verify the spacecraft structure and heat shield during the reentry maneuver.

Mr. ROUDEBUSH. Will the Gemini capsule that you use for the ballistic shot contain all of the electronic equipment, and so forth, that the regular capsule does?

Mr. Low. No, sir. It will not. Of course all of the external shape and structure will be identical to the final configuration. The internal components will be only those needed for unmanned ballistic flight.

Mr. ROUDEBUSH. How many of the reentry models are we buying altogether, 15?

Mr. Low. Twelve flight articles. In addition to that we are buying a number of so-called static test articles for the ejection seat development program.

Mr. ROUDEBUSH. One of the static type vehicles will be used on this unmanned shot, is that correct?

Mr. Low. It will be very similar to one of the static type vehicles.

Mr. ROUDEBUSH. And the adapter module, you will need 15 of those too?

Mr. Low. Yes, sir.

Mr. ROUDEBUSH. I just want to be sure I have my figures correct.

We are buying 15 Titan II's for the entire program and 8 of the Agena stages and 8 of the Atlas boosters?

Mr. Low. That is right.

Mr. ROUDEBUSH. These items which you list for the proposed fiscal year 1964 budget, and I think this gets back to Mr. Fulton's question, for example, let's take Titan II.

You list $46,900,000. What portion of the total cost is the cost of the 15 Titan II's? I think that is what we are trying to get at. Is this the total cost of 15 Titan II's or is it a proportionate share according to scheduling?

Mr. Low. This is a proportionate share.

If you will look at RDO 1–5 you will notice in fiscal 1962 we spent $22,391,000 for the Titan II and $59,280,000 in fiscal year 1963. We need $46.9 million in fiscal 1964 and there will be an additional amount of funding in fiscal year 1965.

Mr. ROUDEBUSH. In other words, we would have to add these figures together for the 3 fiscal years, including the proposed budget, plus what you anticipate the cost will be next year to get our total cost?

Mr. Low. That is right.

Mr. ROUDEBUSH. I think that explains the point I was trying to get at on the scheduling. It is a 4-year scheduling on these particular launch vehicles; is that right?

Mr. Low. That is right.

Mr. FULTON of Pennsylvania. I believe you made an estimate for Mercury of 10 as the number of your missions? I see now that you plan on 12 for Gemini, with 3 backups.

Why wouldn't you use the same norms of estimates and prognosis on the Gemini flight that you have used as a base for a successful Mercury program just being finished?

Mr. Low. In Project Mercury, the mission was tied to a fixed orbit in space. Once the spacecraft had been launched, there were no maneuvers to be done except for the attitude control. There were no rendezvous maneuvers to be learned as there will be in Gemini. Therefore, the Mercury program was built around a buildup in time of weightlessness to assess the man's reaction to this new environment. In Gemini this is also one of our purposes.

As I discussed a few moments ago, we plan to build up in Gemini to a full 2 weeks' duration flight.

However, because our Mercury experience is behind us, we feel we need fewer missions for this buildup than we needed for the buildup in Mercury. The additional missions in Gemini are for the rendezvous flights, whereas I explained a moment ago there are so many possible combinations of things we must learn that we feel eight rendezvous missions is a minimum number of missions to learn all of these things for Apollo.

Mr. FULTON of Pennsylvania. Could you get through with your program on an austere basis, using five or six rendezvous missions which are funded in fiscal year 1964? What effect would that have?

Mr. Low. I think I should say that our people, both in my office and in Houston, feel that the program with eight missions is probably more austere than they would like to see it and it is a minimum program that we now feel is required for our Apollo program. If we cut it down to five, as I mentioned before, some of the items I discussed with Mr. Gurney a moment ago, we would not be able to do; but perhaps more important than that, we would not be able to train a sufficient number of astronauts in flight experience for the Apollo missions.

Major Slayton, who is now as you know, in charge of our astronaut program in Houston, has recently completed a very detailed and intensive study of the training requirements for the pilots for the manned lunar landing mission and he has identified that the 12-program Gemini missions is an absolute minimum to have a sufficient number of pilots ready for the Apollo flight missions.

Mr. FULTON of Pennsylvania. There must be some leeway in your estimates. It would be poor judgment and poor planning if there were no leeway left for the various contingencies that may arise.

What amount is that leeway over and above the addition of the individual costs of the respective flights?

Mr. Low. To the best of our knowledge and in our best judgment, there is no leeway in this budget.

I am very much concerned from past experience that we have budgeted insufficient money because we have not yet started our flight test program and difficulties, the unforeseen difficulties, usually occur in the flight test program.

Mr. FULTON of Pennsylvania. Would you give us your comment as to the effect on the program—this can be done later if you like—that a cut of 10 percent or 5 percent would have? What would be your best approach if we were to say that there should be a postponement of the procurement of the boosters and the vehicles necessary for the later flight? You have planned for these, but you don't know as yet how much progress you are going to make in the research and development on the earlier flights.

Would you just comment on that, please?

Once you have made two or three Gemini flights you will be in a much better position to do more than "guesstimate" what those costs will be for the later flights. At present, no one on earth has any idea of the problems that you are going to run into, large or small, short or long.

In order to have a budget that we can work on, possibly you should recommend to us either a postponement that will not hurt your program, or a statement that you will give us more accurate estimates of later flights. Also, if we ask you to tighten the program up either by 5 or 10 percent, on the $335 million, what effect would that have?

Now those are the various possibilities and alternatives on which we need technical advice as to which is the best approach in the direction of tightening the budget.

Mr. LOW. I would have to provide any effect of a 5 or 10 percent reduction in this budget.

I do know, as Mr. Holmes pointed out, that the schedule is budget critical.

Mr. FULTON of Pennsylvania. We should have the various choices that are open as to cutting this budget commented upon by you. Probably you should put into order of your choice, which approach would hurt the least?

Mr. LOW. I would have to provide the specification later.

Mr. FULTON of Pennsylvania. Could we have a statement prepared on it, Mr. Chairman?

Mr. TEAGUE. Very well.

(The information requested is as follows:)

The information that will be obtained from Project Gemini flights represents a vital link in Apollo design and the assessment of man's reaction to prolonged weightlessness. In view of its pivotal role in the steps leading to manned lunar landing, it is unlikely that a reduction would be absorbed in Project Gemini. The impact of a reduction would result in major reprograming and rescheduling of the Apollo/Saturn effort.

From an academic point of view, a 5-percent cut in the fiscal year 1964 request for Project Gemini would cause a slip of 6 weeks to 2 months in the schedule for the second and subsequent flights. A cut of 10 percent in the fiscal year 1964 program would result in a 4 months' slip for these flights. These reductions would culminate in a much greater increase in cost in later years because of the program stretchout.

Mr. GURNEY. Mr. Lilly, about a week or two ago when Mr. Holmes and Mr. Low were here we discussed the estimate on the Gemini program for 1963.

I think we were talking about $153 million, and it turned out these were not estimates but were "guesstimates" on the part of McDonnell and on the part of NASA. Now as I understand it, this McDonnell contract was formalized only a short time ago, isn't that correct?

Mr. LILLY. That is correct.

Mr. GURNEY. And was formalized after the preparation of this budget we are talking about now, is that correct?

Mr. LILLY. The McDonnell contract was definitized after the preparation of this budget; yes, sir.

Mr. GURNEY. Of this $196,200,000, how much of that figure represents the actual firm figures from McDonnell and its subcontractors?

Mr. LILLY. I think that Mr. Low can discuss the chronology of this contract in more detail.

The contractor was selected, as I recall, in December 1961.

Mr. GURNEY. I remember that, and I don't think we have to go over it again. What I am saying is that of the $196,200,000, how much of that figure is actually in there from firm McDonnell subcontracts such as, for instance, the cables that go into Gemini vehicles?

Mr. LOW. Perhaps I could add to that.

The formal contract negotiations with McDonnell started as early as last August, before we put this budget together. At that time, we had a firm cost proposal from McDonnell which did not change significantly during the negotiations. At that time all of the subcontractors were on board. Perhaps I should not say all, but the major subcontractors were on board with McDonnell, and McDonnell in turn had firm cost estimates from them so that the basis for the number in this budget book is based on firm McDonnell estimates.

Mr. GURNEY. Why did it take you so long to arrive at the final figure if NASA and McDonnell had these figures last fall? Why didn't you formalize the contract before—when was it now—a month ago?

Mr. LOW. The final contract was signed during this month.

Mr. GURNEY. During this month?

Mr. LOW. The detailed negotiations concern themselves with the fee part of the cost proposal during the latter stages of these negotiations.

In these negotiations, we first determined with McDonnell the project costs for the effort involved in a job like this, in a great amount of detail. This is done during the early parts of negotiations. After that, the negotiations concentrate on a fair fee for the contractor and this occurred during the latter stage of the negotiations.

Mr. GURNEY. When you finally signed this contract 2 or 3 days ago—it must have been then because we are not very far in this month—how much did that figure differ from the figure you discussed last fall, do you know?

Mr. LOW. I would have to get the specific figures for the record. It in total differed very little, talking about a few percent only.

Mr. GURNEY. Can we have that figure because this $196 million obviously must have been based upon your conversations last fall?

Mr. LOW. That is right.

Mr. GURNEY. What I am trying to find out is where we are now that you have signed the contract. I think we should have those figures.

Mr. LOW. We can provide those.

(The information requested is as follows:)

The difference between McDonnell's recently negotiated contract cost of $457 million and the estimate of $438 million last fall resulted mainly from necessary program changes. These items include: additional spare parts; the cost effects of a 4-month stretch-out; provision for an interface with automatic checkout equipment; and a spacecraft weight reduction program. Decreased estimates for aerospace ground equipment, launch site support, and test programs counterbalanced the increases to some extent. Further reductions resulted from negotiated decreases in McDonnell's labor rates, general and administrative expenses, and fee.

Mr. FULTON of Pennsylvania. Would you yield?

Mr. GURNEY. Yes.

Mr. FULTON of Pennsylvania. Your previous comment on the McDonnell contract was that it is not a fixed price contract but a cost plus fixed fee contract, so there really is no amount on the McDonnell contract that we can depend on right now?

Mr. Low. The amount in the definitized contract is the best joint estimate between the Government and the contractor of what the effort involved in this work will cost, plus a fee of about 6½ percent.

Mr. FULTON of Pennsylvania. That is simply an estimate and does not bind McDonnell nor does it bind NASA.

Mr. Low. No, sir. What we have to do from here on out is maintain a very tight control on the cost to assure ourselves that McDonnell indeed performs on schedule and delivers the hardware that we are requiring within the dollars allocated for this contract.

Mr. FULTON of Pennsylvania. On McDonnell subcontractors and sub-subs on down the line, are they fixed price contracts, or are they also cost plus fixed fee contracts?

Mr. Low. Some of them are cost plus fixed fee and others are fixed price.

I don't know which they are.

Mr. FULTON of Pennsylvania. Could you set those out so we have an idea of how the contract is set up?

Mr. Low. Yes, sir.

(The information requested is as follows:)

Types of contracts for McDonnell subcontractors and vendors

	Percent of total dollars for subcontractors and vendors	Percent of total number of subcontractors and vendors
Cost-type contracts	81	1
Fixed-price-type contracts	19	99
Total	100	100
Sole source procurements	12	10
Competitive procurements	88	90
Total	100	100

Mr. FULTON of Pennsylvania. When did the $42 million increase become apparent to NASA? Is that a statement by McDonnell that it had to cost $42 million more or was that developed through NASA?

Mr. Low. This was based on the first firm cost proposal we had from McDonnell as analyzed by NASA.

Mr. FULTON of Pennsylvania. And that was $42 million above your own figure, wasn't it?

Mr. Low. That was $42 million above the figure we had estimated a year and a half ago.

Mr. FULTON of Pennsylvania. Could you give us the date of that estimate of cost?

Mr. Low. The approximate date of that would have been in October or November of 1961.

Mr. FULTON of Pennsylvania. Then the $42 million occurred within what time of that date?

Mr. Low. That occurred about a year later, the summer and fall of 1962.

Mr. FULTON of Pennsylvania. Evidently it did not occur all at once so it must have been becoming apparent during the year?

Mr. Low. Yes, sir.

Mr. FULTON of Pennsylvania. How did it arise? You see we have heard this figure and it naturally raises the question that it just did not rise up out of the sea like a monster.

The contract had to be amended in certain respects. How did that happen?

Mr. LOW. There is no single specific line item in the contract to which I could attribute that $42 million.

Mr. FULTON of Pennsylvania. Somebody made an error of judgment. It might have been a misjudgment or a wrongful judgment but it was not correct, let's face it.

Mr. LOW. That is right.

Now in our negotiations with McDonnell, we split the effort into perhaps 20 or 30 major items and under each one of these we have 10 or 15 additional items. The $42 million consists of additions in certain areas, subtractions in other areas. A typical item for instance of major breakdown would include the fabrication of the structure, the actual external shell.

Mr. FULTON of Pennsylvania. Rather than go into it now, why don't you give us the elements of the contract and how they increased or decreased in price during this particular period. You should also give us the reasons for this because we must justify on the floor a $42 million increase in the contract within a period of a year?

Mr. LOW. Yes, sir.

(The information requested is as follows:)

A net increase of $43.1 million in the cost estimate for the reentry and adapter module is primarily responsible for the overall increase of $49.9 million for the Gemini spacecraft. This $43.1 million increase is caused by earlier phasing of subcontractor effort in fiscal year 1963 to meet the schedule requirements. This earlier phasing required an additional $44.4 million. It was offset by a reduction of $1.29 million in the McDonnell in-house requirement.

Mr. GURNEY. One other question along those lines: We have been talking about competitive bidding on this McDonnell contract and you explained why there wasn't competitive bidding on the basic contract.

In your exchange with Mr. Fulton just now, you mentioned that there has been some competitive bidding by the subcontractors so far as McDonnell is concerned. Now, how have you approached that? For example, what policy have you set so far as McDonnell taking competitive bids from subcontractors?

Mr. LOW. In all areas, Mr. Gurney, where we have subsystems that are not Mercury subsystems, McDonnell went out on competitive bid. For example, one of the major subsystems is the fuel cell for electric power generation. We have to go to a new system there because of the much longer duration. In Mercury as you know, we use ordinary batteries which get too heavy for long duration missions.

Now for the fuel cell, because it is a new system, McDonnell went competitively to its subcontractors. Now McDonnell's way, and all of our contractors' way, of selecting subcontractors competitively is very similar to the Government's way of selecting its prime contracts. They write specifications. Subcontractors prepare proposals to these specifications and they are thoroughly evaluated on the technical, management, and cost side by McDonnell, and finally McDonnell's evaluation is checked by NASA and certified as indeed an adequate selection as a subcontractor.

Mr. Gurney. How much would you say of the McDonnell subcontracting was not competitive, percentagewise and dollarwise?

Mr. FULTON of Pennsylvania. I asked for the detail all through that.

Mr. GURNEY. Did you ask for that?

Mr. LOW. I don't have that breakdown with me percentagewise.

Mr. GURNEY. One final question on that and I think this again is important on NASA's policy. Have you gone over very carefully with McDonnell where there has not been competitive bidding and asked them why there wasn't competitive bidding?

Mr. LOW. Yes, sir.

Mr. GURNEY. And did you get a reasonable answer?

Mr. LOW. Sir, we have to approve in Government the so-called make-or-buy policy of McDonnell. By this we mean that we have to approve specifically item by item when they will build things themselves, when they will go out and subcontract and when they go on subcontract, whether by competition or not. We have gone over this item by item and specifically approved the whole make-or-buy list.

Mr. GURNEY. Could you also give us a picture of that when you finish this detail on the McDonnell contract?

Mr. LOW. Yes, sir.

Mr. GURNEY. A picture of a noncompetitive subcontracting and why it was noncompetitive?

Mr. LOW. If you wish, I could read off a list of major subcontractors and show where these differ from Mercury subcontractors.

Mr. GURNEY. I don't think we need to go into it now but I do think we should have the information because this is a very major part of this whole program and certainly the competitive and noncompetitive end of it is extremely important.

Mr. TEAGUE. Mr. Casey?

Mr. CASEY. You have contracted for 12 Gemini spacecraft, and 3 of those 12 are going to be refurbished; is that correct?

Mr. LOW. Yes, sir.

Mr. CASEY. Would you tell us why you need 12? What happens to a spacecraft that cannot be used on your future flights?

Mr. LOW. We believe from our experience in Mercury that if a craft undergoes a complete and full mission that it cannot be reused. This is because it is used so much during the mission. So much life is put on each one of the systems, on the subsystems. The entire external body is seared by the heat of reentry. Any craft going into orbit and brought back would not be safe for an additional manned flight.

On the other hand, if we should be faced with an early malfunction so that we have to terminate a mission during the boost phase, where the spacecraft is then not brought up to the high orbital speed, then we could reuse that craft.

For example, in Project Mercury on the Mercury-Atlas No. 3 mission we flew spacecraft No. 6, I believe. That mission was terminated after about 1 minute, a little less than a minute. In this case there was a booster malfunction. The booster did not program or steer on its trajectory and the mission was aborted by the safety officer—this was an unmanned flight of course—after something less than a minute and at an altitude of about 30,000 feet. The speed at that time was

still fairly low. That spacecraft was refurbished and actually used in the next Mercury flight, the MA–4 mission, which was the first orbital flight.

We did not feel and were not able to reuse any of the spacecraft that actually went into orbit. The same philosophy is being employed in Project Gemini.

Mr. CASEY. How do you propose to use these three that you refurbish?

Mr. LOW. They would be used, and this is now insurance, if you will, against possible malfunctions using these highly complex boosters, they would be used in case there are early aborts, early emergencies in a mission. They would be used for repeat of the same mission we were unable to accomplish. In the same sense we flew a Mercury-Atlas 4 in the mission we planned for Mercury Atlas 3.

Mr. CASEY. Then it is not definite that you will refurbish three of them?

Mr. LOW. No, sir.

Mr. CASEY. Now the figure you gave a while back on McDonnell's contract, does that remain about the same, $456 million?

Mr. LOW. Yes, sir.

Mr. CASEY. What does that cover?

Mr. LOW. This covers the building of the two spacecraft modules, the reentry module and adaptor module. It covers the building of the docking collars or docking adaptors that will be mounted on the Atlas-Agena. It covers also the support by McDonnell Aircraft Corp. at Cape Canaveral of the checkout of the spacecraft and covers the aerospace ground support equipment used for the McDonnell checkout.

Mr. FULTON of Pennsylvania. Did I understand you to say that actually John Glenn went up in a secondhand spacecraft?

Mr. LOW. No, sir.

John Glenn went up in the Mercury-Atlas 6 which was a new spacecraft.

Mr. FULTON of Pennsylvania. So we have never used a secondhand capsule for any manned Mercury flight?

Mr. LOW. No, sir; we have not. The reuse of Mercury spacecraft was with our Little Joe program. Spacecraft 14 was flown twice on Little Joe and Spacecraft 6 was flown twice, and that was on Atlas 3, and 4. Atlas 5 was the chimpanzee orbit flight and Atlas 6 and 7 and 8 were the three manned flights with Glenn, Carpenter, and Shepard. All of these were new spacecraft.

Mr. ROUDEBUSH. How much slippage would we have if we settled on one initial booster; in other words, set the whole project Gemini up on the Titan II and forgot about the Atlas?

Mr. LOW. It is not a matter of slippage, Mr. Roudebush, but it is a matter of the booster that is most suitable for that part of the program.

Now, as far as the manned part of the Gemini program is concerned, we need the Titan II in order to lift the Gemini spacecraft which weighs twice as much as Mercury.

Mr. ROUDEBUSH. What is the thrust on Titan II?

Mr. LOW. About 430,000 pounds at takeoff.

This compares with 360,000 pounds with the Atlas but because the Titan II is a two-stage vehicle it has a capability of putting much more payload into orbit than the Atlas.

Now, there is no booster which combines the Titan II and the Agena. This would be a new booster and it would require major developmental changes and major costs in order to build such a booster. Therefore in order to launch the Agena target vehicle into orbit we are using the Atlas because it has been used in combination in the other programs like Ranger and Mariner. It is also being used by the military as an Atlas-Agena booster. This is the reason for selecting the Atlas-Agena combination.

Mr. ROUDEBUSH. Your first shots will be——

Mr. LOW. The first shot will use only the Titan II. The Atlas-Agena will not be used until the rendezvous missions which will be later.

The Gemini spacecraft will be mated only to the Titan II.

Mr. TEAGUE. What do you anticipate will be the impact of the NASA-DOD agreement on the Gemini program?

Mr. LOW. We seek a very much closer cooperation with the Department of Defense than we have had in the past.

We would expect that we would in the line of scientific experimentation. We will fly in the Gemini program any experiments that are useful not only to us but also to the Department of Defense for advanced technology.

Mr. TEAGUE. You anticipate more flights?

Mr. LOW. We don't expect more flights, but we expect to incorporate in our present flights scientific experiments that are of joint use both to the Department of Defense and to ourselves.

Mr. TEAGUE. Do you have any questions, Mr. Yeager?

Mr. YEAGER. Just a couple, Mr. Chairman.

Can you give us an approximation of the operational costs for carrying out each of these eight rendezvous Gemini flights?

Mr. LOW. The operational costs for each Gemini flight is of the order of $3 million and this includes recovery operations, it includes flight operations, the flight control that goes to all of the downrange stations; it includes Weather Bureau support and things like that.

Mr. YEAGER. What is the overlap, if any, between the first manned Apollo flights according to present schedule and the later manner Gemini flights?

Mr. LOW. There may be about 6 months overlap between the last Gemini flights and the first Apollo flights on Saturn I.

However Apollo rendezvous missions will not take place until we fly Apollo spacecraft on top of the Saturn IB and there will be no overlap. In fact, I believe there will be something like a year's gap between the last Gemini flight and the first Saturn IB flight on Apollo.

Mr. YEAGER. I have one other question on Gemini.

In the breakdown you show on page 5 of volume II an item of "Other," $47.7 million. Can you give us a little information on that?

Mr. LOW. I would be happy to. The "Other" category I have broken down in my own notes under McDonnell in-house effort and McDonnell subcontracted effort.

Under McDonnell in-house effort it includes the test site and launch support by McDonnell and it includes a static test program, a program which we have called Project Orbit in which a Gemini spacecraft will be put into an altitude chamber for periods of days and weeks to simulate as much of the space environment on the ground as we possibly can.

I might point out that it is this same Project Orbit experiment to which we can attribute to a large extent the success of Project Mercury to this kind of a test program.

For example, we identified in Glenn's flight difficulties with the small hydrogen peroxide attitude control jets. As you recall, he had to go from the automatic system to one of the manual systems because one of the automatic jets malfunctioned. Between Glenn's and Carpenter's flights, we did a major program of redesign of the small jets, tested them out in Project Orbit and then they worked in Carpenter's and Schirra's flight.

Other items included under "Other" are the flight simulation, the mission training aids that we need, like the procedures training that we used for Project Mercury, and the engineering reports, test plans, specifications, drawings, manufacturing and quality assurance procedures. Spare parts are included under "Other." This is for the McDonnell in-house effort and spare parts for some of the minor subcontractors that do not fall in the major subcontractor areas.

Mr. YEAGER. What is the percentage of the subcontractor total?

Mr. LOW. The total number under "Other" is $47.7 million. Of that $12.1 million I have programed under subcontractors and $35.6 million, or the balance, under McDonnell in-house effort.

Mr. YEAGER. Thank you. That is all.

Mr. TEAGUE. Mr. Fulton?

Mr. FULTON of Pennsylvania. NASA and the Department of Defense are going to get the gains from the Gemini program. Could you estimate for us with some degree of certainty what the percentage of benefit to each of those two Government agencies will come from the Gemini program? If you cannot make such an estimate, could it not be said then that as there are no specific military missions nor military weaponry systems for space that there might very well be for the security of this country, that a fair division might be about a 50-percent division between each of the two agencies?

You are each going to get a benefit. Nobody on Earth can tell you what the benefit is going to be in this research and development. Possibly we could just say it might be half a security benefit and half a peacetime uses of space research and development benefit. I would like your comment on that.

Mr. LOW. I would like to comment this way. We would have to do the Gemini program, as it now stands, even if there were no military interest in it whatsoever because we need the current and presently outlined Gemini program in support of the manned lunar landing program. In our agreement with the Department of Defense, we have firm agreements that all of the things in Gemini that are directly attributable to the manned lunar landing program shall have top priority in Gemini.

Now on the other hand, on each flight mission we have the capability of performing technological experiments. We have done so in Mercury. We have a rather impressive list of experiments for the next Mercury flights. Many of these experiments are what you might call a spin-off of the major results we are looking for and these I am sure as you point out, Mr. Fulton, will be of equal benefit to the Department of Defense as they will be to NASA.

Mr. FULTON of Pennsylvania. Isn't the Department of Defense sort of a monkey on the back of NASA in the Gemini research and

development program? The DOD is getting a free ride and it is not paying any of the costs.

Mr. Low. We are getting a tremendous amount of support from the Department of Defense in all of our space programs and I think——

Mr. FULTON of Pennsylvania. I hope they are patting you on the back occasionally and saying "Go ahead."

Mr. Low. As you pointed out, I think all of us are intensely interested in getting the most out of the space program both for national defense and for peaceful applications and, for this reason, we are pleased to support the Department of Defense with whatever we can give in Gemini.

Mr. TEAGUE. Any other questions on the Gemini program?

Mr. Low. May I go on with Apollo then?

Mr. TEAGUE. Yes, but you will not have time to finish it.

Do you want to go on with it this morning or would you rather wait until tomorrow?

Mr. FULTON of Pennsylvania. We can get through tomorrow if we don't interrupt him.

What does the witness think? Will you need today and tomorrow to finish?

Mr. PATTEN. What does Mr. Lilly think?

Mr. Low. I am here at your convenience, gentlemen.

Mr. TEAGUE. I have to leave about 10 minutes before 12.

Mr. FULTON of Pennsylvania. Why don't we quit?

Mr. TEAGUE. Will Mr. Holmes be back?

Mr. Low. I am sure he would like to come tomorrow.

Mr. PATTEN. May I ask one question?

You let the Air Force Systems Command purchase the Titan II for you, right?

Mr. Low. That is right; we are purchasing the Titan II from the Air Force Space Systems Division of the Air Force Systems Command.

Mr. TEAGUE. As you did the Atlas?

Mr. Low. Exactly the same as we did the Atlas.

Mr. TEAGUE. We will adjourn until 10 o'clock tomorrow morning.

(Whereupon, at 11:40 a.m., the committee was adjourned, to reconvene at 10 a.m., Wednesday, April 10, 1963.)

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1964 NASA AUTHORIZATION

WEDNESDAY, APRIL 10, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON MANNED SPACE FLIGHT,
Washington, D.C.

The subcommittee met, pursuant to adjournment, in room 214–B, the Longworth Building, Washington, D.C., at 10 a.m., the Hon. Olin E. Teague, chairman, presiding.

Mr. TEAGUE. The committee will come to order.

Mr. Holmes, we are glad to have you back. I would make one suggestion to you. If you like your job, your substitute, Mr. Low, did such a good job yesterday that I would not stay away too much. Be around and keep the home fires burning.

STATEMENT OF D. BRAINERD HOLMES, DEPUTY ASSOCIATE ADMINISTRATOR AND DIRECTOR, OFFICE OF MANNED SPACE FLIGHT, NASA, ACCOMPANIED BY WILLIAM E. LILLY, DIRECTOR, PROGRAM REVIEW AND RESOURCES MANAGEMENT, AND GEORGE M. LOW, DEPUTY DIRECTOR (PROGRAMS)

Mr. HOLMES. Thank you, Mr. Chairman.

Mr. TEAGUE. I believe yesterday we reached Apollo. Can somebody identify it for us bookwise? It is volume II, RDO 1–10. Mr. Holmes, I don't know whether you were told but the House goes in session at 11 a.m. so we only have about an hour this morning.

Mr. HOLMES. Fine. Thank you.

Mr. TEAGUE. I think we have a tentative agreement that members will ask only the questions that they consider very, very necessary and essential so maybe we can go a little faster.

Mr. HOLMES. Thank you, sir.

Shall we start?

Mr. TEAGUE. Go ahead.

Mr. HOLMES. Mr. Low is prepared to discuss these figures in detail. I would like to ask him to do that if that is all right with you.

Mr. Low. Mr. Chairman, in the Apollo spacecraft project that starts on page RDO 1–10, in volume II of the budgetary requests, we have several major categories which include the Apollo command and service modules produced by North American Aviation and for this we are requesting $661,200,000. For the lunar excursion module produced by the Grumman Aircraft Engineering Corp., we are requesting $230 million.

For the guidance and navigation subsystems for both the command and service modules and the lunar excursion module, we are requesting $130,700,000.

Mr. FULTON of Pennsylvania. Could we have a point there?

On the Grumman contract, it is not a fixed-price contract, is it? It is a combination of the estimates to arrive at these figures. The NASA estimates and judgment combined with the contractor's estimates and judgment?

Mr. LOW. That is right. It is a cost-plus-fixed-fee contract.

Mr. FULTON of Pennsylvania. So that really the cost of the contract is not set; it is in the estimate level. Is that correct?

Mr. TEAGUE. Yes; beyond that it changes all of the time; does it not?

Mr. LOW. The current contract with Grumman is based on a defined statement of work, but it is based, as Mr. Fulton points out, on an estimate of the effort required to produce the hardware with Grumman.

Mr. FULTON of Pennsylvania. You are making it on the best judgment and area research on facts available today? As the chairman pointed out, in the future it could go up or down or operate within a certain area?

Mr. LOW. That is right.

Mr. HOLMES. That is right. That is true of the entire program, with very few exceptions.

Mr. TEAGUE. Take the North American $661 million. Would it be difficult to break that down?

For example, this would show that it goes to North American Aviation in California. Would it be difficult for you to break down where the subcontracts go and how this is spread across the country? As Mr. Roudebush says, there is nothing going to Indiana, so we could have some idea of what goes on there.

Mr. LOW. I could read off the list of subcontracts and indicate where they are.

Mr. TEAGUE. Just generally.

Mr. Fulton?

Mr. FULTON of Pennsylvania. Why don't we put it into the record.

Mr. TEAGUE. Let's put it into the record. The members say nothing is going to Indiana and nothing to Pennsylvania. So much is going to Pennsylvania that Mr. Fulton is not saying anything about it any more.

(The information requested is as follows:)

Project Apollo—Geographical distribution of North American's estimated funding for fiscal year 1964 [1]

State	Amount (thousands)	State	Amount (thousands)
Arizona	$2,971	New Jersey	$3,610
California	382,500	New Mexico	18,020
Colorado	2,700	New York	21,150
Connecticut	27,700	Ohio	3,870
Delaware	7	Oklahoma	8,810
Florida	21,800	Pennsylvania	361
Illinois	1,870	Rhode Island	15
Indiana	3,241	Texas	1,420
Iowa	61,500	Utah	56
Maryland	1,800	Virginia	156
Massachusetts	21,200	Washington	78
Michigan	63	Wisconsin	100
Minnesota	75,900		
Missouri	224	Total	661,200
Nevada	78		

[1] This breakdown shows only North American Aviation's direct procurements. It does not show the geographical distribution of the lower tier procurements which broaden the scope considerably.

Mr. ROUDEBUSH. I am not in that status. I am still willing to say we are not getting our share.

Mr. FULTON of Pennsylvania. I must say about Pittsburgh, Pa., that we are willing to put up our own money and help develop installations for NASA jointly so that we are cooperative. I want Mr. Holmes to know that.

Mr. TEAGUE. But I don't believe we are painting a fair picture of the space industry in the country by the way we attribute everything to the prime contractor.

Mr. LOW. Approximately 50 percent of the effort at North American is being subcontracted.

Mr. FULTON of Pennsylvania. It is nice to be a prime contractor, let's face it.

Mr. TEAGUE. If you could put that in the record, I would appreciate it.

Mr. LOW. I would be happy to provide that.

Going on, on page RDO–1–10, the next category we have is instrumentation and scientific equipment.

Mr. TEAGUE. Can you say who has the guidance navigation system? Is it MIT?

Mr. LOW. MIT is the associate contractor to North American and Grumman for the design and engineering and production of initial prototype units of the guidance and navigation systems.

Mr. TEAGUE. Is this an associate contract or subcontract?

Mr. LOW. An associate contract is held directly by NASA.

It is not a North American or Grumman subcontract. The equipment is then furnished to North American and Grumman for installation, but the funding, for example, for this contract goes directly from the Government to MIT and its industrial support contractors.

The industrial support contractors in the guidance and navigation area are the A.C. Sparkplug Division of General Motors for the inertial platform, the Raytheon Corp. for the guidance computer, and Kollsman Co. for the optical part of the guidance system.

The instrumentation and scientific equipment is research and development equipment installed in the spacecraft for test purposes. This equipment is being procured directly by the Manned Spacecraft Center in Houston and furnished to our contractors for installation in the spacecraft.

The next category is "Operations."

Mr. YEAGER. May I ask a question before you leave the LEM? I think in the testimony it is indicated that about $135 million of this fiscal year 1964 figure is for Grumman. Can you tell us what the balance is?

Mr. LOW. $134.1 million of the $330 million is assigned to Grumman within the present scope of the negotiated contract with Grumman.

In addition to that, we have programed $89 million for additional effort that was not identified within the Grumman contract at the time of the contract definitization and $6.9 million for Government-furnished equipment.

Mr. FULTON of Pennsylvania. On those contracts, can you give us your cashbox budget as distinguished from your obligation budget?

Put it in the record. I would like to have the times when you are going to actually need the money.

Mr. Low. Yes, sir; we would be happy to provide that. Did that answer your question, Mr. Yeager?

(The information requested is contained in table G on p. 612.)

Mr. YEAGER. I was not quite sure what the $89 million means.

Mr. Low. The $89 million includes things like special test equipment, support at the White Sands Missile Range for testing, additional ground-support equipment, a special test vehicle for tests at White Sands, and a provision for changes of scope that have been identified by the Government but have not yet been negotiated into the Grumman contract. The Government-furnished equipment includes propellants, primarily for testing.

Mr. TEAGUE. Mr. Fulton?

Mr. FULTON of Pennsylvania. I have not seen in the testimony so far any comments about when you might have money unobligated or unspent from the 1963 fiscal year budget. Could you supply that for the record as to your finishing out the 1963 fiscal year budget on your program plans?

Mr. Low. We can provide that for the record. Our current obligational plan indicates that all of the funding authorized for fiscal year 1963 will be obligated before the end of this year.

Mr. FULTON of Pennsylvania. I would like to have that in the record.

(The information requested is as follows:)

The fiscal year 1963 obligational plan for Project Apollo is as follows:

First quarter	$112, 535, 000
Second quarter	37, 850, 000
Third quarter	169, 651, 000
Fourth quarter	115, 748, 000
Total	435, 784, 000

Mr. TEAGUE. And I would like to suggest that go in back where Mr. Holmes first started discussing that.

Mr. FULTON of Pennsylvania. Likewise, your cashbox budget that you are putting the money out. I would like to know when you are coming up with the actual payment on the contracts.

Mr. Low. Yes, sir. Shall I go on?

Mr. TEAGUE. Yes.

Mr. Low. The next line item is called "Operations" and $16 million is requested. This is further broken down on page 6 of volume V into "Flight Operations" for $5 million, "Recovery Operations" for $9 million, and "Flight Crew Operations," the training equipment for astronauts, for $2 million. The total line item is $16 million.

In the category of launch vehicles, we are budgeting under the Apollo spacecraft program for the Little Joe II launch vehicle which will be used later this year and next year for preliminary flight testing of Apollo command and service modules at the White Sands Missile Range.

Mr. ROUDEBUSH. Could you give us the number of these vehicles? In other words, the number of Little Joes and the Saturns.

Mr. Low. In this year's budget we are requesting funding for four Little Joe vehicles, partial funding for six Saturn I vehicles and partial funding for three Saturn I–B vehicles.

I should point out that in the category of the Saturn vehicles the development of these boosters is carried in our launch vehicle and propulsion budget which will be discussed here in subsequent days.

In the spacecraft budget we are requesting funds for the Saturn launch vehicles beyond those needed in the initial development program. For example, the Saturn that was launched successfully 2 weeks ago was a developmental test vehicle. It is not carried in the spacecraft budget. All Saturn I's beyond the 10th vehicle will be classified as so-called operational vehicles and they will be budgeted in the spacecraft budget because they will be used in spacecraft testing.

For the Little Joe II vehicle we are requesting $5 million this year; $75 million for Saturn I; and $55 million for the Saturn I–B's, for a total of $135 million in the area of launch vehicles.

Mr. FULTON of Pennsylvania. Did the Little Joe II program go up by 500 over the last year, 1963?

Mr. LOW. In 1963 we started the contract. It was not funded for the full year but was for the initial development and production of the vehicles. In 1964 we are requesting funds for production of the vehicles that will be flown in 1964 and early 1965 and for the operational support of these vehicles at the White Sands Missile Range.

Mr. FULTON of Pennsylvania. Has your late start on the Little Joe II program caused you to put off spending any money?

Mr. LOW. No, sir; we are on schedule on the Little Joe II program and the first vehicle is now in its final stages of test, scheduled for launching at White Sands this summer. It was a very rapid development program and it is on schedule now, as I pointed out.

Mr. FULTON of Pennsylvania. What would happen if you got the same money as last year, $4.5 million, for the Little Joe II program?

Mr. LOW. It would delay the initial test program of the Apollo spacecraft hardware and this might then delay all of the other steps in the Apollo program because these initial tests are really some of the most important ones we are performing.

Mr. FULTON of Pennsylvania. How much would $500,000 out of this item delay the Apollo program?

Mr. LOW. I would have to provide that number for the record.

Mr. HOLMES. It is very difficult to give you an answer for the record because if we had to lose $500,000 out of the budget, I would not take it out of the Little Joe II area. I would take it out someplace else and it would be just a delay in the program of $500,000 which we need for the coming year. It would be difficult to answer it applied to this because we would have to balance it against the total program.

Mr. FULTON of Pennsylvania. Mr. Low has made a statement as to the Apollo program, and when you effect the lead item, I think we should know what it means in point of time.

I think he may answer later on that.

Mr. WAGGONNER. What Mr. Holmes is saying is that if NASA is faced with the $500,000 reduction, it is going to reduce it somewhere else rather than here because this is a lead item.

Mr. HOLMES. Yes; and if I did not balance each program area carefully, I would not be fulfilling my responsibility as a program manager.

Mr. WAGGONNER. These are things you have to do first.

Mr. HOLMES. Yes. We can give you that answer, but it is sort of hypothetical.

Mr. FULTON of Pennsylvania. I want to know how much it would delay it, not that you marshal funds from some place else but if this cut is made, I think we should justify it.

Mr. HOLMES. We can get you that information.

Mr. FULTON of Pennsylvania. If you had the same amount as last year, what effect would it have? That is a very logical question.

(The information requested is as follows:)

In all probability, no reduction would be absorbed in the Little Joe II program. Little Joe II is NASA's cheapest, most convenient method for obtaining reliable flight data on the operational aspects of the critical crew safety systems (the launch escape system and the earth landing system) and the structural integrity of the spacecraft. The early shots of Little Joe II are specifically devoted to the abort system essential to crew survival, and utilize production subsystems mounted in boilerplate spacecraft. Later flights are to be used to verify the flight worthiness of the actual spacecraft structure under maximum load conditions and qualify the mission abort and earth landing systems.

Theoretically, the impact of a $500,000 reduction would be to delay the purchase of Little Joe II No. 6 until fiscal year 1965. This effect would cause a schedule delay of 2 months in launching the structural qualification test at high dynamic pressure of airframe No. 002. As a direct consequence, the first manned flight would also slip 2 months.

Mr. Low. The remaining item in the Apollo category is supporting development which includes those contracts that are not directly in line with our major Grumman and North American contracts.

For example, under supporting development we purchased the wind tunnel test models and we purchased time in several wind tunnels. Our propellants for the command module testing is carried under supporting development.

Mr. FULTON of Pennsylvania. Why was it necessary to increase this particular item fivefold for support and development between fiscal years 1963 and 1964? The amount goes from $5 million to $25 million.

You might comment as to what you want next year. There is a fourfold increase between fiscal years 1962 and 1963, and then a fivefold increase between fiscal years 1963 and 1964. This raises a question as to what fiscal years 1965 and 1966 will be.

Mr. Low. One of the major reasons for the increase from 1963 to 1964 is the fact that we are getting in the Apollo program in fiscal 1964 into the major developmental testing and insofar as the wind tunnel testing, the Little Joe testing, and the propulsion testing are concerned, this will be the peak year in fiscal 1964.

Mr. FULTON of Pennsylvania. Then what would 1965 be and 1966?

Mr. Low. My preliminary estimate for 1965 is that there would be no increase in this line item on 1964.

Mr. WAGGONNER. Isn't it true you will be getting into the fabrication of your ground support equipment in fiscal year 1964? You will have finished the preliminary design of the ground support equipment, and you will actually begin to fund for the fabrication and testing phase?

Mr. Low. That is right. Fiscal 1964 in general terms in the Apollo program is considerably higher than 1963 because we are entering, as you point out, the fabrication and testing phase, whereas 1963 was the phase for design and engineering and the construction of mockups.

Mr. TEAGUE. Just where does the money for the General Electric contract appear in the budget?

Mr. Low. Their money appears in the budget under major categories entitled "Integration and Checkout" and "Systems Engineering."

Mr. HOLMES. "Integration and Checkout" starts on RDO 4–1 and "Systems Engineering" starts on RDO 5–1. Both are in volume II of the fiscal year 1964 budget book.

Mr. TEAGUE. We will get to that later.

Mr. LOW. Yes, sir.

Mr. HOLMES. This supporting development does include such things as propellants for the service module and parachute drop tests. As the testing program during this fiscal year has increased, these dollars have gone up.

I agree with Mr. Low that it is going to be nowhere near a 5-to-1 increase. I don't know whether or not there will be some increase, but I would expect it to stay at about the same level for next year.

Mr. FULTON of Pennsylvania. Have you spent your R. & D. facilities money for fiscal year 1963?

What facilities remain to be constructed or paid for?

Mr. LOW. The facilities in fiscal year 1963 were test facilities at the North American plant in Downey, and the propulsion facility for the service module propulsion system at White Sands Missile Range. All of these facilities are now under design and/or construction. Perhaps Mr. Lilly can state whether the money will be spent in full by the end of this year.

Mr. LILLY. The current plans, Mr. Fulton, are that these funds will be fully obligated this year. In terms of actual cash flow from the treasury, I would have to supply that information for you, sir.

Mr. FULTON of Pennsylvania. The funds that you have programed for facilities in the fourth quarter of a fiscal year can probably be programed ahead so that they could very well go over into the first quarter of the succeeding fiscal year since we are looking ahead a period of 15 or 16 months.

Mr. LILLY. Not in many cases. When we program funds for obligation in the last quarter of the fiscal year, we must have the cash and essentially place it in escrow when the contract is let. Practically all of our facilities contracts are fixed-price contracts. The actual cash vouchers come later, but the full amount must be put aside as a full obligation at the point we award the contract.

Mr. FULTON of Pennsylvania. That is a legal requirement?

Mr. LILLY. That is correct, sir.

Mr. FULTON of Pennsylvania. Then it would take a reprograming of your facilities if this committee recommended that you come up with a stretchout of the program in the third and fourth quarters for economy reasons?

Mr. LILLY. That is correct. We would either have to reprogram funds or delay awarding contracts, which would in turn delay construction.

Mr. FULTON of Pennsylvania. There has been no delay on the Apollo program for budgetary reasons insofar as the construction of the facilities is concerned?

Mr. LILLY. No, sir; there has not.

Mr. TEAGUE. Has there been any delay in the Apollo program because of funding problems of any kind?

Mr. LILLY. I will defer to Mr. Holmes on this point.

Mr. FULTON of Pennsylvania. Mr. Holmes is an expert on that.

Mr. HOLMES. The program would go faster if we had had more money, yes. Whether there is a delay or not, I think it is a matter of how one interprets it.

My personal interpretation is that the schedule has not slipped but that the rate would be faster if we had more money.

Mr. TEAGUE. Let me understand what you said.

You say that the program is on schedule and that it has not been delayed because of money, but that if you had more money the program would have gone faster.

Mr. HOLMES. Yes, sir. The reason that those statements are consistent is that we are at the formative stage of the program. In other words, we had to establish the schedules on a later time scale than we would have, had there been more money available.

Mr. GURNEY. I hate to admit this, but I swear there has been testimony that if you had more money you could not have spent it.

Mr. HOLMES. That is just not a statement of fact if it were made.

Mr. TEAGUE. I think it has been made by people much further down the ladder than Mr. Holmes. They were speaking of certain items or certain centers and not of the overall program.

Mr. GURNEY. Specifically, how could it have been speeded up had you had more money to spend? Where could the program have gone faster?

Mr. HOLMES. The facts are that in order to live within the dollars available we cut back overtime to essentially zero and stretched out every major project in the Saturn and Apollo program. We actually reprogramed what was being done in these areas in order to live within the funds.

Mr. FULTON of Pennsylvania. I think the chairman and I can comment on that as to the funding during the past fiscal year. It did become tighter. It was once thought there ought to be something done.

Mr. TEAGUE. Well, the fact of the matter is you would have liked to have had about $500 million more in the past year.

We know you have superiors in NASA, Mr. Holmes, and we know you have to support them, but this is just a matter of fact.

Go ahead, Mr. Low.

Mr. LOW. Our total request for the Apollo budget for the R. & D. direct charges is $1,207,400,000.

In addition to that, we have carried and prorated against the Apollo program $29,728,000 for personnel costs, and $26,020,000 for operation of the installations, for a total request of $1,263,148,000.

Mr. FULTON of Pennsylvania. Can you prorate that figure of $1,263,148,000 with the figure on page 6 of the volume V supplemental data book where it says 1964, $1,556,500 for a total direct R. & D. cost?

If you want to do it later, that is all right.

Mr. LOW. I believe that total includes also——

Mr. LILLY. I will answer that.

The figure of $1,556,600,000, Mr. Fulton, represents the total direct R. & D. category for manned spacecraft systems. It appears in volume II of the fiscal year 1964 budget book, page RDO1–1. The total figure includes the items for "Supporting Research and Technology" ($21.1 million); "Gemini" ($306.3 million); "Apollo" ($1,207.4 million); and the "Mission Control Center Operations" ($21.8 million).

These items total the $1,556,600,000 of direct R. & D. costs requested for fiscal 1964.

Mr. FULTON of Pennsylvania. Then on page RDO1–10, you have also added personnel costs on to operation of installations.

Mr. HOLMES. Yes, sir; that is correct, and the figure that correlates I think on page 6 of volume V is the figure under total for Apollo of $1,207,400,000, which agrees, I believe, with RDO1–1 for the total direct R. & D. cost, exclusive of personnel and other operations.

Mr. FULTON of Pennsylvania. You have a "Mission Control Center Operation" figure of $21,800,000 which is separate from the "Operation of Installations," figure of $26,020,000?

Mr. HOLMES. Completely separate; yes.

Mr. FULTON of Pennsylvania. What is the difference between the two?

Mr. LOW. On page RDO–1–21 we have a complete description of the budget line item for the "Mission Control Center."

Mr. FULTON of Pennsylvania. We will go into it at that time.

Mr. LOW. Yes, sir.

Mr. FULTON of Pennsylvania. Why has "Mission Control Center Operations" gone up from $10,500,000 in 1963 to $21,800,000 in 1964?

Look at the operation of installations; this goes from $12,845,000 in 1963 to $26,020,000 in 1964. What is the reason for these increases?

Mr. LOW. Perhaps the terminology we use, "Mission Control Center Operation," is a misnomer. The mission control center in Houston is being funded in two budgetary categories, the construction of facilities budget for the actual building and the equipment that goes into that building, and in the R. & D. budget for the rental of the major computer complex that has to go into this mission control center, for the operation of these computers, and for the technical services provided by our contract to the Philco Corporation.

The mission control center effort in Houston was only started within the last 3 or 4 months. We are, therefore, only funding about half a year's effort in fiscal year 1963. We are funding a full year's effort in fiscal 1964.

Mr. FULTON of Pennsylvania. So what should the caption be?

Mr. HOLMES. Just drop off the "Operations," is what I would do and just call it "Mission Control Center."

It would be consistent with command and service module and lunar service module.

Mr. FULTON of Pennsylvania. Is it really construction, or is it getting the facilities ready for operation?

Mr. HOLMES. Yes; it is not construction of facilities; it is the construction of hardware, the design of hardware and development of that center, as these other things are related to development of spacecraft.

Mr. FULTON of Pennsylvania. What can you give us as a figure on that?

Mr. HOLMES. I would suggest, Mr. Fulton, that when we turn to that item we could discuss that in full detail and then give you that answer.

Mr. FULTON of Pennsylvania. All right.

Mr. HOLMES. I think that when we are through with this page we could move over to that item. It is the next item.

Mr. TEAGUE. I am not quite through with that page.

Suppose, Mr. Holmes, that the $1,207,400,000 was cut 10 percent. What reprograming would you do? Would you comment as to a cut of that kind?

(The information requested is as follows:)

The impact of a 10-percent reduction in the fiscal year 1964 Apollo spacecraft budget request on Apollo schedules would require major detailed reprograming and reassessment of all other program elements, such as the launch vehicle development of Saturn I, IB, and V and all ground test and launch facilities to accurately forecast total program impact. Any reprograming would have to be analyzed across the whole project scope to insure a balanced and integrated effort for the stretch out of vehicles, spacecraft, and facilities, and the proper emphasis of the most critical elements of the program.

The effect of an artificial 10-percent reduction on the spacecraft effort alone would be to delay the long lead spacecraft procurement scheduled for Saturn IB and Saturn V spacecraft flights. This action would delay the Saturn IB rendezvous flights by 3 to 4 months, with comparable delays for the Saturn V lunar flights.

Mr. HOLMES. I think the direct effect of that cut would be to delay the schedule. The schedule would be delayed by the amount of time necessary to offset the spending rate we have during that period and to achieve a reorientation of the program.

Where we would take the money in order to balance the program, I would have to look in detail before I could give you an answer. I suspect that part would come out of Apollo and part would come out of Saturn.

I doubt that we would cut Gemini because we need that data as rapidly as we can get it, since it may well have an impact on the Apollo design.

Mr. TEAGUE. You are saying that it would definitely delay the Apollo program?

Mr. HOLMES. Yes, sir; definitely delay it. There are no duplicate or redundant key developments to my knowledge underway that one could just drop off and take perhaps greater risks, let's say, in development success.

Since we have a single thread program, if you will—single development— and each thread is needed in order to carry on the program the only alternative I know to having fewer funds is either to operate more efficiently or to slow down the program.

Since we are doing our very best now to operate with maximum efficiency and are working hard on this with our contractors, I am not optimistic that we can achieve savings in that way from a practical standpoint, over and above what I consider a minimum budget as presented here.

Mr. TEAGUE. Would you comment on the amount of this $1,207,400,000 that is committed in the best judgment of NASA and industry?

Mr. HOLMES. You do not mean committed in the accounting sense—you mean committed in terms of being programed?

Mr. TEAGUE. Programed.

Mr. HOLMES. Yes, sir; $1,207,400,000 worth.

Mr. TEAGUE. All of it?

Mr. FULTON of Pennsylvania. Could I ask a question?

Mr. TEAGUE. Mr. Fulton.

Mr. FULTON of Pennsylvania. Following the chairman's comments, there has been testimony that you have succeeded on your estimates of contracts of coming within about 10 percent of the actual figure. This you thought was a pretty good prediction record or performance record. Do you think you can come within the same 10 percent on

the estimates of contracts that are included in this figure of $1,207,400,000?

Mr. HOLMES. Sir, if I recall correctly, I think that the 10 percent to which I was referring was the extent of overall reprograming necessary. I believe that the exact percentage ran about 7.5., which I thought was pretty good performance. I was not thinking in terms of our performance on contracts, which has not been that good, as you are well aware. I wanted to clarify this in my answer.

Mr. FULTON of Pennsylvania. I could think of some that went up $40 or $50 million a year but I am not picking the extreme.

I am taking a judgment level which is an overall general premise or base from past history, and I am then projecting this, as is often done in business, for the coming year. Can you come up within that strict limit on your margins of estimating? Can you get it within 10 percent?

Mr. TEAGUE. Actually you are about 15 or 20 percent short last year.

Mr. HOLMES. Yes. I think from the standpoint of a total reprograming within Apollo, which was about 3 percent last year, or a total reprograming within a spacecraft development or Saturn development, which was about 10 to 12 percent, depending upon the area, that we probably will be able to do that this year.

In terms of staying within that rate on our contract estimates, I very much doubt that our estimates are quite that good.

Mr. FULTON of Pennsylvania. The point is then that you do have this leeway that you have been able to live with so far at a 15 to 20 percent rate is concerned, as the chairman pointed out. My point was specifically that can you come within 10 percent of your estimates? Are we asking too much by saying to you that you should live within a 10 percent variation on your estimates?

Mr. HOLMES. I don't think you are, in relation to reprograming between elements. As far as the total dollar expenditures is concerned, of course we have to live within the total or seek supplementals. I do think we can be more optimistic about our contractor estimates in fiscal 1964 than we could be in fiscal 1963 because we have definitized or defined the programs to a greater extent.

Mr. FULTON of Pennsylvania. And have you held your construction of facilities estimates pretty much the same?

Fiscal year 1963 is $776,237,000, and in fiscal year 1964 it is $800 million, it looks as if $800 million is a rounded figure. Isn't that right?

Mr. HOLMES. I don't think it is a rounded figure.

It is the total NASA figure. The manned space flight figure was in the order of $600 million, as I recall.

Mr. LILLY. On our manned space flight facilities this fiscal year, the figure is $564 million—$564,538,000, as I recall it.

Mr. FULTON of Pennsylvania. On these facilities, if you do not have the money, you can just give a letter of intent on a contract with later performance; can't you?

Mr. LILLY. On facilities contracts, if we do not have the money, we can't do anything. We can't go out on bid.

Mr. FULTON of Pennsylvania. The Army engineers, of course, are handling the contract work?

Mr. LILLY. That is correct. Our normal procedure, Mr. Fulton, is to transfer the funds to the Corps of Engineers before bids are requested.

Mr. FULTON of Pennsylvania. That puts you to the choice of either having to postpone construction or to make a partial contract?

Mr. LILLY. That is correct.

Mr. FULTON of Pennsylvania. Could you make partial contracts?

Mr. LILLY. Not very well. There are certain contracts as you know, like on the large facilities, such as launch complex 39 where the overall work is broken down into many different but interrelated parts. We can contract for certain portions, but any fixed contract on facilities must be a completely defined facility or a portion thereof.

Mr. FULTON of Pennsylvania. This is by virtue of NASA policy, not necessarily by law.

You don't have to have a cafeteria in the Merritt Island industrial complex at a certain point of time, do you? We are not always talking of facilities that will hold a missile on the pad.

Mr. HOLMES. No; but as you well know, with your industrial experience, a cafeteria or other support items can be just about as important as a holddown clamp for a missile in order to have the people there work efficiently, without traveling long distances and so forth to get the work done.

I agree it is not quite as definitive to the last month, but it certainly is, I think, to the last few months about as definitive and that is if you have a large complex of people there, you have to provide supporting facilities for them.

Mr. TEAGUE. Mr. Gurney?

Mr. GURNEY. We have been talking in generalities here. Let's get down to specifics.

The second largest item in the Apollo budget is for the lunar excursion module which is under contract to Grumman. Can you describe how you arrived at this contract? When did you sign the contract? What does the contract cover, and what does it buy as far as hardware is concerned? What does the contract include as far as R. & D. is concerned? How many years more are you going to work with Grumman, beyond fiscal year 1964?

Give us some idea of how you arrive at this figure, and what are NASA's future plans along those lines.

Mr. HOLMES. We certainly have all of that information. I think Mr. Low will be glad to discuss these points.

Grumman is a contract which we definitized very quickly. We in NASA are trying to institute this practice and I was very satisfied to see this contract definitized so rapidly.

We did not authorize Grumman to proceed with work until the contract was definitized. It was not a case, which has been the case with some of our contracts, where a contractor had initiated work and was well underway while it took us a year or more to definitize a contract. By then, we were a long time past what was bid and many changes and many new elements had come into the program, with the result that the final contract might represent a different figure than was bid in the proposal stage.

Mr. LOW. The contract was finally signed on March 7 of this year, but the negotiations were completed on about the first or second of January. Between the first of January and March 7 there was pro-

cedural work, paperwork, legal work, which really did not change the contract in any way, shape or form.

Mr. HOLMES. Could you start with the chronology, going back to the bid?

Mr. TEAGUE. We will go back further and start with the study.

Mr. HOLMES. Start with the study.

Mr. LOW. Fine. I don't have the precise dates on the studies. But in the first half of 1962 we had within NASA an intensive study effort to define the best possible mode for the lunar landing program. By July 1962, we were reasonably sure that the lunar orbit rendezvous was a correct approach and therefore went to industry with the request for proposal in July for the lunar excursion module. In November 1962, we selected the Grumman Aircraft Engineering Co. as a contractor for this work.

Now between July and November all nine bidders prepared their proposals to NASA. These were then evaluated by our Manned Spacecraft Center in Houston and at the completion of the evaluation Grumman was selected as a contractor to build this module.

Mr. WAGGONNER. An announcement was made November 7, 1962.

Mr. LILLY. That is correct; November 7, 1962.

Mr. LOW. On the 19th of November, just about 2 weeks after, or less than 2 weeks after the announcement was made, we initiated negotiations with Grumman for this contract.

Now this, as Mr. Holmes pointed out, was entirely different from our procedures in the past in that usually in that time period we would have signed a letter contract. We would not have had a final contract for perhaps a year or so later, but in the case of Grumman we started formal negotiations 2 weeks after Grumman had been selected, completed negotiations at the end of December and completed all agreements on the contract by the 1st or 2d of January.

The time between January and March 7 as I pointed out, was taken in detailed legal reviews of the contract documents, getting signatures by our contracting officer and by Grumman's corporate officers, and, finally, approval within NASA headquarters of this contract. But for all intents and purposes, the contract was completely negotiated by the 1st of January.

Mr. GURNEY. What were the dollar figures on this contract? This is not a firm contract, it is cost plus fixed fee, is that right?

Mr. LOW. The total dollar figure—it is a cost-plus-fixed-fee figure—negotiated at $387,900,000, including fee.

Mr. GURNEY. This is for everything Grumman is going to do presumably in developing it?

Mr. LOW. That is for everything defined within this contract that Grumman is going to do.

Mr. WAGGONNER. Would the gentleman yield for a question?

The contract signed March 7 is for $386 million. What was Grumman's original estimate?

How much of a variation was there from the announcement on November 7, when they submitted their bid proposal to the point where negotiations and adjustments were made and the final contract signed?

Mr. LOW. I would have to provide the exact number for the record. My best recollection is that the bid was about $40 million less. Now, the bid was based on a specification that NASA had sent to industry

in July. Between July and the time that this contract was fully negotiated, our studies continued and we identified certain changes in the specifications that we incorporated in the final negotiations.

These changes——

Mr. WAGGONNER. All changes requiring additional services?

Mr. LOW. That is right, and when these changes then were negotiated into the contract, this increased by about $40 million.

Mr. WAGGONNER. Could you supply that figure for the record?

Mr. LOW. Yes, sir.

(The information requested is as follows:)

The correct value is $42,984,173.

Our procedure under negotiations however was to take exactly the bid figure in the Grumman proposal and add to that only the changes in scope.

We did not permit or allow any underestimation or misestimation in these negotiations and all of the contractors who were bidding were aware of this procedure before they submitted their proposals.

Mr. GURNEY. What about Grumman's contract figure? Is that based upon firm subcontracts or bids or purely estimates on the part of Grumman?

Mr. LOW. It is based to a large extent on detailed estimates on the part of Grumman and NASA negotiated in the contract for the subcontractors.

Mr. WAGGONNER. I don't understand that. Have the subcontractors submitted figures to Grumman?

Mr. LOW. Grumman has at this time not yet completed negotiations with all of its subcontractors.

Mr. WAGGONNER. How many subcontractors had put in firm bids when you arrived at the $386 million figure back, I presume, in January?

Mr. HOLMES. Before Grumman submitted its bid, it had bids from all subcontractors. In this procurement, as in other procurements, NASA reserves the right to review the subcontractor. We may buy a prime contract proposal but not necessarily buy the subcontractor bids for several reasons. One is that in some cases we have special knowledge that the prime contractor ought to go out more broadly. Certain teams may get together and one doesn't always get the best team. Another reason is that within NASA we have detailed knowledge of what is being used in other parts of the program.

In the case of the lunar excursion module, there are certain systems already being developed for the Apollo command module which we would like to have used to avoid an unnecessary duplication of development. Although Grumman did have these bids, we reviewed with them during this period all of their subcontractors and asked them to go out for firm bids.

Again, sometimes the same subcontractor had been a part of the team and sometimes there are new ones. Therefore, Mr. Low's answer is that Grumman does not, in all cases, have firm bids from these subcontractors because the company has not negotiated with all of the new subcontractors. Grumman originally had bids for these elements when their proposal was submitted.

Mr. GURNEY. One other question.

We have a contract here of $386 million and a figure in this fiscal year of $230 million. Where do you get the $230 million from, and when did you put this $230 million into the budget?

Was that when you had the $386 million figure?

Mr. HOLMES. Yes, it is $387.9 million. I just say that future reference that is the contract figure. I am going to ask Mr. Low to discuss this point in detail but I would like to make one comment before we start. If we press too far into the details of what the Government puts in its budget versus what its relationships are with the contractor, the negotiating position of the Government is injured. Of course we would be happy to discuss it in executive session.

In answering this question we won't push too far but if one wants to get down to the details of every element it would be best to have an executive session—I don't say this critically—but I don't want to be in a position where we can't negotiate with our contractors.

Mr. GURNEY. I understand that.

On the other hand, this committee is trying to determine whether we should recommend $5.7 billion or some other figure, and this is the second largest item in the Apollo program.

Mr. HOLMES. All I am saying is we may request the chairman to have an executive session, in my judgment, the details hurt our negotiating position.

Mr. TEAGUE. We would expect to do just that. At the end of the hearings we expect to have an executive session to go into that.

Mr. LOW. Specifically, Mr. Gurney, these figures were placed in the budget book after Grumman had been selected.

In fact, you will notice that even though the selection was as late as November, the budget book is consistent in that it points out that the Grumman Aircraft Corp. will be the contractor for this work. It is based, then, on the Grumman proposal figure and the initial effort during the negotiations with Grumman.

Mr. GURNEY. Not the final contract figure?

Mr. LOW. Not the final contract but, in the final days of the negotiations, the only things that were left open were the amount of fee to be paid, should it be 6½ or 6.7 or 7 percent. So this is only a very minor part of the cost figure for fiscal year 1964.

Mr. GURNEY. You mean the other figures did not change between November and March?

Mr. LOW. They did not change between the middle of December and the end of December and these figures were put in the budget book in the middle of December. And subsequently they have not changed between then and now.

Mr. GURNEY. How about the $230 million?

Mr. LOW. Now of that $230 million, as I responded to Mr. Yeager earlier, the $134.1 million is part of the $387.9 million in the present Grumman contract. The remaining figures are $98 million for contract changes and additions that have been identified by NASA but have not yet been negotiated as amendments into the contract. And $6.9 million is for Government-furnished equipment.

Mr. GURNEY. I realize that, but how do we know you are going to spend $230 million in fiscal year 1964?

Mr. HOLMES. We can give you, and we would be glad to, in executive session, a breakdown of our elements. In the end I think that

your confidence that we know what we are talking about and know what we are doing will mean more to you than in these estimates we are making. I say this because in every element the estimate is based on our judgment and our experience in the past—over and above a contract figure. In the past I am sorry to say, we have estimated too low rather than too high.

Mr. TEAGUE. Will the gentleman yield?

Mr. GURNEY. Yes.

Mr. TEAGUE. Is it not true that in the whole Apollo program you have hundreds of problems, major problems, that you do not know the complete answer to? Your subcontracts and your prime contracts change as you go along and solve these problems. Until NASA solves these problems you cannot come to a completely firm contract at this time nor for a considerable length of time?

Mr. HOLMES. That is precisely true; yes.

Mr. WAGGONNER. One prime example is this case would be the lunar excursion module. Actually, not knowing at this point exactly what we will encounter on the Moon, I think it is absolutely impossible to define the contract for that vehicle firmly.

Mr. HOLMES. That is exactly correct. In this kind of a development, as in any true development program, you do not know all the answers—partly because of the environment and the techniques of doing work that has not been done before. If we were making breadboxes or automobiles, we would be doing it on a fixed-price basis, with advertised bids, where we could say, "This is what it is going to cost," and if a fellow could not do it for that amount, he could go broke. We cannot go to the Moon that way, since we are charting new courses.

Mr. TEAGUE. Mr. Yeager?

Mr. YEAGER. Since the LEM was not anticipated at the time of your 1963 budget, I gather that the $32 million you show there was a reprograming item?

Mr. HOLMES. That was a reprograming item to get Grumman started.

Mr. YEAGER. What did that buy you?

Mr. HOLMES. Those funds were required for Grumman's fiscal year 1963 effort.

Mr. LOW. It is this fiscal year's effort of Grumman since they started working approximately the first of January.

Mr. YEAGER. That is all Grumman?

Mr. LOW. I believe that is right.

Mr. GURNEY. The only comment I have is that all we have here is a couple of paragraphs on page RDO 1–15, and it seems to me we ought to have a fairly detailed explanation on the time schedule of how they plan to spend this money.

Mr. TEAGUE. Last year, after we finished the public hearings, we met in executive session for these details. We expect to do the same thing this year.

Mr. HOLMES. We have, of course, a tremendous amount of backup data. I could not sit here with any integrity and give you a detailed account of the figure. I would much prefer to present such information in executive session, rather than an open session.

Mr. TEAGUE. Mr. Roudebush?

Mr. ROUDEBUSH. No questions.

Mr. TEAGUE. If we might take the next 3 minutes and go to RDO 1–21 and talk about the control center, that would be a good place to stop.

Mr. LOW. As I mentioned before, the mission control center facility, that is the building that it is going into, the equipment within this building, is being funded as a construction of facilities project and we will discuss this as we go through our construction and facilities budget.

In the R. & D. portion of the budget, we are requesting $21.8 million for two major efforts in connection with the mission control center and these are broken down into two contracts.

The first of these is a computer complex, a series of a number of high-speed digital computers to perform the mission-control function, to analyze the data that comes back from the spacecraft in orbit and on its way to the Moon and to translate these data into those things that the mission controllers in the control center need in order to perform their function in time.

The second part of this request is for the services provided by the Philco Corp., which is our contractor, for the implementation of the mission control center.

I failed to mention that the computer complex is being provided by the contract with the IBM company.

Mr. TEAGUE. Any questions?

Mr. YEAGER. May I ask one question on personnel?

In this entire section, the personnel costs that you indicate assessed against a number of personnel involved shows a salary increase from about an average of $8,500 to about $10,000. Can you explain what this was?

Is this entirely due, or partly due, to the pay raises voted by Congress last year?

Mr. LILLY. Yes. A considerable part of it is due to the increased salary that came about by the pay raise.

Mr. YEAGER. Do you know what that averaged percentwise?

Mr. LILLY. The average was fairly close to 10 percent, as I recall. I will be glad to get the exact percentage for you, Mr. Yeager.

Mr. HOLMES. I don't understand what else it can be. If he has divided the total salary cost by the number of people, which is an arbitrary allocation of the program, what else is there but the increase in the pay raise voted?

Mr. LILLY. In terms of the average, it can depend on the higher level of staffing, as you move along. There could be higher level people in the later increments. However, as I said, the basic increase came out of the pay raise.

Mr. HOLMES. These are arbitrary assignments of the overhead people and Government people to the program. The total is not arbitrary. It is hard for me to see how the structure of skills has changed. We will examine it for the record but I think it must be the President's bill.

Mr. TEAGUE. Thank you.

The committee will be adjourned until Monday, April 22, 1963.

(Whereupon, at 11 a.m., the committee was adjourned, to reconvene at 10 a.m., Monday, April 22, 1963.)

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1964 NASA AUTHORIZATION

MONDAY, APRIL 22, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON MANNED SPACE FLIGHT,
Washington, D.C.,

The subcommittee met, pursuant to recess in room 214–B, the Longworth Building, Washington, D.C., at 10 a.m., Hon. Olin E. Teague (chairman) presiding.

Mr. TEAGUE. The committee will come to order.

The committee is meeting this morning to discuss the subject of high energy fuels. Our first witness will be Mr. Arthur Sherman. Do you have anybody with you, Mr. Sherman?

Mr. SHERMAN. Yes, I have.

Mr. TEAGUE. Do you care to bring them up to the table with you?

Mr. SHERMAN. This is Dr. Seymour, our general manager.

I have Mr. Robert Hermann from our Washington office who will help me with the charts.

(Biographical sketch of Mr. Sherman follows:)

BIOGRAPHICAL DATA ON ARTHUR SHERMAN

During more than 15 years in rocketry, Mr. Sherman has been a major participant in liquid propulsion programs at Thiokol Chemical Corp.'s Reaction Motors Division. He holds a B.S. in mechanical engineering from the City College of New York (1948) and an M.S. in industrial management from Stevens Institute of Technology (1952).

Since 1948, when he joined Reaction Motors, Mr. Sherman's contributions to the advancement of liquid propulsion technology have been numerous. He coinvented the design of the packaged liquid engine and pioneered in its introduction as propulsion for several modern operational weapons systems.

In addition to his other patents and many technical papers in the rocket engine field, Mr. Sherman participated in design, development, and test activities which led to the successful development of the Viking missile engine and throttleable LR99 turborocket for the X–15.

At present, Mr. Sherman directs Rreaction Motors Division's advanced rocket engineering programs in launch vehicle and weapons propulsion, as well as all advanced technology work in controllable, manned spacecraft propulsion and related high energy propellant systems.

Mr. Sherman is a member of the American Ordnance Association and a senior member of American Institute of Aeronautics and Astronautics. As an undergraduate, he was awarded the first junior award of the ARS (new AIAA) for independent work on the design, fabrication, and successful test of an oxygen-gasoline liquid rocket engine.

Mr. TEAGUE. Mr. Sherman, you have a prepared statement?

Mr. SHERMAN. Yes, I do.

STATEMENT OF ARTHUR SHERMAN, DIRECTOR, PRELIMINARY DESIGN, THIOKOL CHEMICAL CORP., ACCOMPANIED BY DR. EDWARD H. SEYMOUR, GENERAL MANAGER, REACTION MOTORS DIVISION; AND ROBERT HERMANN, EASTERN DISTRICT OFFICE, THIOKOL CHEMICAL CORP., WASHINGTON, D.C.

Mr. SHERMAN. Mr. Chairman and members of the subcommittee, we appreciate the opportunity to present our views regarding the state of the art, and the future of high energy liquid propellants. As propulsion people, it is a subject in which we have a very intense interest.

There is, of course, high energy propellant research and development being conducted at many organizations, including our own, oriented toward many types of applications. Provided this propellant research continues on a broad front, developments will come which will ultimately result in real benefit to the space program.

I would like to limit my comments today to the status of efforts to evolve high performance, space storable propellant systems—sytems for the extended duration, complex space missions contemplated in the months and years ahead.

We are concerned with propellants for onboard spacecraft powerplants, those that form an integral part of the spacecraft, that travel with it through space, and that are used to maneuver it or control it in flight.

Such systems will be required regardless of whether chemical or nuclear lower stages are used. Indeed, should nuclear-powered lower stages not be available, then advanced propellant technology becomes even more important.

Spacecraft powerplants need high-energy fuels—fuels that can be stored abroad the vehicle for long periods of time, after which they will perform the intended function during a mission. Figure 1 shows the trip times associated with several missions. You can see that they are quite long.

These are minimum energy trip times that can be shortened, but only at the expense of additional energy.

At present we are limited in our selection of storable fuels for such missions to the combinations based on nitrogen tetroxide as the oxidizer, and hydrazine fuel blends. These are fine propellants. They are well characterized and relatively easy to work with. Today, they are in use in the Titan II missile, and are programed for use in the several Apollo modules.

The principal drawback of these propellants is low performance compared to what may be obtained with the more energetic, but cryogenic propellants such as liquid oxygen-liquid hydrogen, and fluorine used either liquid hydrogen or hydrazine.

All of these cryogenic propellants have been, and are being, evaluated; the liquid hydrogen-liquid oxygen combination is being developed into propulsion systems for a variety of uses.

In my opinion, these cryogenic propellants do not fully satisfy the needs of future spacecraft systems, because they present long-term space storage problems which can lead to performance degradation and operational difficulties.

MISSION TRIP TIME

MISSION	MINIMUM ENERGY TRIP & STAY TIME
SOFT LUNAR LANDING AND RETURN	7 - 14 DAYS
VENUS ORBIT AND RETURN	730 DAYS
MARS ORBIT AND RETURN	970 DAYS
SOLAR PROBE TO VICINITY OF MERCURY - ONE WAY	100 DAYS

FIGURE 1

Over 2 years ago, we began a broad study of old and new propellants, rating them not just in terms of specific impulse but in terms of their bulk densities as well. From this, we determined the relative effect of each on vehicle payload; this, after all, is the prime consideration in evaluating propellant performance.

We found that the oxidizer, oxygen difluoride—to be referred to hereafter as OF_2—had in the course of previous propellant research, been overlooked. We found that it held the promise of yielding not one, but several attractive, high-energy combinations when used with several different fuels—combinations which at the same time were storable for long periods in space.

Studies such as we made have been made before and will be made again, without always producing the same result. The reason for this is the underlying assumptions that are used by the group performing the analysis. Sometimes these are overdone in an attempt to become too sophisticated without having all of the required facts.

Recognizing this potential problem, we reverted back to the very basic formulas that define the velocity imparted to the spacecraft in terms of the properties of the fuels and the structural efficiency of the vehicle.

We assumed that each combination operated at its theoretical combustion efficiency, and we eliminated the very controversial subject of cryogenic propellant boiloff losses and degradation of structural efficiency due to insulation and greater meteoroid shielding requirements.

Thus, the storables and the cryogenics were evaluated in basic terms represented by their performance and density characteristics. While this kind of analysis is subject to change because of detail design considerations for a very specific vehicle, we find it to be an excellent

way of screening many propellent systems and determining those worthy of real effort.

Our propellant screenings were made over a range of spacecraft velocity increments and over a range of engine operating conditions. They included studies of both turbo-pump-fed, and pressure-fed engines.

In figure 2 we have presented a summary of the more significant information plotted for a mission requiring a velocity increment of about 10,000 feet per second. Such a mission might correspond to a lunar landing.

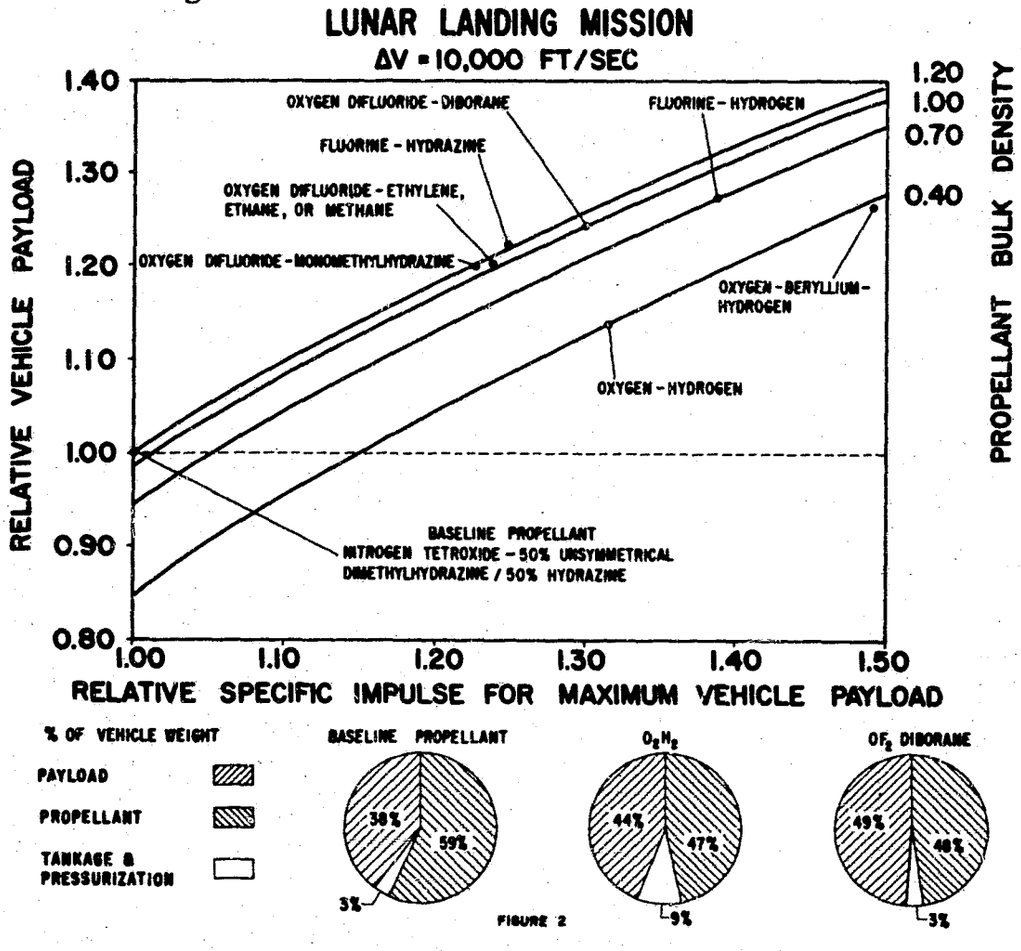

FIGURE 2

The data shows the payload capability of a spacecraft in terms of propellant specific impulse and bulk density and is for a pressurized engine. For comparison purposes, the data are in relative terms with the nitrogen tetroxide-hydrazine fuel blend used as the baseline payload of 1.

The rankings above the baseline show the degree of payload superiority of the various combinations. In other words, those that are shown above this baseline have a greater payload capability.

You will note that those with the highest specific impulse are not necessarily the best. You can visualize the part that low propellant density plays in offsetting high specific impulse when you think in terms of payload capability.

The three pie charts shown in figure 2 illustrate this effect. For the baseline propellant system, the payload represents about 38 percent

of the total weight of the vehicle, while 59 percent is propellant and 3 percent is tankage and pressurizing system.

For the lower density liquid oxygen-liquid hydrogen system, the payload represents 44 percent of the total weight of the vehicle, while 47 percent is propellant and 9 percent is tankage and pressurization.

Thus, by using liquid oxygen-liquid hydrogen, we have increased the payload by a net of 6 percent of the vehicle weight. This was achieved by decreasing the propellant weight 12 percent because of increased specific impulse; however, we have lost half of that gain because of increased tankage and pressurization weights resulting from the lower density.

The favorable results for the OF_2 Diborane combination are shown in the third pie chart.

These numbers in relative terms are shown in the curves of figure 2 for several propellant systems widely discussed as spacecraft propulsion system candidates.

Several other points should be made relative to these curves:

(1) Propellant losses due to boiloff of the cryogenic systems have been ignored for these analyses, as was the vehicle weight penalty associated with tank insulation to minimize these losses. Thus, depending upon the actual mission and the detailed tankage design, the relative payload performance of the cryogenic systems will be degraded; for short missions—not significantly, for long missions—quite significantly. The space storable OF_2 systems will not experience these losses.

(2) The OF_2 systems involving fuels such as monomethyl-hydrazine, ethane, methane, and ethylene fall on or about the same constant bulk density line as does the baseline nitrogen tetroxide-hydrazine blend. This means that, all other things being equal, a spacecraft propulsion system using the baseline propellants could be upgraded to provide some 20-percent vehicle payload increase by an oxidizer substitution. It obviously does not mean that all you have to do is drain out the nitrogen tetroxide and pour in the OF_2 to realize a 20-percent performance gain. There is a good deal more work to do than that. But it does mean that a basic pattern can be established to provide vehicle performance upgrading without making a completely new beginning.

Figure 3 shows the same kind of information that was shown in figure 2, except that the mission velocity increment is over twice as great and might correspond to a portion of a planetary mission.

Here again, the three pie charts describe the density—specific impulse problem very well. This becomes a particularly important problem when we are working with such high velocity increments where, in effect, we have a flying tank.

Payload under such circumstances is only a very small percentage of the total vehicle weight. Thus, differences in tankage weight have a profound effect on payload.

We can see that the lower propellant weight resulting from higher liquid oxygen/liquid hydrogen specific impulse is offset by the greater tankage and pressurizing system weights caused by lower density. Thus for this kind of mission, the liquid oxygen/liquid hydrogen combination in a pressurized vehicle appears to be not much better than the baseline, whereas the OF_2/diborane payload is twice that of the baseline.

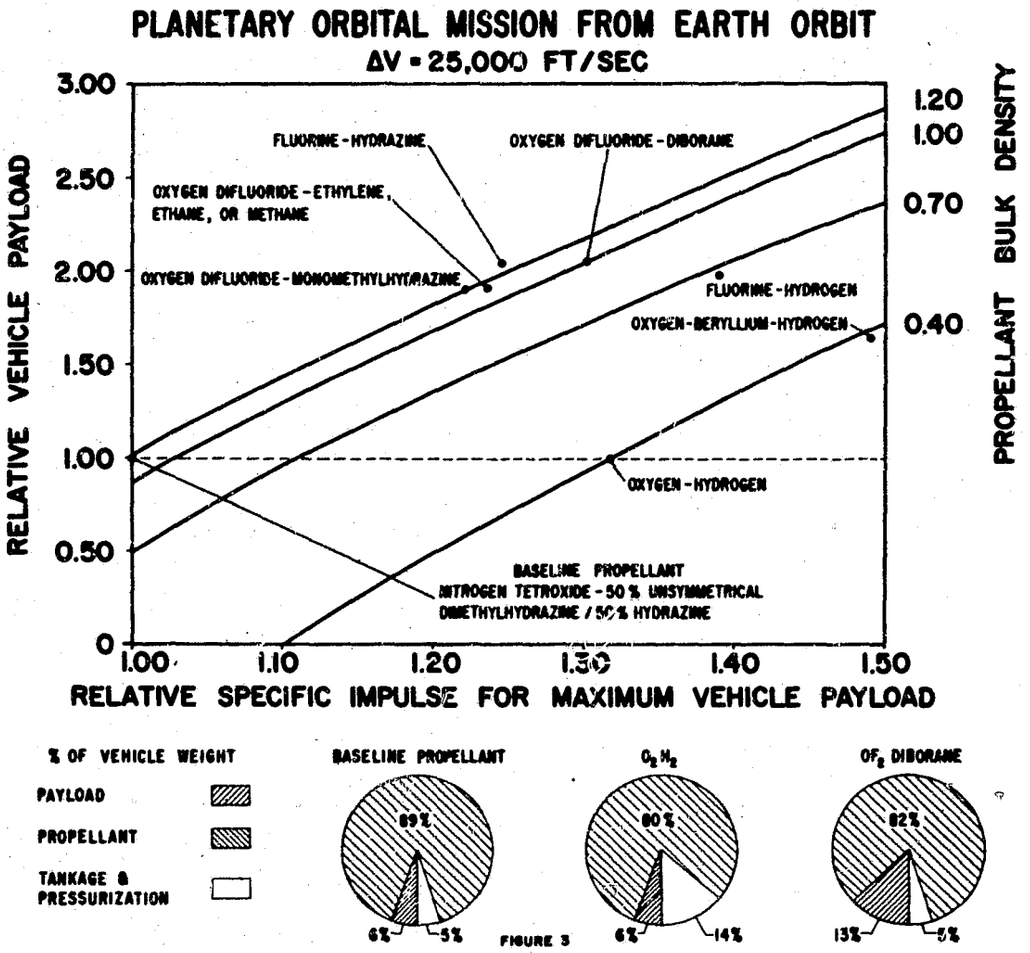

FIGURE 3

In figure 4 we have shown the liquid ranges of the various propellants, the lower value being their freezing point and the upper value the temperature at which a vapor pressure of 200 pounds per square inch absolute is developed.

It can be seen that there is considerable overlap in the liquid ranges of OF_2, diborane, ethane, ethylene, and methane. This overlap occurs within equilibrium temperature ranges which can be achieved in space by vehicle coatings and orientation. The fact that the propellants have common, wide liquid temperature ranges, coupled with the ability to establish a vehicle equilibrium temperature anywhere within this range, allows them to be stored for long periods in space, without loss or insulation.

The liquid hydrogen temperature range is too low to permit passive long-term storage and therefore requires external insulation to minimize these boiloff losses. In addition, the difference in liquid temperature range between hydrogen and both fluorine and oxygen makes it necessary to provide insulation between tanks as well.

Because of the importance that we attached to these theoretical studies, we undertook using corporate funds to explore experimentally the behavior of OF_2 with various fuels. Our initial concern was with the OF_2 itself, since the fuels were well characterized. When we started, we made our own OF_2. Subsequently, with NASA support,

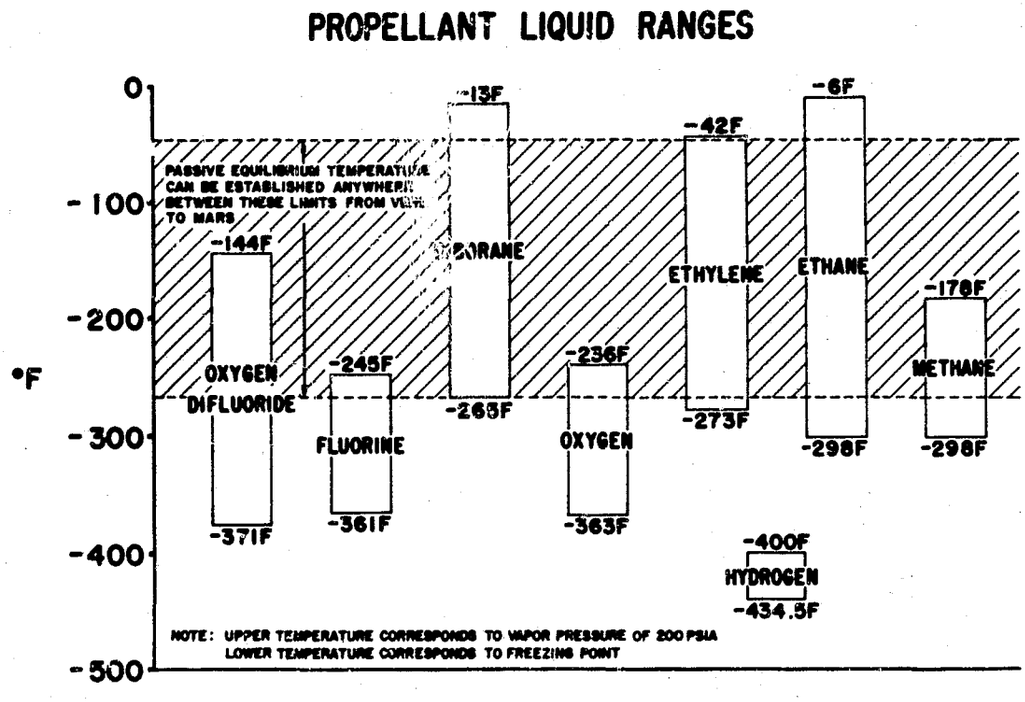

FIGURE 4

Allied Chemical in Baton Rouge entered into pilot production and the supply picture has changed considerably.

The overall pattern of events is shown in figure 5. What is shown is a progression of work beginning back in April of 1961, which I will review briefly.

The first OF_2 firings were made with hydrazine-type fuels, using engines developed initially for use with nitrogen textroxide and hydrazine blends. The objective was to determine whether there was any practical basis for achieving the potential growth pattern we talked about in the previous charts. The hardware stood up well, high performance was obtained, and the OF_2 behaved itself very well. Although there is obviously more work to do in this area, it appears to us that a relatively straightforward upgrading path has been demonstrated.

Because this intermediate upgrading step was achieved without unusual problems, it was decided to push forward toward the testing of the OF_2/diborane combination because of its even higher performance potential.

After our initial corporate-supported firings with OF_2/diborane proved to be successful, we received a small contract from NASA to determine the properties of OF_2 and to determine the combustion efficiencies of OF_2/diborane in a small rocket motor. The program was begun in June 1962 and was completed at the end of the year.

Much was learned about the detailed properties of OF_2; the net result is that there appears to be nothing fundamental about this oxidizer which would preclude its use in a spacecraft or anywhere else. It behaves itself very well and can be handled safely with proper procedures available at any rocket testing establishment.

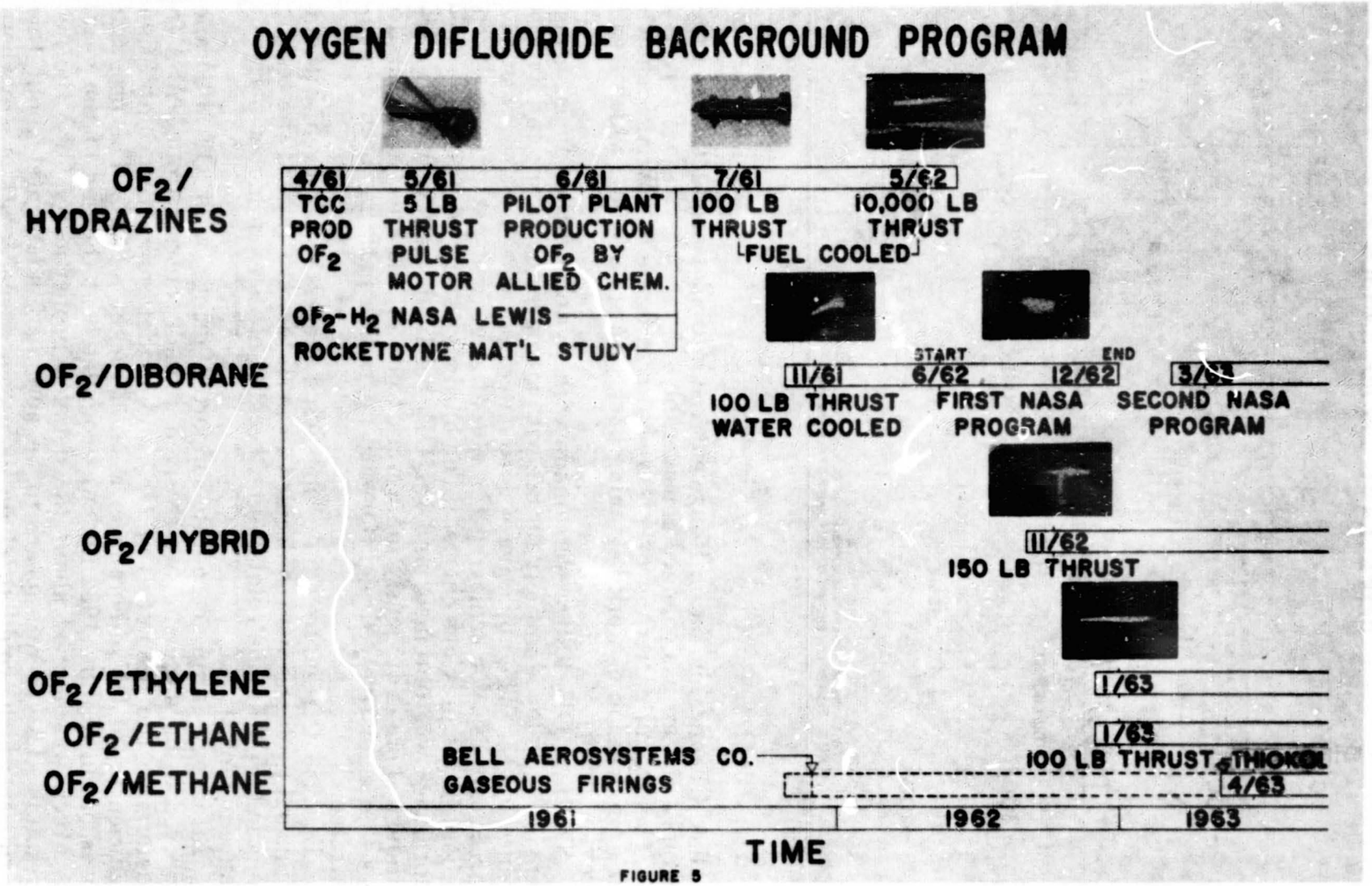
OXYGEN DIFLUORIDE BACKGROUND PROGRAM
OF2/ HYDRAZINES
4/61
5/61
6/61
7/61
5/62
TCC PROD OF2
5 LB THRUST PULSE MOTOR
PILOT PLANT PRODUCTION OF2 BY ALLIED CHEM.
100 LB THRUST FUEL COOLED
10,000 LB THRUST
OF2-H2 NASA LEWIS
ROCKETDYNE MAT'L STUDY
OF2/DIBORANE
START
END
11/61
6/62
12/62
100 LB THRUST WATER COOLED
FIRST NASA PROGRAM
SECOND NASA PROGRAM
OF2/HYBRID
11/62
150 LB THRUST
OF2/ETHYLENE
1/63
OF2/ETHANE
1/63
OF2/METHANE
BELL AEROSYSTEMS CO. GASEOUS FIRINGS
100 LB THRUST THIOKOL
4/63
1961
1962
1963
TIME

FIGURE 5

The small-scale motor tests showed that safe, spontaneous ignition could be achieved with OF_2/diborane both at sea level and 80,000 feet. Combustion proceeded smoothly and high performance was achieved—actually within 95–96 percent of theoretical value. Significantly, test operations also proceeded smoothly and safely.

Though the tests were gratifying, they did raise some questions that need answering. High performance apparently occurs over a narrow range of mixture ratios and does not follow the relatively flat theoretical prediction. We have called this "performance peaking."

In all, 52 firings were made, using both uncooled and water-cooled hardware in which heat transfer measurements were taken. Our interest in heat transfer data is very great since we are dealing with a propellant combination whose greatest potential problem is hardware cooling. The propellants themselves are not good coolants and one must look to alternate cooling and material approaches.

The choice of materials is made difficult because, depending upon the pressure and mixture ratio at which one chooses to operate, we are dealing with combustion gases whose theoretical temperatures range between 6,300° and 7,500° to 8,000° F. By way of comparison the nitrogen tetroxide hydrazine family of propellants have combustion temperatures in the 5,000° to 5,200° F. range. There are however, several approaches to these problems that bear careful evaluation.

As a result of what had been learned during our first program, NASA, in March of this year, contracted with Thiokol to continue work in the combustion efficiency and engine cooling areas. This program is scheduled to run through this year. We are, in the meantime, and with corporate support, conducting tests using other fuels with OF_2 to broaden the OF_2 technology base.

In the second NASA program we are going to investigate the performance peaking problem. This will be done at a thrust level where meaningful information can be obtained. It is our belief that peaking may be eliminated by proper injector design; we will therefore evaluate several injector types and design criteria. This is something we were unable to do during the first program because of its limited scope. We are also going to evaluate the engine cooling situation by testing several small-scale ablative chamber designs.

Both the first and second NASA-supported programs are technically interesting and scientifically rewarding. But at the present effort level, it will be a very long time indeed before the performance and space storability potential of OF_2/diborane is evaluated and put to useful purpose.

Realization of the advantages of this propellant system requires a vigorous planned program to establish as rapidly as possible the technology needed to permit applied development of propulsion systems. It is our view that this technology can be established before the end of calendar 1963 by pursuing additional effort, over and beyond that now being supported.

This involves work on the cooling problem in a more realistic scale such as 2,000-pound thrust, or higher, by conducting work on several alternate nonabaltive cooling concepts, and by performing tests with high expansion area ratio nozzles at simulated altitudes to determine if the assumed shifting equilibrium performance is actually being obtained.

At the end of calendar 1963, we will have been working under contract for about 1½ years. In this time and with adequate support, we should be able to determine if the OF_2 Diborane approach does, in fact, fulfill the promise it shows on paper. If it does, then we can move on to the demonstration of an experimental flight engine. If it does not, then we must look to some other fuels with OF_2. Unfortunately, at our present pace, we will be well into calendar 1964 before any such judgment can be made. This in turn will postpone the day when a true high performance, space storable engine can be available.

Assuming that we can proceed at a sufficient pace to resolve the technological questions by the end of calendar 1963, we could then begin logically with the demonstration of an experimental high energy engine. Such an engine, oriented for use as propulsion for a to solar or a planetary probe, would have a fixed thrust of about 2,000 5,000 pounds. This would be an economical size with which to work, and the engine size would permit technology to be translated to other applications. As shown in figure 6, a flyable engine of this size could be available by midcalendar 1965.

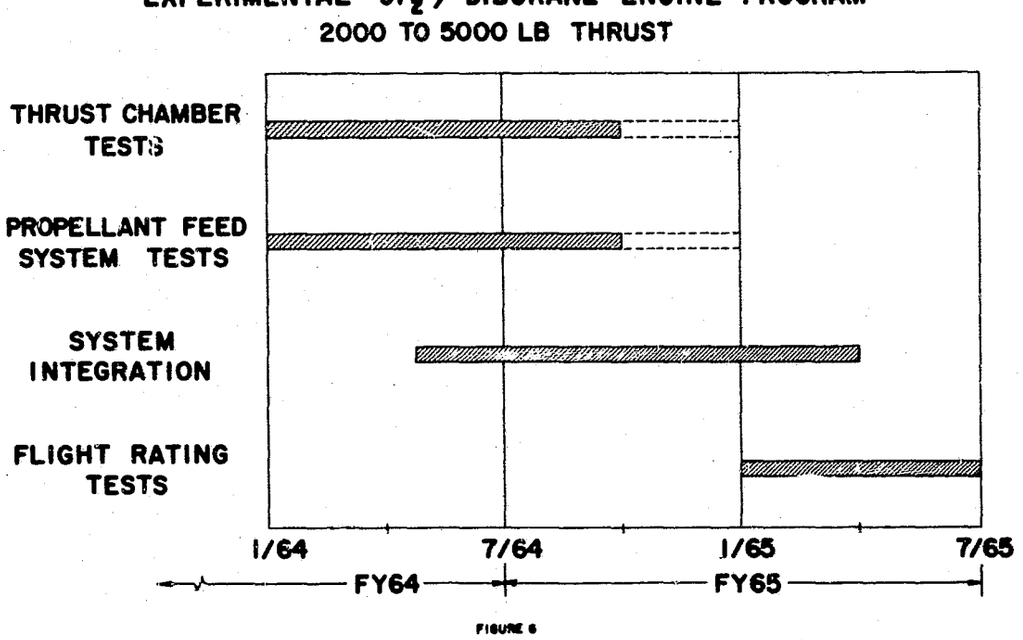

FIGURE 6

The next logical step to this one would involve the development of a larger, man-rated, and controllable propulsion system such as the types to be used in the Apollo vehicle. By combining the technology from the Apollo engine programs with the OF_2 technology, it should be possible to have such a high energy system available for use in the latter half of calendar 1966 if work were begun in mid-1964.

The point here is that, even if we start in midcalendar 1964, it will be the latter part of 1966 at the earliest, before an advanced engine such as this could be ready for flight testing.

To the best of our knowledge, there is nothing now in development that can provide the performance and space storable capabilities of such an engine in this time period. This lack of a high-energy payload

propulsion system will continue to place tremendous and costly burdens on the ever more important and far more expensive booster stages below.

I would like to conclude my remarks with these three comments:

(1) There is definite, foreseeable need for high energy, space storable propellant systems for long-term use in space—a need that cannot be adequately met, in my opinion, with present cryogenic systems.

(2) The most promising approach to satisfying this need is an OF_2 based propellant system using diborane or several of the carbonaceous fuels. This approach provides growth potential of systems using present day storables, as well as growth margin for new systems.

The last point I would like to make is that initial efforts have been encouraging and have defined the main problem areas. Though these problems are being pursued, a more vigorous and continuing effort is needed to resolve them in timely fashion.

Thank you.

Mr. DADDARIO (presiding). Thank you, Mr. Sherman, for the statement. I think we can proceed with some questions by the staff. Do you have any questions, Mr. Hines?

Mr. HINES. Yes, sir.

Mr. DADDARIO. Please proceed.

Mr. HINES. Mr. Sherman, what was the amount of the initial contract with NASA?

Mr. SHERMAN. I believe it was about $200,000.

Mr. HINES. And that ran for how long?

Mr. SHERMAN. From June 1962 through the end of the year—about 6 months.

Mr. HINES. What is the amount of your present contract?

Mr. SHERMAN. It is about $475,000, and we are partially funded.

Mr. HINES. How much of your corporate funds are being invested in this?

Mr. SHERMAN. Quite a bit. We consider the actual number to be proprietary.

Mr. DADDARIO. Can you break that down into percentages, the ratio between NASA dollars and company dollars in this program? If you can't do it now, could you make arrangements to give us the figures?

Mr. SHERMAN. I think we could.

Mr. HINES. Historically, Mr. Sherman, when were the technologies developed for the fuels which we are now using in the space program?

Mr. SHERMAN. For propellants used in spacecraft such as Apollo, the technology is probably 5 to 10 years old.

Mr. HINES. Would it be a logical statement to say that the flight decisions, mix decisions made in 1958 precluded the launching of unique or special studies into fuel research to be accomplished within the time schedule we have been faced with?

Mr. SHERMAN. Correct. You would not be flying today with these advanced propellant systems, if that is what you mean.

Mr. HINES. Yes; that is what I was driving at. So the decisions then made by NASA were the ones they had to make, because this technology was new?

Mr. SHERMAN. That is right, there were not many choices available at that time other than the nitrogen tetroxide hydrazine family.

Mr. HINES. That is the point.

From looking at the performance charts, the question arises: Why do anything further with liquid oxygen and liquid hydrogen and some of the other cryogenics? What is your opinion?

Mr. SHERMAN. There are several reasons for going further with liquid oxygen/liquid hydrogen. This propellent combination is quite useful in the booster stages. My charts referred primarily to spacecraft propulsion, the long-term missions for space. In the booster stages liquid oxygen/liquid hydrogen does not face the storability problems associated with long-duration spacecraft missions, and there is need for the high specific impulse performance in these stages. Further, you can get this performance while avoiding the problem caused by toxicity at a launch site which other high-energy propellants would cause as booster propellants.

There are major operational problems with liquid oxygen/liquid hydrogen boosters, but these are resolvable, I am sure.

Mr. HINES. In your fifth chart you showed a chain of events involving OF_2. Would you say that all the events other than those listed as NASA programs were corporate funded? If so, how much was involved?

Mr. SHERMAN. The events shown in the chart were largely corporate funded. There are several shown that involved firings at Bell, under Air Force sponsorship, I believe, materials testing at Rocketdyne, and some firing work at NASA-Lewis. The extent of Thiokol funding will be provided for the record as previously requested by Mr. Daddario.

Mr. HINES. Your firing program involved engines of only 100-200-300-pound thrust, is that correct?

Mr. SHERMAN. In the OF_2/Diborane area they did. In the case of OF_2 and hydrazine fuels we went to 10,000 pounds of thrust. Our current efforts with other fuels are at lower thrust levels.

Mr. HINES. Is it your belief that larger scale programs involving higher thrust levels would perhaps negate or refute some of the minor problems you ran into? In other words, if you scale up would this obviate or make clear the problems you are wrestling with?

Mr. SHERMAN. It would make clearer the problems and would give us a great deal more flexibility in working them out. The cooling and injection problems are much more difficult on a very small scale.

Mr. HINES. Mr. Sherman, you brought up the problem of cooling these engines. Is this a special or unique problem with high-energy fuels?

Mr. SHERMAN. Yes, it is, particularly with OF_2 and diborane, because neither of the fuels is an outstanding coolant. The combustion temperature is very high, between 6,300° and 8,000° F. However, cooling is not particularly bad with OF_2 and the hydrazines. We have fuel cooled this combination without any real difficulty. We do not believe OF_2 diborane cooling or more properly, hardware durabiliy, to be an insurmountable problem—difficult but not insurmountable.

Mr. HINES. What technology would you use to cool these engines, in general?

Mr. SHERMAN. Several fundamental approaches can be used. One, of course, is the approach we are trying to evaluate now, although I think at too small a scale; that is, ablative technology. There are new materials that bear investigation, both new ablative materials,

and new uncooled, or high-temperature materials. Also, there are several combinations of approaches that can be used, that look attractive on paper. But you need a reasonable-sized engine to work them out.

Mr. HINES. What schedule would that be?

Mr. SHERMAN. A minimum of 2,000 to 5,000 pounds.

Mr. HINES. That is all.

Mr. DADDARIO. Mr. Fulton?

Mr. FULTON of Pennsylvania. We are glad to have you here, and I compliment you on your excellent statement. It is detailed enough that it points out to us what we can anticipate on the general approach to these high-energy, space-storable propellant systems. As you say, these can be used for extended-duration complex space missions in the months and years ahead.

At the present time it takes about 1,000 pounds on the ground to put 1 pound in Earth orbit. It costs about $1,000 to $20,000 a pound to put a payload in Earth orbit. We are talking about expensive programs. Any increase of payload for the same amount of booster and propellant is therefore a great gain, isn't it?

Mr. SHERMAN. Yes, quite a bit.

Mr. FULTON of Pennsylvania. So that what we are really talking about when we speak of high-energy propellants is saving the taxpayers' money by reducing the size of the booster and the propellants, not only in the spacecraft itself, but also in the amount necessary to place the vehicle into orbit, is that not the case?

Mr. SHERMAN. This is generally so; yes. You can do a fair amount of development of these spacecraft propulsion systems for what it costs to develop these large boosters.

Mr. FULTON of Pennsylvania. Would you explain that a little bit?

Mr. SHERMAN. The costs for large booster development are quite substantial. By having higher energy spacecraft propulsion available we can make much greater use of existing boosters, and avoid the necessity for major booster development with every new application.

Mr. FULTON of Pennsylvania. The United States is at the point where, without high-energy fuels, we are getting larger and larger boosters containing more and more lower grade propellants, and therefore we have a high overall cost. While if we went into higher energy fuels, an increase in the applied specific impulse of a high-energy fuel would result in a proportionately greater increase in payload. For example, it might run to 10, 15, 20, 30 percent more payload, isn't that correct?

Mr. SHERMAN. That is correct.

Mr. FULTON of Pennsylvania. Where we have space storable fuels that are likewise high-energy fuels, don't we also add safety and reliability to a space mission?

Mr. SHERMAN. Yes, this is so. You will notice that our charts are for pressurized systems. One of the reasons for doing this is to use simple systems, systems which contain high-energy propellants which are spontaneously ignitible in space, so as to increase spacecraft propulsion system reliability.

Mr. FULTON of Pennsylvania. Some of the members of this subcommittee, as well as members of the full committee, have been very interested in seeing that enough attention is paid to broad programs in high-performance, space-storable propellent systems of the high-

energy type. I have read an article which said that the Russians are already experimenting with the boranes and fluorine, and high-energy fuel systems. Under those circumstances, if we are in a race of any type to get to the Moon first, we should have the broad-based, high-energy-fuel research and development program, should we not, either as the prime source of propellant or as a backup system? Would you comment on that?

Mr. SHERMAN. I think you should have them—this country is committed in the time scale that we are talking about, to the use of existing propellent systems, such as the baseline propellent system, nitrogen tetroxide/hydrazine blends for spacecraft propulsion. But the reason for pursuing the higher energy systems is the very obvious and logical growth pattern that all spacecraft systems have undergone and will continue to undergo. As soon as we get the first two people down on the lunar surface there is undoubtedly going to be a requirement to get them some more supplies, or get more of them there.

There isn't any question in my mind but that there will be a serious need for high-energy propellants.

Mr. FULTON of Pennsylvania. For deep-space programs of any type or variety?

Mr. SHERMAN. For deep-space probes, long-term orbiting missions, extended manned flights, this sort of thing.

Mr. FULTON of Pennsylvania. With the problems occurring in the development of nuclear fuels, it is obviously an insurance to develop these high energy fuel engines as well as the fuels themselves, is that not correct?

Mr. SHERMAN. Yes, sir.

Mr. FULTON of Pennsylvania. Would you explain that a little bit?

Mr. SHERMAN. Well, the advantage of the nuclear system, of course, is that it provides greater margin in terms of payload, and allows the use of larger payloads. The lack of such a system puts a greater emphasis on the need for a good, high-performance upper stage propulsion system, because without nuclear lower stages, we are now back to depending on chemical systems for boost. We no longer have the same flexibility, or the same margin that the nuclear stages would provide.

Mr. FULTON of Pennsylvania. Since the Apollo program depends so much on hydrogen alone, the cost of insulating the space vehicle is causing an extra expense to the taxpayers. Secondly, this limits the space vehicle so that we do not have the safety and reliability, and backup systems built into the spacecraft.

Mr. SHERMAN. The Apollo spacecraft, per se, is going to contain storable propellants of the low energy range; namely, nitrogen tetroxide and hydrazines. Several booster stages will use liquid oxygen/liquid hydrogen. Here we have a development problem which must receive serious attention. However, from the standpoint of spacecraft reliability I don't think we have the situation that we would have, in my opinion, liquid oxygen/liquid hydrogen were also used aboard the spacecraft. We will of course have significant spacecraft propulsion, safety, and reliability considerations with which to be concerned—but the use of storable, spontaneously ignitable, pressurized fuels makes the problem much more direct.

Mr. FULTON of Pennsylvania. Hydrogen boils at minus 425° below Fahrenheit and absolute zero is minus 456° F. When the temperature

of outer space, without any reflective body near, is about minus 410° F., it can be readily seen that hydrogen will boil off, is that not correct?

Mr. SHERMAN. This is correct. This is one of the points I tried to make in my discussion of figure 4.

Mr. FULTON of Pennsylvania. Hydrogen will boil away more rapidly where it is near a reflective body. When a space vehicle approaches the Moon on the sunny or reflective side, we would have a real insulation problem to keep hydrogen from just boiling away.

Mr. SHERMAN. On the sunny side of the lunar surface, we will have a problem with almost any propellant system and some protective means must be provided. However, propellant storability during the course of long flights can be achieved with space storables. Coating the surface of the spacecraft, and orienting the vehicle relative to sources of heat such as the Sun, to establish a heat balance within the spacecraft so that temperatures of the propellants are maintained in the range where they remain liquid.

The problem with hydrogen, of course, is that its temperature is much too low to do this.

Mr. FULTON of Pennsylvania. When you use oxygen with hydrogen in a spacecraft, there are additional problems. I believe that the oxygen boils at 297° below zero; is that correct?

Mr. SHERMAN. Yes, sir.

Mr. FULTON of Pennsylvania. Since these two fuels have a different boiling point, you would have to have adequate insulation between the two fuel tanks or compartments.

Mr. SHERMAN. That is correct.

Mr. FULTON of Pennsylvania. That adds to the weight, too; does it not?

Mr. SHERMAN. Yes, sir.

Mr. FULTON of Pennsylvania. You mentioned that your original program with NASA whereby Thiokol was given a $200,000 contract from fiscal year 1962 funds for research on high-energy fuels ended at the end of that year. I believe that program ended about the beginning of December 1962; did it not?

Mr. SHERMAN. That is correct. The experimental work ended very late in November and then there was some cleaning up to do through December.

Mr. FULTON of Pennsylvania. End of November or the first of December?

Mr. SHERMAN. Yes, sir.

Mr. FULTON of Pennsylvania. You also spoke of another contract with NASA which would come from fiscal year 1963 funds. I believe the amount of that contract is $375,000?

Mr. SHERMAN. That is the first funding increment. I think the total program runs $475,000.

Mr. FULTON of Pennsylvania. I was present at a hearing before another subcommittee of the House Science and Astronautics Committee and the comment was made that the research program on high-energy fuels with Thiokol was moving ahead. I understand, however, that it was only on March 20, 1963, that you got the go-ahead from NASA on the $375,000?

Mr. SHERMAN. That is correct.

Mr. FULTON of Pennsylvania. Therefore, that means that from the end of November 1962 to March 20, 1963, NASA had really no program in operation with Thiokol.

Mr. SHERMAN. That is correct. Negotiations with NASA were underway during this period, and the final report of our first program was being approved and published. The negotiations were protracted because of a change in personnel on the NASA technical team at Lewis Laboratories where this program is monitored.

Mr. FULTON of Pennsylvania. Do you feel that unless adequate funds are given to high-energy fuels, that we will fall behind and cannot have high-energy fuels by 1965–66?

Mr. SHERMAN. Yes, sir.

Mr. FULTON of Pennsylvania. So that in looking at this, without criticizing NASA, but rather to emphasize NASA's high energy fuel programs for which they have received many compliments, would you say that Congress should emphasize and provide more money to NASA for these programs?

Mr. SHERMAN. Yes, sir.

Mr. FULTON of Pennsylvania. Should this committee authorize more funds for this program in the coming fiscal year in order to insure that it is carried out at an expeditious rate?

Mr. SHERMAN. My view is that you should; yes.

Mr. FULTON of Pennsylvania. I have spent some time at Edwards Air Force Base and have gone over the situation with Colonel Norton of the Air Force. His comments, as well as my followup on the experiments, have led me to believe that the experiments in high energy fuels have been moving along well and are successful. These experiments point to a good conclusion if the work is carried on, isn't that correct?

Mr. SHERMAN. We believe this to be the case, yes, sir.

Mr. FULTON of Pennsylvania. As a matter of fact, your experiments at Thiokol, including your tests of these smaller engines, have achieved ratings above 85 to 90 percent of theoretical capacity.

Mr. SHERMAN. Actually, our achieved combustion efficiencies are up to about 95 to 96 percent. The fly in the ointment is the——

Mr. FULTON of Pennsylvania. Don't say me.

Mr. SHERMAN. Is the apparent peaking of this performance.

Mr. FULTON of Pennsylvania. Yes. But that is in order to stretch out the performance over a range of mixture ratios rather than to find whether there is the inherent capacity in the fuel.

Mr. SHERMAN. We have demonstrated that there is the capacity in the fuel and that it certainly can be achieved. I for one am not overawed at this peaking problem. I think it can be worked out.

Mr. FULTON of Pennsylvania. You have not only the peaking problem but also the problem of ablative materials that are necessary for development of adequate nozzles. Could you comment on that?

Mr. SHERMAN. There is a materials problem. Ablative materials are one approach to it; the other approach being high-temperature materials used alone or in combination with other mechanisms of cooling. But there is this total cooling problem that needs work.

Mr. FULTON of Pennsylvania. Do you believe that a good, well-organized, and efficiently handled research and development program in these high-energy fuels is necessary in order to properly approach the U.S. missions in space?

Mr. SHERMAN. Yes, sir. We need this to go on beyond the missions that are presently planned, very definitely; and we need it also as insurance for those missions that are now defined.

Mr. FULTON of Pennsylvania. Have your relations with the Air Force and NASA been satisfactory? Do they feel that the results you have obtained on your experiments so far have pointed in the right direction and are constructive contributions?

Mr. SHERMAN. We have kept the Air Force advised as to the results of our testing. Whether they are in agreement with them, or believe as strongly as we do in this approach, I think is something the Air Force can best answer.

Mr. FULTON of Pennsylvania. This committee and the Senate Committee on Aeronautical and Space Sciences authorized an extra $1 million in fiscal year 1963 for research and development of high-energy fuels. Do you believe that this authorization should be continued in the coming fiscal year to emphasize research and development programs in high-energy fuels?

Mr. SHERMAN. I certainly think we need to emphasize this program of research and development in high-energy propellants. I really can't say, whether the exact figure of $1 million is sufficient or not. I think certainly from——

Mr. FULTON of Pennsylvania. I am not talking of an exact amount; I am just saying emphasize.

Mr. SHERMAN. Emphasize, very definitely.

Mr. FULTON of Pennsylvania. You indicate on page 12 of your statement that: "The objective was to determine whether there was any practical basis for achieving the potential growth pattern shown in the previous charts. The hardware stood up well, high performance was obtained, and the OF_2 behaved itself very well. Although there is obviously more work to do in this area, it appears to us that a relatively straightforward upgrading path has been demonstrated. Because this intermediate upgrading step was achieved without unusual problems, it was decided to push forward toward the testing of the OF_2/diborane combination because of its even higher performance potential."

I think that is an excellent statement. Are you therefore recommending that we go ahead with the research and development in this area by placing emphasis on it to have an efficient, economical, and broad-based space program in the future?

Mr. SHERMAN. Yes; I do.

Mr. FULTON of Pennsylvania. Would you amplify that a little bit? If we do not do this, what would happen to your scientific team that has been working on these problems?

Mr. SHERMAN. Well, the point that I tried to make in that particular comment was that the analyses that we have made, that I showed this subcommittee in figures 2 and 3 indicate two things: They indicate first of all, that of all the space storable propellant systems that we or anyone else have come across, OF_2/diborane certainly appears to be the highest performing system. The intermediate step that I referred to, involves the use of OF_2 with several of the other carbonaceous fuels. The point here is that our concern initially was: Is this an attractive intermediate step? From the data it appears as though we can realize a 20 percent performance improvement in essentially the same vehicle by this relatively direct first step. We did this. We made the tests, and convinced ourselves that this upgrading, if you will, is a relatively straightforward one. It is not

without its problems, but these are more of a direct engineering nature than a way-out research effort.

The move then was to see whether the additional increment in performance could be obtained with the OF_2/diborane. Here, of course, is where with NASA support we are now working, and we are convinced that this step can be achieved.

Now I don't know whether I have answered your question fully.

Mr. FULTON of Pennsylvania. Yes, I think you have done very well. Actually, the Air Force recommended an advanced ATP, advanced technical program, on this particulr aspect of the high, energy fuel research and development, did it not?

Mr. SHERMAN. I gather it did.

Mr. FULTON of Pennsylvania. One of the most critical points on the development of these engines for space is the ablative materials research and development. Dr. Bisplinghoff testified on the 27th of March 1963, when I had asked him the question, that there was simply a $40,000 contract with the General Electric Co. in this field for work on ablatives for nozzles and nozzle development. To me that is a very small program for one of the key problem areas.

Do you think that the emphasis could be increased in the field of developing ablative materials for nozzles for high energy propellants and other fuels?

Mr. SHERMAN. There needs to be some very substantial work done in this area of materials, ablative as well as nonablative, but heat resistant materials. Two types of work need to be done. One involves the more fundamental materials research, getting at the properties of materials and organizing their structure so they will perform properly.

The other involves more of an applied engineering effort to marry known materials and known fabrication processes to existing propellent injection systems.

This is a problem not necessarily with high energy propellants alone. It is a problem that needs real support with some of the low-energy propellent systems as well.

Mr. FULTON of Pennsylvania. That is all.

Mr. TEAGUE. Mr. Daddario?

Mr. DADDARIO. No questions.

Mr. TEAGUE. Mr. Hines?

Mr. HINES. Yes, sir. Thank you.

How much more money would you think it would require to get the answers on OF_2 diborane to accomplish the job by the year's end?

Mr. SHERMAN. This is a difficult question to resolve quantitatively, since what one group considers an answer, may not necessarily be considered a definitive answer to somebody else.

I think this is a situation where it can be stated generally that substantial additional effort is required. Certainly we could support in terms of productive areas of investigation something between two to four times the present support level.

Mr. HINES. Two to four times?

Mr. SHERMAN. Yes, sir

Mr. HINES. Would a similar ratio also be reflected in the number of people you would have to have?

Mr. SHERMAN. Not necessarily, no. It is not a direct relationship.

Mr. HINES. Where would this money be expended?

Mr. SHERMAN. Primarily in the exploration of various hardware and analytical approaches to some of the problems we have been discussing. They do not scale directly with people.

Mr. HINES. I see. Is Thiokol working alone in this area or does it have some subcontractors? I am trying to define the scope of the team which you are using.

Mr. SHERMAN. We have been working with Allied Chemical in connection with the evaluation of the properties of OF_2, and likewise with Callery in connection with diborane. I believe there is some testing work underway at other rocket companies with OF_2.

Mr. HINES. Are all the major elements of the industry working with you in this area and exchanging information?

Mr. SHERMAN. Well, certainly relative to the propellants themselves. Yes; this is so.

Mr. HINES. The whole team is not necessarily only interested in Thiokol work?

Mr. SHERMAN. I would say from the combustion standpoint it is, but by and large there is a large interest developing in this propellant system throughout the industry.

Mr. HINES. What would be the cost of the experimental engine program you showed in your last chart?

Mr. SHERMAN. Here again you get into semantics, in an effort to determine when you have satisfied yourself or someone else that you have an engine ready for flight.

Mr. HINES. I agree.

Mr. SHERMAN. A program such as we showed in figure 6 could cost anywhere between $5 and $8, or $9 million without the propellants.

Mr. HINES. Could you give us some idea of the missions that you think space storable propellants could be used for after 1966?

Mr. SHERMAN. Well, I think we will be faced with a situation, such that after the first series of the the Apollo firings are successful, we will want to do things in the way of upgrading the capability of the mission. This is just a natural evolutionary process. I think it is in this area that we require some real high energy propellants.

As a further thought, I believe that sometimes we tend to get too deeply committed to this business of a specific mission for a specific propellant. In some of these spacecraft we are talking about a situation where maybe 70, 80, or 90 percent of the weight of the spacecraft is tied up in propulsion and in propellants. The importance of propulsion is very evident, and it has always been a fact that propulsion has led events and been a pacing factor in progress. I think you need to develop this technology for the sake of the technology, itself, because once this is done, the missions will become very evident.

Mr. HINES. Do you think that it would be easier to man-rate a rocket system using the OF_2 diborane and such other fuels as opposed to the ones that NASA is now planning to use?

Mr. SHERMAN. No; it won't be easier; these and all high-energy propellants are more difficult.

Mr. HINES. It will be more difficult?

Mr. SHERMAN. Yes; you will have a lot more work to do.

Mr. HINES. I see.

Mr. SHERMAN. But this is all part of what needs to be done. It has got to be undertaken and with emphasis.

Mr. HINES. Thank you, Mr. Chairman.

Mr. TEAGUE. Any questions?

Mr. ROUDEBUSH. I have no questions.

Mr. RIEHLMAN. No questions.

Mr. DADDARIO. You refer on page 1 of your statement to the nuclear lower stages. By limiting your thinking to nuclear lower stages, you do not preclude the possibility of using nuclear power in the upper stages, do you?

Mr. SHERMAN. I don't preclude it, but I suspect it is a fair way off.

Mr. DADDARIO. Yes; but even though it may be a fair way off, we have important programs in this area. We will not be able to achieve our ultimate goals in space until we develop a nuclear power capability in upper stages, isn't that correct?

Mr. SHERMAN. Well, I think here we have to differentiate between the so-called conventional nuclear power and the electrical propulsion systems that are being considered for these very long deep space, interplanetary missions.

I think most of our present thought—and I should emphasize that I am not a nuclear propulsion expert—most of our present thinking in this area relates to the use of nuclear propulsion in upper stages as a booster or a substantial velocity increment producer. I don't believe we are talking about nuclear propulsion systems for the long-term, on-board spacecraft propulsion.

Even if we are, we will still require chemical propulsion for some of the smaller mission functions. For example, I don't see functions such as landings, attitude control, and midcourse correction, which require low total impulse, as being useful nuclear propulsion functions.

I think you are always going to require high performance chemical propellants aboard these vehicles.

Mr. DADDARIO. You have made some reference to the use of diborane and fluorides in an Apollo-type program. You don't, however, see any problem with the Apollo program as it is presently being conducted, do you?

Mr. SHERMAN. From the standpoint of its capability to perform its mission?

Mr. DADDARIO. Yes.

Mr. SHERMAN. No; I don't.

Mr. DADDARIO. You made a comparison in an answer to a question put to you by Mr. Fulton that I did not quite understand. That was in reference to additional capability which might be added to the Apollo program by the use of OF_2. Would you explain that a bit further?

Mr. SHERMAN. Oh. Well, I was referring in that instance to what I believe will undoubtedly occur. It has happened on every program that I have ever seen, and I suspect it will happen again. Once the initial effort has been successful, using present-day propellants, there is undoubtedly going to be a requirement to upgrade the mission and accomplish more with it, requiring more payload.

I think that the present mission probably comes pretty close to the limit with respect to present-day available storable propellants.

Mr. DADDARIO. Isn't this always the case? As we go into a program, we always see other things we might do to build up our capabilities. We must be careful though not to constantly redirect our forces as the result of the improvements in our knowledge and technique as programs develop.

Mr. SHERMAN. I don't think it is a case of redirecting in the middle, I think it is a case of growing beyond.

The Gemini-Mercury situation is a pretty clear illustration of having accomplished one mission and done it successfully several times, and now the intent is to upgrade the mission and accomplish more with it.

This means more payload. For an upgraded Apollo mission we will run into trouble getting more payload with present-day storables and present boosters.

Mr. DADDARIO. But we have had some talk here this morning about adding steam to this high energy fuel program by additional appropriations. There always comes a question to my mind and to, I am sure, other members of this committee, about how many of these programs can we keep going at the same time. We certainly have to pick and choose. If we have national goals established, and programs which can accomplish these goals, the question arises as to where we should begin limiting our activities.

In reference to your statement this morning, do you believe that the development of this kind of fuel is imperative to the accomplishment of our national goals and that it is vital that we expend additional large sums of money to develop these fuels as well as the others which are being developed?

Mr. SHERMAN. The general answer to the question is yes. I think we have the situation today where there is a clear requirement for higher energy, long-term space storable propellants. The problem is try and find the best one, the one to support.

Our analyses, the charts that I showed you, and they are just two of very many, indicate that there is a promising approach involving the use of oxygen difluoride as the oxidizer.

We are at the moment striving to climb to the top of the tree in the sense of going after the diborane combination with OF_2. Should that fail, and this is the point I tried to make in this paper, should that fail to prove as attractive, in fact, as it does on paper, we may have to set our sights a little bit lower. However, there are places along the family of curves where you can set your sights, a little bit lower, and still see some significant performance gains.

The point here is that I think these approaches we talked about need to be pursued vigorously because at the moment I know of no other approach that gives us a space storable high energy propellant capability.

Mr. TEAGUE. Any further questions?

Mr. FULTON of Pennsylvania. I have one.

Mr. TEAGUE. We have another witness, Mr. Fulton, but go right ahead.

Mr. FULTON of Pennsylvania. On page 16 of your statement you say that at the end of 1963 you will have been working under contract for about one and a half years. That means that your current contract with NASA runs out at the end of December 1963?

Mr. SHERMAN. That is correct.

Mr. FULTON of Pennsylvania. Unless funds are provided there will be an interval when nothing is done on high energy fuels, is that not correct?

Mr. SHERMAN. Unless funds are provided in the form of either increasing the scope of the present contract or doing something about a new one, yes.

Mr. FULTON of Pennsylvania. From December 1963 until the fiscal year ends June 30, 1964, there might be a time when the programs do not have adequate funding and the scientific teams would have to be disbanded. This is true at Thiokol, as well as with Callery Chemical Co. and Bell, is that not correct?

Mr. SHERMAN. This would probably be true for ourselves, and Callery, and Allied. I believe Bell has support to some extent from the Air Force involving a rather special approach.

Mr. FULTON of Pennsylvania. You also say in your statement:

> In this time and with adequate support, we should be able to determine if the OF_2/diborane approach does, in fact, fulfill the promise it shows on paper. If it does—then we can move on to the demonstration of an experimental flight engine. If it does not, then we must look to some other fuels with OF_2. Unfortunately, at our present pace, we will be well into calendar 1964 before any such judgment can be made. This in turn will postpone the day when a true high performance, space storable engine can be available.

Then on page 17 you say:

> It should be possible to have such a high energy system availabe for use in the latter half of calendar 1966 if work were begun in mid-1964.

You further say:

> A flyable engine of this size shown in figure 6 could be available by mid-calendar 1965.

Is that not in your statement?

Mr. SHERMAN. Yes. Basically so. There are three things that are being talked about there, one involves an early resolution to what is basically I think Mr. Daddario's question, which is "Where do you put your money, where do you place your emphasis?"

We are trying to resolve this question as to the relative merits of OF_2 diborane and we can come to the end of this resolution by the end of calendar 1963 provided there is an additional support.

It is important to come to this resolution because if we don't, it will drag on and on and on, and never come to any kind of positive answer.

Mr. FULTON of Pennsylvania. The gain of 20 percent in performance would be a real step forward if we could reach it in the NASA program?

Mr. SHERMAN. Yes, it would.

Mr. DADDARIO (presiding). You are however, in touch with NASA on this particular problem. You are negotiating with them so there is no lack of contact to get your points across to NASA?

Mr. SHERMAN. No; we have maintained an input relative to our own technical planning and recommendations in this area.

Mr. DADDARIO. So if there are any limitations, it involves the negotiations going on with NASA, and their thinking as to the value of your program which has already been partially funded by them?

Mr. SHERMAN. This is so. The value of the program, as NASA sees it, is something I think you would have to discuss with NASA.

Mr. FULTON of Pennsylvania. The question is whether the NASA funding is sufficient to achieve the most efficient type of program?

Mr. DADDARIO. Yes, I think it is important for us, Mr. Fulton, to recognize that. However, it is also important for us not to leave any illusions about one important fact; NASA is looking into the program; they have funded it in the past, and they have the facts

available to them to make a decision as to whether or not there will be additional funds.

Are there any further questions?

(No response.)

Mr. DADDARIO. If not, Mr. Sherman, thank you very much. It has been a very illuminating discussion and very helpful to the committee.

We will proceed with Mr. Toering, manager of the Defense Products Department of the Callery Chemical Co.

Do you have other witnesses with you?

Mr. TOERING. I have several colleagues with me and I trust a few friends, and I have asked Mr. Carpenter, manager of our Washington office, to join me at the table.

Mr. DADDARIO. Fine. Do you have a biographical sketch?

Mr. TOERING. It is the last page of the summary, yes, sir.

(The biographical sketch follows:)

BIOGRAPHY OF A. J. TOERING

Albert J. Toering is manager, defense products of Callery Chemical Co. He joined Callery in April 1957 but prior to that time was employed by its parent company, Mine Safety Appliances Co., since 1935. During the period of 28 years his major assignments have been in the area of the company's business with Government. Since joining Callery he has had the responsibility of management of all contacts and contractual relations with the Government.

He holds the bachelor's and master's degrees in engineering from Columbia University. In 1934 he was elected to Sigma Xi, national research honorary society. He is the author of one technical book and has contributed to numerous technical publications.

From 1940 to 1946 he acted as technical field representative to the armed services and was awarded the Distinguished Civilian Award by both the Navy Department and the Department of the Army. He served in Europe as a working member of the TIIC.

Mr. Toering is a member of the American Institute of Mining Metallurgical and Petroleum Engineers; of the American Society of Safety Engineers; of the American Institute of Aeronautics and Astronautics; and the American Ordnance Association.

Mr. DADDARIO. We are pleased to have you here.

Will you proceed with your prepared statement?

STATEMENT OF A. J. TOERING, MANAGER, DEFENSE PRODUCTS DEPARTMENT, CALLERY CHEMICAL CO.; ACCOMPANIED BY R. A. CARPENTER, MANAGER, WASHINGTON OFFICE

Mr. TOERING. Thank you, Mr. Chairman and members of the committee.

Callery is pleased to respond to this committee's invitation to comment on the state of the art of high-energy chemical propulsion, and to present the viewpoint of an industrial organization engaged solely in the synthesis, development, and production of high-energy chemicals. We feel we have a moral and a professional responsibility to state certain facts as we see them and as we have experienced them. We believe our remarks represent the views of the entire chemical propellant industry. Callery is owned in equal shares by the Mine Safety Appliances Co. and the Gulf Oil Corp. The company was founded in 1948 specifically to pursue the development of high-energy boron fuels, and Callery's role in Project Zip was presented to this

committee at hearings in September of 1959. To review briefly, in 1952 the Bureau of Aeronautics launched a multimillion-dollar project to discover liquid high-energy fuels and develop practical processes for their production. Private industry could not assume the burden of this type of development because of the lack of a civilian market and the financial risks involved. Essentially, the Government put Callery in business, since the research and development and subsequent construction of production facilities was financed entirely by Government contract. A major facility was built at Muskogee, Okla., and today it is the free world's only established source for low-cost tonnage production of diborane, which is the building block for all high-energy boranes. After the termination of Project Zip, Muskogee produced 275,000 pounds of pentaborane for the Air Force, completing that task in April of 1962. Since that time the plant has been in hot standby status and as a result of Air Force action earlier this year is being reduced to caretaker status (with the consequent dissolution of the Callery technical team at the Muskogee location).

During the past 5 years in addition to continuing the exploitation of boron hydrides, we have broadened our research to include solid oxidizers, such as nitronium perchlorate, and liquid oxidizers in the fluorine field. The most attractive of the candidate propellant materials all present the same problems which have plagued the boron hydride program.

THE STATE OF THE ART IN PROPELLANT CHEMISTRY

Propulsive power is the key to space missions because it determines how much weight can be made available in the payload, and there is no question about the need for greater propulsive power and increased payload in America's space and defense effort. The United States has, thus far, had only low thrust, moderate specific impulse rockets when compared to the U.S.S.R. Our missions have been a larger number of lightweight payloads compared to a lesser number of heavy U.S.S.R. vehicles. The United States has relied on sophistication, and our unique capability to miniaturize electromechanical instruments has offset the Russian advantage of high-thrust boosters. However, from here on, manned space flight will be the dominant factor of space missions, and we cannot miniaturize man or his life support equipment. The United States must get greater propulsive power and higher payload capability. Greater propulsive power is now available through high-energy propellant chemistry.

The useful weight which a rocket can carry into orbit or on a course to outer space is dependent on the thrust, specific impulse, and the number of stages.

Multiple-stage rockets will always be necessary but the fewer the better for reliability. The trend will be to standardize on a first-stage booster coupled with a second accelerator stage, both considered together as a launch vehicle. On top of these the space vehicle will have an additional propulsion stage to inject it into orbit, to change or correct its course, return it to Earth, and so forth.

Thrust is most important in the first-stage booster which must move the entire weight off the Earth against the pull of gravity and the drag of the atmosphere. We can increase thrust by increasing size as we are doing in the Saturn and large solid-propellant programs,

but there is a limit imposed by the effects on launch-site areas of firing such huge rockets. Also there is a hazard in simply accumulating tremendous amounts of potential explosives in one place. We should continue to develop high-thrust boosters but they will not be the total answer to greater payloads.

Specific impulse is the measure of how much thrust we can get from each pound of rocket propellants. High-energy fuels contain more built-in power than conventional fuels and can give more thrust per pound when burned. We could increase the thrust of first-stage boosters without increasing their size by substituting high-energy fuels. This may be possible to some extent but is limited by two factors. First, the booster uses the vast majority of all the fuel consumed on a given flight. High-energy fuels invariably cost 10 to 100 times as much as the conventional petroleum-derived hydrocarbons and their companion oxidizer, liquid oxygen. Economics, generally, therefore, show that the first stage should use cheap, albeit lower specific impulse propellants. Secondly, the exhaust gases of the first stage must not present a problem to the launch area. Unfortunately, most of the high-energy propellants and their exhaust products are toxic or corrosive compared to the conventional hydrocarbons.

The places to use high-energy fuels to increase payload are in the second-stage sustainer of the launch vehicle and in the onboard propulsion system of the space vehicle. The quantities of propellant are not so great as to make cost a significant factor. Exhaust gases do not impinge on the launch site. Most importantly, the increase in specific impulse in these upper stages will allow significantly larger payloads to be launched with the same conventional boosters.

I would like to add parenthetically, I generalized in making this last statement. There is considerable work being done with the use of high-energy propellants as additives and this is looking rather attractive. I did not mean to overlook or eliminate the possible consideration of such additives, but generally this is the case with the high-energy fuels, they are expensive and they have other problems such as toxicity.

WHAT IS A HIGH-ENERGY PROPELLANT?

Rocket-propulsion energy results from the combination of chemicals in the combustion chamber to produce heat and gases. Early rockets used commonly available fuels such as hydrocarbons (kerosene, asphalt, and various polymers) and oxidizers such as nitric acid, chlorates, and liquid oxygen from the air. These combinations in both liquid and solid rockets give performance values in terms of specific impulse in the 230 to 300 range. Shortly after World War II it was recognized that superior fuels might be made of compounds of hydrogen with lightweight elements such as lithium, beryllium, boron, and aluminum.

In 1958, after Sputnik galvanized the United States, Dr. George Kistiakowsky visualized the need for a substantial improvement in rocket propellants. The Advanced Research Projects Agency of the DOD invited the chemical industry to participate in Project Principia, to develop better chemical fuels and oxidizers for rocket propulsion.

These advanced propellants were to give specific impulses of 290 to 400 seconds and have become commonly known and referred to as

high-energy propellants. In addition to the ARPA program, other efforts were carried on by the military services and by industry to find the ultimate in chemical propulsion.

This search is the key to progress in flight-propulsion power. As has been succinctly stated recently by Mr. John L. Sloop:

> Propulsion is the key to space exploration and our push to the Moon in this decade will depend completely on chemical propulsion.

Historically, man has always planned his explorations in flight around the propulsion powerplants which were available. Each advance in engine development made new payloads, speeds, and endurance possible. This is no less true today. There can be no substitute for advanced propulsion capability.

Since 1958, understanding of basic thermodynamic considerations has made it possible to predict which of the chemical compounds and elements would be the best propellants. The lightweight elements in the periodic table are the ones of choice and the number of combinations of these elements into compounds with physical properties (melting point, boiling point, and so forth) which lend them to use in rocket engines, is not infinite.

Within the last 4 years the chemical industry has exhaustively studied these various combinations, until now it can be stated that most of the data are at hand. It is unlikely that any startling new chemical propellants will be discovered. It is this state of the art which leads us to believe that advanced chemical propellants are available which give a meaningful improvement in payload or velocity increment.

LIQUID HYDROGEN AS A HIGH-ENERGY PROPELLANT

It is essential to clarify the position of liquid hydrogen in the spectrum of chemical propellants. Hydrogen is a superior fuel and it certainly will find its uses in space propulsion. However, its very low density and extremely low boiling point lead to operational disadvantages. The problems of the Centaur program are well known. Analyses of other missions such as lunar landing and small stages designed for deep-space exploration show that liquid hydrogen is actually inferior to other combinations. The report of the ad hoc Committee on High-Density, High-Specific-Impulse Propellants to the Aeronautics and Astronautics Coordinating Board, DOD–NASA is commended to the committee's attention. The "confidential" classification of the report precludes its discussion here.

The point is, there are some missions in which liquid hydrogen cannot be used because of its lack of space storability. There are other missions where liquid hydrogen combinations are inferior because of the low density of hydrogen. In these missions, high-energy, high-density propellants are essential to deliver the required payload and/or the velocity increment.

In addition to the laboratory research which has uncovered new chemical propellants, the United States has the unique capability to manufacture large quantities at a low enough cost to make their use in rocket engines feasible. No other country in the world has a chemical industry equal to ours. The economic large-scale production of intricate chemical molecules requires the utmost in chemical

processing ingenuity. Today, the United States can provide quantities of high-energy propellant ingredients.

THE ECONOMICS OF HIGH-ENERGY PROPELLANTS

The conventional fuels in use today in the Atlas, Titan I, and Saturn are liquid oxygen and RP–1. The latter is a kerosene fraction derived from petroleum. These propellants are cheap and readily available because they occur in nature and have only to be separated from air and crude oil. Propellants of higher energy content are not naturally occurring.

The high-energy fuels under consideration today are chemical compounds such as diborane, pentaborane, hydrazine, oxygen difluoride, and the elements fluorine, hydrogen, and beryllium. These propellants are prepared from raw materials such as borax, natural gas, minerals, and ores which are found in nature in a low-energy state. A number of complex chemical processing steps and the input of energy in the form of electricity or heat are necessary to transform these raw materials into high-energy propellants. The concept is to package a maximum amount of energy into a given weight and volume using earthbound factories so that this energy can later be released to power the free-flying rocket. The expense of this transformation is justified in two ways. The greater energy content compensates for the cost per pound of propellant; and some missions simply could not be accomplished at all with conventional fuels.

The economics of chemical processing are definitely dependent on the volume produced. Regardless of the chemical complexity of the material, the cost usually becomes reasonable if a large, continuously operating plant can be built. However, investment in such a plant must be justified solely by the requirement for a propellant, because only rarely does a high-energy propellant chemical also have a commercial use which justifies large-scale production.

Thus, propellant production is subject to the whims and uncertainties of the Government market. In this restricted market there is a high risk of obsolescence. In addition, Government fiscal policy limits long-range production planning for what is, essentially, a long leadtime component of improved space systems.

The normal orderly development of a new chemical is a long-term process, costly in time and money. A rule of thumb in the chemical industry is "test tube to tank car in 7 years." The program normally proceeds through the following general stages:

1. Laboratory: Synthesis of new compounds and evaluation of their theoretical performance.
2. Bench scale: Development of process, demonstration of good yield at reasonable cost, and small-scale performance tests.
3. Pilot plant: Adaptation of process to commercial methods and equipment, and intermediate-scale performance tests.
4. Production plant: Design, construction, and operation, including training of skilled personnel; and full-scale performance tests and operational use.

Unless stage 4 is reached and maintained long enough to amortize the development and facilities costs, no large quantities of chemicals at reasonable cost can be made available.

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In the case of the exotic high-energy propellant chemicals the development timetable is condensed and distorted. Test quantities of propellant chemicals are demanded by engine developers during the chemical research stage where the per pound cost is very high. Maximum quantities are required during the development and testing phases of the engine, vehicle, or weapons systems; and when the system is proved out, operational flights consume relatively little propellant. Just when demand for chemical production would be reaching a sustained peak in commercial markets, the demand for propulsion chemicals drops to a minimum.

In view of the problems and risks involved for the chemical manufacturer, better Government planning than now exists is essential.

Coordinated planning of the development of an engine and a parallel development of its chemical fuel as a long leadtime item are necessary. Off and on, poorly planned programs discourage technical people and companies who engage in these operations. Discontinuities increase the ultimate cost. Procrastination delays the time when the high-energy fueled engine could be aiding the space program.

WHAT IS RECOMMENDED

Based on the fact that a propellant, with little or no commercial use, must be provided concurrently with a weapons or space system, a new approach to scheduling is necessary. The present methodology dictates that new propulsion systems cannot be developed beyond the feasibility stage unless a specific mission requirement exists. When the requirement does occur, the system designer cannot wait for advanced propellent development and tailors his payload to the lesser capabilities of existing propellants and engines.

The Advanced Research Projects Agency did establish a concentrated program in chemical propellant systems. This substantial effort by Government and industrial laboratories to find better propellants is drawing to a close. Dr. G. V. Mock has stated, "In a certain sense this is the last onslaught this country can make on the periodic chart." If it were likely that some new "wonder chemical" would turn up, further delays in engine development and use might be justified. But all evidence is to the contrary and the materials we have listed in table I are acknowledged to be the best candidates.

(The information referred to is as follows:)

TABLE I.—*Chemical propulsion—Theoretical specific impulse in space for upper stage application (P_c=1,000 psi, P_e=0.2 psi)*

Common name	Symbol	Specific impulse (seconds)	Comment
Systems involving liquid hydrogen—low density, non-space-storable:			
Hydrogen-lox	H_2O_2	470	Available in Centaur engine.
Hydrogen-fluorine	H_2F_2	489	R. & D. completed.
Systems involving cryogenics but space storable:			
Kerosene-lox	RP-1-O_2	379	Available in Atlas and Titan I.
Hydrazine-fluorine	N_2H_4-F_2	436	R. & D. complete.
Pentaborane-fluorine	B_5H_9-F_2	460	No work done.
Pentaborane-oxygen difluoride	B_5H_9-OF_2	466	Do.
Diborane-oxygen difluoride	B_2H_6-OF_2	468	NASA development underway.
Systems involving noncryogenics—earth storable and space storable:			
Nitrogen tetroxide-hydrazine blend.	N_2O_4, 50 percent N_2H_4, 50 percent UDMH.	354	Available in Titan II.
Pentaborane-hydrazine	Joshua—B_5H_9-N_2H_4	411	R. & D. stage underway.
Beryllium	Be additives	360-380	Research results only.

The ARPA program does not provide for process development or for flight weight hardware to use the new chemicals. A partial effort is made within Government to provide for process studies. For example, the manufacturing methods branch of the Air Force sponsors limited work to take promising propellant chemicals from the synthesis stage through process development. There is today, unfortunately, no functioning mechanism in the executive branch of the Government to coordinate the ultimate production step, unless and until a systems requirement calls for sufficient quantity of material to justify construction of a production facility. Process development is an important step forward but the technical people, know-how and a going, operating facility are the prime ingredients for low-cost tonnage production. Here is the area where coordinated Government planning and subsidy appear essential if the promise of the exotic materials is to be translated to actual use.

We maintain that the broad mission requirement for high energy, high density propellants does exist today. It is in the form of the lesson taught by history that advances in propulsion power have led the way into new regimes of flight. Each time a better engine has been built, the mission and payload have been quickly visualized to utilize its capability.

The recommended approach to the problem will make necessary a long-range program with higher dollar value than is presently provided. This program should be devoted to insuring the availability of high energy propellant chemicals for use in both solid and liquid systems. High energy propellants are the key to advanced propulsion and we are needlessly limiting choice and postponing our achievement of preeminence in space by not using them.

Thank you, Mr. Chairman.

Mr. DADDARIO. Thank you, Mr. Toering.

I am pleased to see Congressman Melvin Price of Illinois. Would you care to join us?

Mr. PRICE. Thank you. I have some guests.

Mr. DADDARIO. I would like to comment upon your statement by saying that it is very objective and analytical. It not only sets out

the problems involved, but makes some constructive suggestions and offers some straight from the shoulder criticism which is unusual, but welcome.

It is very helpful to us to know how the chemical industry has been affected, and what steps might be taken to alleviate some of the problems which occurred in the past. I want to thank you for the very thought-provoking statement that you have prepared and presented to us this morning.

We will follow the same procedure as we did with the previous witness. Mr. Hines, would you proceed with your questioning.

Mr. HINES. Thank you.

Mr. Toering, apart from your production responsibilities at Muskogee, how long has Callery undertaken research?

Mr. TOERING. Callery has been basically in the research and development of high-energy propellants for about 15 years.

We started in the program originally in boron hydride research.

Having looked at the periodic table we resolved that boron was an area of promise and this was our basic program. We have during the last 15 years worked in many different areas of propulsion chemistry.

Mr. HINES. Has that research effort been at a steady level or has it been increasing?

Mr. TOERING. It has been widely fluctuating, actually, Mr. Hines. We were at a rather high level comparative to other research programs; during the main period of Project Zip we were at a level of about $5 or $6 million of research effort a year.

Mr. HINES. I see.

Mr. TOERING. Our level is something less, about half or less than that now.

Mr. HINES. Government funded, of course?

Mr. TOERING. Government funded.

Mr. HINES. Is the Air Force the only military agency that has been interested in boron derivatives?

Mr. TOERING. The original work was Navy sponsored but all of the services and NASA are interested in the high-energy materials and we have had contracts with all of the agencies.

Mr. HINES. I understand these contracts have now terminated.

Mr. TOERING. We are continuing research in some other areas, and I mentioned other propellant chemicals in my paper.

I referred to oxidizer work. We are doing work on fluorine oxidizers, and on nitronium perchlorate which is one of the more promising solid oxidizers at the present time.

Mr. HINES. Has Callery participated in any actual test programs other than its own?

Mr. TOERING. Only to the extent that testing is an essential part of basic research. We do miniature scale firings. We don't get into engine development programs or into the larger scale firings.

Mr. HINES. How large is your team at Callery?

Mr. TOERING. I must differentiate between the locations. We have our research and development activities at Callery, Pa. Our production plant is at Muskogee, Okla., and we have a company-owned plant at Lawrence, Kans., which has been shut down now for 4 years.

Mr. HINES. I see.

Mr. TOERING. At Muskogee we have at the present time about 105 people. This is being reduced currently under negotiation with Air

Force, ultimately to what is hoped by Air Force to be a level of about 30 people.

Air Force has given us that as a directive at this point to try and achieve. At the Callery location we have approximately 150 employees.

Mr. HINES. Engineers?

Mr. TOERING. Engineers, chemists, and research operators, yes.

Mr. HINES. Could you explain to the committee what is meant by "hot standby"?

Mr. TOERING. I might get into semantics. All persons don't mean the same thing by "hot standby."

Generally, what was intended and was defined in the contract which we had with the Air Force, and which has now been terminated, was that hot standby meant that we keep a technical team and a capability in the plant that we could start up again in 6 months.

Mr. HINES. This is at the same time maintaining the team?

Mr. TOERING. This would mean if you are going to restart in 6 months, and not have to recruit and retrain highly skilled personnel that you would have to retain the key individuals at least and our present complement of 105 does represent the hard core of that team.

Mr. HINES. In other words, for 6 months they would be nonproductive, which would be an expensive item?

Mr. TOERING. Not entirely nonproductive in the sense there are other jobs that have to be done.

You must maintain the plant and with the types of materials that we work with this can be an important job. We have also been working in other areas, as, for example, the use of liquid diborane, which is of interest in the NASA program and in an Air Force program and in others.

The team is not just sitting idly by. They have been fully occupied up until this point.

Mr. HINES. Has NASA been aware of the work that Callery has been doing up to the current state of the art? Have you communicated your ideas to NASA?

Mr. TOERING. We have been in communication with, and in fact we were under contract to NASA for some time. We had a contract with NASA on the BN system jointly with the Reaction Motors Division of Thiokol 4 years ago. That continued for 1 year and then was terminated. Also, we are working currently with them on the diborane/OF_2 system. We are supplying materials for them. We have also been in discussion with them about the possibility of contractual coverage for doing work in handling, safety and other aspects of working with liquid diborane. This is still under review. It has not been funded.

Mr. HINES. Is this with Mr. Sloop's office?

Mr. TOERING. This is with Mr. Sloop's office and with Lewis Research Center.

Mr. HINES. What are the amounts of your NASA contracts at the moment?

Mr. TOERING. At the present time we have only one contract with NASA. That is for the production of diborane for the reaction motors program, and is $26,000.

Mr. HINES. But no research?

Mr. TOERING. No research.

Mr. HINES. Has your research been oriented toward general high-energy propellant research as opposed to, for example, exclusive concentration on OF_2?

Mr. TOERING. Well, if I can anticipate your question a bit.

Going back to the beginning, we had the job of trying to find a high-energy fuel, one that would be liquid and useful in a turbine engine. We went back to fundamentals, looked at the periodic table and decided what would be the most useful. We also covered a broad spectrum of research on fuels and oxidizers in both the solid and liquid areas; oxides of fluorine, nitronium perchlorate, and other fuels as well as the boron hydrides. We have contracts in a number of different areas right now.

So it hasn't been limited specifically to diborane. We consider diborane important because it is a building block, it is a basic building stone for any of the boron hydride high-energy propellants such as decaborane, or pentaborane.

Mr. HINES. In your statement you mentioned certain missions that could not be achieved using the conventional propellants we are now employing. Could you describe some of those missions for us?

Mr. TOERING. Certainly in the present agenda for space programs there are none that are specifically such. But the point was made by the representative from Reaction Motors that propulsive power and engine development has led the way. The development of new space requirements or new systems or new applications would certainly result if we had more propuslvie power.

One application possibly that we might consider right now would be the lunar excursion module. It has been resolved not to go by this course, but if we had started 2 years earlier, I think it might be the answer today.

Similarly, if we delay another 2 years we will be in the same position when we try to consider other missions down the road.

Mr. HINES. In other words, you are saying that greater knowledge in high-propellant research could have a direct influence on the philosophy of missions that NASA is attempting to accomplish?

Mr. TOERING. This is our opinion, and I think it has been expressed by a number of other people.

Mr. DADDARIO. Mr. Patten?

Mr. PATTEN. No questions.

Mr. DADDARIO. Mr. Roudebush?

Mr. ROUDEBUSH. No questions.

Mr. DADDARIO. Mr. Riehlman?

Mr. RIEHLMAN. No questions.

Mr. DADDARIO. Mr. Fulton?

Mr. FULTON of Pennsylvania. I would like to compliment you on your excellent statement. I believe that you have adequately outlined the challenge of these high-energy fuels as well as the fact that the United States must get greater propulsive power and higher payload capability.

I have read with interest your comments on the Advanced Research Projects Agency of the Department of Defense, and likewise your comment that there is within the executive department at the present time no adequate civilian counterpart of ARPA. This would lead me to the conclusion that probably the National Aeronautics and Space Administration should have an administrative setup that would be, in short, a NARPA, is that right?

Mr. TOERING. Yes, sir.

Mr. FULTON of Pennsylvania. The Department of Defense is limited by the fact that it must have specific mission requirements for weaponry systems in order to go ahead with the broad research and development programs.

Mr. TOERING. Yes, sir.

Mr. FULTON of Pennsylvania. When the Air Force recommends advanced research programs to the Department of Defense, they are then met with the question: "Well, what are you going to do with it specifically by way of a military mission?"

Would you comment on that?

Mr. TOERING. Would you give me the question again, Mr. Fulton?

Mr. FULTON of Pennsylvania. Would you read that?

(Question read.)

Mr. FULTON of Pennsylvania. This is in respect to the boron programs.

Mr. TOERING. I think this is one of the issues I tried to make basically in a general way rather than referring to our specific program and our own trials, if I can put it in those terms.

In Government procurement and in the development of a problem such as we have in chemical propulsion, Government funding is tied specifically to the weapons system concept. The possibility of going along in research and development on an on-and-off basis exists unless it is tied to a weapons system.

Mr. FULTON of Pennsylvania. The real place for such a broad base research and development program is in NASA, under present statutes, is that not correct?

Mr. TOERING. It wouldn't necessarily be limited to NASA as a medium. In the Department of Defense, certainly, we had a possible area for hiatus in the research programs and ARPA has filled this need. They were instituted to get some continuity in the research, to get a lot of people in industry interested, to get major programs going. They were funded at a very good level.

Now, on the other hand, their charter is limited in aspect. It goes through the basic research program. There is no coordinated program for development on the same plan. We must then jump forward to a weapons-system concept before you get support for a continuous coordinated program.

Mr. FULTON of Pennsylvania. So that it does mean that NASA could perform this function because of the broad charter of NASA on research and development?

Mr. TOERING. Yes, sir; I would say that undoubtedly NASA considers in their own inhouse planning that they accomplish this mission. I think, on the other hand, our overall problem in Government is that we go forward on a weapons-system basis and on an annual review for fiscal purposes that does limit long-range planning.

Now in the chemical industry we can't operate this way. We have to have long-range, definitized, continuous funding and continuous planning.

Mr. FULTON of Pennsylvania. You referred in your statement to the report of the ad hoc Committee on High Density, High-Specific-Impulse Propellants of the DOD-NASA Aeronautics and Astronautics Coordinating Board. Is that the recent report released in October of 1962?

Mr. TOERING. That is right, sir.

Mr. FULTON of Pennsylvania. What effect does the present plans have on your scientific team at the production facility in Muskogee, Okla.? You stated that this is the only facility in the free world for the low-cost tonnage production of diborane which is the building block for all high-energy boranes. Would you comment on that? Isn't it limited severely, and if the free world wants this kind of research and development in the high-energy field of the boranes, that plant should not be dismantled.

Mr. TOERING. That is our feeling, Mr. Fulton; yes, sir.

Mr. FULTON of Pennsylvania. You commented upon the fact of "hot standby," which means that it would take 6 months to put the plant back into operation.

Mr. TOERING. Yes, sir.

Mr. FULTON of Pennsylvania. What would it cost to put the Muskogee plant on "hot standby"?

Mr. TOERING. To maintain the plant in "hot standby" would cost approximately $1¼ million a year.

Mr. FULTON of Pennsylvania. $1,250,000 a year?

Mr. TOERING. Right, to restart the plant over a period of 6 months would cost about $1 million.

Mr. FULTON of Pennsylvania. If the plant were put on caretaker status, how long would it take to put the plant back into operation? Secondly, what would be the cost of maintenance? Thirdly, what would be the cost of building up to a full program of production?

Mr. TOERING. We come back dangerously to the question of semantics in defining "caretaker." Caretaker can be at several possible levels. The level which Callery has recommended to the Air Force and we are discussing still on this point, so I don't want to belabor it, but it would take us approximately 12 months to restart under our interpretation of caretaker.

With the interpretation placed on caretaker by the Air Force we can make no guarantee; we don't know; we don't have experience with it; we think it would be at least 12 months or longer, and would cost on the order of $3 million.

Mr. FULTON of Pennsylvania. What would the cost of placing the plant in this reduced caretaker status with dissolution of the Callery team at Muskogee, Okla.? Has the Air Force budgeted on cost? Do you know what the cost would be?

Mr. TOERING. I am not certain what the Air Force have in their own judgment budgeted, Mr. Fulton. I estimate that to get caretaker status from the date March 1 is about $800,000.

Mr. FULTON of Pennsylvania. That is also my recollection of the cost figures. Therefore, in order to keep the plant going for a year it costs $1,250,000 in "hot standby," and to reduce it to caretaker status costs $800,000. There is only $450,000 difference in cost between the two, is that correc

Mr. TOERING. That is during the first year, Mr. Fulton. Of course, during subsequent years caretaker would be at a lower cost for continued maintenance.

Mr. FULTON of Pennsylvania. The longer the plant is in caretaker status, the longer it will take to get it back into operation, as well as the increased cost to put it back into operation?

Mr. TOERING. That is correct, sir.

Mr. FULTON of Pennsylvania. Looking at this from the overall standpoint of the Government, would you say that by keeping the Muskogee plant in hot standby it would be worth the $450,000? Consider the research that would be done on the hot standby as well as some production, and, likewise, preventing the dissolution of the Callery technical team at Muskogee?

Mr. TOERING. Of course, this has been our opinion, Mr. Fulton.

Mr. FULTON of Pennsylvania. Would it be very worthwhile not to dissolve this Callery technical team?

Mr. TOERING. We think so.

Mr. FULTON of Pennsylvania. How long did it take you to build up this scientific team?

Mr. TOERING. Well, we have been at this business for 15 years. I would say that the average period of employment of most of our people is getting on to 10 years.

Mr. FULTON of Pennsylvania. How many people will be discharged by placing the Muskogee plant in caretaker status?

Mr. TOERING. In our present planning by November 1 we will move from 105 people presently there to approximately 40.

Mr. FULTON of Pennsylvania. So that this is causing unemployment in the area and it would cause distress in that community, will it not?

Mr. TOERING. That is right, sir.

Mr. FULTON of Pennsylvania. If it is kept on hot standby this will not occur?

Mr. TOERING. Correct, sir.

Mr. FULTON of Pennsylvania. So for $450,000, how many jobs are being lost?

Mr. TOERING. Approximately 65 jobs by my terminology. If we go to complete caretaker, as defined by the Air Force, it would be an additional 10 or 11 people who would be discharged.

Mr. FULTON of Pennsylvania. If there was an agreement by the Air Force and NASA whereby they combined their authorized funds, the Air Force putting in $800,000 they would spend reducing the plant to caretaker status, and NASA putting in the additional $450,000, it would be possible to keep the Muskogee plant in hot standby, is that correct?

Mr. TOERING. That is correct, sir.

Mr. FULTON of Pennsylvania. Then in my opinion, it would seem logical to have NASA and the Air Force combine their forces in order to make this saving not only to the taxpayers, but also to assist the research and development of high-energy fuels.

Mr. DADDARIO. Just one question, Mr. Toering.

At page 15 you refer to the fact that there is no functioning mechanism in the executive branch of the Government to coordinate the ultimate production step. Would you give us your thoughts as to how that coordination could be brought about? What do you have in mind?

Mr. TOERING. Well, we had a similar situation in research and this gap was closed by the institution of the organization ARPA. Possibly broadening of the charter of ARPA or as Mr. Fulton suggested a few minutes ago, a specific function established within NASA could accomplish a departmental effort for coordinated continuation of development programs, just as we are doing in research today.

Mr. DADDARIO. But there is nothing in NASA's charter which inhibits its taking this step to meet this need?

Mr. TOERING. Not to my knowledge.
Mr. DADDARIO. If it felt that it had to.
Mr. TOERING. That is right, sir.
Mr. DADDARIO. Mr. Hines.
Mr. HINES. Yes, sir.
Is Callery's activity dependent upon the research and development done by other organizations in engine development?
Mr. TOERING. That is right, sir.
Mr. HINES. Are you kept informed of these developments?
Mr. TOERING. We work very closely with the engine development companies. We have been very closely associated with Reaction Motors; for example, we have had the relation of subcontractor to them on a number of contracts; in fact, we have also been prime in a contract where they have been subcontractor.
There is a very close relationship. This also applies to other companies. We are working closely with Rocketdyne on the Joshua system.
Mr. HINES. Does their level of progress in engine development show promise to Callery?
Mr. TOERING. We think so.
Mr. HINES. In your communications with these people, do you see any difficult engineering problems that may prolong the active status of Callery?
Mr. TOERING. Difficult, but not unsolvable.
Mr. HINES. That is all.
Mr. DADDARIO. Mr. Fulton?
Mr. FULTON of Pennsylvania. I believe that you explained your contracts with NASA. As I recall Dr. Bisplinghoff's statement, the Callery Chemical Co., also has a contract with the Jet Propulsion Laboratory. I believe the contract concerns the borane ingredients on the JPL solid program, doesn't it? Isn't the amount of the contract $50,000?
Mr. TOERING. Yes, it is in solid work, Mr. Fulton. The technical content is restricted information, so I can't discuss it here, but it is not specifically related to the problem we were discussing this morning of the diborane-oxygen difluoride.
It is boron hydride work, yes.
Mr. FULTON of Pennsylvania. There is a $15,000 program on the toxicity of oxygen difluoride. To me that would seem to be small, because you can't even write a report for $15,000. Would you recommend an increase on that?
Mr. TOERING. I am not certain I would like to comment on the oxygen difluoride because that is Allied's problem, but in diborane certainly I think there is work that should be done. This is a relatively new and untried material.
There is work to be done in safety, handling, toxicity.
Certainly there is also an oxygen difluoride.
Mr. FULTON of Pennsylvania. There is a $50,000 program in the current NASA budget for the handling of diborane. But this doesn't seem to me to be hitting the fundamental problem. They won't be able to do much for $50,000.
Mr. TOERING. It won't solve the problems in a short time, no.
Mr. FULTON of Pennsylvania. Because of the need for high-energy fuels, do you recommend that Congress should emphasize high-energy fuels so that we can assist NASA in developing these programs?

Mr. TOERING. Yes, sir, I do.

Mr. DADDARIO. Mr. Toering, I want to thank you for your testimony. I also want to note for the record that Congressman Ed Edmondson of Oklahoma is with us today, and we are very pleased to have him here.

The statement you have given, and the answers to the questions posed have been excellent. I want to thank you for the effort you put into the statement and for the value of your statement to this committee.

Yes, Mr. Fulton?

Mr. FULTON of Pennsylvania. I would likewise compliment the congressman from Oklahoma for his interest. Mr. Edmondson consulted with various members of the committee and sat in on meetings with NASA and the Air Force on this high-energy fuel problem; particularly the innovation of the production problems at Muskogee plant, and keeping together the technical and scientific team.

I would also like to compliment the majority leader, Congressman Carl Albert of Oklahoma, who has been very interested in this particularly severe problem in Muskogee, Okla. This morning he telephoned me to see if we on this subcommittee were proceeding adequately or should we have his help.

He did say that because of the start of the weekly calendar, he has meetings with the Speaker and various others in the leadership to implement certain bills coming up on the floor, and that he could not be here this morning.

Mr. DADDARIO. Thank you, Mr. Fulton. The Democrats are always happy to hear compliments, especially from Republicans, and to have cooperation.

This meeting will recess until 2 o'clock this afternoon.

(Whereupon, at 12:03 p.m. the committee recessed, to reconvene at 2 p.m., on the same day.)

AFTERNOON SESSION

Mr. DADDARIO (presiding). The meeting will come to order.

We are pleased to have you here, Mr. Sloop.

Mr. SLOOP. Thank you.

Mr. DADDARIO. Our witness this afternoon is Mr. John L. Sloop, Director of Propulsion and Power Generation, Office of Advanced Research and Technology, NASA.

I understand, Mr. Sloop, you have a prepared statement?

Mr. SLOOP. Yes; I do.

Mr. DADDARIO. We will incorporate your biography at this point. Will you proceed, please?

(The biographical sketches of Mr. Sloop and Mr. Myers follow:)

JOHN L. SLOOP, DIRECTOR OF PROPULSION AND POWER GENERATION

John L. Sloop was appointed to his current position on February 19, 1962. In this assignment he plans, directs and coordinates the NASA programs of research, technological studies and developments in the general area of propulsion and power generation systems as applied to solid- and liquid-fueled rocket engines and other propulsion systems except nuclear.

Previously, he has served (since November 1, 1961) as Deputy Director of Launch Vehicle and Propulsion in the NASA Office of Space Sciences, and from April of 1960 as Technical Assistant to the Director, Office of Space Flight Programs.

Prior to this time he was Chief of the Rocket Engines Branch at the NASA Lewis Research Center.

Mr. Sloop came to Lewis in 1942, having served briefly with the NACA at Langley. From 1942 until 1945 he performed research on aircraft ignition systems. During this time he devised a quantitative method for measuring spark plug fouling, investigated chemical inhibitors and their effects on engine operating conditions.

In 1945 he was assigned to rocket research, heading the rocket engine cooling group. In 1949 he was made Chief of the Rocket Research Branch, serving there until transfer to Washington in 1960. He served as the NACA (NASA's predecessor organization) representative on the NACA Subcommittee on Rocket Engines from 1951 to 1958. During this period he constantly sought to demonstrate the importance of rocket research and the necessity for increased effort in this field.

He and his group did important work on hydrogen-oxygen and hydrogen-fluorine propellants. The work on hydrogen-oxygen served as a basis for starting the development of engines using this combination which now occupy a position of key significance in the NASA space propulsion program.

He has authored many scientific papers on the results of specific research projects and has made presentations before numerous technical societies, including the Society of Automotive Engineers, American Rocket Society, American Chemical Society, and the Institute of Aerospace Sciences. He is a fellow member of the AIAA Society, and a member of the Washington Philosophical Society.

Mr. Sloop was born in Charlotte, N.C., on September 6, 1916. He received his B.S. degree in electrical engineering from the University of Michigan in 1939.

Mr. and Mrs. Sloop and their four children live at 8311 Melody Court, Bethesda, Md.

Boyd C. Myers II, Director, Program Review and Resources Management

Boyd C. Myers II is Director, Program Review and Resources Management of the NASA Office of Advanced Research and Technology in Washington, D.C. He has held this position since November of 1961.

Mr. Myers' office is responsible for establishing and managing program approval and review systems. It provides OART with a centralized resources management operation. Besides assuring the validity of program plants, Mr. Myers' office processes research and technical reports and performs liaison activities for the NASA Research Advisory Committees.

Mr. Myers has been associated with NASA and its predecessor, National Advisory Committee for Aeronautics (NACA) since 1947. He is the author of numerous technical publications in the field of aerodynamics and has specialized in flight safety, stability and control, icing, meteorology, operating problems, and human factors. He is a former chairman of the Washington section of the American Institute of Aeronautics and Astronautics.

Born October 7, 1921, in Alexandria, Va., Mr. Myers is a 1946 graduate of the Virginia Polytechnic Institute where he received a B.S. degree in aeronautical engineering. His college studies were interrupted by 2 years of military service with the Army, Navy, and Air Force. Mr. Myers also took a University of Virgina extension course at Hampton, Va.

Mr. Myers joined the staff of the NACA Langley Aeronautical Laboratory, Hampton, Va., in January 1947 as an aeronautical engineer. In 1950 he was assigned to NACA Headquarters in Washington, D.C., as an aeronautical research scientist. Eight years later he was named Chief, Operating Problems, Research Division.

In 1960, after NASA had taken over the NACA organization, Mr. Myers was named Technical Assistant to the Director, Office of Advanced Research Programs, with responsibility for program planning and coordination.

Mr. Myers and his wife, the former Helen DeWitt Long, reside at 3902 Ryegate Lane, Stratford Landing, Alexandria. They have three children, Boyd C. III, Helen Leslie, and Michael Banks. Mr. Myers' father, Leslie L. Myers, resides at 6807 North Shore Drive, Chicago, Ill.

STATEMENT OF JOHN L. SLOOP, DIRECTOR, PROPULSION AND POWER GENERATION, OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY, NASA; ACCOMPANIED BY BOYD C. MYERS II, DIRECTOR, PROGRAM REVIEW AND RESOURCES MANAGEMENT

Mr. SLOOP. Mr. Chairman and members of the subcommittee, it is a pleasure to discuss with you the NASA program on high-energy propellants. This is a very vital part of our advanced research and technology program on chemical propulsion that was discussed briefly before Mr. Karth's subcommittee earlier. By "high energy propellants," I mean propellants that have higher performance than those in general use today.

Our interest in high-energy propellants dates back to the middle forties. A large amount of research on high-energy propellants was conducted by NACA, as well as by others. In particular we did work on hydrogen as a high-energy propellant in the fifties and this contributed to the development of the RL–10 engine. It also led to the choice of oxygen-hydrogen for the upper stages of Saturn I and Saturn V.

We in research see possibilities for using other high-energy propellants in space exploration. At a meeting on fluorine at the NASA Lewis Research Center this month involving NASA, DOD, and industry, several speakers opened their remarks on a note of nostalgia, harking back to work on this subject of 15 years ago.

Let me assure you, however, that we are not thinking or dealing in the past. I firmly believe there are many opportunities ahead to use high-energy propellants in our space exploration work. The conference I mentioned indicated that one phase of high-energy propellant research in the 1953–59 period is just beginning to reach fruition and offers significant potential gains in payload for existing vehicles as well as future ones. Much more work, however, remains to be done.

I would like to take you through some of the steps of examining high-energy propellants and I will illustrate a few of the numerous factors and problems that we discuss and work with and some of the gains that we see.

For purposes of discussion we can consider the work on high-energy propellants as divided into three phases, research (basic and applied), advanced technology, and development for a specific mission. This is illustrated by my first figure (fig. 141).

The first phase is basic and applied research; second is advanced technology; and third, development.

My responsibility within the Office of Advanced Research and Technology deals with the first two phases.

The work in development is the responsibility of a user office; for example, the Office of Manned Space Flight, the Office of Space Sciences, and the Office of Applications.

In research we look for propellants of very high energy potential and desirable chemical and physical properties. To do this we examine a large list of propellants. Some of these may have been examined in the past—but we may look at them again in the light of new applications or new uses.

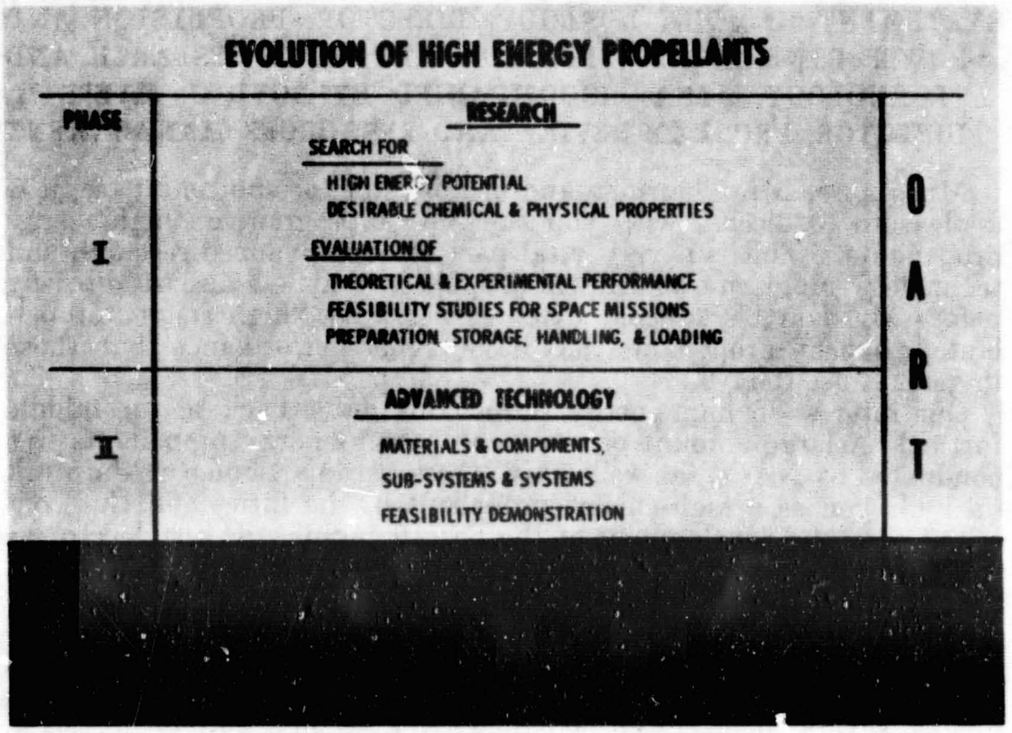

FIGURE 141

Early in the work we do theoretical performance calculations to determine their potential performance, and we select the more promising ones for experimental performance.

At the same time we may conduct studies, analytical or experimental, on the preparation, the manufacture, the storage, handling and loading characteristics. In addition, we examine these various combinations for their use in potential space missions. We consider oxygen difluoride and diborane as an example of a propellant combination in the research phase. As the work progresses we enter into the advanced technology phase which involves details of components, subsystems and sytems.

Component work, for example, includes such things as pressurization, pumps, turbines, gas generators, valves, igniters, injectors, combustion chambers, nozzles, cooling techniques, and thrust vector control.

Following work on components, a breadboard or boilerplate system may be studied and this may lead into flight components and systems. A final step is a feasibility demonstration of a complete prototype system.

Hydrogen-fluorine is an example of a combination that has gone through the research stage, through a great deal of technology and is now in the breadboard system stage. It remains to be demonstrated as a complete flight system.

I would like to emphasize that a propellant combination may be selected at any time for development. The more research and technology performed prior to its selection for development, the more information will be available for a good selection, and the better the chance for rapid development of the engine without major problems.

Oxygen-hydrogen is the only high-energy combination in the development stage today. As you know the R–10 engine using oxygen and hydrogen developed by the Pratt & Whitney Aircraft is now well advanced and ready for vehicle applications. In fact, I learned just last week that they had made their 3,000th firing of this engine and have accumulated a total firing time of 400,000 seconds.

Let me now discuss in more detail some of the advanced research and advanced technology processes. The research process illustrated here includes the synthesis of new propellants or preparing mixtures of known ones, determination of basic thermodynamic data such as the heat of formation and thermodynamic functions over a temperature range and measuring physical and chemical properties.

From a knowledge of a number of propellants, the acceptable chemical and physical properties, the new developments in mission requirements, and theoretical calculations, one can assess the potential of new propellants or reevaluate older ones that may have been passed over.

I mentioned that an early step in considering propellants is computing theoretical performance. A great deal of work in this has been done over the years. At the Lewis Research Center, for example, we have issued 27 reports over the 1948–60 period giving theoretical performance of a number of propellant combinations over a wide range of conditions.

This work includes the assembly or calculations of thermochemical data, devising techniques for machine calculations, revising these whenever necessary or when new data come up.

High speed computing machines now make possible a very rapid exploration of a large range of conditions on a request basis. I recently asked for data on OF_2 and diborane and obtained a 1½-inch stack from the Lewis Research Center by return mail and I brought it with me just to illustrate the great amount of data that a high speed computing machine can give you on short notice.

These calculations give the performance of oxygen difluoride and diborane, at chamber pressures from 60 pounds per square inch to 1,000 pounds per square inch over a range mixture ratios; it contains the temperature, specific impulse in a vacuum, the constituents, and a range of expansion ratios.

We have, then, at our fingertips methods for exploring theoretically the range of performance of new combinations provided we have good thermochemical data.

The next slide (fig. 142) shows some of the data that one gets from theoretical calculations.

This vertical scale is vacuum specific impulse.

This is the pounds thrust per pound per second flow of propellant. The horizontal scale of the density of the propellant combination; that is, the mean density of the fuel and the oxidizer at one particular mixture ratio.

Hydrogen-oxygen is at this point and diborane and oxygen difluoride here.

There is a 3 to 1 difference in their density, for example, but hydrogen oxygen gives higher performance. This vertical line represents an uncertainty in the theoretical calculations and this uncertainty is expressed this way: the top of the curve represents the assumption

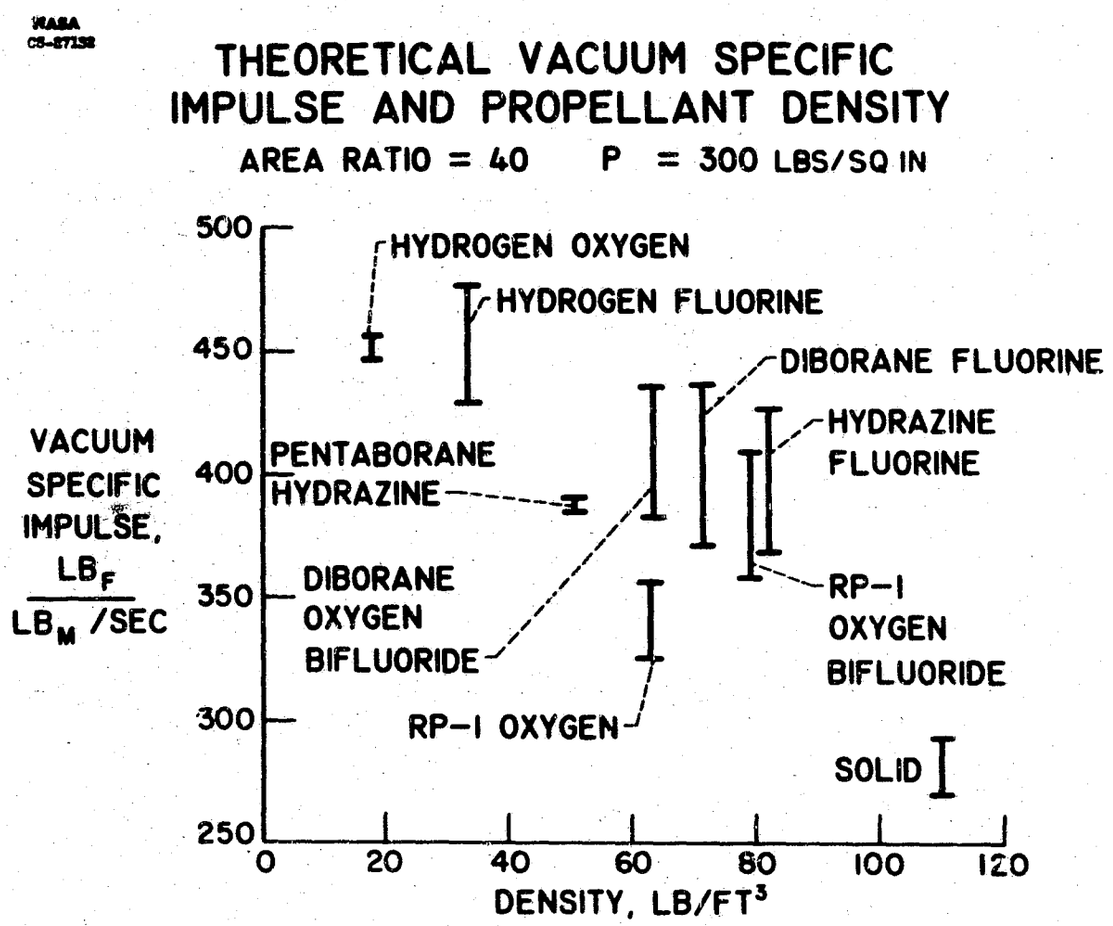

FIGURE 142

that the gases expand throughout the nozzle in what we call equilibrium expansion.

This is where the gases adjust instantaneously to the temperature and pressure in the nozzle as it goes from the chamber through the nozzle.

The lower part of the line represents what we call frozen expansion. This is where the assumption is made that the expansion through the nozzle is so rapid that the composition of the gases in the combustion chamber does not have a chance to adjust to the changing pressure and temperature. The uncertainty or the difference between equilibrium and frozen on oxygen-hydrogen is quite small, but it is quite large for some of these other combinations, including diborane and oxygen-difluoride.

This can be shown in a little more detail by the next slide (fig. 143).

Again I have plotted specific impulse, this time as a function of the oxidizer to fuel ratio.

The top curve represents equilibrium expansion and the bottom curve frozen expansion.

There are several things of interest here. One is the fairly wide difference between the two curves; the other is that the peak occurs at a higher oxidizer to fuel ratio under equilibrium conditions than it does for the frozen conditions.

The real case is somewhere in between and where that place is can be determined only through experiments.

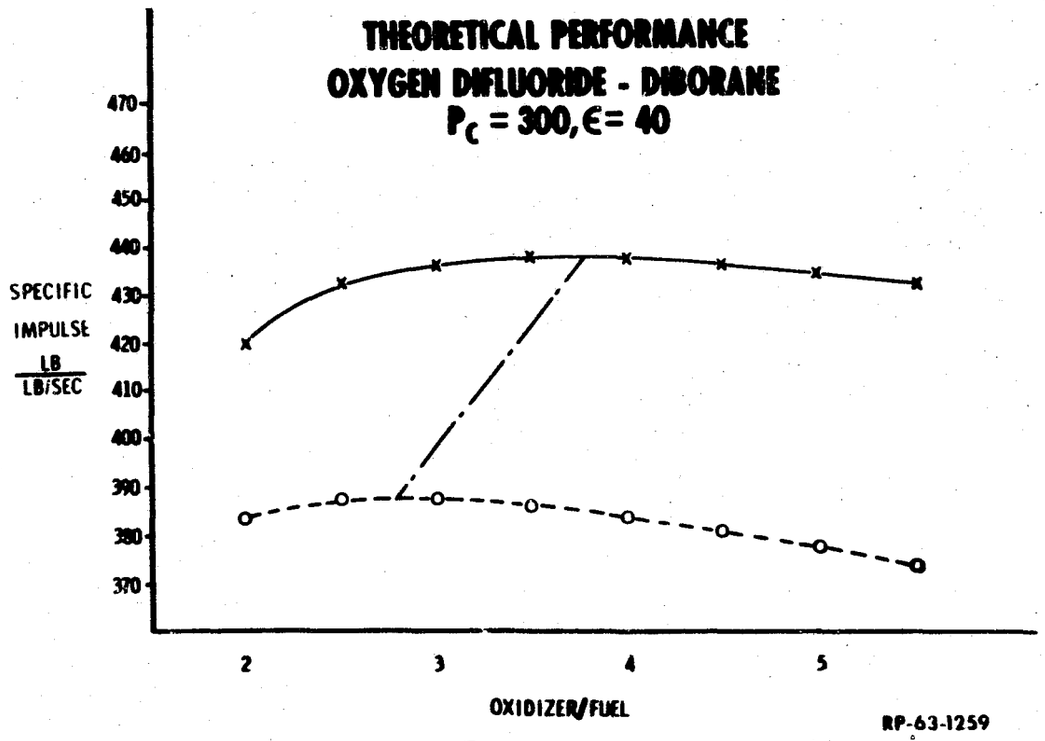

FIGURE 143

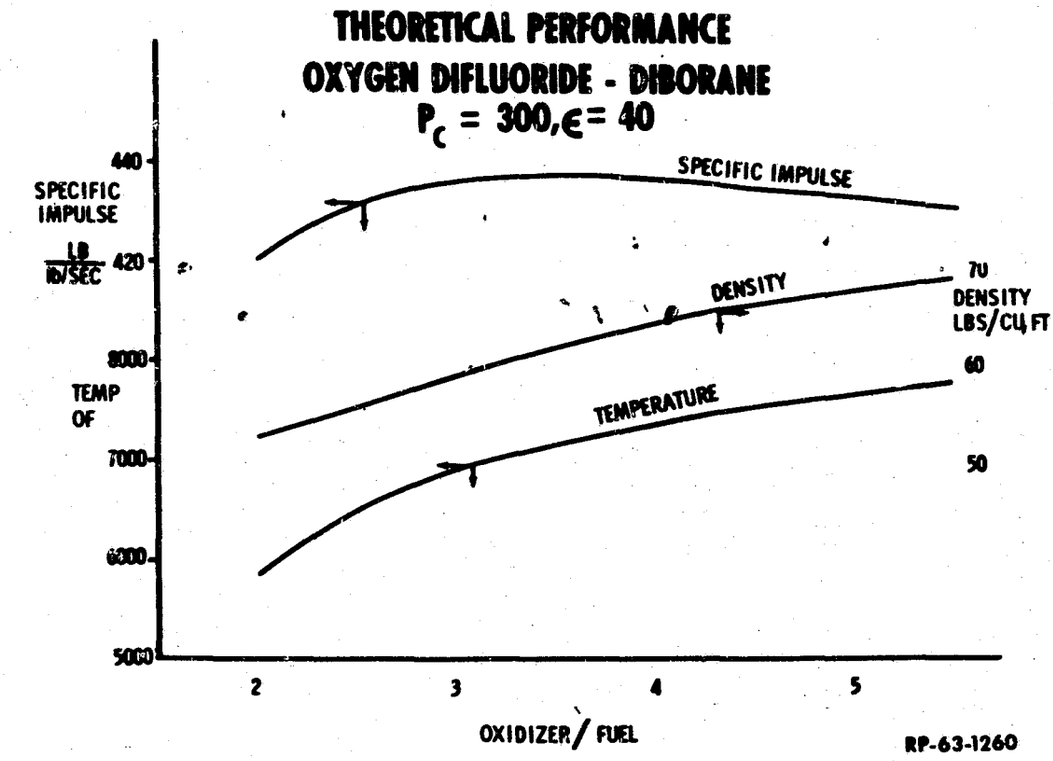

FIGURE 144

The above figure (fig. 144) shows a little more data on oxygen-difluoride and diborane again from theoretical calculations. The vacuum specific impulse is again plotted as a function of the oxidizer

to fuel weight ratio. The top curve is a specific impulse for the equilibrium case taken from the previous slide. The middle curve shows the increase in density as we go up in oxidizer to fuel weight ratio. The lower curve shows an increase in temperature as oxidizer to fuel ratio is increased.

Here are some of the decisions that a vehicle designer might face. For example, he would like to operate at as high an oxidizer to fuel ratio as possible, because this means a higher density. This means smaller tanks for a given amount of propellant. An engine designer, on the other hand would rather work more toward the center of the curve where the combustion temperature is less, and therefore presents a smaller cooling problem.

What we need to do, then, is to get data over this entire set of conditions so that we can make the best choice of operating condition.

LIQUID RANGE OF SEVERAL ROCKET PROPELLANTS

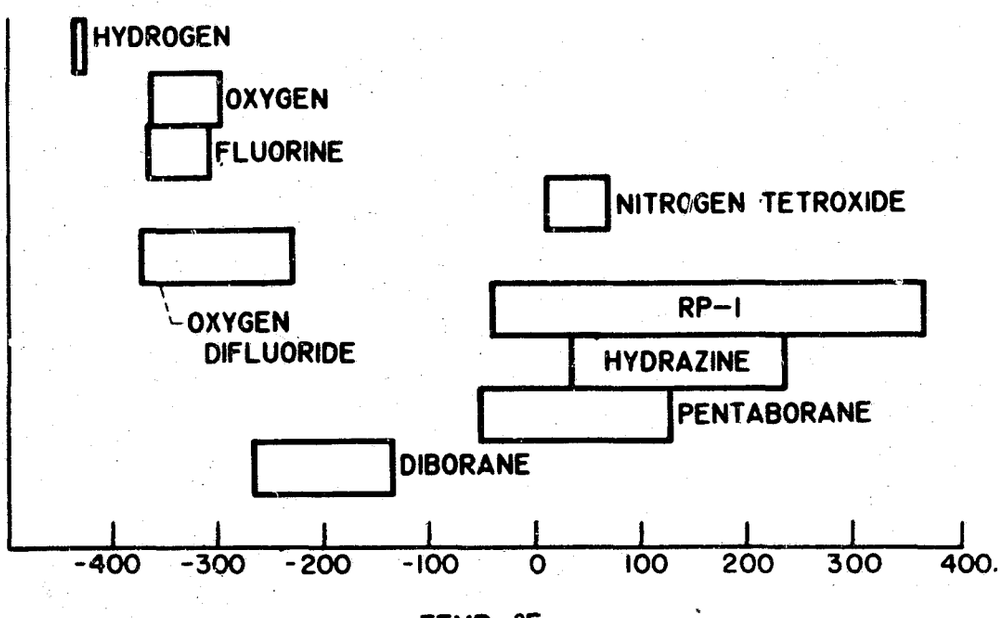

FIGURE 145

The above figure (fig. 145) is very similar to the one presented this morning by Thiokol, and I will pass over it very briefly. It shows the liquid range of several rocket propellants. Space storability is a condition that is still not completely defined. What we mean by space storability is the ability to maintain the propellants in space under thermal equilibrium conditions and this is a function of how well we protect or insulate the tanks.

If, for example, we want to maintain propellants at the —250° that was mentioned this morning, we would require insulation and spacecraft orientation. If we tried to take liquid hydrogen into space for long durations, we obviously would have a greater problem because of the lower temperature, but again we do have the possibility of insulation and minimizing the hydrogen boiloff.

Exactly how much propellant loss you would get and what temperature you can maintain in space remains to be seen.

Some other propellant combinations that look promising are the addition of beryllium to oxygen and hydrogen and the addition of lithium to hydrogen and fluorine. These have theoretical specific impulse values considerably higher than other combinations. They have a number of problems that must be solved, though, before they become practical.

So far I have just talked about some of the theoretical considerations. The promising ones, as I mentioned, are evaluated experimentally to determine if the theoretical promise can be realized in practice and to measure heat transfer. These experiments are usually done with moderate-sized engines to keep the cost down and to allow a variety of conditions to be explored. Obviously we can't explore experimentally all the detailed conditions that we do theoretically. It would be quite expensive.

The Lewis Research Center, for example, has operated an engine with diborane and hydrogen peroxide, liquid oxygen, and liquid fluorine over a period from 1948 to 1951. A number of other combinations have been examined, including intensive work on oxygen-hydrogen and fluorine-hydrogen.

This kind of work has been extended through contracts with industry. For example, you heard this morning that we had contracted with Reaction Motors Division of Thiokol Chemical Corp. to determine certain properties of oxygen difluoride and to determine combustion efficiency using a small-scale rocket. We feel these engine tests have been disappointing up to date. They are shown qualitatively on this next slide (fig. 146). Again I have plotted specific impulse against the oxidizer to fuel ratio and, as you will recall, the theoretical curve is quite flat over a fairly broad oxidizer-to-fuel weight ratio and that a vehicle designer would like to run at conditions to the right because this means the propellant is denser there—the oxidizer is four times as dense as the fuel.

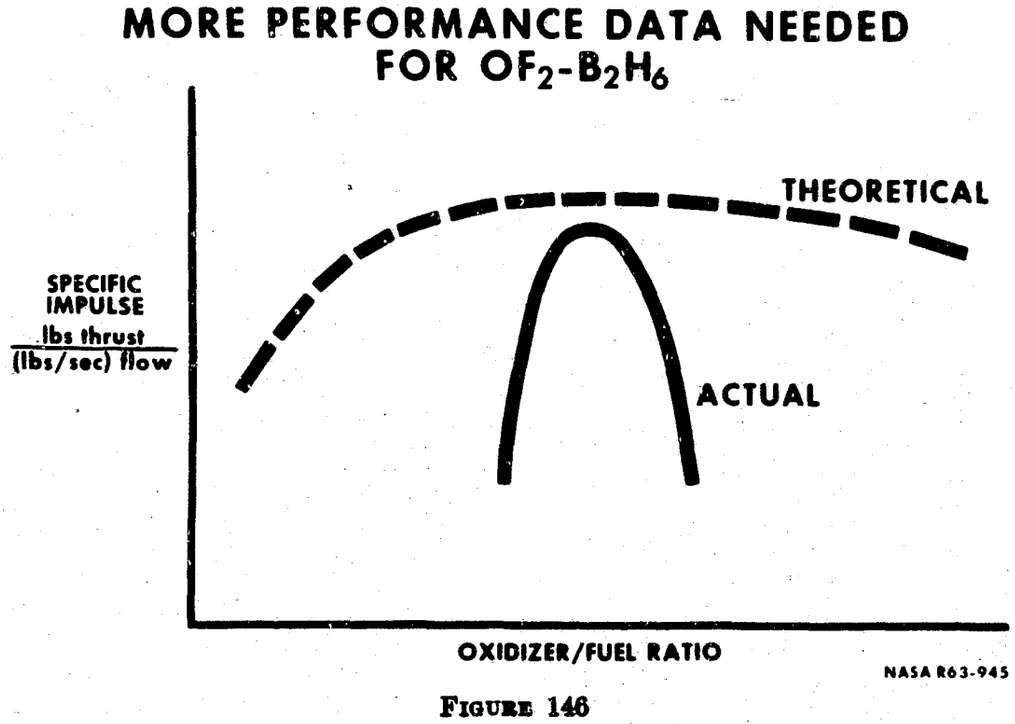

FIGURE 146

The lower curve represents experimental data and we were quite disappointed in this because we expected or hoped that it would follow the theoretical over the broader mixture ratio region.

Mr. FULTON of Pennsylvania. The chart shows that the peak performance of the actual came within a few percent—maybe 6 or 8 percent less—than your theoretical computation.

Mr. SLOOP. This is almost a diagramatic representation. I did not attempt to show it with great accuracy.

Mr. FULTON of Pennsylvania. No; but I say it looks about 6 to 8 percent less.

Mr. SLOOP. Based on very little experimental data.

Mr. FULTON of Pennsylvania. That is correct. Your chart shows that you need to lengthen the peak performance time, and, likewise, that you have to do experimental work on injection or flow.

Mr. SLOOP. Yes. This shows that a great deal more work is needed to determine why this happened and to extend high performance over a complete mixture range.

Mr. FULTON of Pennsylvania. Fine. That, of course, shows that in the particular OF_2–B_2H_6 combination there is good inherent performance possibilities. However, when using this small type engine without adequate research and development on injection systems or fuel control valves, the period of peak performance does not last an appreciable time.

Mr. SLOOP. Well, I think that it is too early for us to really draw conclusions about whether or not we can get high performance over this entire range with this combination.

Mr. FULTON of Pennsylvania. No, that is not——

Mr. SLOOP. We don't know.

Mr. FULTON of Pennsylvania. No; that is not what I said. I really said the converse of that. Your experiments show that at that particular level of experiment the peak performance time was short. In addition, I said that your chart obviously shows above 90 percent actual peak performance as compared to your theoretical computation of peak performance for a short time.

Mr. SLOOP. Over this very narrow mixture range and with very short runs and with very few runs. We need to check this point further.

Mr. FULTON of Pennsylvania. That is correct.

Mr. SLOOP. This is why we have follow-on work on it.

Mr. FULTON of Pennsylvania. Now you are right down my line; we need to check this point further.

Mr. SLOOP. Oh, absolutely.

Mr. FULTON of Pennsylvania. This indicates to me that you need the authorization to go ahead with the mechanical equipment and the systems equipment components in order to prove this out.

Mr. SLOOP. We may be in semantics problems, but I consider this research and not component development.

Mr. FULTON of Pennsylvania. It is a case where you have two types of research. You have done the initial research on the chemical propulsion which I would simply call the supporting research. Maybe you need an authorization for advanced research and technology.

Mr. SLOOP. We have asked for additional funds in high energy propellants in fiscal 1964 and it is our intent to try to explore this combustion anomaly further.

Mr. FULTON of Pennsylvania. I am carefully using the language that you used previously to us.

Mr. SLOOP. Yes, sir; I say this is still in phase 1 until we can find out why this anomaly exists.

Mr. FULTON of Pennsylvania. You had given us the three stages—one, research . . .

Mr. SLOOP. Right.

Mr. FULTON of Pennsylvania. I understood that you have two kinds of research. From my previous knowledge, one is supporting research, and the other is advanced research and technology. Today you said that you had the second stage of advanced technology and third stage of development.

My point was: It seems obvious from your own chart that the theoretical computation and the highest actual performance of the OF_2–B_2H_6 combination works out very well, but the time of peak performance is very short. Therefore, you are on the advanced technology approach, which is your second level. Do you need further authorization to work this out?

Mr. SLOOP. We need further work and funds to investigate this. If I could go back to my first slide I will show you where I consider this particular propellant combination. If you were to ask me where diborane/OF_2 is today and where it will be in fiscal 1964, I would point right there to experimental research, sir, and not down here to component technology.

Mr. FULTON of Pennsylvania. Theoretical experimental performance, is that where you mean?

Mr. SLOOP. No, sir. I have to explore experimental performance over this mixture range to find out whether or not it is worthy of carrying further into the component and engine stage. Until we know that it can get this high performance, it is pointless to go into expensive development programs.

Mr. DADDARIO. Let's continue with your statement. We can come back to the questions later.

Mr. SLOOP. Very good. Now let us consider cooling. The theoretical calculations have already indicated a big potential problem with oxygen difluoride and diborane because of the very high combustion temperatures. The temperatures are on the order of 7,000° to 8,000° on the operating conditions. It is over 8,000°, for example, at 1,000 pounds per square inch, and it is under if you go as low as 60 pounds per square inch.

These values are far higher than any materials we have today can withstand. How do we cool this engine? A common way of cooling liquid rocket engines in the past has been to use one of the propellants as a coolant. Hydrogen, for example, is an excellent coolant because it has a high specific heat. Diborane and oxygen difluoride are poor coolants, and in addition they decompose on heating.

I have a figure (fig. 147) to illustrate this point. It is a little complicated, but here I have plotted an index which is the ratio of the amount of cooling required by the engine, divided by the cooling capacity of the propellants. If this index is 1, there is just enough cooling capacity in the propellants to cool the engine.

If it is below 1, there is ample cooling capacity and if it is above 1 there is a lack of cooling capacity. The horizontal scale is the mixture expressed as the proportion of fuel by weight—which is another way of plotting fuel to oxidizer ratio.

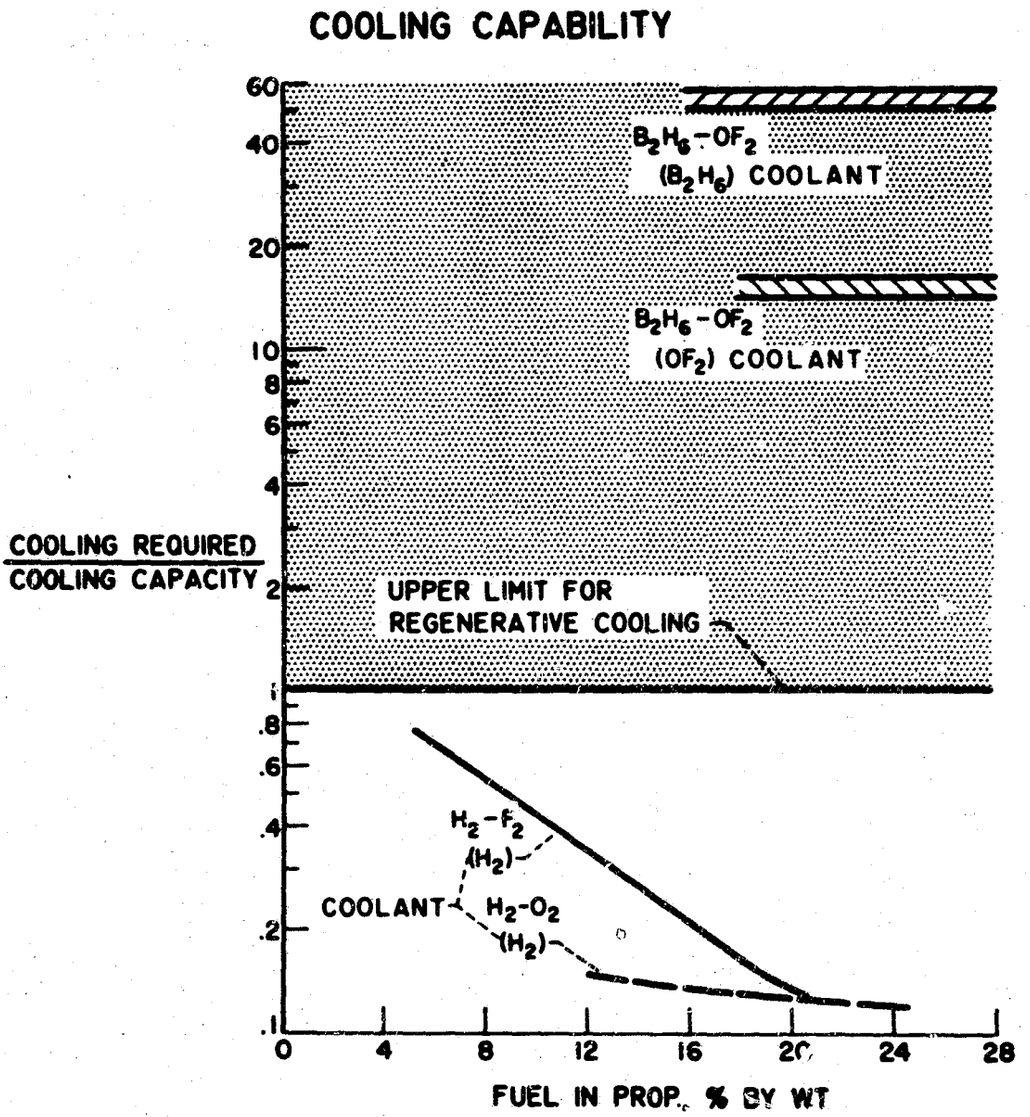

FIGURE 147

You will notice that hydrogen-fluorine and hydrogen-oxygen fall well below the limit of regenerative cooling and this is caused by the fact that hydrogen is an excellent coolant, as I mentioned previously.

On the other hand, if we consider the oxygen difluoride as a coolant, we find we are deficient by a factor of 15 and if diborane is the coolant we are deficient by a factor of almost 60. So this very obviously means that we must find some other way to cool.

What will this be? Well, one technique would be to use very high temperature materials and we are exploring this in our other technology areas.

Another method is film cooling, where we lay a cool film on the inner surface of the combustion chamber to shield the walls from the hot gases. Another technique is to use ablative materials. We think ablative materials to be a promising method for this application, but want to point out there are no suitable ablative materials at present for these high temperatures and a fluoride atmosphere.

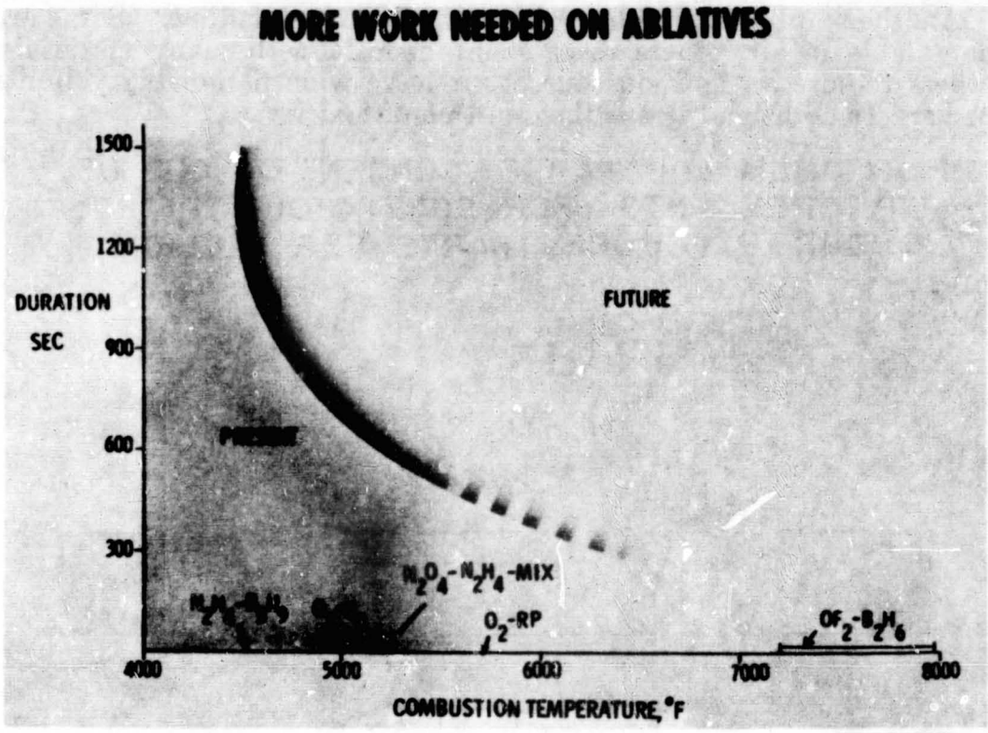

FIGURE 148

I have illustrated this by the above slide (fig. 148) which plots the burning time of a rocket or duration as a function of combustion temperature. In addition, I have shown the combustion temperature of several combinations such as oxygen-hydrogen, oxygen-RP fuel, and the oxygen difluoride diborane. This broad curve represents the approximate limit of our present technology and to operate with diborane-oxygen difluoride for 800 to 900 seconds would require being far beyond present technology. We intend to increase our effort on ablative cooling in fiscal 1964.

Ablative material technology can apply to a number of high-energy propellants, so we feel that this is a very desirable direction to go.

Other propellant work of growing importance is the use of additives to current propellant combinations to improve ignition, combustion characteristics, or performance. In 1956 the Navy, General Electric Co., and the NACA investigated the advantages of additives to the oxygen-RP combination.

There is a great potential in improving existing engines by following this path and we plan to pursue it in cooperation with other NASA program offices.

Another additive of research interest is ozone fluoride. This powerful oxidizer added in small quantities (1 part in 2,000) to liquid oxygen can produce spontaneous ignition of the oxygen-hydrogen combination, according to work by the Stanford Research Institute. Other propellant research is investigating the possibilities of gelling liquids, including cryogenics, to improve their behavior in a zero-g environment.

Another problem in high-energy propellants is handling. Some are flammable in air, others react spontaneously with many materials, others require an ignition source but have wide flammability limits in air. In addition there is the question of toxicity.

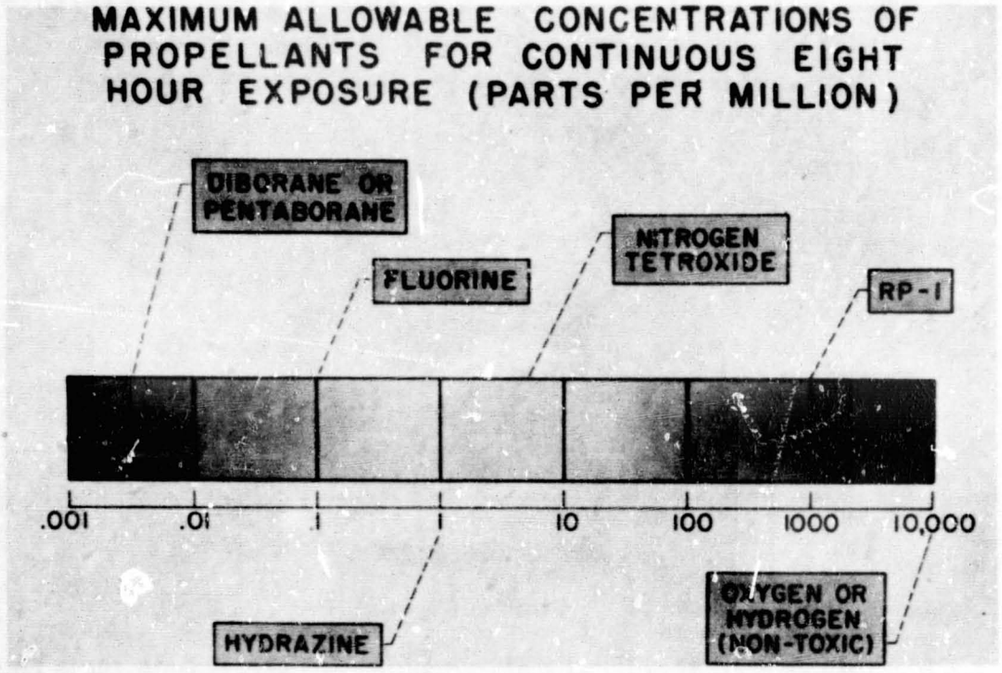

FIGURE 149

The above figure (fig. 149) shows the toxicity of some propellants. This is the maximum allowable concentration of propellants for continuous 8-hour exposure, expressed in parts per million. Over on the far right, 10,000 parts per million, are oxygen and hydrogen which are nontoxic. RP–1 falls at about 1, nitrogen tetroxide at about this point, hydrazine at about one part per million, fluorine at 0.1 part per million. Diborane and pentaborane are even more toxic, and oxygen difluoride is much more toxic than fluorine.

Mr. FULTON of Pennsylvania. At that point, you have had no trouble handling any of these so far?

Mr. SLOOP. We have had no accidents, that is right, sir.

Now when theoretical and experimental data are all available for propellant combination as I mentioned previously, we must assess them for suitability for a specific mission. My next slide (fig. 150) is an illustrative example of one particular analysis that was made for a kick stage, that is a little high-energy upper stage on top of an Atlas-Centaur, the idea being to use it for solar probe payload.

Here is plotted payload in pounds (vertical scale) against the paraheloan distance in astronomical units—that is, in units of the distance between the Sun and the Earth. This design point was for 0.2 of an AU. You notice that we have computed this particular stage for a number of different propellant combinations, both pumped and pressurized. They vary in payload at the design point from a little over 250 pounds for the lower one to a little under 500 pounds for the upper one. The storables (nitrogen tetroxide and hydrazine mixture) is the lower curve.

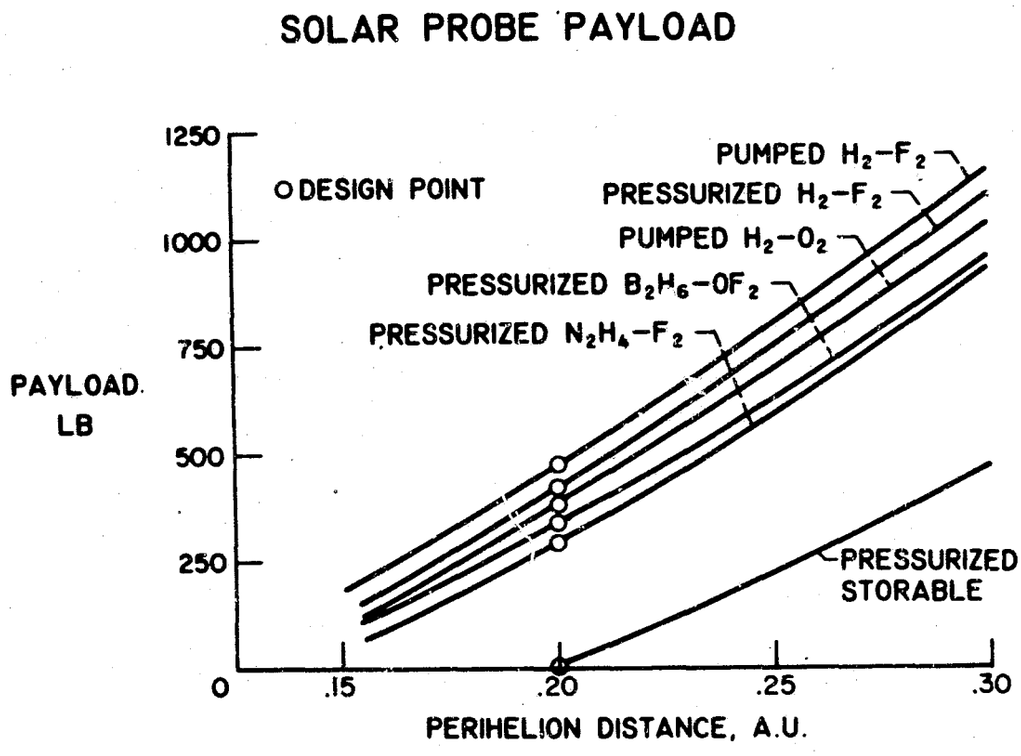

FIGURE 150

Such results as these must always be considered with caution because they are strongly dependent on the assumptions and the applications involved. As the requirements change or as the technology advances, the relative results can vary considerably.

In addition to our own work, we stay in contact with the Department of Defense and use their information where applicable to NASA programs. The Air Force, for example, is investigating a number of interesting high-energy propellants, including hybalenes and you will hear from them later.

We keep in contact with the ARPA work on fundamental propellant chemistry aimed at finding new compounds yielding an increase in specific impulse. Recently they added hybrid propellants to their program. We are currently investigating three solid propellants which are complex compounds containing boron, nitrogen, and hydrogen atoms. We contracted with the Callery Chemical Co., Food Machinery Corp., and American Cyanamid to produce approximately 100-pound quantities of these propellants which JPL will use in small scale rocket evaluation tests.

A current contract with Callery Chemical Co., that Mr. Fulton mentioned this morning, is underway and we plan an evaluation and test program with the propellant at JPL in fiscal 1964.

In advanced technology the research work on propellants is applied to components, subsystems and systems of useful size. The next slide shows an injector developed at the NASA Lewis Research Center that yields high performance with oxygen hydrogen and with hydrogen fluorine.

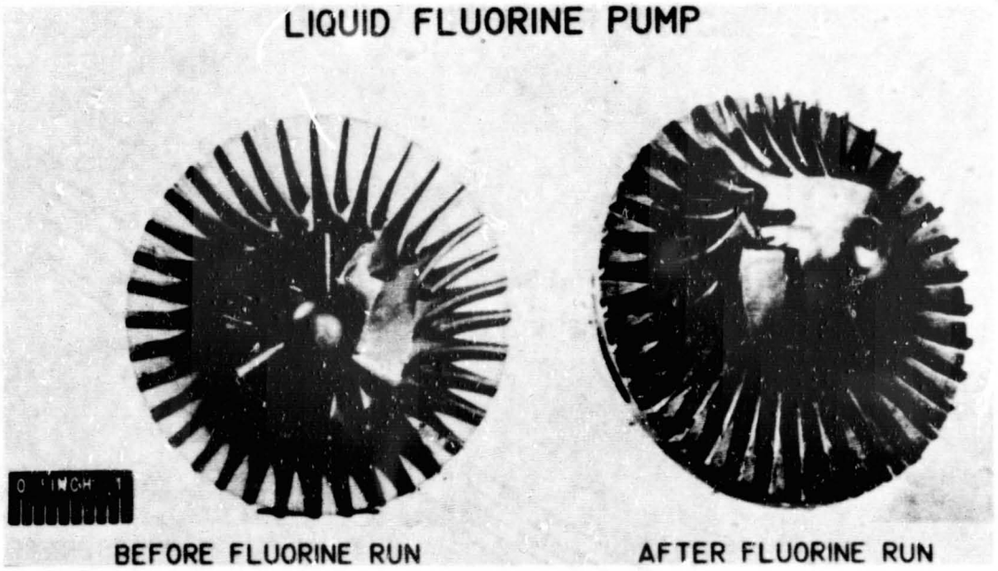

FIGURE 151

The above slide (fig. 151) shows a pump impeller both before and after some recent tests using liquid fluorine. Although fluorine is very reactive, there was no apparent effect on this impeller that was observed. I have brought along with me another impeller which is part of a cooperative effort between the Pratt & Whitney Aircraft and the Lewis Research Center. They are investigating this particular design for its suitability for use with liquid fluorine.

There has been considerable work in this country on both fluorine hydrazine and fluorine hydrogen. For example, technology work at Bell Aerosystems Co. on H_2–F_2 under NASA sponsorship is illustrated by the next three figures. The first figure (fig. 152) shows a view of

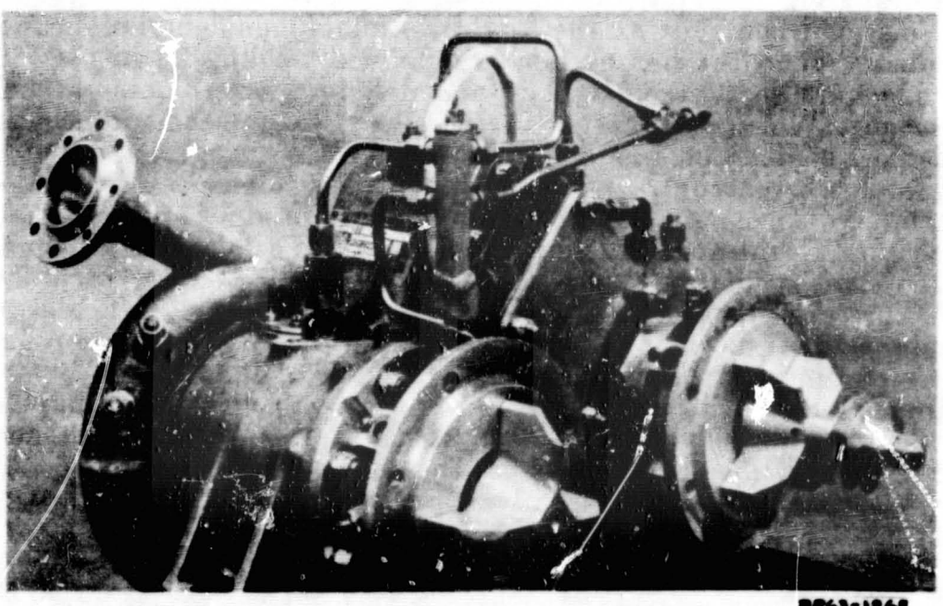

FIGURE 152

an experimental turbopump that operated successfully with fluorine in tests several years ago.

FLUORINE-HYDROGEN TURBOPUMP FED ENGINE

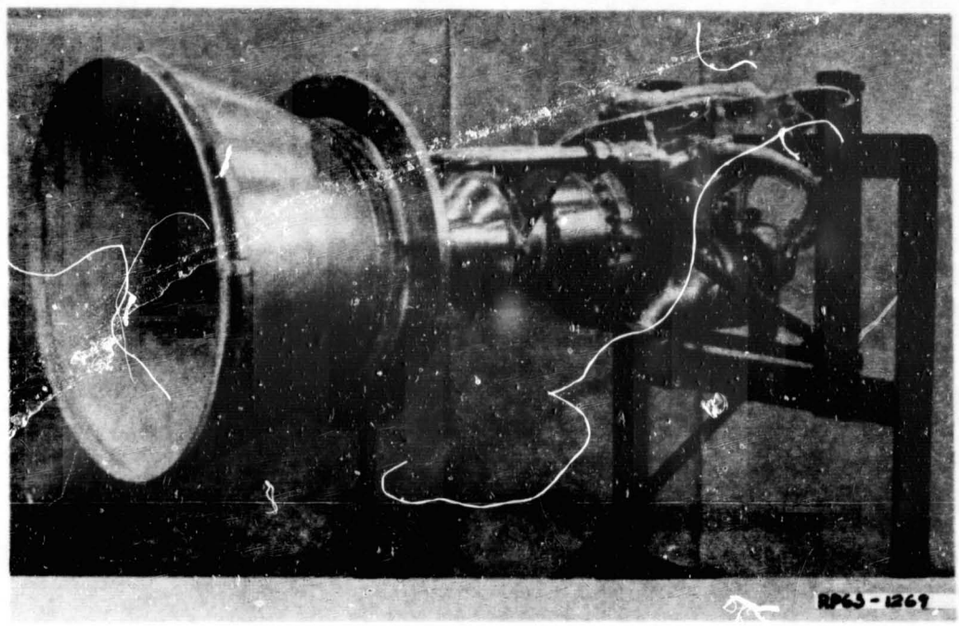

FIGURE 153

The above figure (fig. 153) is what we call a boiler plate engine or system consisting of the turbopump and thrust chamber assembly which also operated successfully as indicated by figure 154.

In fiscal 1964 we are asking for funds to do advanced technology on engine systems using hydrogen and fluorine. We believe that the potential gains in work on this combination are sufficiently advanced to make this a very desirable step.

The last phase in the evolution of propellants is development. The next slide (fig. 155) shows three engines now in development using oxygen and hydrogen. The RL–10 engine shown on the far left, 15,000 pounds thrust, was mentioned previously. Work was started on it in October of 1958. It completed its preliminary flight readiness test in November 1961. An improved version completed its readiness test in June 1962, and it is now ready for application in both Centaur and Saturn stages. The J–2 is 200,000 pounds thrust and this work was started in 1960. The M–1 was initiated in 1962, initial 1.2 million, now 1.5 million pounds thrust.

In summary, I have attempted to give you a picture of some of the considerations and work that we do in research and advanced technology on high-energy propellants and we are requesting an increased effort in this area in 1964.

Thank you.

Mr. DADDARIO. Mr. Sloop, I want to thank you for your statement. It is excellent and will be of extreme value to the committee. Before we get into the questioning, however, how would you like to work the charts? As you explained them, they did not necessarily

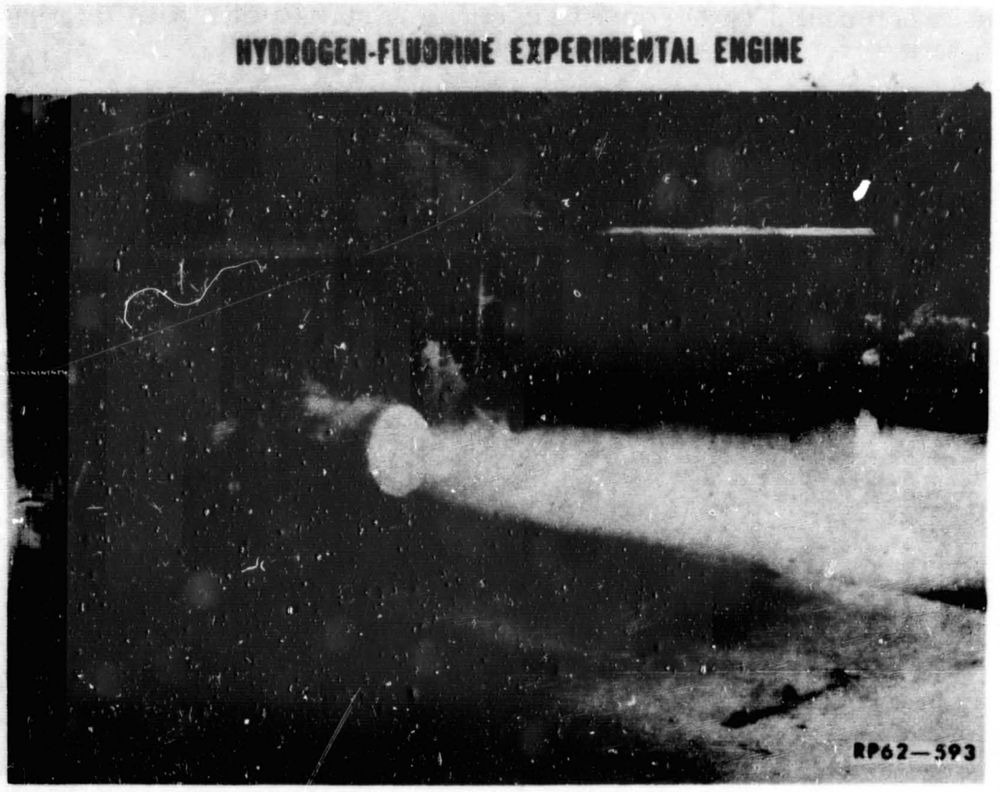

FIGURE 154

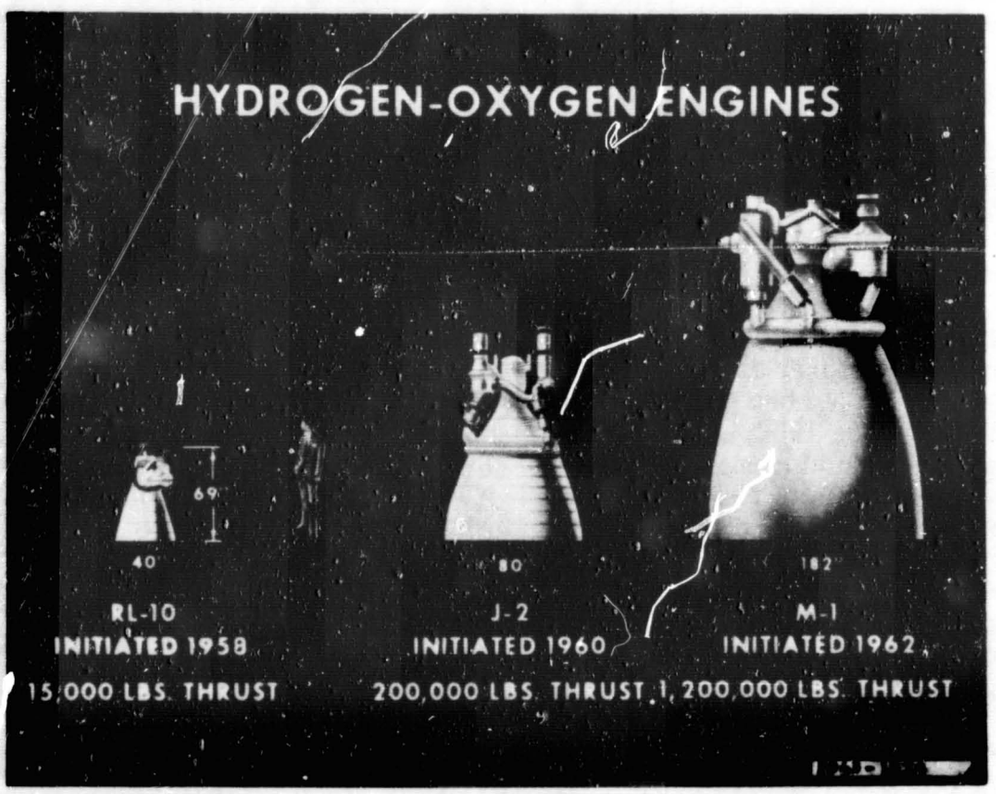

FIGURE 155

fall in the exact place with the statement, and I wonder if you would like to have the opportunity of reviewing the record when it has been prepared.

Mr. SLOOP. Yes.

Mr. DADDARIO. Then you can see that they are properly placed in the record, if that meets with the approval of the committee.

Mr. Hines, have you some questions?

Mr. HINES. Yes, sir.

Mr. DADDARIO. Proceed.

Mr. HINES. Mr. Sloop, is your high-energy fuel research wedded directly to engine development?

Mr. SLOOP. No; it is not. We in the Office of Advanced Research and Technology have the freedom to look at a large number of propellant combinations and use our own judgment as to whether or not we think they have a future potential.

Mr. HINES. Does the engine development dictate the emphasis that you place on your research in fuel development?

Mr. SLOOP. It doesn't dictate the emphasis at all, but it might influence it, because we maintain constant communication between the people who are using the propellants and ourselves. After all if the technology we develop isn't used, it is of no value, so we are constantly trying to tell engine developers what we are doing and the results we have, and trying to get them to use the results. Oftentimes there is a backflow of comment such as "Why don't you do this or that," or "Why don't you work in a particular direction because of a problem here?" This interchange of information is going on constantly, working back and forth.

Mr. HINES. I understand that you have a close working relationship with the Air Force programs; is this not so?

Mr. SLOOP. We follow their work quite closely; yes.

Mr. HINES. Then this contributes to your sum of knowledge?

Mr. SLOOP. Yes.

Mr. HINES. Mr. Sloop, I would like to ask you some questions with regard to the funding of your program. I notice that the Air Force program funding is considerably higher than the one you are responsible for. It covers both solid and liquid propellants. Can you explain the disparity between your two programs? Why does this exist?

Mr. SLOOP. We, in looking——

Mr. FULTON of Pennsylvania. Isn't the Air Force about 10 times more than yours?

Mr. HINES. Approximately 10 times; that is right.

Mr. DADDARIO It may be included in the question when he answers. Will you proceed, Mr. Sloop?

Mr. SLOOP. When we look at research that needs to be done, we take into account the work that other people are also doing in order not to duplicate this and we have a close working relationship with the people who are doing work in this area.

We look upon it from our own point of view, the need to do high energy propellant work for space explorations. If the work is already underway and proceeding in a satisfactory manner, we turn our attention in other directions.

So that you might say these two are complementary in the sense that if it is being done in our satisfaction elsewhere, we put our

attention on other things that aren't being done. If it is not being done for our purposes, we see that it is done and this may explain in part why theirs is larger.

They have had an interest in high energy propellants for a long time as you know, and have had a large program going. Our predecessor, NACA, also worked in research on high energy propellants but did not carry it into the engine stage. It was mostly research.

Mr. HINES. Would it be better to say that the Air Force is conducting research on high energy fuels in which NASA would have a greater interest than the Air Force does?

Would this be true?

Mr. SLOOP. I don't know that that is so.

We have different constraints in many cases than the Air Force. I am thinking now of applications, say, for military purposes, such as for ballistic missiles. In ballistic missiles, for example, they must worry about logistics and the materials that they can deploy in many sites. We don't have this problem, so we are free of that constraint.

We are trying to look at propellants and their application from a space exploration point of view and we apply our own ground rules or framework of reference. When we find information lacking we go after it. This is the way we work.

Mr. HINES. I see. How much money did you spend last year for such research?

Mr. SLOOP. $2,818,000.

Mr. HINES. And you are asking this year for——

Mr. SLOOP. $3,306,000.

Mr. FULTON of Pennsylvania. May I make a correction, Mr. Chairman?

Mr. DADDARIO. Certainly.

Mr. FULTON of Pennsylvania. This committee added $1 million to the NASA budget request. My complaint is that you did not spend it. You thought you only had $2.8 million but you really had $3.8 million for that type of program in fiscal year 1963.

Mr. SLOOP. We spent over a million dollars in the area that you mentioned, Mr. Fulton, and it is included in the $2,818,000.

Mr. FULTON of Pennsylvania. When you had $2.8 million in your program and we added a million dollars more for high energy fuels, why didn't you spend the $3.8 million?

Mr. SLOOP. I don't believe, Mr. Fulton, that the high energy propellants was taken out as a separate item last year. Was it?

Mr. MYERS. No.

Mr. SLOOP. This is Mr. Boyd Myers who came in late. He has the budget figures.

Mr. DADDARIO. We are happy to have you, Mr. Myers.

Mr. MYERS. Thank you, Mr. Daddario.

Actually, Mr. Fulton, the $1 million which was authorized was over and above. This is included in the figure which Mr. Sloop mentioned for high energy fuels.

Mr. FULTON of Pennsylvania. Could I give you the budgetary figures as I recall them?

In fiscal year 1963, $25,119,000 was budgeted for high energy fuels of which $2,818,000 was on the high energy propellants?

Mr. SLOOP. That is correct.

Mr. FULTON of Pennsylvania. We then authorized another $1 million so that you should have had $3,818,000 in the program. Mr. Sloop is saying that you only used $2,818,000.

My complaint was that we gave you the extra $1 million for fiscal year 1963 for high energy propellants, but you did not add it to your budget and accelerate the program.

Likewise, I found a hiatus or gap on the Thiokol contract between November 27, 1962, and March 20, 1963.

Mr. DADDARIO. Mr. Sloop, can straighten this out? Taking into consideration Mr. Fulton's request, could you let us know the amount of money you had for this program last year?

The amount spent, and the amount left over, if any?

Mr. SLOOP. I have a listing of the amount of money that we have spent that relates to boron fuels directly and some work that partially relates to diborane and the sum of these two is something over $1,600,000.

Of this $1,135,491 plus 52,000 additional, I believe, has been allocated for the boron-related fuels, OF_2 and diborane.

Mr. DADDARIO. Then as I understand it, you spent $2,818,000 last year?

Mr. SLOOP. Sir, you are talking about the year that won't end until June 30 and we are still spending it.

Mr. DADDARIO. Yes. Is all that money committed?

Mr. SLOOP. Yes, sir.

Mr. DADDARIO. Does it include the additional $1 million which Mr. Fulton referred to?

Mr. SLOOP. Yes, sir; it does.

Mr. DADDARIO. Once those moneys are finally spent, what will it amount to?

Mr. SLOOP. The $2,800,000 figure that we gave you before.

Mr. DADDARIO. How does that reconcile?

Mr. FULTON of Pennsylvania. I understood Mr. Myers to say that you had 450,000 in your work at JPL on the borane fuels. Is that not correct?

Mr. SLOOP. We spent $462,000 at JPL this fiscal year.

Mr. FULTON of Pennsylvania. All right.

Mr. SLOOP. On high energy solid propellants related to boron. We spent more than that on high energy solid fuels.

Mr. FULTON of Pennsylvania. That is right.

Mr. SLOOP. I believe we spent $491,000 on solid propellants there, of which $462,000 is on fuels related directly to boron.

Mr. FULTON of Pennsylvania. Then you have a figure on RDO–22 of $2,818,000 under 1963 labeled "High Energy Propellants."

Does that figure include the congressional increase of $1 million?

Mr. SLOOP. It does.

Mr. FULTON of Pennsylvania. What was your original budgetary figure then for fiscal year 1963, $1,818,000?

Mr. SLOOP. As I recall the high energy propellants as a separate item was not a budgetary figure last year, so that I am unable to tell you at this time exactly what it was, but I assume it was the $1,818,000.

The numbers that we are talking of, I want to point out, are what we call direct R. & D. costs and do not include the operation of the research centers which are additional funds in this area.

Mr. FULTON of Pennsylvania. Was your major diborane-fluoride contract with Reaction Motors Division of Thiokol Chemical Corp. for $375,000 actually fiscal year 1962 money?

Mr. SLOOP. No, sir; that is fiscal year 1963.

The $200,000 that you heard this morning was fiscal year 1962.

Mr. FULTON of Pennsylvania. The original $200,000 was fiscal year 1962?

Mr. SLOOP. Yes. The $375,000 is fiscal year 1963. This was the contract that was let March 20 that you mentioned this morning. While we are on the subject you mentioned this disparity——

Mr. FULTON of Pennsylvania. Don't leave that.

Mr. SLOOP. OK.

Mr. FULTON of Pennsylvania. If it is fiscal year 1963 funds, why was it that there was the period from November 27, 1962, to March 20, 1963 when nothing was done on this contract? There was testimony this morning that there was a gap when the first contract ended. The new contract for 1963 did not begin until March 20, 1963, and you already had the money authorized by this committee?

Mr. SLOOP. Well, Mr. Fulton, I looked that up over lunch and I have the report of the Reaction Motors Division. They made their 50th and last run on November 27, 1962.

Mr. FULTON of Pennsylvania. That is the date they commented on?

Mr. SLOOP. Now, you realize the day they make the run, the data has to be reduced, it has to be plotted, they have to discuss it, they have to write a report. And so the interval that you mentioned started with the last minute of operation of the experimental engine work and included the period when the engineer and his supervisors at Reaction Motors examined the data, made their report to us, the time we spent in sitting down and talking with them about the work, and, the time we took to decide on the next course of action.

Mr. FULTON of Pennsylvania. You should continue the experiments rather than have a gap. This committee, although not in this particular instance, frequently hears complaints of stop and start contracts. The contractors say they don't know what they are going to do next.

This clearly looked like a time when a company was just sitting idle with its test equipment while NASA was making up its mind how to go ahead with the money already allocated.

Mr. SLOOP. Well, this is the way we do our work. After completion of experiments, we plot the data, we examine it, we sit down and we try to understand or explain it.

After all, this anomaly that I showed you, is quite surprising. In all my years in rocketry, which started in 1945, I have yet to see so strong an anomaly as this.

So this was quite puzzling to me as well as to Thiokol.

Mr. FULTON of Pennsylvania. You mean the fact that you had an extra $1 million given to you by Congress was the anomaly?

Mr. SLOOP. No, sir; I am saying the results that Thiokol obtained that showed this strong peaking. So when you see results like this you ask the experimenter to check his measurements, be sure they are right, check his computations, make sure that everything was what he thought it was.

This took time, checking back and making sure that the results were the very best measured data that we could possibly get. Then

we had to ask ourselves: Is this a measurement problem, an experimental problem, an injector problem, or is it the nature of the combustion process itself?

We talked to people in various disciplines about this to try to arrive at some explanation. This takes a little time. This is the way research is done. If you get an unusual result it takes quite a bit of discussion to try to arrive at an explanation. I don't think this is an unusual process at all. It is something that we like to do to make sure that what we do next is the most fruitful approach.

Mr. DADDARIO. It is your opinion this was a normal relationship. There was no gap and this is the way in which you handle your dealings with companies who are doing research for NASA under these circumstances?

Mr. SLOOP. Yes, sir. We like to examine their results and to find out—to assess these results and sit down with them and decide whether or not additional work is necessary or whether or not this completes the work.

This is a natural review process.

We do this with all our contracts.

Now, we like to keep this review time short and I would not say that this particular period was normal, I simply say that when things are unusual it takes longer.

Mr. FULTON of Pennsylvania. From my experience with airplanes, having served as one of the Navy members on the aircraft scheduling unit at Wright Field in World War II, a delay of 4 months before deciding to continue these experiments would have caused some concern at that period in our history. So that in transposing that experience to this, it causes me some concern. Not that it is either abnormal or a mistake, but everyone knows that equipment should not be lying idle. Thiokol made progress to a point where the inherent computed efficiency of the propellant is apparent, but they have not been able to obtain a peak performance for any substantial duration. To me, the first thing to check would be the records to see if they were correct, and then probably start in on a fuel control or an injection system to see what it could do. Why wouldn't that be logical?

Mr. SLOOP. At the completion of their contracted effort, we had to assess their results and determine what to do next. We were not sure at that time just exactly what would be the best course of action.

Mr. DADDARIO. Mr. Hines.

Mr. HINES. Mr. Sloop, would you say that high-energy fuels are required for use in our missions projected from 1967 onward? Would this be a reasonable time period?

Mr. SLOOP. I think that high-energy fuels will be very useful. We think hydrogen oxygen is high energy and as you know it is the cornerstone of our space effort now.

And I think that it and other high-energy propellants will be used throughout the rest of this decade and into the next.

Mr. HINES. Would you say that the utilization of these fuels as propellants would parallel the nuclear engine?

Mr. SLOOP. Absolutely. I agree with the statement made this morning that there are various uses for chemical propulsion systems that we will have uses for even after we have a working nuclear stage which will be some time from now.

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This is because there is no single propulsion system, and never has been, that fits uniquely all possible applications.

Even with nuclear and with electric propulsion systems, we will have need for chemical systems, for takeoff, for landing applications, for storing power, for short bursts of energy at one of the planets and things of this sort.

We see a long and continued need for chemical propulsion.

Mr. HINES. Would you say that the Office of Manned Space Flight is the Office in NASA that will make the greatest use of the technologies that you develop?

Mr. SLOOP. Yes, certainly in the manned space effort that is so and, of course, we have use for high-energy propellants in the unmanned scientific explorations and in the application areas, as well.

Mr. HINES. Do these other, shall we say, colleagues of yours, place demands upon your shop to come up with projected propellants for future missions?

Mr. SLOOP. They look to us to establish the research and technology base upon which they can build whenever they get a specific mission.

In other words, if we have done our job right there will be enough technology on hand for them to develop engines rapidly and with reasonable cost.

Mr. HINES. There was mention this morning of missions that NASA wishes to accomplish in the future which cannot be accomplished with conventional fuels. Could you outline some of these missions in which high energy propellants would be used?

Mr. SLOOP. Well, I am not sure of the things you are referring to, but I will say that we have always found a use for high energy propellants whenever we developed the technology.

This has been our history. We have constantly sought to get more energy per pound of propellants.

Mr. HINES. In other words, your program is not necessarily designed to fill a gap which the conventional propellants could not satisfy; this is not the major impetus behind your program, is that correct?

Mr. SLOOP. It is our intent to try to find high energy propellants that will do a bigger and better job in space applications.

Mr. HINES. And give you more capability?

Mr. SLOOP. Absolutely.

Mr. HINES. This is perhaps a loaded question, Mr. Sloop, but I don't mean it to be: In comparison to the level of accomplishment that you have achieved a year ago, do you feel that there has been an improvement or progress of a significant order of magnitude achieved by your programs to date?

Mr. SLOOP. Well, an order of magnitude is a factor of 10, sir, and this is quite a big change.

Mr. HINES. I agree.

Mr. SLOOP. I feel that we have made significant improvements. I think that we see the things that need to be done in a much clearer light. I think the work that we have done is very encouraging. We have evidence almost every day of some of the technology work that we have done being fed into contractual bids for some of the practical systems that are going into development and we feel that we are making a contribution.

Whether someone would put a multiplication factor of 10 on it, I won't say.

Mr. HINES. I realize this is a problem you could not answer exactly.

Do you feel that you have enough money to pursue your program adequately?

Mr. SLOOP. Yes, I do. I think that we have a very well planned and integrated program which will give attention to those problems we think are important. I also feel that I have some flexibility. As the research results unfold we can make certain minor adjustments within our program to emphasize or take advantage of new developments and to shut off work on things which no longer look fruitful.

With this flexibility in mind, the answer is very definitely "Yes."

Mr. HINES. Then would it be logical for me to assume that you have not known of any program under your direction to be hamstrung or throttled by lack of funds?

Mr. SLOOP. That is right.

Mr. HINES. That is all, Mr. Chairman.

Mr. DADDARIO. Mr. Sloop, what is the figure in this year's budget? You gave that to us before.

Mr. SLOOP. Three million—in what, sir, high energy propellants or the whole——

Mr. DADDARIO. No, high energy propellants.

Mr. FULTON of Pennsylvania. $3,306,000.

Mr. SLOOP. $3,306,000.

Mr. DADDARIO. What was the figure you originally submitted to the Bureau of the Budget?

Mr. SLOOP. What is that, sir?

Mr. FULTON of Pennsylvania. What figure did you ask for originally when you submitted your request to the Bureau of the Budget?

Mr. SLOOP. For fiscal 1964?

Mr. FULTON of Pennsylvania. Yes.

Mr. SLOOP. In fiscal 1964 it was the same, $3,306,000.

Mr. DADDARIO. Then you are getting what you have felt you need for your program?

Mr. SLOOP. Yes. I should point out that other moneys that we are spending in propulsion analysis, like the work I mentioned here, is definitely related to high energy propellants, and some of the technology work that we are doing, is not included in the figure that I gave you.

Mr. DADDARIO. Can you break that down for us, then, so we will know what you requested for fiscal year 1964 in each of the categories?

Mr. SLOOP. The total is $35,075,000 in all of the chemical propulsion research and technology.

Mr. DADDARIO. Can you break that down, now?

Mr. SLOOP. It is broken down into four parts, aerothermochemical analysis and materials, $7,025,000. I am reading from RDO–22, sir.

The high energy propellants, $3,306,000, launch vehicle technology, $4,474,000, experimental high-energy engine of hydrogen fluorine which I mentioned previously, $1,574,000, and advanced spacecraft engine technology, $5,681,000. And that adds to $22,494,000. And then we have personnel costs and operation of installations which brings the total to $35,075,000.

So in high energy propellants in fiscal 1964 we are doing more than the $3,306,000; we are doing the $1,574,000 specially for the high energy engine I mentioned and parts of the other subjects.

It is hard to break the figures into precise categories and say exactly how much goes into energy propellants. The calculating machines will compute a low energy propellant just as rapidly as they will a high and we don't categorize this work as high energy propellants.

Mr. DADDARIO. Can you break down the figures so that we will know what your original request was in all of these categories?

Mr. SLOOP. The request you see here, sir, is my original request.

Mr. DADDARIO. In every area?

Mr. SLOOP. Yes, sir.

Mr. DADDARIO. That is what you requested of the Bureau of the Budget in the first instance, and you got what you have asked for?

Mr. SLOOP. To the best of my knowledge that is so.

Mr. DADDARIO. Is that your understanding, Mr. Myers?

Mr. MYERS. Well, Mr. Chairman, we first went to Dr. Bisplinghoff with our program as to what we would like to have, and what we think is necessary.

Mr. DADDARIO. Start from there and tell us what you asked for in those instances, and how you finally got to the point where you had these figures approved by the Bureau of the Budget?

Mr. MYERS. I can't do this off the top of my head.

I can only tell you that we submit a request to Dr. Bisplinghoff, and he submits a budget to Dr. Seamans and NASA's management.

Once the determination is made as to what the overall budget will be, discussions are held with the Bureau of the Budget. We then come back and we go over all limitations. Dr. Bisplinghoff is given a guide to go by, and from that works up the best program he can get within the dollars available. Then we go back to Dr. Seamans and these figures are submitted to the Bureau of the Budget. As Mr. Sloop said, this is the figure that we submitted to the Bureau of the Budget.

Mr. SLOOP. That is correct.

Mr. DADDARIO. That is the point we are trying to get at, this figure reflects an adjustment of original thinking insofar as this year's program is concerned.

Mr. MYERS. I think you can—that is right.

Mr. DADDARIO. This committee is concerned with propulsion as has been indicated over the course of the last several years. It would be of help to us to know what your original plans were? What amounts were involved and what did those programs entail?

Mr. MYERS. As you know, budgeting is a reiterative process. All during the year adjustments are made; the flexibility Mr. Sloop spoke of occurs during the year in exercising technical judgments as to what is the best course to pursue.

In any given program, or any small part of a given program, if we go down one road and it does not look like the program is panning out or we are not getting the results expected, we may change direction and put funds into other areas.

This occurs throughout the year in any given budget, so that it is very difficult to reconstruct. You have to go back to each technical decision that is made by men working at the bench and by men in headquarters. It is very difficult to reconstruct this because there are many day to day sort of management decisions.

Mr. DADDARIO. I could have a very strong basic argument and disagreement with you on your last statement. This is one of the reasons that I inquire into this, so that we might have more exact information and will not be faced again with the reprograming which was implicit in last year's budget.

We are constantly advised that NASA, as its programs become more definitive, will have less reprograming.

You last statement would indicate to me that there is a great possibility that this is not so. However, that is besides the point. The purpose of this discussion is to find out what your original ambitions were in the propellant field.

Mr. FULTON of Pennsylvania. Would you yield? I would like to agree with the chairman on that. This committee was told that fiscal year 1963 would be the first clear-cut year on figures.

During fiscal year 1962 NASA had taken projects from many portions of NASA and formed the Office of Advanced Research and Technology. You are correct in your statement as to fiscal year 1962 when the budget estimates were prepared. However, fiscal year 1964 was the year you should have come up with the divisions that the. chairman has asked for at your various levels of budget requests. So I would agree with the chairman.

Mr. MYERS. I would like to clarify one point, Mr. Daddario. The reprograming, I think, was only of the order of $300,000, that we added to this particular program during fiscal year 1963.

In other words, this was a reprograming action, and it was an addition to the program, not a subtraction. The whole Office of Advanced Research and Technology's entire reprograming for the year in many, many small areas, only amounted to about 3 percent.

So the overall reprograming actions are small in the amount of money, and these are reflected by technical judgments that are exercised during the year. For example, we are talking to you now about fiscal year 1964, and we are thinking about 1965 and 1966, and so forth. We cannot make exact judgments as to what the technology situation will be, or the research situation will be, when we actually get into that year. We think that 3 percent is a very small change of mind, so to speak, as to how to proceed.

Mr. DADDARIO. Well, that being the case, insofar as these figures are concerned, then we ought to be able to get to an answer to my question.

If the changes are so small and you have gotten your programs down to such a precise level, and I quite agree with you that 3 percent would be a small change, then we ought to be able to get down to exact figures. These figures must reflect themselves in the original requests which you submitted while preparing your program. We should know what you would have liked to have had for this year, so that we can determine what you were originally shooting for. Are those figures available, or could they be made available?

Mr. MYERS. All I can say now is that we will attempt to reconstruct those and see if we can submit them for the record. However, I would like to make one general statement which we have made before in other hearings. Each program office, as represented by Mr. Sloop within the Office of Advanced Research and Technology, has objectives and things they would like to do, and for which we do not have enough funds.

This is true of all of our programs. So, in this process, we must evaluate these on the best technical judgment so we can to do the best job we can, to milk the cream, so to speak, of the barrel by doing those things that will give us the best advancement. We cannot always provide everything each individual would like to do in his program. It is in this context that we do have these technical judgments which modify what is finally submitted to the Bureau of the Budget. This is done in the best technical judgment of the Administrator, the Deputy Administrator, and the Associate Administrator.

Mr. DADDARIO. I recognize that, and it is somewhat the process of adjustment through which this committee is going during these NASA authorization hearings. However, I think it is important for us to understand what flexibility there was in the final judgments made within NASA.

It is in this context that I ask for this information. I hope it might be available because by the time you submit your final figures you have already gone through a process of adjustment and you have had to tailor your programs accordingly.

I do not want to know the suggested programs that were submitted to you by the people who are immediately below you, but, rather the figures you approved and submitted for fiscal year 1964.

(The information referred to is as follows:)

Management discussions were held early in 1962 for fiscal year 1964 budget plans. In these discussions judgments were made as to the level of effort needed in advanced research and technology in chemical propulsion. These judgments were expressed in the form of guideline figures ($2,497,000 for basic research, $20 million for applied research and advanced technology, total $22,497,000 for direct R. & D. costs).

These figures represented an appreciable increase over the fiscal year 1963 effort which, at that time, was still under consideration by the Congress. Mr. Sloop was asked to prepare a program based on the $20 million direct R. & S. cost and he did. This plan plus the $2,497,000 R. & D. direct cost prepared by Dr. Kurzweg constitutes NASA's submission to the Congress.

Mr. FULTON of Pennsylvania. What figures did Dr. Bisplinghoff receive from you, and then what figures did you get back from Mr. James Webb? You were asked on April 7, I believe, by Mr. Karth, to provide these figures within the next several days.

Mr. SLOOP. I think they were provided, weren't they?

Mr. MYERS. I am not sure.

Mr. FULTON of Pennsylvania. It is remarkable that this subcommittee arrived at the same point that the Subcommittee on Space Sciences and Advanced Research and Technology arrived at when we feel we don't have the figures that we can act on.

I might comment on your 3-percent changes. We must remember that there are no line items on the various types of projects or programs, and it is very easy to just change the emphasis from one to another. That would not require a transfer of funds, is that correct?

Mr. SLOOP. I can make adjustments subject to Dr. Bisplinghoff's approval of funds within the chemical propulsion and I feel this is necessary. I feel this is necessary in research because we try to emphasize the important things and we try to use our judgment as time goes on to constantly appraise the program and keep it as pertinent as possible.

I am an enthusiast for my program and there are things I would like to push, but I work within a different set of constraints than

my supervisor who has a broader responsibility and who must think of other programs.

So this is a reiterative process as Mr. Myers pointed out in which we make an appeal for what we think should be done in the following year and these have to be considered in the light of the overall program and adjustments are made. During this reiterative process we generate a budget framework and we work within this framework.

Mr. DADDARIO. We are pleased to know what your ideas are. It does not happen often, but as Mr. Fulton indicated, last year we did add funds in the area of propellants.

So if we can be convinced that it is important, it may be of considerable help to some of your programs.

Mr. SLOOP. We are pleased with your support.

Mr. FULTON of Pennsylvania. We feel that the high-energy fuels must be emphasized now, and that you must have adequate leeway and authority to operate.

Mr. SLOOP. Yes, sir.

Mr. FULTON of Pennsylvania. But in my long time in Congress you were the most reluctant person I ever pushed on Santa Claus' lap. I never saw anyone so reluctant.

Could I ask you about the extra million dollars you received? Did you spend it well?

Mr. SLOOP. We think we are spending it well, yes, sir.

Mr. FULTON of Pennsylvania. For example, if you hadn't gotten it, you would not have spent the $320,000 with the Jet Propulsion Laboratory on solid propellant motors using boranes, and you needed it, didn't you?

Mr. SLOOP. For 1962, yes, sir.

Mr. FULTON of Pennsylvania. Yes, but you needed the money, didn't you?

Mr. SLOOP. Absolutely.

Mr. FULTON of Pennsylvania. And then on the Jet Propulsion Laboratory solid program on the borane ingredients, with Callery Chemical, that $50,000 you needed that, didn't you?

Mr. SLOOP. That is included in the number I gave you, and yes, sir, we certainly did use that to good advantage.

Mr. FULTON of Pennsylvania. And because you, on March 20, 1963, executed a new contract with Reaction Motors Division of Thiokol Chemical Corp., you certainly needed the $375,000 for the engine tests with diborane and the oxygen difluoride, didn't you?

Mr. SLOOP. Yes, we did.

Mr. FULTON of Pennsylvania. And you used the money well.

Mr. SLOOP. We used that. I want to point out that we used $100,000 more than that to buy the OF_2, and we are using I believe the number given this morning by Callery, which was $26,000 for diborane.

Mr. FULTON of Pennsylvania. You bought 2,000 pounds of the OF_2 from the Allied Chemical Co. for your experiments, didn't you?

Mr. SLOOP. We are in the process of doing that, yes.

Mr. FULTON of Pennsylvania. And you spent $34,000 with Callery Chemical Corp. for diborane, didn't you?

Mr. SLOOP. They mentioned the figure of $26,000, so it sounds like we got a good buy.

Mr. FULTON of Pennsylvania. Then with the General Electric Co., when you entered the $40,000 contract for ablatives on nozzles you needed that money, didn't you?

Mr. SLOOP. Yes.

Mr. FULTON of Pennsylvania. The money was well spent; it wasn't wasted?

Mr. SLOOP. Absolutely not.

Mr. FULTON. Actually, the development of high-energy fuels, ablative materials, injection systems, and nozzle conformations are the most important, aren't they?

Mr. SLOOP. Yes. I might mention that we are negotiating a combustion project with New York University which will examine the combustion process of OF_2 diborane.

Mr. FULTON of Pensylvania. When we were discussing this key problem last year then, this committee was of assistance to you in giving you the $1 million, because you have justified every one of these items.

Mr. SLOOP. We certainly are grateful for your support.

Mr. FULTON of Pennsylvania. You say that you are spending $50,000 out of the $1 million for the handling of the diborane. You certainly need to know how to handle it, don't you, because you pointed out how——

Mr. SLOOP. Sir, there is a correction here.

We have not budgeted $50,000 for diborane in fiscal year 1963. I believe this was mentioned earlier in the testimony, and as far as I know, it is correct.

Mr. FULTON of Pennsylvania. Mr. Toering, as I remember, said there was $50,000 to learn how to handle diborane because of its toxic properties.

Then when you spend $15,000 on a program in 1963 for the handling of, or investigating the toxicity of oxygen difluoride, you certainly needed that amount of money.

Mr. SLOOP. In regard to that particular study, Mr. Fulton, we have referred that work to our office of biotechnology and human research, where we have some M.D.'s who are helping us with the toxicity studies. They are making a very thorough appraisal of the whole field. It may well be that this study will be larger than the $15,000 that you mentioned.

Mr. FULTON of Pennsylvania. Yes, but——

Mr. SLOOP. This will come in fiscal 1964.

Mr. FULTON of Pennsylvania. If you did not have the $1 million this committee gave you, you couldn't have even started on it.

Mr. SLOOP. We could not have done——

Mr. FULTON of Pennsylvania. You pointed out on your charts today what a problem toxicity is with these high energy fuels.

Mr. SLOOP. That is right.

Mr. FULTON of Pennsylvania. So that if you didn't get the $15,000 to start on it, you wouldn't have been into the program at all.

Mr. SLOOP. That is correct.

Mr. FULTON of Pennsylvania. Now, when we are trying to help you, we are certainly not trying to get you to spend money that isn't necessary. We heard this morning, however, that there would be a 20 percent gain in performance by the use of high-energy fuels. Some of us, when we objected so strongly to the Nova last year, were

concerned that rockets are getting as big as elephants and the payload as small as rabbit heads. When rockets get to be the size of the Capitol dome, or as somebody said, the Washington Monument, and we hear that high energy propellants can increase fission, we will call it, approximately 20 percent, not to follow up these leads is costing the taxpayers money in the long run. The fact that we can have extra factors of safety and reliability in the flights and these deep space probes should be a real concern too.

In a technological report of NASA in February 1963, you had favorably commented that there seemed to be a 5 to 10 percent gain in fission on the Borane-Hydrade combinations.

On page RDO 20–4 of the budget books it speaks well of high-energy propellants and the possibility of these hydrazinborane compounds.

I will give you the quote. It says: "Also work was conducted on the evaluation of oxygen difluoride and diborane as a high-energy propellant combination. This work showed high-combustion fission in a small rocket motor. It is planned to increase the work in the coming year."

Obviously when I see that in your backup books, I would expect you to come in and say: "We want to have a good, efficient program for the coming year."

Then when we were looking at your charts this afternoon, twice you mentioned that these experiments on those small rocket motor-type tests have turned out "disappointingly."

Mr. SLOOP. Mr. Fulton——

Mr. FULTON of Pennsylvania. It just does not fit together. What you send up here for your justification doesn't coincide with your comments in regard to your charts. I wish you would correlate them for us.

Mr. SLOOP. In my statement before Mr. Karth I used the identical chart I showed this afternoon and also I pointed out that the results were disappointing. I am sorry if you have received the impression that I am not interested in this combination. I am very much interested in this combination.

Mr. FULTON of Pennsylvania. Not at all. We are trying to help you; if I didn't think you were interested, I wouldn't be here.

Mr. SLOOP. I feel we have a long way to go to explore this, and I am not quite ready to rush out of the very elementary laboratory experiments into full scale development. I want to do research and technology.

Mr. FULTON of Pennsylvania. Just hold on that point. Nobody, so far, has referred to the development at this point. You gave us the second stage.

Mr. SLOOP. Yes sir.

Mr. FULTON of Pennsylvania. It was the second stage that we talked about. There were the two kinds of research, and then we talked about the technical development. We haven't gone into development of engines.

The report that I spoke of was Kurt Stehling's report of February 1963 on the diborane oxygen difluoride.

Your conclusions seem to be adverse to that report.

Mr. SLOOP. Did he not qualify his statements in the report you mentioned, saying that he had not had time to examine this combination fully?

Mr. FULTON of Pennsylvania. But to me that is the whole point of research and development.

Mr. SLOOP. Yes sir.

Mr. FULTON of Pennsylvania. And that is why we do the research.

Mr. SLOOP. And that is why we are here.

Mr. FULTON of Pennsylvania. When an outstanding scientist such as Kurt Stehling tells us there looks like a 5- to 10-percent gain, and we have the practical men in the field working on experiments who tell us that there is about a 20-percent gain in fission possible, then we should be doing more work in the field.

I was out to Edwards Air Force Base and said to Colonel Norton: "Are you willing to put those chickens on your uniform up as a guarantee that you have full faith and confidence in this program?" He said: "Congressman, I certainly am."

You cannot prejudge programs. We are talking to you about your emphasis with a longer term view in mind than just the immediate ice cream and cake, today or tomorrow. That is why we are talking at such length. Some of us are vitally interested that the United States become preeminent in space. The one place where we are behind the Soviets is in the area of propellants. Why we aren't making more of an effort on propellants, I just cannot see.

As a matter of fact, it is worse when I hear that the total amount spent was not the $3,800,000 I had originally thought, but only $2,800,000 which included the $1 million that the committee gave you in 1963. Even if it had been the $3 million, that is only one-tenth of what the Air Force is spending on their emphasis of this type of high-energy fuel program. We are not criticizing you, but this is something that we must look into.

MR. SLOOP. We are putting emphasis on the areas of OF_2 diborane which we think are the critical problems, and we have been in close contact with the Air Force, and they know of our work. They are following it with us. They are counting on us to carry forward the technology in this area, and we believe that we are working on the major problems that must be solved.

After all, if we can't cool it we can't use it.

Mr. FULTON of Pennsylvania. If you had four——

Mr. SLOOP. If we can't get high combustion efficiency over a wide range of mixture ratios, if we hit a fundamental snag we want to know it as soon as possible.

So we are going after this hammer and tongs, and I think the statement—made this morning by Thiokol—indicated that they are vigorously pursuing the objective of getting good performance over a wide range of mixture ratios—is a good one.

That is just one problem.

Another is cooling, previously mentioned.

A third problem is one of obtaining high performance at simulated altitude. Will the real gases follow the top curve or the bottom curve shown previously?

We want to find this out, and we intend to get after these problems this year. When we get these three problems solved, then we go further.

Mr. FULTON of Pennsylvania. How can you answer it without money?

Mr. SLOOP. Sir, we are spending money on it.

Mr. DADDARIO. Mr. Sloop, Mr. Fulton is one of the strongest advocates of this program. He did not say you are not pursuing this in a critical way, I can attest to the fact that he did not.

Mr. FULTON of Pennsylvania. No.

Mr. DADDARIO. I, personally, in listening to your report, can see no lack of enthusiasm on your part.

Mr. SLOOP. Thank you.

Mr. DADDARIO. Nor anything about which to criticize you. In fact, I think you have shown the type of objectivity that a person in your position must have.

The objectives of the committee, however, are to take into consideration your problems, and to see what might additionally be done in the field of propellant technology. This has caused the committee some concern in the past. As I recall, 3 or 4 years ago Mr. Teague constantly asked that we have a greater multithrust program in all areas. His suggestions at that time were greeted with a lack of enthusiasm by NASA.

As a result, we find that if we do pursue this subject and keep after it, somehow or other it works out much better. I would like you to keep this in mind in reference to the questioning you are undergoing today.

Mr. FULTON of Pennsylvania. Wasn't the extra $1 million during the current fiscal year a pleasant sensation?

Mr. SLOOP. Yes, sir.

Mr. DADDARIO. A million dollars always is, Mr. Fulton.

I would like to pursue one other line of questioning, if we could, Mr. Sloop, and that is your work with the Department of Defense.

You said that you coordinate with them?

Mr. SLOOP. Yes.

Mr. DADDARIO. I would like to know how you do it. What is the system you use?

Mr. SLOOP. There are many ways this is done. As you may know, I worked for the NACA for many years and had a very close association with the Air Force people in rocket propellants when they were at Wright Field and later transferred to Edwards.

Bill Schnare, Bill Knapp, Colonel Patillio, and some of their people.

I frequently talk with them, either on the phone or by visit. One night after dinner, for example, we talked about our programs until 1 o'clock in the morning.

This is what I would call a very informal type of exchange. Whenever any special interest comes up, we talk. For example, we got interested in a certain program that I cannot mention in an open meeting and we called the Air Force and asked what their plans were on this item. They told us they had no interest in this area, so therefore we proceeded. This informal working relationship goes on at all levels at headquarters and centers.

Now we have more formal arrangements, such as the Aeronautics and Astronautics Coordinating Board which has a number of panels. I am on the launch vehicle panel and a number of NASA and DOD programs come to this panel and we discuss them. Recently the Air Force discussed before this panel some of their thinking and plans in high-energy propellants.

In addition, we have the Chemical Propulsion Information Group. This is a coordinating group involving several Government agencies.

They hold meetings each year, both in liquid rockets and in solid rockets in which the latest technology is presented.

In addition they have working panels in which members from Air Force and NASA and ARPA and Navy get together and discuss their programs. We exchange information on this basis, so I feel we have a very well coordinated program and a very good working relationship with the Air Force.

Mr. DADDARIO. As informal as it is, you feel it meets the needs of the day?

Mr. SLOOP. The coordination, yes, sir; I feel that we have adequate channels for meeting and discussing. It is as easy as picking up the phone and chatting.

We see each other quite frequently, whenever our paths cross and when we get together on specific problems.

There is no lack of communication that I am aware of. It has been very good.

Mr. DADDARIO. You are also in charge of the solid propellant work?

Mr. SLOOP. The research and technology of solid propellants, yes, sir.

Mr. DADDARIO. That includes the work being done at JPL?

Mr. SLOOP. Yes, sir.

Mr. DADDARIO. I had inquired some time ago as to the reasons why JPL had been given the capability of constructing its own mixing unit for solid propellants. Is this necessary in view of the fact that we have industrial concerns capable of providing whatever type of solids you need for experimental purposes. Isn't this also placing a Government-sponsored agency in competition with industrial concerns capable of meeting this need? Can you give us your thinking on that?

Mr. SLOOP. Well, I don't think that there is a conflict here, Mr. Chairman.

As you know, the JPL was an early pioneer in rocket propulsion, including solid propulsion. Some of the people at JPL spun off and formed the Aerojet Corp.

They have had a long history of leadership in solid-rocket research and I think that it is quite normal that people active in the field should have the necessary tools to work with.

If this includes small mixers, to make special blends and so forth, I think this is quite good. I think that if they were competing in a manufacturing sense, this would be something else, but I don't believe they are.

Mr. DADDARIO. Aren't they competing in the sense that their rightful purpose in performing their research function is to stimulate industry to participate and to make the necessary investments to build up the capacity to provide whatever mixes and whatever types of solids they might need? If you take into consideration the companies involved and who could certainly meet these requirements, it would seem, with proper liaison between JPL and these companies, such as Thiokol, that these requirements could be met most satisfactorily. How would this inhibit JPL's capability if they were to work closely with one of the companies involved in solids in order to meet these experimental requirements?

Mr. SLOOP. Again, I think there is no conflict. I think they already are working very closely with these companies. If you will recall recently an article in the Astronautics Journal which showed that

some analysis in which JPL had advocated solid-propellant boosters. They work with industry and universities; for example, they help monitor contracts for NASA with industry, and they have a research group that works on problems of research and special problems that we have.

Mr. DADDARIO. I think they do an excellent job in all of these areas, but I am confining myself to this one incident where it seems that moneys were provided for a facility which I question is necessity.

Mr. SLOOP. I was about to mention that ARPA has sponsored a fundamental study of propellant properties and inspection techniques at JPL but has felt that this is beyond the point of their basic charter, and has asked the NASA to support this work. We are planning to pick this up in the latter half of fiscal year 1964.

We feel that the work we have going, in my area at JPL is very definitely research and technology oriented. I am not familiar with the specific piece of equipment that you are referring to; I am just saying in a general sense that I think they need the tools to work with in research to carry out special mixes and things of this sort.

Mr. DADDARIO. Any questions, Mr. Patten?

Mr. PATTEN. No questions.

Mr. DADDARIO. Mr. Sloop, thank you very much.

You have been very helpful to the committee and we want to thank you for having stayed with us during the long afternoon.

Mr. SLOOP. Thank you.

Mr. FULTON of Pennsylvania. I have enjoyed your comments, Mr. Sloop. We are trying to be helpful to NASA in working out a good program on high-energy fuels.

Mr. SLOOP. We appreciate your interest and support.

Mr. DADDARIO. Thank you.

Before proceeding with the next witness, I would like to include for the record a statement submitted by Mr. W. G. Gisel, president, Bell Aerosystems Co.

(The statement referred to is as follows:)

BELL AEROSYSTEMS CO.,
Buffalo, N.Y., April 19, 1963.

HON. OLIN E. TEAGUE
Chairman, Manned Space Flight Subcommittee, Committee on Science and Astronautics, House of Representatives, Washington D.C.

DEAR MR. TEAGUE: Bell Aerosystems Co. is pleased to submit the following information in reply to the invitation of the Committee on Science and Astronautics of April 19, 1963. This material has been obtained from our high-energy propulsion work and confirms the feasibility of utilizing liquid fluorine as a rocket oxidizer.

We have been engaged in the research, development, test and production of rocket propulsion systems for more than 20 years. Bell at present manufactures the Agena rocket engine which has achieved an unmatched record of reliability in space operations.

Work with high-energy propellant combinations was initiated at Bell in 1948 with test firings on a chlorine trifluoride/hydrazine rocket motor. Our liquid fluorine work began early in 1956 under USAF and NASA contracts and continued until June 1962. Subsequent funding has not been provided since Government propulsion engineers consider that the time has arrived to develop an operational fluorine propulsion system.

Tests have been conducted utilizing rocket engine systems with fluorine as an oxidizer and ammonia, hydrogen, anhydrous hydrazine, and hydrazine blends as fuels. The first fluorine rocket test firing was with an engine of 35,000-pound thrust. In 1959, a series of demonstration tests were made with a complete turbopump-fed, regeneratively cooled fluorine/hydrogen engine at 12,000-pound thrust.

In the conduct of this work, extensive experience has been gained with all aspects of rocket technology, handling, transportation, safety, and test stand operations. It is important to note that in carrying out hundreds of test runs using fluorine, we have not experienced a single lost-time accident to any personnel.

The information presented below summarizes the fundamental merits of liquid fluorine as a rocket oxidizer and also, in a general manner, indicates the status of fluorine rocket development and its readiness for application to the national space programs. It might be appropriate to note here that other organizations known to have conducted tests of fluorine rocket motors are NASA Lewis Research Center, Cleveland; Air Force Rocket Propulsion Laboratory, Edwards, Calif.; and Rocketdyne Division, North American Aviation, Inc.

FLUORINE BASIC ADVANTAGES

The principal advantages of fluorine are as follows:

1. Superior specific impulse.
2. High density: Minimizes vehicle size and weight.
3. Hypergolic: Needs no ignition system.
4. No detonation hazard: Burns rapidly when mixed with fuels.

The most outstanding features of fluorine-oxidized rocket systems are their high specific impulse and small tankage volume required (because of high density). These two factors determine payload capability.

A comparison of the three currently proven high-energy propellant combinations is shown on the left side of figure 1. The specific impulse of the fluorine-oxidized combinations is seen to bracket the oxygen-hydrogen performance with fluorine-hydrogen presenting the maximum specific impulse for a practical, proven propellant combination. The fluorine plus oxygen and oxygen difluoride propellant combinations are shown on the right side for reference. The values shown are 95 percent of theoretical, vacuum, for an expansion ratio of 50 and chamber pressure of 500 p.s.i.a. for all propellants. As shown on the bottom of the figure, fluorine-hydrazine presents the smallest volume requirement; fluorine-hydrogen needs twice as much; and oxygen-hydrogen requires nearly four times the volume.

Figure 2 shows the relationship of payload capability to stage velocity increment for high-energy propulsion systems. The range of stage velocity increments covers those for space missions of current interest to both USAF and NASA and the 30,000-pound propellant load selected is near-optimum for use with Thor, Atlas, Titan, and Saturn boosters. The vehicle mass fractions are shown in parentheses and the specific impulse values of figur 1 have been used. The distinct advantage of fluorine rocket systems is clearly seen.

Although the cost of liquid fluorine (estimated at $1.50 per pound for engine development quantities) is somewhat higher than other current propellants, this cost is not significant in relation to the overall vehicle development and launch costs. The cost effectiveness in terms of dollars per pound of payload delivered to orbit is a minimum when fluorine is used. Industrial producers estimate large-quantity fluorine costs to be 50 cents per pound. Raw materials are readily available and production poses no problem. Attachment A from the Allied Chemical Corp., currently the only supplier of liquid fluorine, amplifies this information.

The rocket propulsion work carried out by Bell during the past 7 years, utilizing fluorine as oxidizer with hydrazine and hydrogen as fuels, has included application studies. The general scope of our work is shown in figure 3.

Security restrictions prohibit a complete delineation of the many achievements with fluorine rocketry. However, we would be pleased to present additional data and display samples of rocket engine components at the convenience of your committee under appropriate security conditions. At that time, we will show certain advantages which result from the application of fluorine to the NASA Apollo lunar program. Also, we will present the scientific payloads which fluorine upper stages can place on various important national space missions when used with currently developed lower stage boosters (e.g., Thor, Atlas, Titan, and Saturn). Suffice to say, the application of a fluorine high-energy upper stage to a present space booster can thereby postpone the necessity for development of a new and much more expensive booster vehicle.

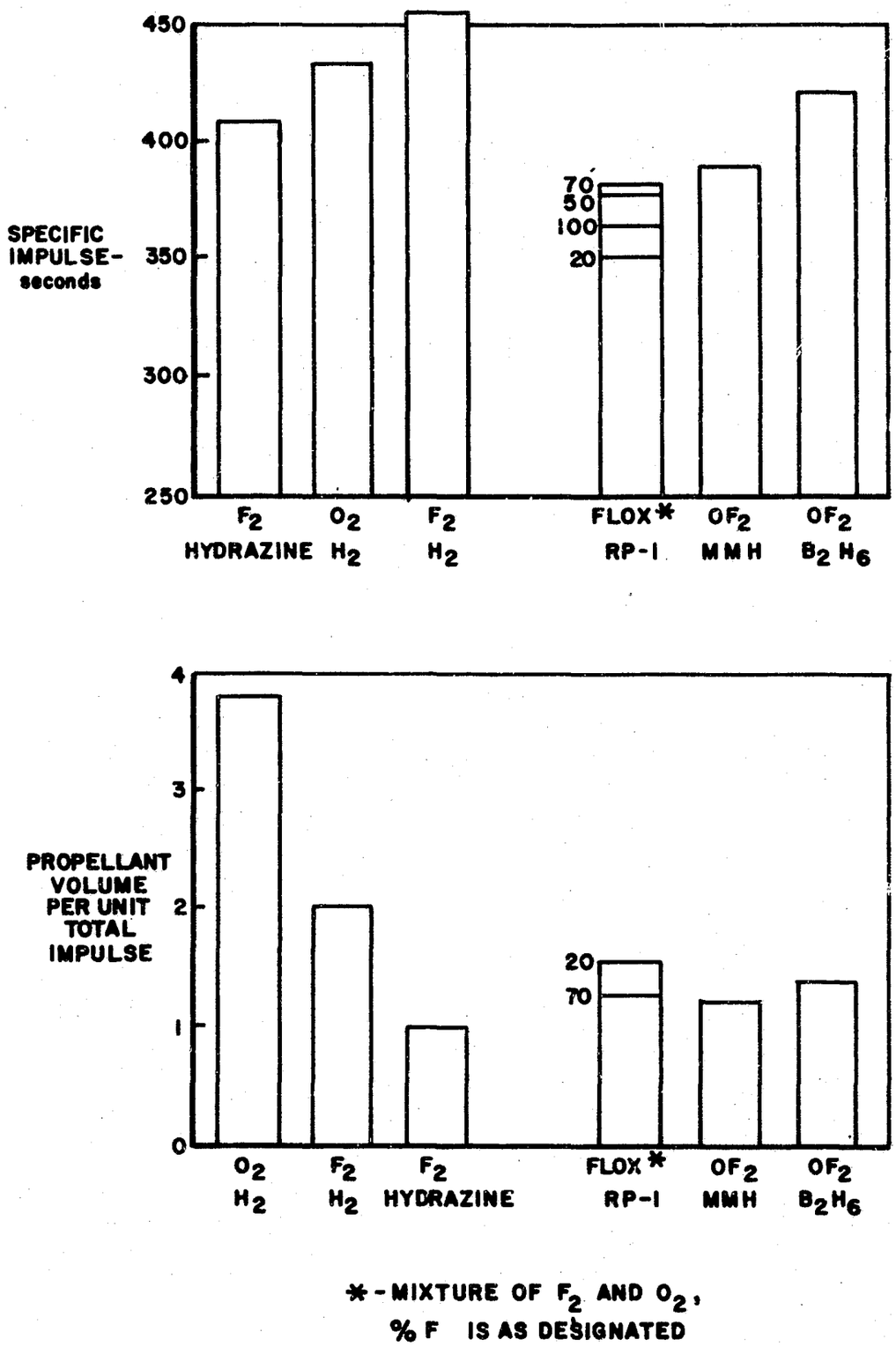

Figure 1. Propellant Performance and Size Effects

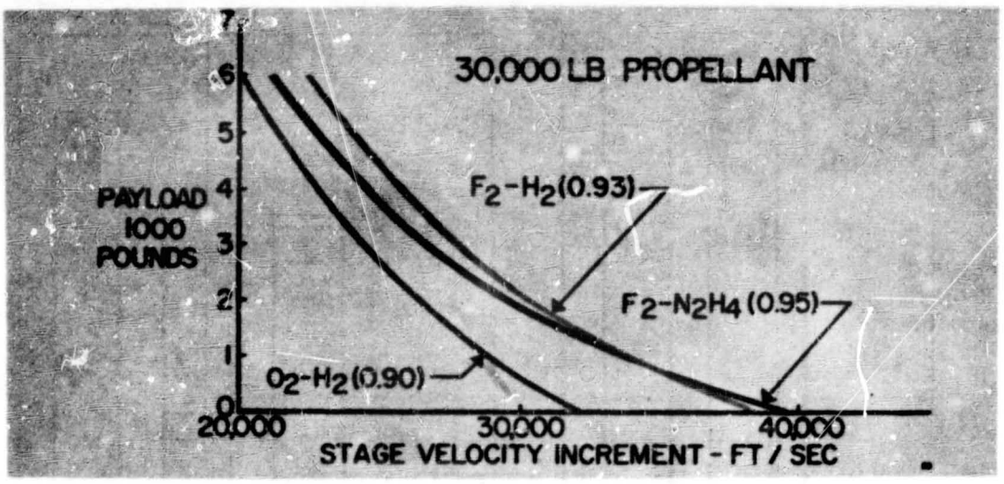

Figure 2. Payload Performance

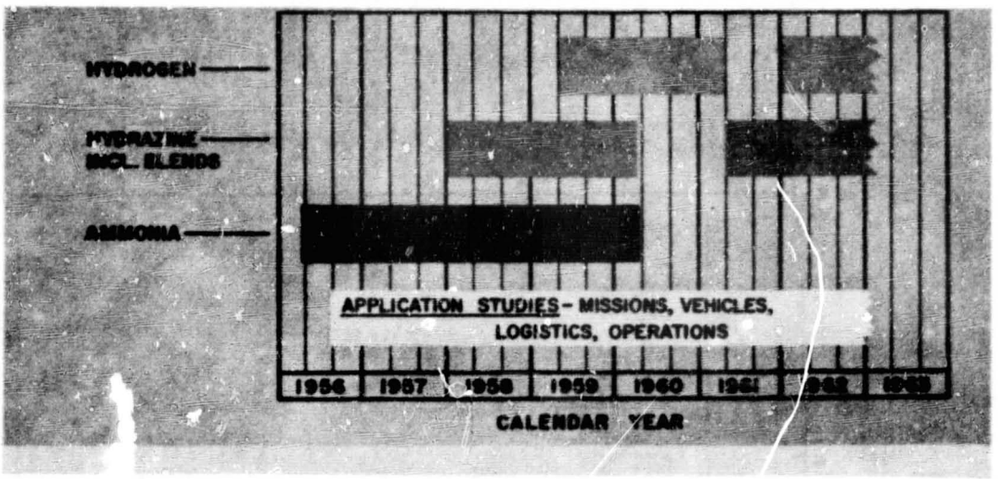

Figure 3. Fluorine Investigations

The following are Bell's key achievements which were cleared for public release in 1960.

1. Over 600 firings at thrusts to 35,000 pounds.
2. Over 80,000 pounds of liquid fluorine consumed—largest quantity used by any organization.
3. A 100-percent safety record using normal personnel safety protection and safety measures which are similar to those used with common rocket chemicals.
4. High-speed fluorine-hydrogen turbopump developed for large output capacity and high discharge pressures.
5. Current materials, processes, and parts have been adapted to fluorine rocket systems.
6. Series of full-scale firings of several thousands of pounds thrust complete turbopump-fed fluorine-hydrogen engine (fig. 4).

The question logically comes to mind: If fluorine technology has reached an advanced status, then why has it not been selected for an operational use? We believe this fact is attributable to three basic reasons:

(1) Although our Nation continually puts forth general requirements for the placement of large payloads on space missions and although fluorine upper stages undeniably result in maximum payload capability, firm specific requirements have not been established that have clearly required the development of a fluorine propulsion system.

(2) Sufficient funds have not been available for the development of an operational system in parallel or as backup to any other high-energy upper stage development. It is generally accepted by key Government rocket personnel that only the lack of a specific mission requirement and funding delays the development of an operational fluorine system.

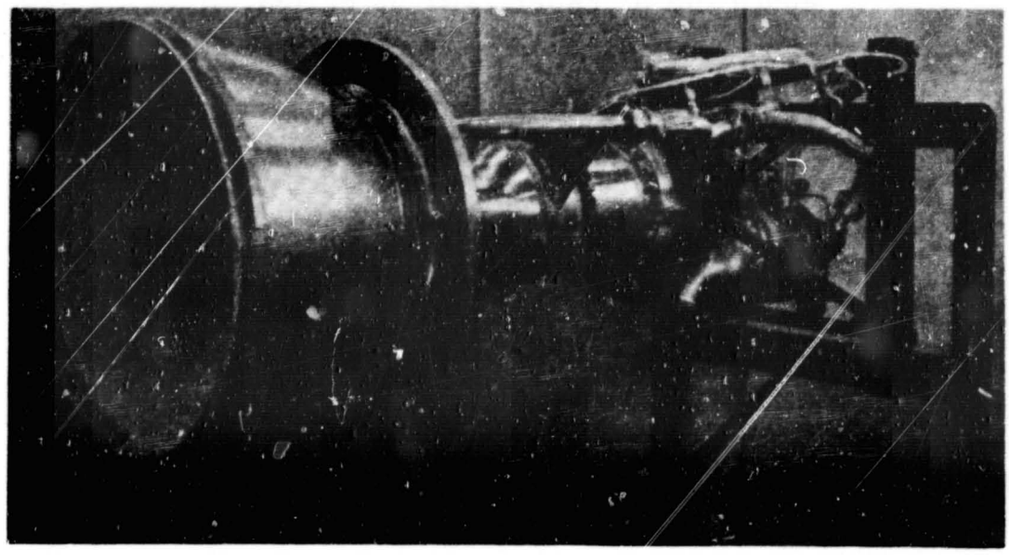

Figure 4. Fluorine-Hydrogen Turbopump Fed Engine

(3) There has previously been some reluctance to accept fluorine for operational use because of handling, transportation, and toxicity considerations. We are pleased to note that this reluctance has now been dispelled and that NASA and USAF personnel see no major problems with the use of fluorine upper stages at Cape Canaveral.

The readiness of fluorine (with both hydrogen and hydrazine) for application to the development of operational vehicles has also been recognized by top NASA Headquarters personnel. Figure 5 presents a NASA chart (produced about a year ago) which depicts the relative status of various propellant combinations. It may be noted that hydrogen-fluorine and hydrazine-fluorine propellant combinations are the only high-energy combinations which have currently completed the technology and experimental phase and are now ready for operational system application. Other high-energy combinations using fluorine and boron compounds show promise for the future. Research on these compounds most certainly should continue in order that potential benefits may be evaluated, leading to operational applications.

We are firmly convinced that fluorine, used in conjunction with hydrogen and hydrazine, can be used for operational rocket propulsion systems at an early date. An estimated $30 million has been expended to date on fluorine rocket technology. This technology is now at a more advanced state than was the case with any other propellant combination prior to its assignment to an operational mission role. These extensive efforts will result in a shorter development time and lower cost to the Government for the development of a useful flight system.

Unsolicited proposals have been submitted to both USAF and NASA for fluorine propulsion systems. Extensive studies have indicated that development of a flight fluorine engine in the 25,000- to 40,000-pound thrust range can be completed through its preliminary flight rating tests (PFRT) in 30 months and at a cost of less than $50 million.

Bell is continuing its experimental and study efforts, using company funds, in the fields of fluorine rocket propulsion and upper stages since we believe that application of this propellant can truly maximize the U.S. payload capability. We are convinced that operational fluorine systems can and should be produced an that missions using such systems can be flown in less than 3 years. Bell's history as a reliable producer of rocket engines on schedule underlines our capability in such predictions. We urge the early procurement of fluorine propulsion as the means that will most effectively advance our country's space position.

Very truly yours,

W. G. GISEL, *President.*

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EVOLUTION OF PROPELLANT SELECTION

PROPELLANT COMBINATION	RESEARCH		TECHNOLOGY		DEV.
	BASIC	APPLIED	CONCEPTS, EXP. COMPO., SYS.	EXP. ENGINES	
RP (KEROSENE) - OXYGEN	✓	✓	✓	✓	✓
HYDRAZINE - NITROGEN TETROXIDE	✓	✓	✓	✓	✓
HYDROGEN - OXYGEN	✓	✓	✓	✓	✓
HYDROGEN - FLUORINE	✓	✓	✓	✓	
HYDROGEN - OXYGEN DIFLUORIDE	✓				
HYDRAZINE - FLUORINE	✓	✓	✓	✓	
HYDRAZINE - OXYGEN DIFLUORIDE	✓	✓			
PENTABORANE - OXYGEN DIFLUORIDE	✓				
DIBORANE - OXYGEN DIFLUORIDE	✓	✓			
PENTABORANE - HYDRAZINE	✓	✓			
HYDROGEN - BERYLLIUM - OXYGEN	✓				
DYDROGEN - LITHIUM - FLUORINE	✓				

✓ STATUS

RP 62-590

Figure 5. Evolution of Propellant Selection

FLUORINE PRODUCTION

In continuous production since 1947.
Over 100 million pounds produced, handled and used in past 15 years.
Plant operations similar to common chemicals.
Safety record—no lost-time accidents.
Abundant supply of raw material.
Quantity production lead time—6 to 8 months.
Cost approximately $1 to $1.50 per pound for engine development.
Possible ultimate price in several million pounds per month requirements $0.50 per pound (including plant amortization).

FLUORINE TOXICITY

Effects of fluorine on the human body are noncumulative.
Limited exposure may be repeated daily.
Concentrations as high as two parts per million are common in manufacturing plants.
Fluorine is not insidious—it is impossible to voluntarily breathe harmful concentrations.

FLUORINE TRANSPORTATION

Methods

Road: 5,000-pound and 20,000-pound capacity tank trailers.
Rail: 50,000-lb tank cars.

Experience

Shipped by road since 1956, 320 million pound-miles of liquid without incident.
Five road tank trailers in use since 1956, with only minor maintenance.

MR. DADDARIO. Our next witness is Col. Paul J. Atkinson, and this will be in executive session.

Will all unauthorized personnel please leave the room.

Mr. FULTON of Pennsylvania. Is there any part you could give in open testimony?

Colonel ATKINSON. No, sir; we did not prepare it that way.

(Whereupon, at 3:49 p.m. the subcommittee proceeded in executive session.)

1964 NASA AUTHORIZATION

WEDNESDAY, APRIL 24, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON MANNED SPACE FLIGHT,
Washington, D.C.

The subcommittee met, pursuant to recess, in room 214–B, Longworth Building, at 10 a.m., Hon. Emilio Q. Daddario presiding.

Mr. DADDARIO. This meeting will come to order.

We are pleased to see you here again this morning. I think we better get right down to business. We will turn the floor over to you, Mr. Holmes. Do you have a statement to make?

STATEMENT OF D. BRAINERD HOLMES, DEPUTY ASSOCIATE ADMINISTRATOR AND DIRECTOR, OFFICE OF MANNED SPACE FLIGHT, NASA, ACCOMPANIED BY WILLIAM E. LILLY, DIRECTOR, PROGRAM REVIEW AND RESOURCES MANAGEMENT, GEORGE LOW, DEPUTY DIRECTOR FOR PROGRAMS, AND R. A. DIAZ, ASSISTANT DIRECTOR FOR FACILITIES, PROGRAM REVIEW AND RESOURCES MANAGEMENT

Mr. HOLMES. No, Mr. Chairman, I don't. We planned to get into the facilities, to justify the manned spacecraft portion of the budget.

Mr. DADDARIO. Fine, we can start from there.

Mr. HOLMES. Yes, sir. Mr. Low will lead our presentation. He is supported both by Mr. Lilly and Mr. Diaz.

Mr. DADDARIO. Would you like to bring Mr. Diaz up to the witness table?

Mr. HOLMES. Thank you.

Mr. LOW. Mr. Chairman——

Mr. DADDARIO. Mr. Diaz, I think you might be better off sitting at this end of the table and it will give you an area to spread your work out.

Mr. HOLMES. Thank you, Mr. Chairman.

Mr. DIAZ. Thank you, sir.

(The biography of Mr. Diaz is as follows:)

RODOLFO A. DIAZ

Rodolfo A. Diaz has been Assistant Director for Facilities, Program Review and Resources Management, Office of Manned Space Flight, NASA Headquarters, since December 1961.

Prior to joining NASA Mr. Diaz was Chief, Facilities Division, Air Research and Development Command. He was with that organization for 18 years, beginning in 1941. Two of these years he spent with the same unit while on active duty with the Army Air Corps (1944–46).

Mr. Diaz was born August 4, 1914, in San Juan, P.R. He was educated in San Juan schools and received a bachelor of science in engineering degree at North Carolina State University in 1939. He is a registered engineer in the state of Ohio.

Mr. Diaz is married to the former Pauline E. Tilley. They live at 6220 Warwick Drive, Washington, D.C.

Mr. DADDARIO. Mr. Low, will you proceed.

Mr. LOW. Mr. Chairman, the facilities we plan to cover this morning are those that support the development and test of our spacecraft. These are listed in our budget books, volume IV, part 2, on page CF 8 and following pages.

Those will be the facilities at the Manned Spacecraft Center at Houston.

Mr. FULTON of Pennsylvania. What page again?

Mr. LOW. CF 8 pages 1 through 42. We will also discuss one facility listed under the heading "Various Locations," the facility located at White Sands, N. Mex. It will appear on page CF 13-36—and one facility at our Launch Operations Center, which will appear on page CF 6-64. I will refer to these pages again later as I cover the various facilities.

With your permission, Mr. Chairman,I would like to go through a brief presentation using some charts we have prepared to tie the need for the facilities together with our spacecraft testing requirements.

I have shown first of all the Apollo spacecraft and its various modules (fig. 156), the launch escape tower, the command module which houses the three men, the service module which is a propulsion system used, for example, to put the command module into lunar orbit and take it out of lunar orbit, and the lunar excursion module which is used for the landing itself. As we have discussed previously, the command and service modules are produced by the North American Aviation Co.; the lunar excursion module by Grumman Aviation Engineering Co. In flight, all of these modules in a lunar mission will be on top of a Saturn-5 launch vehicle.

In the development of these modules, we must test them under various simulated flight conditions, and we have found in all of our space-flight experience that this test program, an intensive test program, should lead to a much better flight success ratio. In fact, it is a mandatory thing to do, in order to avoid many failures in flight.

For example, the spacecraft and the various modules have to be tested aerodynamically in wind tunnels over various speeds ranging from subsonic speeds to very high speeds, simulating the launch of the booster and the reentry.

Aerodynamic test facilities are in existence in this country both within the NASA and within the Air Force and these facilities are being used in testing the Apollo, and also, of course, the Gemini modules.

In addition to the aerodynamic testing, we must also test the structure and the heat protection on the command module to make sure that they can withstand the launch environment, the vacuum of space, and the high heat of reentry.

Various subsystems and components must also be tested. Mechanical subsystems like the environmental control system will have to be subjected to the noise and vibration of the launch, will have to be tested in the vacuum of space, and the various systems will have to be evaluated. The same for the electronic and electrical subsystems.

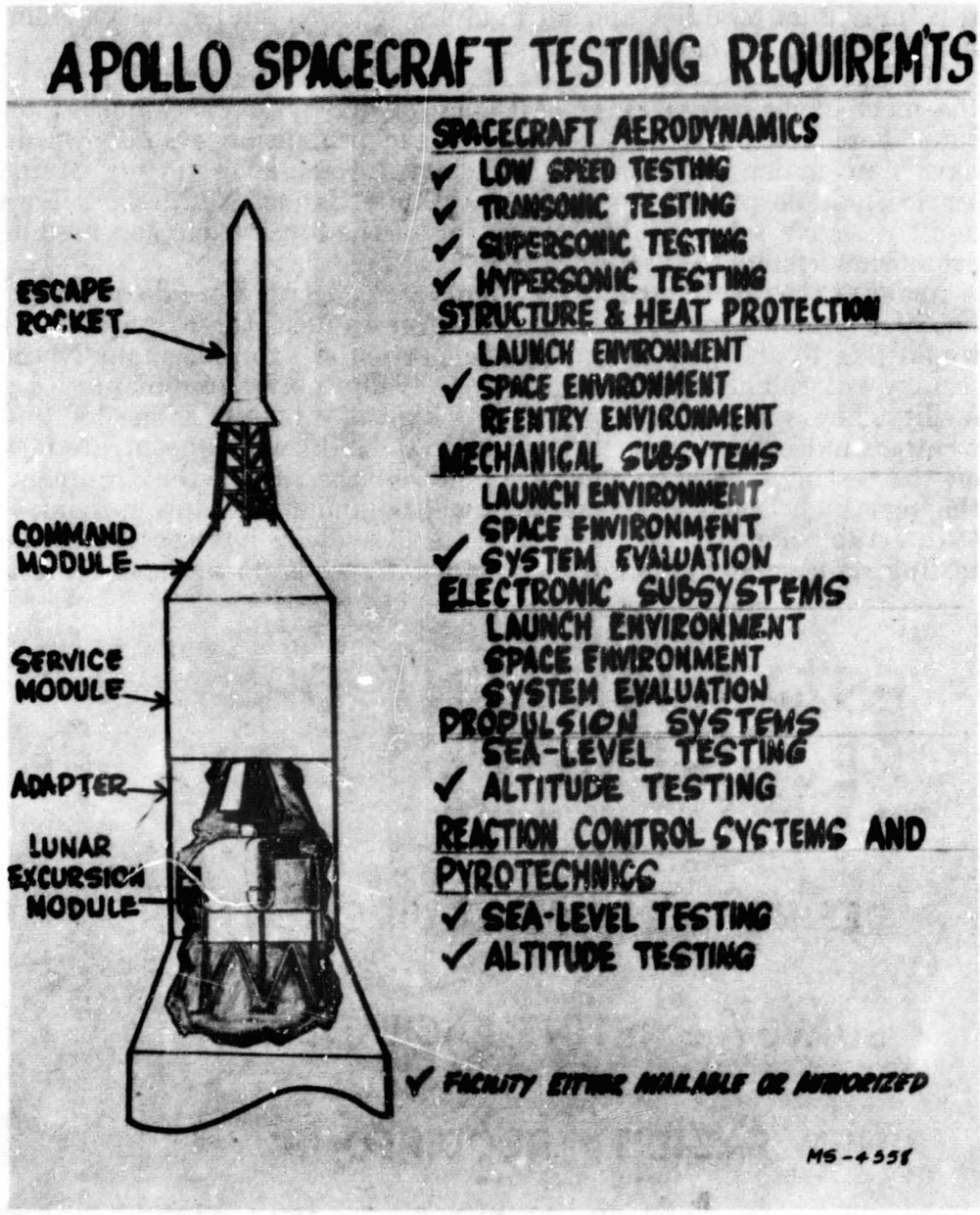


FIGURE 156

The propulsion system—and as you know there are a number of major propulsion systems in this spacecraft—for example, a 22,000-pound-thrust engine in the service module, two somewhat smaller engines in the lunar excursion module—all of these must be designed, developed, and tested to assure the required degree of reliability before the mission is undertaken.

Finally, the smaller propulsion systems, reaction control systems that stabilize the craft's attitude, must also be developed and tested. I have indicated here by check marks those facilities that are either now available or authorized for the Apollo systems testing.

For example, in Houston in your fiscal year 1962 budget, we requested some large environmental chambers that will allow us to

test individual modules and all modules together under the vacuum, heat, and cold of space.

We have, in previous budgets, facilities for systems evaluation of the mechanical subsystems. Although I have no checkmark indicated here under sea-level testing for the propulsion system, we do have now under development a facility for sea-level testing of the service module propulsion system at White Sands, N. Mex., but we don't yet have a facility for the testing of the lunar excursion module propulsion system.

As far as the reaction control systems are concerned, we do now have facilities under construction at Houston to test these systems. I would like to show by example, one particular example, namely the reentry environment testing, how we develop our requirements for a facility, how we then determine what kind of a facility is needed and whether, indeed, a new facility is required. So I will concentrate now on the testing of the command module in the reentry environment, the very high heat and speeds that will be undergone during reentry.

In establishing the requirements, we first of all have to define the testing requirement (fig. 157), under what speeds do we have to test,

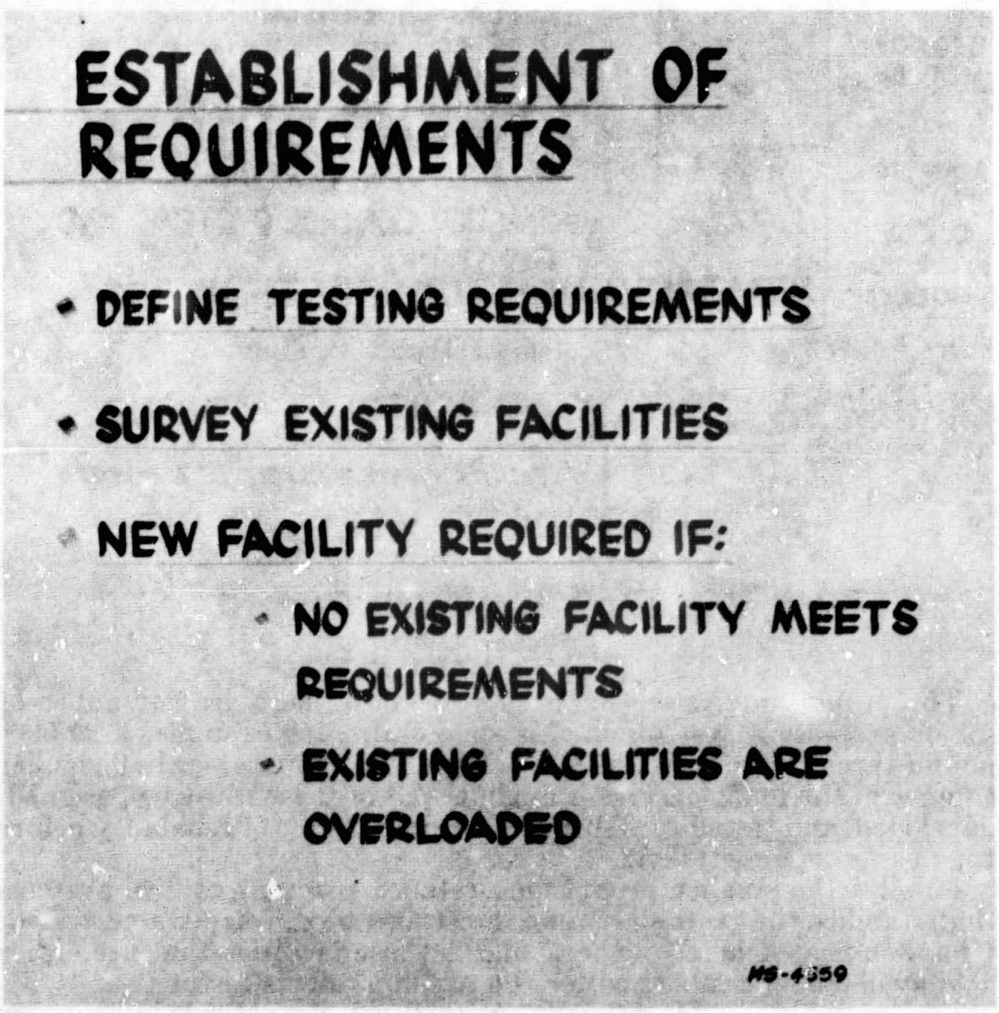


FIGURE 157

what mach numbers, what temperatures, what levels of vibration and noise.

Once we have defined this requirement, the first step we take is to survey existing facilities. Are there existing facilities anywhere in this country that meet the performance requirements, that indeed can simulate the temperatures or the speeds that we need? Once we have completed this study, we then lay out a requirement for a new facility, if either there is no existing facility that meets our requirements or if all existing facilities are overloaded at the present time and cannot absorb the additional load.

A typical requirement (fig. 158) that I talked about before, is the testing of the command module undergoing the high heat of reentry. Coming back from the Moon, the Apollo command module will reenter the Earth's atmosphere at about one and a half satellite speed, 36,000

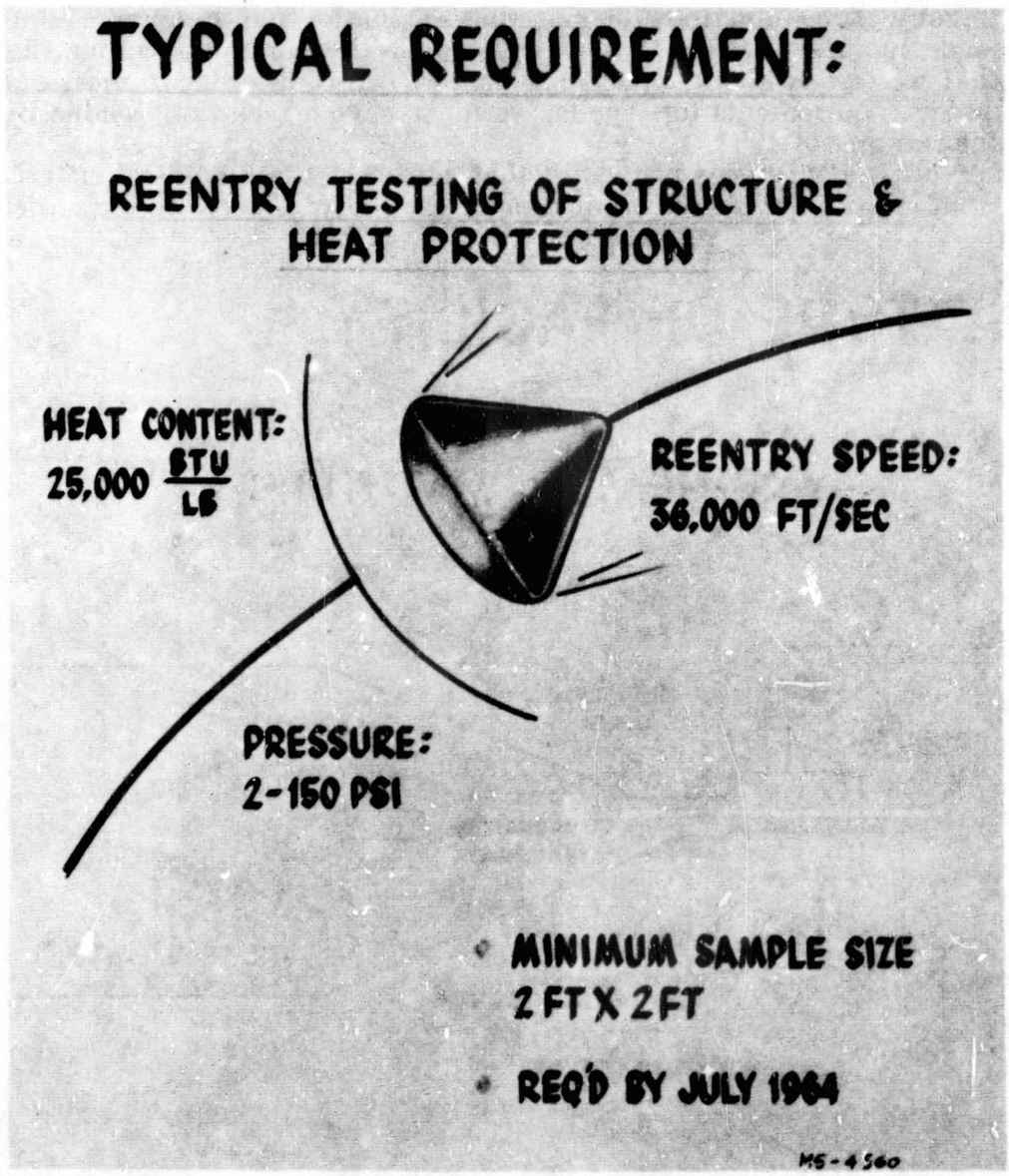


FIGURE 158

feet per second, or about 25,000 miles an hour. A satellite reenters the atmosphere at about 17,000 to 18,000 miles an hour. As this body comes in at a very much higher speed than a reentering satellite, the heating due to the compression of the air and due to the friction of the air, is many times larger than it is for reentering satellites. So this is, indeed, a new phenomenon that we will not have undergone in either the Mercury or Gemini programs.

For example, in this region in the shock wave here, we will reach temperatures as high as about 100,000° Fahrenheit. Behind the shock waves the temperatures will be more like 20,000° Fahrenheit. The index of the heat, or the temperature or heat content, is a critical number that defines the requirements for the facility.

In particular, a body coming in at this speed will come in at a heat content value of 25,000 B.t.u. per pound, at a pressure range of about 2 to 150 pounds per square inch, depending on the altitude. In order to get a true simulation for materials evaluation for these large command modules we feel that we must have the minimum sample size that we test of about 2 feet in diameter. Also, in order to meet our design requirements for Apollo, we must have a facility available by the summer of 1964.

Now the only type of facility that can meet these kinds of criteria is an electric arc-heated wind tunnel (fig. 159). There are a number

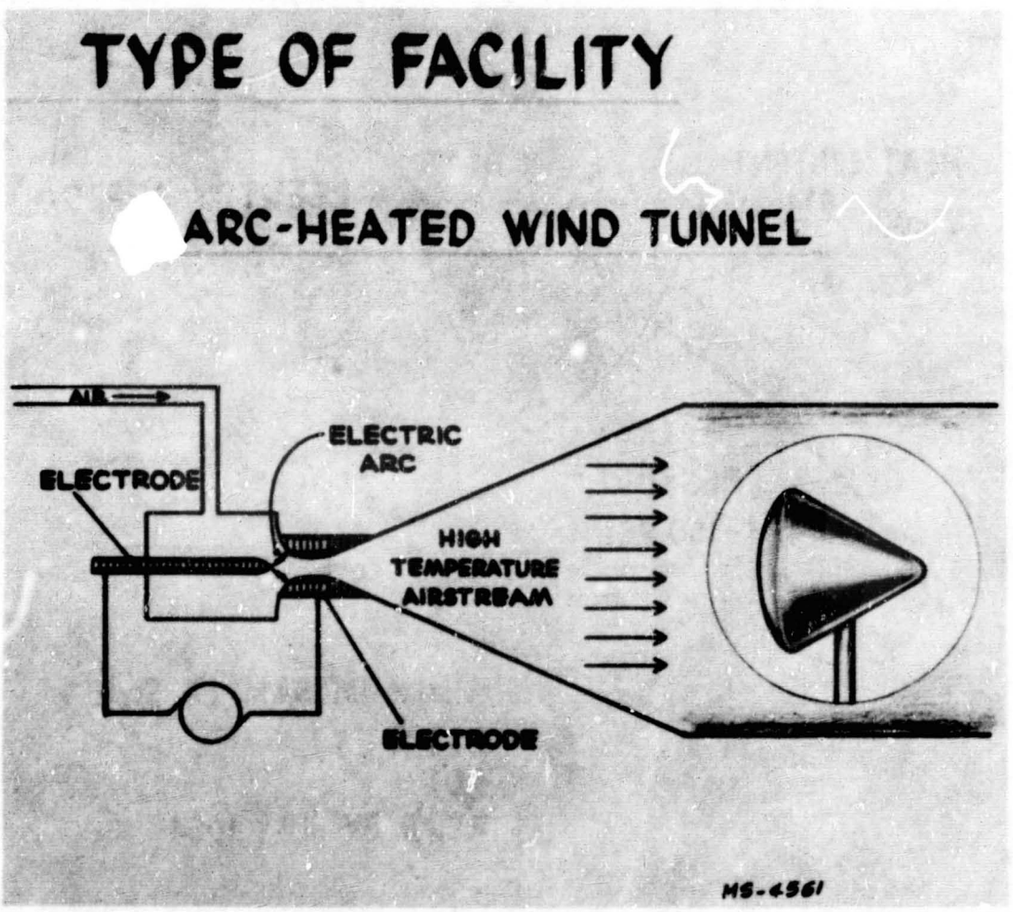


FIGURE 159

of different types of high temperature facilities, heaters, lamps, quartz tubes, but in order to get the very high temperatures that we need here and at the same time simulate the dynamic flow conditions, studies have indicated that only this type of facility will indeed give the kind of simulation that we need.

This looks very much like a conventional wind tunnel, except that the air is not just injected and expanded through a nozzle, but, as it is expanded through the nozzle, it is heated by an electric arc. By paying special attention to the design of this arc, one can pour a tremendous amount of energy into the airstream to get the very high temperatures needed for this kind of testing (fig. 160).

Once this requirement is determined, then we survey all existing electric arc-heated wind tunnel facilities. Again I will repeat the requirement that I had on the previous range.

We need a heat content of 25,000 B.t.u. per pound. This is the heat content that is equivalent to the velocity of returning from the Moon. We need a pressure range of 2 to 150 pounds per square inch;

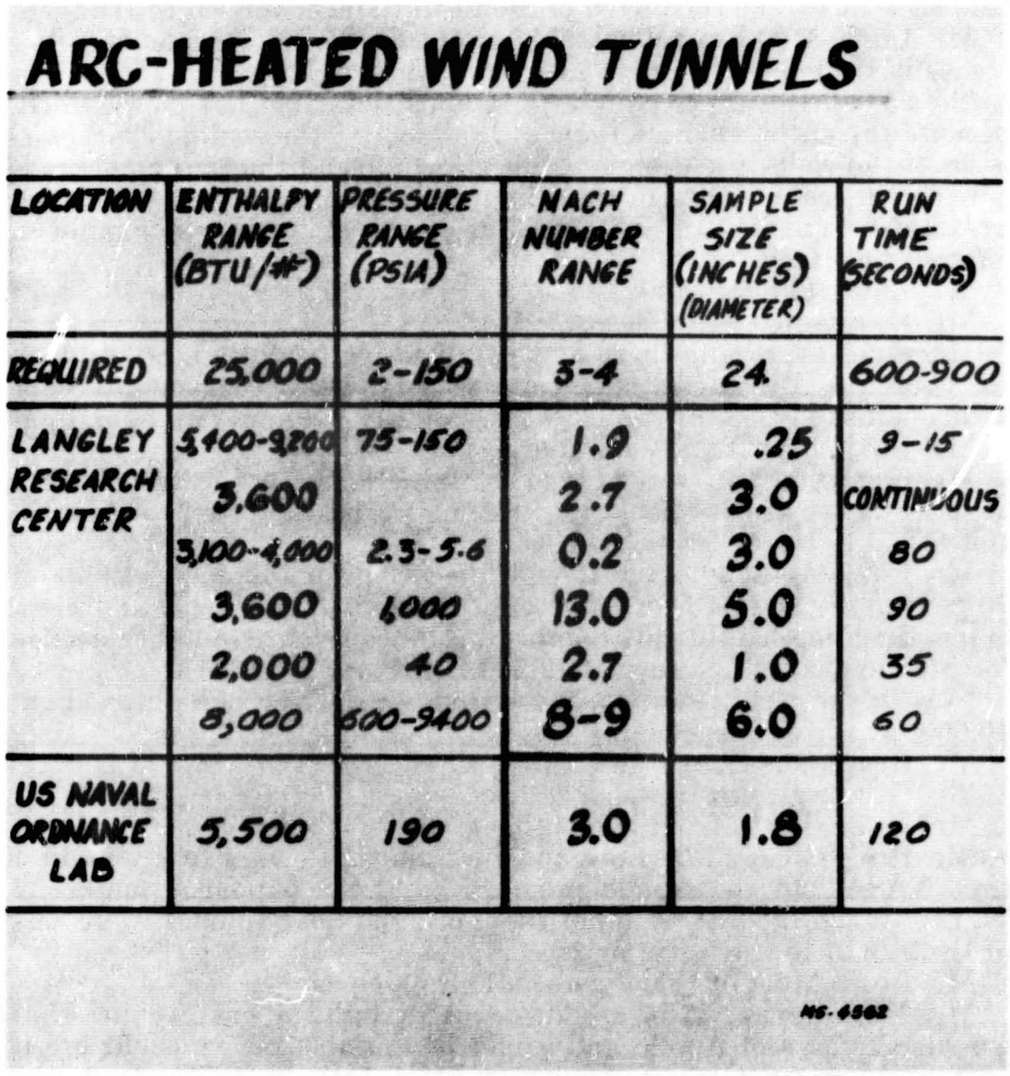


FIGURE 160

the actual speed of the flow need not be as high as the reentry speed, because the flow, once it is established supersonically, will flow around the model at much lower speeds, so we don't have to go to the very high speeds of reentry.

I mentioned the sample size before. We need a running time of about 10 to 15 minutes in order to simulate the total reentry flight path, that is, the running time of the facility at any given time.

We looked at all existing facilities with arc-heated wind tunnels, and there are 17 of these in the country now. But you will notice most of them have the capability to heat the air only to a very much lower temperature. Here the heat number is between 5,000 and 10,000 for most of these facilities. We need 25,000. Most of them are considerably smaller than we need. As far as the pressure range is concerned, they cover both sides of what we need. The list is continued——

Mr. ROUDEBUSH. Question, Mr. Chairman?

Mr. DADDARIO. Mr. Roudebush.

Mr. ROUDEBUSH. Mr. Low, haven't we already built heated wind tunnels that can be converted or modified to meet this objective?

Mr. Low. Mr. Roudebush, in order to get this tremendous increase in heat input that we need from these relatively low numbers to the 25,000 B.t.u. per pound, these facilities could not be modified, because the entire characteristic of the facility, the cooling characteristics of the walls, the design of this electrode and the arc chambers is entirely different for one of these larger facilities.

Mr. ROUDEBUSH. Are you telling us we are going to have to build an entirely new facility?

Mr. Low. That is right.

Mr. DADDARIO. Mr. Gurney?

Mr. GURNEY. I note there that your heating facilities now range up to 8,000 B.t.u. per pound. Your reentry speed for the Mercury vehicle and the Gemini vehicle was what—17,000 miles an hour?

Mr. Low. 17,000 miles an hour.

Mr. GURNEY. You were able to use these after having tested them at much lower heating ranges for testing purposes. Can you explain this?

Mr. Low. Actually, even though the speed for Mercury was about 70 percent of the speed for Apollo, the total heating, the heat number, is less than one-half of this number. The equivalent number needed for Mercury is of the order of 12,500 B.t.u. per pound.

Now in the facilities in existence then we did get as high as about 10,000, which was reasonably close in the simulation.

Mr. ROUDEBUSH. Are you through?

Mr. GURNEY. Yes.

Mr. DADDARIO. Mr. Roudebush.

Mr. ROUDEBUSH. Mr. Low, the question that comes to my mind is that NASA had the Apollo program on the books for a number of years. When did NASA build these original heat tunnels, were any of them built in the last 2 or 3 years?

Mr. Low. Most of them were, Mr. Roudebush——

Mr. ROUDEBUSH. Why couldn't NASA build a heat tunnel that would take care of Apollo and would be variable, so we could use it both on Mercury, Gemini, Apollo, and the other projects?

Mr. Low. These arc-heated types of wind tunnels are a fairly new invention. In fact, the first one was built in about 1957 or 1958.

We did not know how to build them to get to these very high heat numbers at that period time. In fact, my last research effort in the NACA Laboratory in Cleveland before I came to Washington was to develop one of these facilities and we had a tremendous effort to even get up to values like 5,000. This was in 1957. And at the same time, because this was a new type facility, we were not able to get to higher values. A tremendous amount of progress has been made in the meantime and we now have facilities under design up to this value, but they are not in existence yet.

Mr. GURNEY. How does the one at Langley and the other listed at the bottom of the page that shows 8,000 differ from the one you propose to build?

Mr. Low. In the amount of energy, the size of the electrodes, size of the chambers, and amount of energy that can be put into the airstream.

Mr. GURNEY. Why couldn't NASA, for example, put larger electrodes in the facility and adapt it to this program?

Mr. Low. This would lead to an entirely new facility, because the electrodes, the chamber itself, really is the heart of the facility.

Mr. GURNEY. You mean not the electrodes but the size of the chamber?

Mr. Low. I will come back to this chart (fig. 159, p. 762). This is, of course, an oversimplified picture.

The amount of temperature that we can get into the airstream, the amount of heat that we can get, depends critically on the specific design of this whole chamber here. For example, in order to stabilize the electric arc and keep it from burning holes in either this part, either the anode or the cathode, one has to place a magnetic field around the whole chamber, magnetic coils, and let the arc rotate around the chamber and diffuse itself.

All of these elements are intimately tied into the facility. If the size of the facility was doubled or tripled, either in energy content or in heat content or in physical size, this would indeed then be a new facility.

Mr. ROUDEBUSH. Mr. Chairman.

Mr. DADDARIO. Mr. Roudebush.

Mr. ROUDEBUSH. I would like to return to my previous line of questioning, Mr. Low. What does NASA intend to do at the present time with these heated wind tunnels, of which there are several existing in NASA's inventory? Is there any use for them at the present time?

Mr. Low. Absolutely, because there will be additional tests of ballistic missile nose cones, for example. There will be new shapes, new sizes. Many of these facilities were developed initially in support of the ballistic missile program. They will be used in further tests of Gemini and Dyna-Soar and other satellite programs that are coming along.

Mr. ROUDEBUSH. Are they currently in use?

Mr. Low. Yes, sir.

Mr. ROUDEBUSH. Tests are being made there?

Mr. Low. That is right.

Mr. ROUDEBUSH. I said a moment ago that there have been plans for the Apollo program for a number of years. How did you originally plan to test the Apollo if you were unable to devise such a heated wind tunnel?

Mr. Low. We had at one time a flight test program for Apollo to test the reentry bodies at these high speeds in flight. When the Apollo program was initially conceived we had as part of the program an Atlas-Agena reentry body program. We have felt now that, since these type of facilities have come along, we can test in one of these facilities over and over again what we could do in one Atlas-Agena flight.

A flight program to do this kind of testing would probably have cost $100 to $200 million. The cost of this particular facility is of the order of two and a half million dollars. So by going to a ground facility, the test program can be reduced by a tremendous amount in cost.

Mr. ROUDEBUSH. In other words, this ground facility is in lieu of actual flight tests.

Mr. Low. That is right.

Mr. ROUDEBUSH. And does NASA intend to pursue the plan in the future of using these types of facilities rather than repeated flight tests?

Mr. HOLMES. I would like to comment on this, if I may, Mr. Chairman.

Mr. DADDARIO. Of course, Mr. Holmes.

Mr. HOLMES. This is not any change in our basic planning. In other words, our total Apollo program did plan for an increment of facilities in fiscal year 1962, and a larger increment in fiscal year 1963. These facilities we are requesting in fiscal year 1964, and there will be some in fiscal year 1965. I couldn't honestly say to you that the first month of planning after that date of May 1961 that we could have definitized each of these facilities, but I think the point of my statement is that this is not a sudden change in our planning. It merely is a definitization of our planning where we merely expected to request from the Congress authorization to build facilities over a period of several years, in order that they would come to their fruition for their use according to their proper time scale.

Mr. ROUDEBUSH. Where are you going to build this? At Houston?

Mr. HOLMES. At Houston; yes, sir.

Mr. ROUDEBUSH. That is all.

Mr. DADDARIO. Mr. Fulton?

Mr. FULTON of Pennsylvania. How much will this facility cost; in what time period do you need the money, and how much do you need in fiscal year 1964?

Mr. Low. We are requesting $2,915,000 for this facility. Since we need the facility about 15 months from now, we need all of the money in fiscal year 1964.

Mr. FULTON of Pennsylvania. So that you will obligate the money immediately?

Mr. Low. Yes, sir.

Mr. FULTON of Pennsylvania. Why are you putting this facility——

Mr. DADDARIO. Just a moment please, Mr. Fulton. Do you have something to add, Mr. Diaz?

Mr. DIAZ. We will start design of the facility in May of this year and expect to have the construction completed by July of 1964.

Mr. FULTON of Pennsylvania. You will only be 1 month in fiscal year 1965 before you have the complete facility?

Mr. DIAZ. Yes, sir.

Mr. FULTON of Pennsylvania. Constructed.

Mr. DIAZ. That is correct.

Mr. FULTON of Pennsylvania. My next question is this. Obviously reentry speeds of 25,000 miles an hour, and 36,000 feet per second, are tremendous speeds. When we are able to have reentry on both Mercury and Gemini at much lower speeds, why do you not decelerate the capsule or put it in orbit so that it can come in at the Gemini and Mercury speeds at 15,000 to 17,000 miles an hour?

Mr. LOW. Mr. Fulton, it would take a substantial amount of propulsion in order to slow down from 36,000 to 25,000 feet per second. This in turn means that we have to have a much larger spacecraft or a much larger booster before we leave the Earth's surface.

For example, to do this, our Saturn V booster would have to be about three times the size it is now designed for, in order to carry this added amount of fuel and propulsion to the Moon and back to slow down from 36,000 to 25,000 feet per second.

Mr. FULTON of Pennsylvania. That raises the question as to the proportion of the retrorockets compared to the payload of the capsule of the Mercury. My feeling was that the package of retrorockets is not such a large item in proportion to the total payload.

Mr. LOW. That is absolutely right, Mr. Fulton. But the retrorockets only slow the Mercury capsule down by about 700 feet per second. In other words, the Mercury capsule is traveling at 25,000 feet per second; after the retrorockets are fired it is traveling in excess of 24,000 feet per second. They only apply a very small velocity decrement.

Mr. FULTON of Pennsylvania. It is still 17,000 miles an hour.

Mr. HOLMES. Yes.

Mr. LOW. Yes.

Mr. HOLMES. I think, if I may comment, I think that the advantage we have in Mercury and other Earth orbital flights merely stems from the fact that Earth orbital speeds are only 17,000 to 18,000 miles an hour, so we only have that kinetic energy to dissipate as we come back into the atmosphere.

Mr. FULTON of Pennsylvania. Why, Mr. Holmes, isn't the returning Moon rocket package brought back to Earth by going into Earth orbit and slow down gradually as in Mercury and Gemini? Why isn't it put in Earth orbit?

Mr. HOLMES. We are studying whether or not we will come back directly to a spot on Earth from the translunar trajectory or whether we put it into orbit. But in either case, it is accelerated by the pull of the Earth's gravitational field so that we will crash into the Earth's atmosphere at 36,000 feet per second or 25,000 miles an hour. It won't help us at all, for instance, to penetrate this atmosphere in a more shallow fashion, which is one of our worries, because then we would be dissipating this heat over a longer period of time.

We probably wouldn't be able to withstand the heat. We would like to come in at an angle that gives us a vertical corridor of about 40 miles so that we won't be too flat for this great heating, or too steep or too flat so that we go right around the Earth with no perigee on the path, and go back to the Moon.

The only solution we see to do what you are indicating would be to somehow slow down this spacecraft before it entered the Earth's atmosphere at all from its 36,000-foot-per-second velocity. I think

the only way to do that would be as Mr. Low indicated, to dissipate energy by retros or something which would add a great deal of weight.

Mr. FULTON of Pennsylvania. Those of us who have witnessed these countdowns know what a tremendously complicated and technical program it is. A countdown in lunar orbit with three men circling the Moon at approximately 2,000 miles per hour, and trying to come back to Earth and land in a 40-mile corridor when the Earth is revolving at 1,100 miles an hour, to me sounds almost impossible just on the basis of either safety or reliability for the return. The question then arises not only as to the building of this facility and coming in at these speeds, but won't some sort of retrorocket or reverse propulsion be needed in order to be able to make a guided trajectory for Earth reentry?

Mr. DADDARIO. Mr. Fulton, it seems to me that Mr. Holmes has already answered that question.

Mr. FULTON of Pennsylvania. I hope he has, but it certainly worries me.

Mr. DADDARIO. I think he already has answered that.

Mr. FULTON of Pennsylvania. Could you answer that?

Mr. HOLMES. All of our analyses to date in our mission profile studies indicate that the navigation accuracies required are well within the state of the art, in fact, don't exceed the precision we have in our present ballistic-missile systems. I think perhaps if one considers that it is a 2½ to 3-day trip from the Moon, and that we can navigate and make minor course corrections which have a great deal of effect at the end, with very little propulsion, that it tends to mitigate the circumstances and make such a reentry possible.

Mr. DADDARIO. I would like to confine the rest of the discussion today, if we might, not to the theory and the application of these programs to those theories, but to the facilities and the costs. We don't have enough time to go into——

Mr. FULTON of Pennsylvania. You have to see whether this is necessary.

Mr. DADDARIO. Yes.

Mr. FULTON of Pennsylvania. And if it is not——

Mr. DADDARIO. We are not going to argue, however, as to how it will be done at this morning's session. We can do it some other time. I would like to confine the discussion to the facilities, their costs, and the necessity for having them.

Mr. Gurney?

Mr. GURNEY. Back to this wind tunnel again, could you flip over the picture——

Mr. FULTON of Pennsylvania. Could I be excused? I have a Judiciary Committee hearing I must attend.

Mr. DADDARIO. Surely.

Mr. GURNEY. I still haven't satisfied my own mind why you can't use the existing facilities in part at least? For example, if you have an automobile, and you have an engine, you can put another engine in and still use the same automobile chassis. By the same token, why can't you use one of the existing wind tunnels or the wind tunnel portion and adapt the electrode part to it? Can you explain simply why you cannot do that? Why isn't that feasible?

Mr. Low. I think I can, Mr. Gurney. For example, a conventional wind tunnel, supersonic wind tunnel, has a wall that is usually de-

signed out of steel, maybe a 1-inch-thick steel plate. It may have some jacks on it, which are similar to automobile jacks that can adjust the shape of the wall and all of these things are designed together for a certain temperature, humidity, speed, in order to come out with the flow conditions that are needed here.

If suddenly we come up with a condition where we have twice the amount of heat in the air stream as we had before, then the amount of heat transfer to this wall will also be at least twice as high.

Mr. GURNEY. I understand.

Mr. LOW. It means then that whatever metal was used here, whatever cooling, or perhaps there is even no cooling at all, that was used here in the other tunnel, would not be adequate. So that the whole design of this wall would have to be changed, it would have to use new cooling coils.

Mr. GURNEY. I understand that.

Mr. LOW. And things like that.

Mr. GURNEY. All right. Now what about the rest of the wind tunnel, the parallel line part of it there on the end?

Mr. LOW. This, I think the point I made, Mr. Gurney, probably applies to the whole design.

Mr. GURNEY. I see.

Mr. LOW. The windows themselves, in fact, one may not be able to have windows in these high-speed tunnels. This section undergoes heat transfer just as much as this section does.

Mr. GURNEY. In other words, those you have now, I think I understood you to say, you ran up to temperatures of 10,000°, is that right, or some sort of a relationship?

Mr. LOW. That is right.

Mr. GURNEY. Was this in the test of the Gemini and Mercury?

Mr. LOW. That is right.

Mr. GURNEY. And actually this metal that is used in those wind tunnels would melt under these conditions?

Mr. LOW. That is correct.

Mr. GURNEY. OK. Now the other question is this: You have a $2½ million facility here. Do you plan to build an entire building to house this thing; is that what you are going to do?

Mr. LOW. No. This will be housed in a facility that is part of fiscal year 1962 construction program at Houston.

Mr. GURNEY. In other words, you have the building now, you are simply going to put this inside of it?

Mr. LOW. That is right.

Mr. GURNEY. My question was directed really to: Can you save any money by using an existing building? You are saying: "Yes, we are going to do that." Is that correct?

Mr. LOW. Yes, sir.

Mr. RIEHLMAN. Just one question, Mr. Chairman, before you conclude.

Mr. DADDARIO. Mr. Riehlman.

Mr. RIEHLMAN. Will this new facility meet the needs of NASA in the years to come? Will it be adequate for your tests in the next several years?

Mr. LOW. It will meet the needs, Mr. Riehlman, for any vehicle that reenters the Earth's atmosphere at the speeds up to the speed we will be coming back from the Moon on.

For example, if and when we embark on a planetary program, the reentry speed will be even higher than the ones we are talking about now and this facility will not meet those needs.

Mr. GURNEY. In other words, this wind tunnel that you are building right now and the experimental work that will be conducted, will not be adequate for any other future program other than that of the manned flight to the Moon and return?

Mr. LOW. Of the programs that are planned now this is the main program that it will be used for. I am sure, though, as with all of our other facilities in NASA, that as new programs are developed, other uses for this facility will be found.

A very good example of the use of facilities is a towing chamber designed for seaplane hulls at Langley Research Center many years ago. It was one of the very useful facilities in the Mercury program in getting the water handling characteristics of the Mercury spacecraft.

So I think we have always found that facilities designed and used for an entirely different purpose are most useful for a later program.

Mr. HOLMES. I might comment directly on this too, I think there is good likelihood, if we get the kind of correlation between this ground testing and what actually happens in our flight experience that we hope to get, that this might well be used for our planetary shots. We may be talking of 41,000 or 42,000 feet per second, compared to 36,000 feet per second. Further, we must remember there is only a 2-foot diameter sample and the reason for the relatively small sample is that these are tremendous energies to generate and release and it is a very difficult thing to simulate in a test facility. So there has to be correlation between that and the roughly 13-foot Apollo diameter.

I would think this is a real step forward in the capability of tests at these very high atmospheric velocities and it will be a very useful thing for general application and for other programs in the future.

Mr. DADDARIO. Colonel Gould?

Colonel GOULD. The fiscal year 1964 program includes, at Langley, a Hot Structures Test Facility, and at Ames there is included a Structural Dynamics Laboratory, both justified as being necessary to carry on research in the fields of atmospheric reentry and both with regard to heating problems.

What is the relationship of the facility at Houston to these other two facilities?

Mr. LOW. Which facility was this at Langley?

Colonel GOULD. At Langley, the hot structures test facility.

Mr. LOW. As I understand this facility at Langley it is a shock tube type wind tunnel. I am not sure whether this is the same facility, but one that I have listed here, which has a test duration of only microseconds, fractions of a second. For the Apollo reentry, as I pointed out, we have to test for periods up to 10 to 15 minutes. The Langley facility, therefore, is not adequate for this purpose.

Colonel GOULD. Why couldn't the Langley testing be carried on at Houston?

Mr. LOW. I am not familiar in detail, Colonel Gould, with the Langley facility and I don't know what other requirements it does meet that the Houston facility does not meet.

Mr. GURNEY. May we have for the record what the difference is?

Colonel GOULD. Could you provide a statement for the record as to the relationship between those two facilities and the proposed reentry materials and structures evaluation facility at Houston?

(The information requested is as follows:)

ATMOSPHERIC REENTRY MATERIALS AND STRUCTURES EVALUATION

The MSC facility, page CF 8–9, will test materials specimens 24 by 24 inches in size at enthalpies up to 25,000 B.t.u./lb. which duplicates the reentry condition for the Apollo mission.

The Langley hot structures portion of the Fatigue Research Laboratory, CF 5–11, is limited to testing materials specimens up to 1.5 inches in diameter at enthalpies up to 16,000 B.t.u./lb. Larger size specimens and the actual reentry enthalpy of 25,000 B.t.u./lb. are absolute requirements for Apollo spacecraft development.

The Ames Research Center Structural Dynamics Laboratory, CF 1–25, can generate enthalpies of the order of 10,000 B.t.u./lb. for practical material specimen sizes. This is completely inadequate for Apollo spacecraft development purposes.

In summary, neither the Langley nor the Ames facilities approach the enthalpy and specimen size capability which will be provided by the MSC facility and which are absolutely essential for Apollo spacecraft development testing.

I have one more question. Mr. Diaz you mentioned that you are going to initiate design in May of this year?

Mr. DIAZ. Yes, sir.

Colonel GOULD. Are you committing prior years' funds for this purpose?

Mr. DIAZ. We are using fiscal year 1963 advanced design funds, sir.

Colonel GOULD. In what amount?

Mr. DIAZ. Our plan is to provide $220,000.

Colonel GOULD. Has this commitment of advance design funds been taken into account in the development of the estimate for this project? You are asking for, I believe, $223,000 for design and engineering services as part of the $2,915,000. In computing that estimate, did you take into account the $220,000 out of fiscal year 1963 money that would be committed?

Mr. DIAZ. The $223,000 that appears in the project would be reduced by the $220,000.

Colonel GOULD. I see.

Mr. HOLMES. In general, Mr. Chairman, I think that for questions that relate to facilities that are not in our program, that we may have to give you this information for the record instead of just talking off the top of our heads.

Mr. DADDARIO. Yes; we would prefer it for the record. I think Colonel Gould's question and some of the others which have preceded it are extremely important. Since this facility is able to do more than others, the question must come to mind as to whether the others are being used, as Mr. Roudebush has pointed out, but also can some of them be eliminated.

Mr. HOLMES. Yes, sir.

Mr. DADDARIO. We would like you to go further into that. I just have one question in this area, and I hope that might be the final one so that we can proceed to the other projects.

It was my understanding, Mr. Low, that you felt that this facility would save $200 to $300 million in testing which would otherwise have to be done in flight. It was my further understanding from Mr. Holmes, that this kind of a facility, although we did not at that time have the capability of designing it, was part of the original Apollo program.

Does this mean that the saving of the $200 or $300 million was indicated in the first instance by the kind of an arc-heated wind tunnel that you had in mind but had not designed, or that the $200 to $300 million savings will be reflected now that you have thought of the capability and have brought it to the point where it will be constructed? Where does this saving indicate itself?

Mr. HOLMES. I think it indicates itself in really the very initial planning. I don't believe we really gave serious consideration to utilizing flight tests for all of our heating measurements, with the tremendous expenses of boosters and so forth.

Mr. DADDARIO. That answers the question.

Mr. RIEHLMAN. Mr. Chairman.

Mr. DADDARIO. Yes.

Mr. RIEHLMAN. Could they pull the microphone a little bit closer? It is sometimes difficult to hear.

Mr. HOLMES. Sorry.

Mr. RIEHLMAN. That is all right.

Mr. GURNEY. One final question, then.

Mr. DADDARIO. Yes.

Mr. GURNEY. It certainly occurs to the committee, I think, as we have listened to the description of various kinds of testing devices in this heat field, and also the fact that we are going to need another one sometime in the future, that there seems to be little correlation or advanced planning on any of these. This is not intended to be critical of you, it is simply intended to state a fact.

This Moon program certainly has been going on for a number of years and the need for this kind of a facility was apparent. Is there any way to design something into this test facility that can be utilized in the step beyond the Apollo program? You have indicated, for example, that there is going to be higher reentry speeds and therefore more heat. Can't you beef up the walls of this thing so that you could substitute a different set of electrodes when we get ready to do further testing on another program? Has any thought been given in the design of this facility so that it can be utilized in future programs?

Mr. LOW. Yes, Mr. Gurney, I believe it has. I would like to address myself to the first part of your question, if I may.

In the time period, 1955 to 1960, one of the most difficult problems in the field of space flight missile design, was how to handle the very high heating rates that were suddenly upon us, an order of magnitude higher than we faced in airplane designs until that time period. In that time period then, every laboratory in the country studied various ways of achieving higher temperature airstreams to do the kind of testing we are talking about here. And the kinds of things that were discussed then, and many of them were discarded, could make up a very, very long list of things, such as, pebble-bed heaters and a device that we called a Gatling gun, which was a series of shock tubes around the circumference of a barrel, each shock tube giving a very quick shot of hot air, then finally the bunch of them continuing a full stream.

Mr. DADDARIO. Mr. Gurney, could we allow Mr. Low to give this answer for the record?

Mr. GURNEY. Yes, indeed.

(The information referred to is as follows:)

The MSC atmospheric reentry materials arc jet facility will provide test capability required for the Apollo mission. The facility is designed to the limits of the present state-of-the-art. Facilities' designers are continually studying methods to extend performance of present facilities to meet the test requirements of more advanced missions. In this case, it is not possible to extend the performance capability with our present knowledge. Advances in the state-of-the-art frequently are made possible by developing entirely new concepts of design.

Mr. DADDARIO This covers a wide area. The committee has constantly been concerned with how these facilities can be used as national assets, and where the greatest number of people could use them. If that could be provided for the record, we would appreciate it.

Mr. Low. Yes, sir.

(The information referred to is as follows:)

The mission of the Manned Spacecraft Center is the development of spacecraft for manned exploration of space. The people most concerned with the development of manned spacecraft are located at this Field Center and the developmental testing tools required to accomplish the Center's mission can be most efficiently utilized, both technically and logistically, by these people in their laboratory workshops. This centralized location of such facilities at a Government laboratory makes them equally available to all contractors and helps to minimize the construction, at Government cost, of similar facilities at several contractors' plants.

Mr. DADDARIO. Now as I understand it, this arc-heated wind tunnel is being given as an example of your method of arriving at the kind of facilities which will be built?

Mr. Low. That is right.

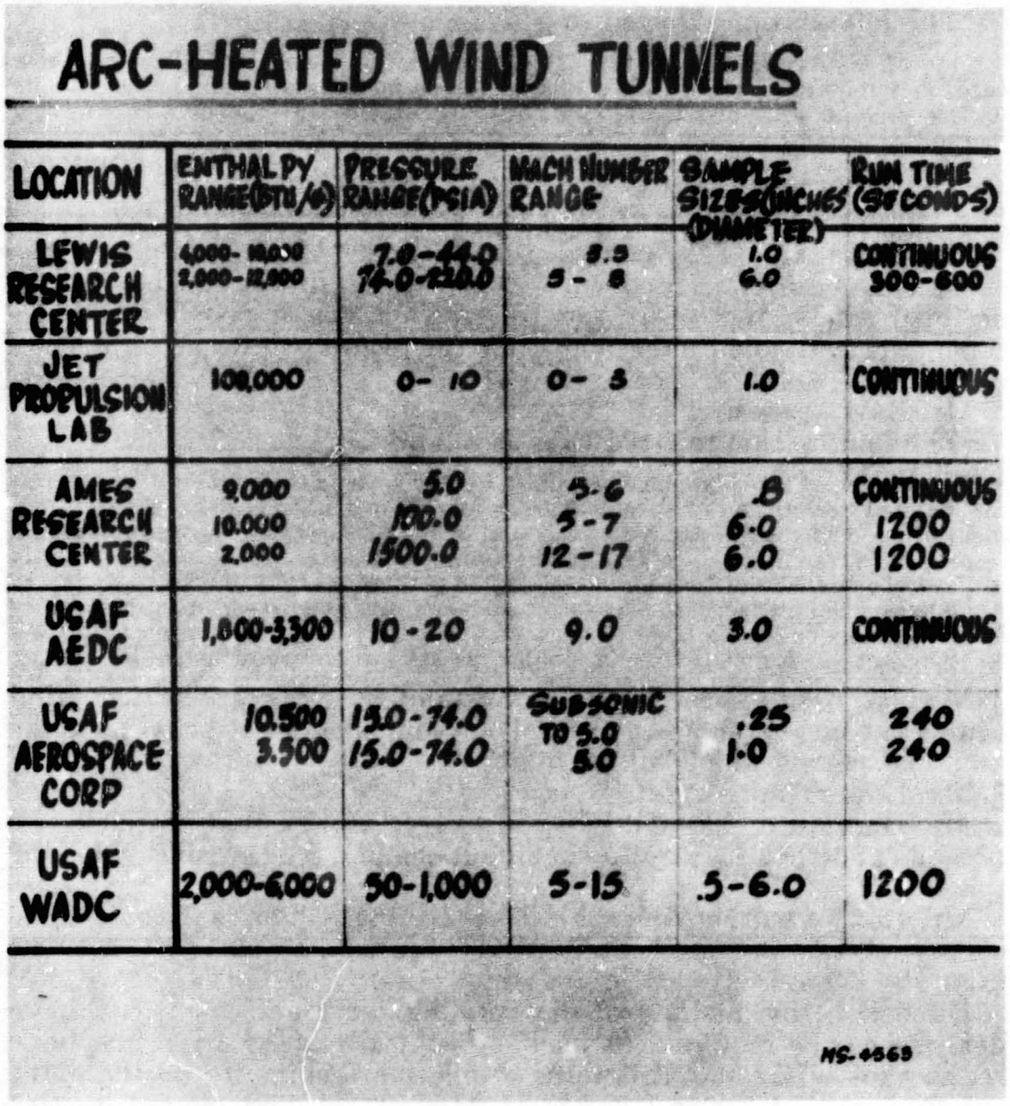
Mr. DADDARIO. I would like you to get through that as quickly as possible and then let's go to the line items and we can start breaking this down.

Mr. Low. I will skip over this page (fig. 161). This is the additional survey of existing arc-heated wind tunnels. I have given some examples before.

Now with this method of determining the requirement, we have determined the requirement for one facility, namely the atmospheric reentry materials and structures evaluation facility, to do the entry environment testing as I have indicated on my first chart (fig. 156, p. 759) let me come back to that for a moment now.

You will notice there were a number of test requirements, eight to be specific, that do not have check marks here. To meet all of these eight requirements, we need the following five facilities which we are requesting this year, atmospheric reentry materials and structures evaluation facility; launch environment and antenna test facility, for launch environment tests; Spacecraft Control Technology Laboratory; ultra-high-vacuum space chamber facility; and the lunar excursion module test facility at White Sands (fig. 162).

I have summarized all of these facilities on the next page, in addition to one or two others (fig. 163). This is the one we have been discussing for $2,915,000. For the launch environment and antenna test facility in Houston, we are requesting $7,482,000; for the Spacecraft Control Technology Laboratory in Houston, we are requesting $6,106,000; for the ultra-high-vacuum facility in Houston, $2,685,000; the lunar excursion module test facility at White Sands, $15 million; and in Houston, a project engineering facility for $2,761,000. This is one group of facilities for spacecraft development.



ARC-HEATED WIND TUNNELS

LOCATION	ENTHALPY RANGE (BTU/#)	PRESSURE RANGE (PSIA)	MACH NUMBER RANGE	SAMPLE SIZES (INCHES DIAMETER)	RUN TIME (SECONDS)
LEWIS RESEARCH CENTER	4,000-12,000 2,000-12,000	7.0-44.0 74.0-220.0	5.5 5-8	1.0 6.0	CONTINUOUS 300-600
JET PROPULSION LAB	100,000	0-10	0-5	1.0	CONTINUOUS
AMES RESEARCH CENTER	9,000 10,000 2,000	5.0 100.0 1500.0	3-6 5-7 12-17	.8 6.0 6.0	CONTINUOUS 1200 1200
USAF AEDC	1,800-3,300	10-20	9.0	3.0	CONTINUOUS
USAF AEROSPACE CORP	10,500 3,500	15.0-74.0 15.0-74.0	SUBSONIC TO 5.0 5.0	.25 1.0	240 240
USAF WADC	2,000-6,000	50-1,000	5-15	.5-6.0	1200

MS-4569

FIGURE 161

For spacecraft operations and simulation, we are requesting this year: for additions to the Mission Control Center, $8,409,000; for a mission simulation and training facility, in Houston, $2,216,000; for Center support facilities in Houston to support all of these additions to the Houston plant, $5,162,000; for a total request for facilities in support of spacecraft, with the exception of those facilities at the Launch Operations Center which I will cover separately, of $52,736,000.

This covers the facilities listed for spacecraft support under the location "Manned Spacecraft Center" and under "Various locations," for subtotals of $37,736,000 at the Manned Spacecraft Center, and $15 million at White Sands listed under "Various locations."

Mr. DADDARIO. Can we then get on to the Manned Spacecraft Center? We will start with a few general questions on the overall situation involving that Center.

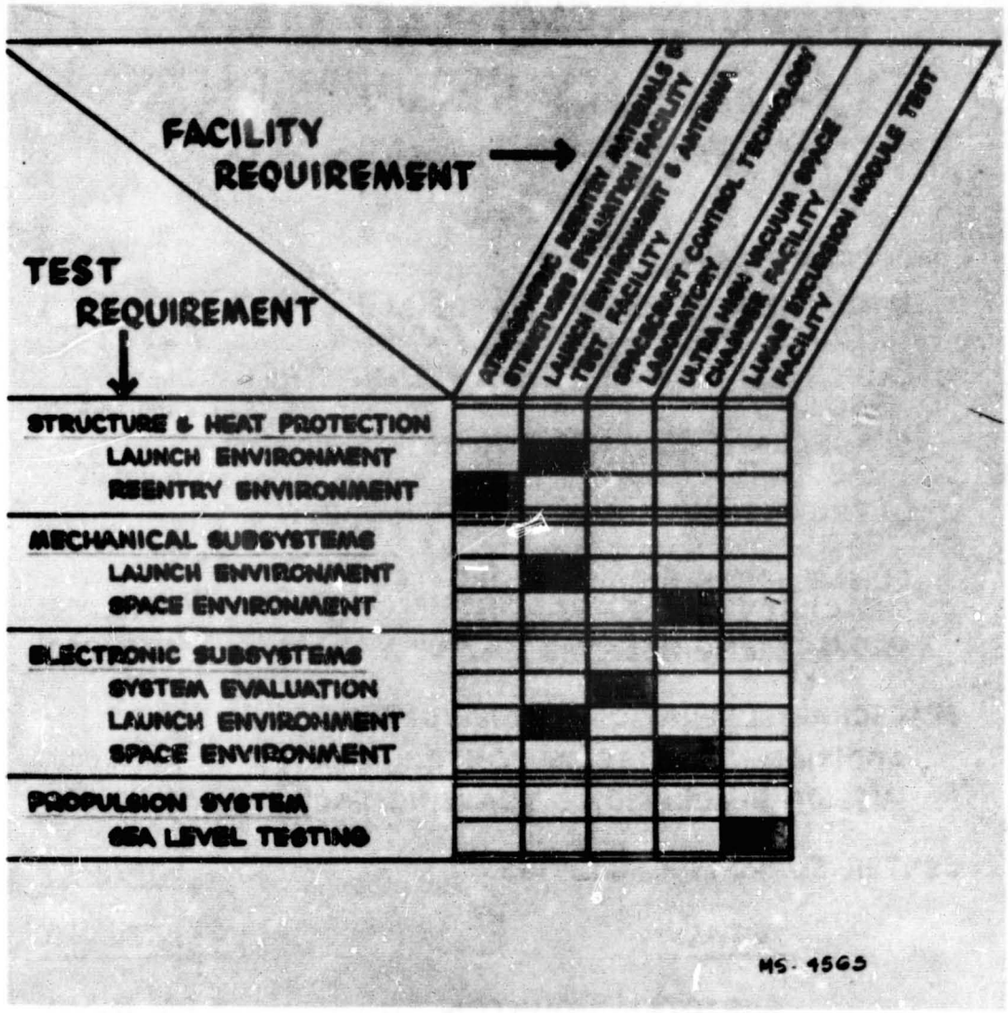


FIGURE 162

Colonel GOULD. Mr. Low, to date from the fiscal years 1962 and 1963 programs there have been a total of $115.3 million authorized or reprogramed into the Manned Spacecraft Center, for facilities to get the initial work underway. As of this date how much of this $115 million have been obligated?

Mr. LOW. I think Mr. Diaz may be able to answer that.

Mr. DIAZ. We have a total of about $60 million for fiscal year 1962.

Colonel GOULD. $60 million obligated?

Mr. DIAZ. No. We have obligated about $38 or $39 million.

Colonel GOULD. How much of the $60 million has been committed?

Mr. DIAZ. NASA has committed the $60 million. Approximately $20 million is yet to be obligated. This will be obligated for the Environmental Facility in the next 3 or 4 months.

Colonel GOULD. So you have a total then of $38 million out of the fiscal year 1962 money obligated?

Mr. DIAZ. Approximately, yes.

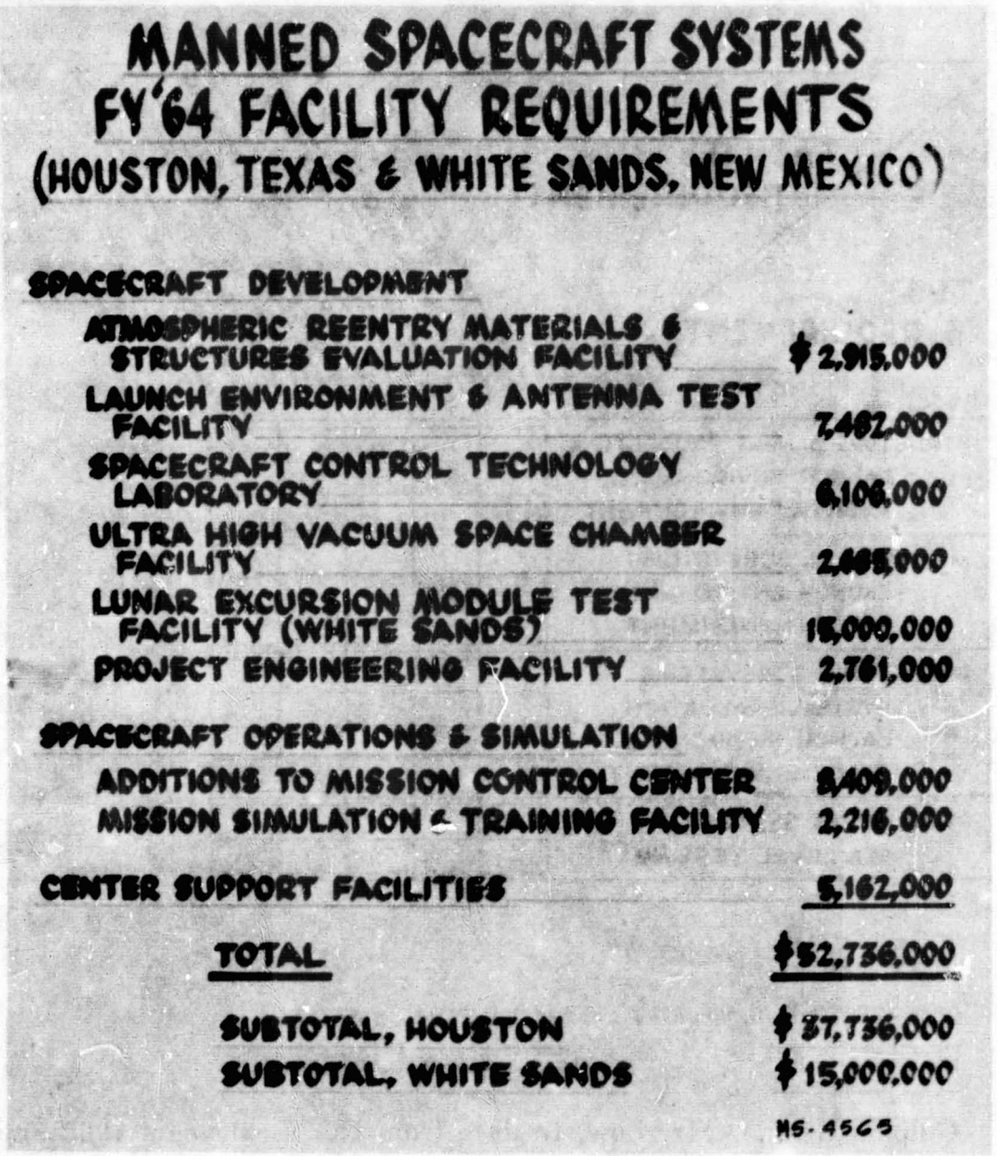


FIGURE 163

Colonel GOULD. $38 out of $60 million. Now for fiscal year 1963 you were authorized $30.8 million, reprogramed $5 million, and reprogramed from "R. & D. general," $17 million, or a total of $52 million, I believe. How much of that has been obligated?

Mr. HOLMES. Do you have that or do you want to supply it for the record?

Mr. LILLY. I will supply the exact number for the record.

Colonel GOULD. All right.

(The information requested is as follows:)

The total fiscal year 1963 authorized funding for MSC is approximately $46 million ($30.8 million initial authorization, $5 million reprograming within C. of F., and $16.7 million reprograming from R. & D. general minus $6.5 million from deletion of MSC C. of F. project 3563).

The total authorized funding for the Manned Spacecraft Center in fiscal year 1963 is approximately $46 million. This figure represents $30.8 million in initial authorisation, $5 million reprogramed within construction of facilities (C. of F.),

and $16.7 million reprogramed from research and development, general, minus $6.5 million from the deletion of the Manned Spacecraft Center C. of F. project 3563. Of this $46 million, $27 million has been obligated as of March 31, 1963. It is estimated that the remaining $19 million will be obligated during the summer of 1963.

Mr. HOLMES. As you know our practice in NASA is to request funds for the total cost of a facility with the exception of these large ones like the vertical assembly building, where we do request on an incremental basis. So this necessarily, because of construction time, makes our obligations and certain of our expenditures follow at some length the request for funds.

Colonel GOULD. I understand that, Mr. Holmes. With your fiscal year 1964 request of $37.7 million, this will bring the total amount authorized for this Center to $153 million.

What is the total estimated cost of all of the known requirements beyond the fiscal year 1964 program for this Center?

Mr. LILLY. In terms of identified ones right now, Colonel Gould, approximately $25 to $30 million.

Colonel GOULD. Is that over and above the $153 million?

Mr. LILLY. Over and above. There will, as you know, be new facility requirements, but in terms of completion of the facilities that we now have underway that amount will be required.

Mr. HOLMES. It is my opinion, though, Colonel Gould, that over the next 5 years we will see this NASA facility grow to a Center costing about $250 million. I think we have indicated that before.

I think Mr. Lilly's answer refers directly as he said, to the definitized requirements which are primarily the fiscal year 1965 items that we are working on right now. Is that correct?

Mr. LILLY. That is correct.

Colonel GOULD. As you know, Mr. Holmes, the committee has recently visited Houston, and I for one would like to compliment you on your master plan at this site. It is a well defined layout.

However, it appears that your requirements are programed only through fiscal year 1965. Knowing what your present mission is, at least during this decade, it would appear that the master plan could be fully laid out by placing all known requirements on paper and arriving at a preliminary estimate as to how much it is going to eventually cost to build this facility, based upon known requirements.

What you have said here today is that your requirements are now firm only through fiscal year 1965. is this correct?

Mr. HOLMES. What I specifically said was the figure that Mr. Lilly gave you, which he called definitized items, were those through fiscal year 1965. I think we have broader plans in a less definitive way that go out a good many more years than that.

Colonel GOULD. I see.

Mr. DADDARIO. You are talking about a future expenditure then beyond fiscal year 1965 of some $72 million?

Mr. HOLMES. Yes, sir, but I would like——

Mr. DADDARIO. You mentioned $250 million and this is, however, part of your master plan?

Mr. HOLMES. Yes. I would like to say that that statement of mine is not one that is backed up by detailed analysis but just an estimate based on experience of what I think would be necessary to provide this facility with the growth it probably should have prior to

reaching a state of maturity. And we have based that on our experience with the other centers.

Colonel GOULD. One further general question.

At the present time you are occupying leased space in Houston and also temporary space at Ellington Air Force Base, as I understand it. Would you give us the total amount of leased space that you are occupying in Houston and the total amount of space at Ellington, please, and the annual costs?

Mr. LILLY. We will provide that for the record.

(The information requested is as follows:)

The total leased space that we are occupying in Houston and the total amount of space at Ellington Air Force Base is as follows:

Location	Amount of space	Annual cost
	Square feet	
Houston	358,796	$1,102,084
Ellington	316,671	

Colonel GOULD. Very well.

Based upon the authorized projects for fiscal years 1962 and 1963, how much leased space will be terminated when these facilities are completed?

Mr. DIAZ. We expect it will be approximately 280,000 square feet.

Colonel GOULD. Out of a total of?

Mr. DIAZ. Of approximately 358,000.

Colonel GOULD. Is that figure space leased now or leased plus Air Force space temporarily assigned to NASA?

Mr. DIAZ. This is just leased.

Colonel GOULD. Just leased?

Mr. DIAZ. That is right.

Colonel GOULD. That is all I have, Mr. Chairman.

Mr. DADDARIO. We can then proceed with the line items, Mr. Low.

Mr. LOW. On page CF 8–3, Mr. Chairman, we are requesting additional funding for the Mission Control Center in Houston. Specifically, we are requesting $8,409,000 for equipment items within the Mission Control Center. The building itself, and some of the equipment will have been purchased——

Mr. DADDARIO. Can you hold it just a moment until we get everybody squared away.

Mr. PATTEN. Is it in volume IV?

Mr. DADDARIO. Volume IV.

Mr. PATTEN. All right. Thank you.

Mr. DADDARIO. Are you all set? Thank you, Mr. Low.

Mr. GURNEY. What page?

Mr. HOLMES. CF 8–6.

Mr. LOW. The line items on that page and 8–7 and 8–8 for a total request of $8,409,000. As I pointed out this is for equipment items within the Mission Control Center, since the building itself was funded totally from fiscal year 1963 funds.

Specifically, we are requesting funds for the balance of display and flight controller's console equipment, simulation equipment, and the laboratory and office equipment. Most of these items were partially funded in fiscal year 1963.

Mr. DADDARIO. Just keep moving along, Mr. Low. We will stop you if there are any questions.

Mr. Low. The next item is on page CF 8–9, Atmospheric reentry——

Colonel GOULD. May I ask a question, Mr. Chairman.

Mr. DADDARIO. Yes.

Colonel GOULD. On the project for the addition to the Mission Control Center, the equipment instrumentation and support systems amount shown for fiscal year 1963 on page CF 8–3 indicates a total of $11,411,100.

Mr. Low. Yes, sir.

Colonel GOULD. During a recent visit to Houston, the committee learned that more favorable bids had been received on some of this equipment and that it would be less than the $11,411,100, and I think Mr. Holmes mentioned this in earlier testimony. What is the revised amount for the equipment shown on this page, please?

Mr. Low. Colonel Gould, I don't recall any previous statements by Mr. Holmes on this. The equipment purchased here is being purchased under a contract with the Philco Corp. for the implementation of the Mission Control Center. We have definitized that contract recently at almost the exact amount that we had budgeted for. And there were no changes in fiscal year 1963 or 1964 requirements.

Colonel GOULD. The requirement for fiscal year 1963 then is still $11,411,100?

Mr. Low. To the best of my knowledge, yes.

Colonel GOULD. Would you check on that, please——

Mr. Low. Yes, sir.

Colonel GOULD (continuing). And supply for the record the latest revised figure.

(The information requested is as follows:)

During the subcommittee's recent visit to the Manned Spacecraft Center, a fiscal year 1963 figure of $10,147,900 for the Mission Control Center equipment was mentioned. However, the Manned Spacecraft Center figure did not include costs for the control building electrical equipment ($610,000), the control building emergency air-conditioning equipment ($200,000), and the heating and cooling plant equipment ($435,200). These items are included in the fiscal year 1964 budget book. If these costs are added to the $10,147,900 MSC figure, the amount for fiscal year 1963 is the same as shown in the fiscal year 1964 budget book, i.e., $11,411,100.

The requirement for fiscal year 1963 is still $11,411,100 for the Mission Control Center equipment in the Philco contract.

One further question: Will any of the equipment originally located in the Mercury Control Center at LOC be incorporated into this facility?

Mr. Low. No major items of equipment will be relocated to Houston.

Mr. FUQUA. Is this equipment obsolete now; it can't be used in the Gemini program?

Mr. Low. The Mercury equipment in the Mission Control Center is particularly suited to Project Mercury and cannot be used for the control of the Gemini or Apollo missions. There is additional equipment being used for the early Gemini flights at the Cape Canaveral Control Center that is actually equipment that is being budgeted for and purchased for the Mission Control Center in Houston and it is only temporarily being installed at Cape Canaveral.

Mr. FUQUA. Will it be transferred?

Mr. Low. It will be transferred to Houston from Cape Canaveral after the first few Gemini missions.

Mr. GURNEY. On the facilities on page CF 8–6, for $8,511,700, that I take it was an estimate in last year's budget; is that correct?

Mr. Low. That was a reprogram——

Mr. GURNEY. How much of that has been spent and how much of it has been obligated?

Mr. LILLY. Mr. Gurney, that item was not in the 1963 budget, because this was a facility which was started, using reprograming authority.

Mr. GURNEY. I see.

Mr. LILLY. The contract for this particular item has been under negotiation. I believe a contract was awarded in the first part of April and the figure is about $8,400,000—something of that nature. I can provide the current CWE on that item for you if you like.

Mr. GURNEY. None of this has actually been spent?

Mr. LILLY. To my knowledge no funds have been paid to the contractor yet.

Mr. GURNEY. You feel the obligated amount is quite close to that?

Mr. LILLY. Yes.

Mr. GURNEY. Can you furnish that figure?

Mr. LILLY. Yes, sir.

Mr. GURNEY. Thank you.

(The information requested is as follows:)

A contract was awarded on phase II for $7,879,402 on March 27, 1963. The balance of the funds was awarded on phase I of the contract, which was given out earlier. All of these funds have been obligated.

Colonel GOULD. Going back to the figure for equipment shown on page CF 8–7, the revised equipment figure that we have been advised of is $10,147,900. The question is: Has this variance been taken into account in the development of the 1964 estimate?

Mr. LILLY. Well, I would say, Colonel Gould, if that is the figure, which we will check, then it couldn't have been taken into account in this $11 million.

Mr. Low. We will have to check that number.

Mr. HOLMES. Did that number come from Houston?

Colonel GOULD. Yes, sir.

Mr. Low. What is that number again?

Colonel GOULD. $10,147,900.

Mr. DADDARIO. OK. Let's go.

Mr. Low. Shall I go on to the next facility? The Atmospheric Reentry Materials and Structures Evaluation Facility is the one that I used as an example before. It is listed on page CF 8–9 and the following pages. The requirement for this facility, Mr. Chairman, I believe——

Mr. DADDARIO. You have gone into that sufficiently.

Mr. Low. I have discussed it. As I mentioned also, this facility will be installed in an existing building; we are requesting $42,000 for minor modifications to this building to adapt it to this facility and, in addition to that, we are requesting $2,650,000 for equipment, instrumentation, and support systems, primarily for the arc-heated wind tunnel and its power supply; and $223,000 for design and engineering services for a total request of $2,915,000.

Mr. DADDARIO. Fine.

Mr. Low. The next facility item is the center support facilities. These are listed on pages CF 8–12 through 19. This item encompasses additional site development and utility installations, facilities construction and modifications, including an addition to the central heating and cooling plant and an additional cafeteria. Equipment, instrumentation, and support systems here include additional boilers, compressed air systems, mechanical control system, and so forth. The total request is $5,162,000.

Colonel GOULD. Mr. Low, I notice that your breakdown includes primary and secondary roads. I think NASA already has been authorized $920,000 for roads alone. This estimate here is for $501,000, which would bring you to about $1,400,000 for secondary and primary roads.

Does this fiscal year 1964 increment complete all of the roads required for this Center?

Mr. DIAZ. Yes, essentially it does, Colonel Gould.

Colonel GOULD. This also includes security patrol roads, is this correct?

Mr. Low. That is correct.

Colonel GOULD. I notice, also, that you are going to add some additional parking area in the amount of $167,000. The justification indicates that you already have existing or authorized enough parking space to provide for 2,500 vehicles, is this correct?

Mr. DIAZ. This is correct.

Colonel GOULD. This will provide an additional 830 spaces. What criteria do you use in developing requirements for parking spaces for your personnel?

Mr. DIAZ. We are presently using a 1:1.5 ratio for parking space.

Colonel GOULD. One space for every one and a half persons?

Mr. DIAZ. Right.

Colonel GOULD. It would appear that with Clear Lake City being built up in the vicinity of this Center that probably a lot of personnel may use car pools, plus commercial transportation that I assume will be placed in operation for this Center. Isn't the criteria used a little high?

Mr. DIAZ. My understanding of the area is that car pools simply don't work too well down in that area for various reasons.

Mr. Low. I think there are two reasons for that. One is that the people involved in this type of program, and this was our experience when the Space Task Group was at Langley Field also, work long hours and they work different hours. Some of them will work from 6:30 in the morning until 8 o'clock at night, and others from 7 until 7. So that they generally cannot rely on a car pool to get back and forth to work. Also in the Houston area the people have located in a number of different localities so that they cannot generally combine and get to work together. So there is less car-pooling with this type of work going on, with this type of location, than one might find in the normal type research center.

Colonel GOULD. What criteria do you use at other Centers under the manned space flight program for parking areas?

Mr. HOLMES. I think we have to get that for the record.

Mr. DIAZ. We will provide that for the record.

(The information requested is as follows:)

The criterion we are using at MSC for parking is 1 to 1.5 at the present time. By the end of fiscal year 1966 this ratio will be approximately 1 space to every 2 people. The criteria we are using for parking at the other Centers is 1 to 1.75.

Mr. HOLMES. My industrial experience, and I have had considerable experience building parking lots for our own plant, has been a 1½ ratio or less. In some places the number got down to where we thought each person was bringing in two cars. It is one of these things it has always been hard for me to understand why the ratio should be that way, but that has been my experience over a number of years. I don't think this is unique.

Mr. FULTON of Pennsylvania. What ratio does your present 2,500 facility give you?

Mr. LILLY. The ratio that we have used in terms of the total requirement, which will provide us with a total of 3,300 as I recall it, will be based on a ratio of about 1½ to 2. Based on a projected growth of the facility it would handle up to 6,000 people.

Mr. FULTON of Pennsylvania. Suppose you just stayed where you are at the 2,500 vehicles capacity, what ratio would that be?

Mr. HOLMES. Today we have about 2,600 people, excluding visitors. By the time the people move into the facility we should be in the high 3,000's.

Mr. LOW. Plus contractor personnel, plus visitors.

Mr. HOLMES. Yes, the contractor personnel and visitors have to be added. I would think a conservative estimate would be about 1½ to 1, that is between 1½ and 2 people to a car.

Mr. FULTON of Pennsylvania. How does this compare with other Government agencies; does this correspond?

Mr. HOLMES. I think we have to get that for the record, both for the other NASA centers and other Government agencies. It is consistent, I think, with industrial practice.

Mr. PATTEN. Would you like the figures on that for the House Office Building?

Mr. DADDARIO. That would be an interesting statistic.

Mr. PATTEN. I think it is about one parking space for about every seven people. For the Library of Congress only 15 people out of 100 can park their car.

Mr. HOLMES. Washington seems to be unfortunately somewhat different. We have in our case five parking spaces for 400 people.

Colonel GOULD. Mr. Lilly, would you compare this criteria with GSA and Department of Defense standards, please, and provide it for the record?

Mr. LILLY. Yes, we will be glad to provide this information for the record.

(The information requested is as follows:)

The criterion that DOD is using for parking at their facilities is the ratio of 1 to 1.5. GSA has no standard criteria. Their design of parking areas is determined by local circumstances.

Colonel GOULD. With regard to the 6,000 personnel figure by the end of fiscal year 1966, is it anticipated that all of these people will be working a normal 8 hours a day, during the same period of time in a 24-hour day?

Mr. LOW. The largest percentage of these people will be working daytime hours. There will be some people, small number of people

that will have to support tests in the various facilities around the clock.

Colonel GOULD. When you say the "largest percentage" what do you mean, 80 percent of the people, or 75 percent, or what?

Mr. LOW. I would have to get that number also for the record. My guess would be that it would be 95 percent.

(The information requested is as follows:)

The projected population at the Manned Spacecraft Center by fiscal year 1966 will average in excess of 5,900 people during daytime hours and will reach approximately 6,100 people during periods of peak activity. An additional personnel complement of approximately 100 will be working nights at that time. In arriving at the 5,900 and 6,100 numbers, the following factors were considered:

Permanent personnel.
Contractor employees.
Visitor traffic.
Temporary personnel.
Personnel temporarily assigned to other locations.
Personnel on travel.
Personnel on sick leave or vacation.

Colonel GOULD. I think this is a very important figure because it provides the basis upon which you predicate all of your support facilities, and although there are 6,000 people to be using this facility, we know that they are not all going to be there at the same time.

With regard to the cafeteria, in the fiscal year 1963 program, I believe, a cafeteria was included. As I understand it, the contract cost on that was about $463,000, if I am not mistaken. Is that correct?

Mr. DIAZ. I do not have that figure here, Colonel Gould. As I recall, that was the approximate figure.

Colonel GOULD. Is it about $450 to $460,000?

Mr. DIAZ. That is about right.

Colonel GOULD. This one I notice is priced out, not counting equipment, at $354,000. Why the difference in cost?

Mr. DIAZ. Well, the first cafeteria, as you recall, contained a central kitchen. The new facility is a serving cafeteria. It does not have a kitchen.

Colonel GOULD. The one in the fiscal year 1963 program will accommodate 2,500 people; is that correct?

Mr. LILLY. On a 2½-hour feeding period; that is correct. It seats 500.

Colonel GOULD. This second cafeteria is intended to accommodate another 2,500?

Mr. LILLY. On a 2½-hour feeding period.

Mr. DIAZ. Yes.

Colonel GOULD. Two and a half hours. What will be the personnel strength by the end of fiscal year 1965 when this cafeteria will come into being?

Mr. HOLMES. Approximately 4,800 to 5,000 people. We haven't settled our budget for fiscal year 1965 for personnel yet, but that would be my estimate.

Mr. DIAZ. By the end of fiscal year 1964 we will have 4,800 people.

Mr. LOW. This figure includes contractor people.

Mr. DIAZ. Yes.

Mr. HOLMES. The numbers I was giving for the end of fiscal year 1965 will be NASA personnel. In fiscal year 1964 it will be something under 4,000; if you add contractors it will be another 800.

Colonel GOULD. When you compute your criteria for a cafeteria, do you assume that all people will use the cafeteria?

Mr. LOW. We are assuming here that for a Center that will have 6,000 people on location, that we should be able to feed 5,000 people on a two and a half hour feeding cycle.

Colonel GOULD. In developing the criteria for this Center, however, have you not taken into consideration that Clear Lake City, which apparently is going to be a booming city, will provide some of this support?

Mr. LOW. It has been our experience, at least at the other NASA Centers, that during the half hour time allowed for lunches people can not leave the base, but have to eat on the base.

Colonel GOULD. Would you explain to the committee, please, what this central mechanical control system consists of in the amount of $330,000?

Mr. HOLMES. Will you answer that?

Mr. DIAZ. We will provide it for the record.

(The information requested is as follows:)

1. The central mechanical control system for the central heating plant consists of an alarm-logger console and a control console.

2. The control console consists of the following components:

(*a*) Motor start-stop: The motor start-stop module permits the operator to "start or stop" all building air-handling unit fan motors and all building chilled and hot water pumps.

(*b*) Damper controls: The damper control module permits the operator to open or close air-handling unit outside air intake dampers.

(*c*) Temperature reset: This module permits the operator to reset the temperature of the air leaving the cooling coils and the air-handling unit.

(*d*) Filter pressure differentials: This module permits the operator to monitor the filters on each air-handling unit to determine when filters require changing.

(*e*) The control console is provided with graphic representation of each air-handling unit system serving the buildings. Also this basic console is designed to incorporate the required relays and wiring for future buildings.

3. The alarm-logger consists of the following components:

(*a*) Alarm scanner: This module automatically scans all critical temperature and pressure points for all "off-normal" or "alarm" conditions.

(*b*) Logger: This part of the alarm-logger permits the operator to schedule the logging of pertinent data to determine total tons of refrigeration to each building, total steam consumption to each building, and to log system performance of each air-handling unit air-conditioning system. The logger module is designed for the future addition of all flows, temperatures and critical pressures of the central refrigeration systems and steam boilers in the central heating and cooling plant and utility points in the future buildings.

Colonel GOULD. That is all I have, Mr. Chairman.

Mr. DADDARIO. Any questions on this item, gentlemen?

(No response.)

Mr. DADDARIO. Please continue.

Mr. LOW. The next item, starting on page CF 8–20 is the Launch Environment and Antenna Test Facility. This facility will consist of a number of components for testing spacecraft and their subsystems under the conditions of vibrations encountered during the launch in the acoustic environment encountered during the launch. It will provide an anechoic chamber for antenna testing, simulating free space, and it will provide an antenna range for narrow beam antenna testing. In this combined facility we plan to subject the Apollo

command and service modules and the lunar excursion module to the environment that these modules will undergo in the launch phase of a mission. In addition to that we will be able to test the antennas simulating the space phase of the mission.

We are requesting for this facility a total of $7,482,000. This includes $315,000 for site development, $3,446,000 for facility construction and modifications, $3,119,000 for equipment, instrumentation, and support systems and $602,000 for design and engineering.

Colonel GOULD. Mr. Low, at the Marshall Center NASA has in being or programed an Acoustical and Vibration Test Facility for launch vehicle development. Why can't these facilities at Marshall be used for this purpose?

Mr. LOW. The major reason for this is that we plan to subject an Apollo test article, spacecraft No. 8, to all sorts of individual and combined environmental testing, simulating the Apollo mission. The same spacecraft will be used in the environmental test chambers which was in the Houston program for fiscal year 1962. It will undergo the vibration and noise testing that I have indicated here, the antenna ranging and antenna testing. As we make modifications to the spacecraft in the qualification program, determined in one facility, we must then again check out and test these modifications in all facilities. It is this kind of combined testing on a single-test article that we feel is absolutely essential to get the Apollo spacecraft to the state of reliability that we need for this mission.

Colonel GOULD. You are saying then that there are three tests in this development level at Marshall, is this correct?

Mr. LOW. No; the Apollo spacecraft itself will not be tested in the facilities at Marshall. The launch vehicles will be tested there.

Colonel GOULD. What types of testing will the contractor be required to perform?

Mr. LOW. The contractor in his plant will do what is normally termed acceptance testing. He will assure that the spacecraft and its components, indeed, meet their specifications.

The long-term environmental testing, the subjecting of the spacecraft to more severe environments, heat and cold, vibration and noise, than the specifications call for, for long periods of time, this will be done on a single test article in the Houston facility.

These tests will be similar to the so-called Project Orbit tests that we used in Mercury, that is, long-term environmental tests where we proof tested before each flight that a spacecraft modification would indeed work. This will not be done in the Apollo program at the contractor's plant, but will be done in Houston.

Colonel GOULD. Has the design been initiated on this project?

Mr. LILLY. No.

Colonel GOULD. Do you intend to initiate it in advance of authorization?

Mr. DIAZ. That is correct, in May of this year.

Colonel GOULD. You are going to initiate it in May?

Mr. DIAZ. That is correct.

Colonel GOULD. What is the design and construction leadtime?

Mr. DIAZ. We expect to start design in May and complete the construction in April of 1965.

Colonel GOULD. Is this another instance where you are going to use fiscal year 1963 advance design funds?

Mr. DIAZ. This is correct, sir.

Colonel GOULD. In what amount, please?

Mr. DIAZ. $217,000.

Colonel GOULD. Is that $217,000 included in the estimate on page CF 8–27?

Mr. DIAZ. It is part of that estimate.

Colonel GOULD. It is part of it. So you will have used fiscal year 1963 money to defray $217,000 out of the $602,000 requested, is that correct?

Mr. LILLY. That is correct. As you recognize the agency has submitted a reprograming action which is in effect a borrowing action to allow this design to get started.

Mr. DADDARIO. Mr. Fulton?

Mr. FULTON of Pennsylvania. How far will this site be from existing utility installations and other facilities at this particular location?

Mr. LOW. On page CF 8–1 we have a site plan for the Houston facilities. The facility in question is within the overall complex of facilities. It is building No. 14, shown along Second Street about halfway between Avenue E and the next street up.

Mr. FULTON of Pennsylvania. Will you hold your book up and point that out?

Mr. LOW. I think Mr. Lilly has a larger map here.

Mr. FULTON of Pennsylvania. I think I have it, but can you show it definitely? Just hold it up.

Mr. DIAZ. It is right here, sir.

Mr. FULTON of Pennsylvania. It is the black one on this diagram in the book?

Mr. DIAZ. That is right, right here.

Mr. FULTON of Pennsylvania. So it is not at a remote distance then?

Mr. DIAZ. No, sir.

Mr. FULTON of Pennsylvania. Between this proposed construction and other buildings in this same complex?

Mr. LOW. No, sir, this was part of the overall master planning for the Center.

Mr. FULTON of Pennsylvania. Why does it cost so much to connect up the various tunnels, roadways, and things of that type, when it is in so close to the other buildings?

Mr. LOW. Mr. Diaz, do you want to speak on that?

Mr. DIAZ. These are normal utility connections for a structure of this type.

Mr. FULTON of Pennsylvania. Don't you already have Second Street in? Why do you need an access road at $14,000? Why does it cost you $45,000 for a utility tunnel extension when you already have the utilities in right along Second Street?

Mr. HOLMES. Why don't we supply a detailed answer for the record.

Mr. FULTON of Pennsylvania. You see some of us have been down there. There is a tremendous amount of land. I want to see that these things aren't being put out like islands.

Secondly, when you have other buildings there that the utilities have already been connected to, it becomes a real question to me why you need all this extra money when you are right in the center of a complex.

Mr. DIAZ. We can provide it for the record and give you the distances in every case and the unit cost.

Mr. FULTON of Pennsylvania. All right. That is all.

(The information requested is as follows:)

An entrance road is required from Second Street in order to provide access to the launch environment and antenna test facility, also, service areas are required in the vicinity of this building. The $14,000 includes the cost of both of these items.

The utility tunnel extension is required to being in the utility lines from the mains located adjacent to Second Street. The length of this utility tunnel extension is approximately 300 feet. Based on actual bid process for this item in the fiscal year 1962 construction at Clear Lake, the unit cost for this extension was estimated at $150 per linear foot.

On the master plan as approved for the Manned Spacecraft Center, the major utility systems were developed and designed so that all utility expansions and connections to the planned facilities could be constructed at the most economical cost. Distances and unit costs for facilities requiring these utility tunnels are as follows:

Page	Item	Length (linear feet)	Total cost
CF 8-26	Launch environment and test facility	300	$45,000
CF 8-31	Mission simulation and antenna training facility	300	45,000
CF 8-32	Project engineering facility	100	15,000
CF 8-40	Spacecraft Control Technology Laboratory	345	52,000

Mr. DADDARIO. Any further questions?

Colonel GOULD. No, sir.

Mr. DADDARIO. Will you proceed, Mr. Low, please.

Mr. LOW. The next facility listed on page CF 8–28 is the mission simulation and training facility. This building will house the Gemini and Apollo mission simulators and the docking simulator for both Gemini and Apollo. The mission simulators, themselves, are being procured under our R. & D. contracts with McDonnell and North American for Gemini and Apollo respectively.

The purpose of this project is to provide a building to house the simulators and to provide the peripheral equipment that is needed with these simulators.

We are requesting on page 8–31, a total of $2,216,000 for this building; $167,000 for site development and utility installations; $1,342,000 for facility construction and modifications, $466,000 for equipment, instrumentation, and support systems, and $241,000 for design and engineering services.

Colonel GOULD. Mr. Low, as I understand it you have already initiated procurement from prior years' money for the Gemini simulator, Gemini translation and docking simulators, the Apollo mission simulator, and the Lunar Excursion Module Simulator. What are the delivery dates for these simulators?

Mr. LOW. All of these simulators will be delivered before this building is ready and they will be housed in temporary buildings around Houston at Ellington Air Force Base before they are moved into this building. I don't have the exact delivery dates with me.

Colonel GOULD. Are you going to be able to find temporary buildings which have the necessary environment to run these simulation devices?

Mr. LOW. Yes, we have located the buildings that will be used for these facilities.

Colonel GOULD. Why wouldn't it be possible to continue using these temporary buildings for another year or more?

Mr. Low. At the time period that this building will come into operation, which will be in the summer of 1965, the most intensive part of the Apollo training will start and, in this time period, we feel that we must have the mission simulators tied in closely with the Mission Control Center, which will also be located in this Houston complex, for the overall training for the Apollo Earth orbital missions and later on for the lunar missions.

Mr. Holmes. I think it should be emphasized that we are operating in a most inefficient manner now, being located in some 17 different locations; we are wasting money; we are wasting time. I would like to do everything possible to consolidate this total operation down there at Clear Lake as soon as possible.

Mr. Daddario. Why are you adding to the problem?

Mr. Holmes. We aren't adding to the problem.

Mr. Daddario. You are adding to the problem if you have additional simulators which you are going to place in buildings already obtainable, as I understand it, for this purpose. I agree with you that you are operating inefficiently at the moment. Wouldn't it be better to wait until this building is completed and the simulators placed immediately into that building?

Mr. Holmes. No, sir; it is the same problem we are in today, where we must must carry on the work, we must carry on the development—in this case we must carry on the simulation as early as possible. So, as soon as the simulators are completed and ready, we will start using them.

Mr. Daddario. As inefficient as it may be.

Mr. Holmes. Unfortunately we must start using them 15 or 20 miles away, with the transportation problem to Clear Lake; yes, sir.

Mr. Daddario. Do you really gain time by doing that?

Mr. Holmes. Oh, very much; absolutely.

Mr. Daddario. Well if you do, then go back to Colonel Gould's question. If you can operate properly even at that distance, why can't you continue for another year or so? It seems to be self-defeating.

Mr. Holmes. I don't think so. I think the question is, wouldn't it be nice if we could legally transfer it on the 1963 budget and start working on it yesterday and get it done——

Mr. Daddario. It would be nice, except for the fact that in spending this much money, you can't go back to 1963. That is exactly what we are talking about. We would like to be able to spend the money efficiently and put everything at one time and at one place. The committee is always being asked to appropriate funds which in the final analysis will be spent in a very inefficient manner, and this is a very expensive way to appropriate money.

Mr. Holmes. I think my point is, which I don't think I am doing very well in explaining, I think my point is that it is more efficient to spend this $2 million in 1965, and let us operate with these simulators in fiscal 1964, than it is to wait until fiscal 1965 and have just 1 more year of less efficient operation. That was really the only point I was trying to make.

Mr. Roudebush. Would you yield there?

Mr. Daddario. Yes.

Mr. Roudebush. I would like to know—you speak of the difficulty in transportation, Mr. Holmes, what is the number of personnel involved?

Mr. HOLMES. I think it is 17. I might be incorrect in that number, but one or two locations. We have today something around 2,600 people.

Mr. ROUDEBUSH. All right.

Mr. DADDARIO. Mr. Gurney?

Mr. GURNEY. Well, why wasn't this building started sooner if the simulators will be available?

Mr. HOLMES. That is a very good question. Unless someone here knows the answer, I would like to give it to you for the record.

Mr. DADDARIO. Would you please provide it for the record? Let's not leave that hanging out in space.

Mr. HOLMES. Yes, sir.

(The information requested is as follows:)

At the time of the fiscal year 1963 budget submission, we could predict the need for simulator housing facilities. However, simulator design details were too preliminary to determine the exact configuration of such facilities. Since that time, simulator designs have progressed sufficiently to allow us to determine the unique facility configuration necessary to accommodate these simulators.

Mr. FULTON of Pennsylvania. Your method of setting up how you are approaching the construction of these facilities, site development and utility installations, I noticed is different on the various buildings and facilities you are speaking about. It appears that you have no uniform method by which we can compare the buildings and facilities. For example, if you look on CF 8–26 you find the list under B, "Site development and utility installations." If you look on page CF 8–31, on another facility it is different, and if you look back on the others you find that it is set up differently for each one of the buildings. Why is that?

I think there should be an explanation why on CF 8–26, electric power and distribution cost $80,000 in that facility, but on CF 8–31, electrical power and distribution cost $68,000. Why is there a difference?

Mr. Low. The exact number, Mr. Fulton, depends on the power-load requirements for the equipment within the building and the distance of the building from the existing power tunnel. So in each case this was computed based on actual requirements.

Mr. FULTON of Pennsylvania. When I see utility tunnel extensions on CF 8–26 at $45,000, and on CF 8–31 and find it is $45,000 again, it seems to me that is just a very broad-brush estimate. Just exactly the same dollar amount.

Mr. Low. The utility tunnel, I am not sure whether you saw those, Mr. Fulton, when you were at the site, but these are large, underground tunnels.

Mr. FULTON of Pennsylvania. I was there. I didn't know whether it was a sewer or a tunnel.

Mr. Low. Which carry all of the utilities and I am told that for the type of construction needed in that area these major utility tunnels were required. The cost for these is estimated on a running-foot basis.

I would then guess, and I have to provide for the record the detailed answer, that we need exactly the same length of connecting tunnel to the simulation building on page 8–31 as to the other building on page 8–26.

Mr. FULTON of Pennsylvania. If you will look at CF 8–31, you will find a $14,000 item for grading and erosion control. But if you look

back at the previous facility, CF 8–26, you find it is $88,000 for the same item, grading and erosion control. Why this big difference? Are you locating the buildings right in one place and wrong in the other?

Mr. DIAZ. It depends, sir, on the general work that has to be done in the particular area, and the unit cost; we can provide you with the unit cost in each case.

Mr. FULTON of Pennsylvania. How does the rate per square foot cost of construction that you have shown on these various facilities compare with construction costs in this general area?

Mr. LILLY. The cost index here at Houston is 0.95 compared to the Washington area, 1.

Mr. FULTON of Pennsylvania. Now $33.10 per square foot on a building of 40,550 square feet on CF 8–31, how does that compare with local rates?

Mr. DIAZ. This unit cost——

Mr. FULTON of Pennsylvania. Let me just finish this. For example, on CF 8–26 you find a facility of 47,600 square feet at $64.43 per square foot, and the next item on that page is $32.80 per square foot for a facility of 5,800 square feet.

Mr. LILLY. These depend, Mr. Fulton, on the particular kind of structure. The one that you referred to as being $64 a square foot is a structure 120 feet high. It must also be on pilings. This facility also has special requirements for electrical, heating, ventilating, air conditioning, vibration and noise control feature. The square footage alone is, as you recognize, not a real good measure in many cases.

Mr. FULTON of Pennsylvania. I think we should have, with the chairman's permission, for the record the reason for the variation in costs, where there are wide differences at various facilities. Go through the book to do that, without going into it at this time.

Mr. DADDARIO. Will that be too much of a problem to get that together?

Mr. DIAZ. We can do it.

(The information requested is as follows:)

The variation in costs, for similar items under the site development and utility installation category, is attributed to such factors as: length of utility connection, area of land to be graded, soil conditions, method of erosion control, and special type or capacity of each utility. The following chart is an example of two facilities in which similar items appear but the costs are different. An explanation of how the costs were determined is included.

Page	Item	Quantity	Unit cost	Total cost	Remarks
	MISSION SIMULATION AND TRAINING FACILITY				
CF S-31	Grading and erosion control	4 acres	$3,500 per acre	$14,000	This item includes grading, tilling, fertilizing, spot sodding, and landscaping.
	Access road	2,100 square yards	$5.70 per square yard	12,000	This item provides for an entrance road and service hardstand.
	Electric power and distribution			68,000	The total includes cost of special power equipment required for simulator and computer loads.
	Special power equipment		Lump sum	(28,000)	
	Electrical power distribution	4,000 lineal feet	$10 per lineal foot	(40,000)	
	Utility connection			28,000	This item includes extending water, gas, chilled water, steam lines, storm, and sanitary sewer lines to the subject building.
	Water	200 feet	$4 per lineal foot	(800)	
	Gas	500	$3.40 per lineal foot	(1,700)	
	Storm sewer	300	$10 per lineal foot	(3,000)	
	Storm sewer manholes	5	$500 each	(2,500)	
	Sanitary sewer	250 feet	$7 per lineal foot	(1,750)	
	Sanitary sewer manholes	4	$650 each	(2,600)	
	Chilled water and steam piping	600 feet	$26.10 per lineal foot	(15,650)	
	Utility tunnel extension	300 feet	$150 per lineal foot	45,000	This item houses steam lines, chilled water lines, communication lines, and sewer lines.
	PROJECT ENGINEERING FACILITY				
CF S-32	Grading and erosion control	3.4 acres	$3,500 per acre	12,000	This item includes grading, tilling, fertilizing, spot sodding, and landscaping.
	Access road	527 square yards	$5.70 per square yard	3,000	Includes the interim road and service hardstand.
	Electric power and distribution	2,500 feet	$10 per lineal foot	25,000	Provides power and distribution from substation.
	Utility connections			16,000	This item includes extending water, gas, chilled water, steam lines, storm, and sanitary sewer lines to the subject building.
	Water	200 feet	$4 per lineal foot	(800)	
	Gas	235	$3.40 per lineal foot	(800)	
	Storm sewer	500	$10 per lineal foot	(5,000)	
	Storm sewer manhole	3	$500 each	(1,500)	
	Sanitary sewer	200 feet	$7 per lineal foot	(1,400)	
	Sanitary sewer manhole	2	$650 each	(1,300)	
	Chilled water and steam piping	200 feet	$26.10	(5,200)	
	Utility tunnel extensions	100 feet	$150 per lineal foot	15,000	This item houses steam lines, chilled water lines, communication lines, and sewer lines.

Mr. ROUDEBUSH. Mr. Chairman.

Mr. DADDARIO. Yes, sir.

Mr. ROUDEBUSH. I would like to repeat a question to you. I think you might have misinterpreted my earlier question in reference to the number of employees involved in this transportation problem. I was referring only to this building.

Mr. HOLMES. In this building that houses our simulators?

Mr. ROUDEBUSH. That is right, not the total number.

Mr. HOLMES. I am sorry. Thirty, perhaps.

Mr. ROUDEBUSH. In other words, this transportation difficulty that you spoke about using temporary buildings involves only about 30 people rather than the several thousand you mentioned a while ago?

Mr. LOW. Thirty people running this facility. In addition to that there are probably several dozen that must participate in various of the simulations that are going on.

Mr. ROUDEBUSH. Yes; but the building won't be in constant use. You won't be running simulation tests every day; they will be run rather periodically rather than continuously.

Mr. LOW. I believe, Mr. Roudebush, that in this time period where we must simulate missions of 1 to 2 weeks' duration and train numbers of crews, we will be simulating day and night, almost continuously.

Mr. ROUDEBUSH. Yes; but then there may be a period that it is not used for a while; isn't that so?

Mr. LOW. Possibly.

Mr. HOLMES. The inefficiencies to which I was referring were not the ones for going there in the morning and going back at night, such as the people are located permanently there, but rather those who have offices at Clear Lake or the astronauts themselves, will be continually leaving there and having to go to Houston to these locations. That is the kind of inefficiencies I was talking about, although I did misinterpret your question. I am sorry.

Mr. ROUDEBUSH. I thought we better correct the record.

Mr. DADDARIO. Colonel Gould?

Colonel GOULD. What is the total cost of the simulators that you now have under procurement?

Mr. LOW. I would have to provide it for the record.

Colonel GOULD. What is the rough figure?

Mr. LOW. The Apollo simulator itself is about $10 million.

Colonel GOULD. Just for the Apollo mission simulator. Do you have any idea on the other simulators?

Mr. LOW. The numbers I have here total up to $33 million.

Colonel GOULD. In other words, this facility, taking into account its equipment, is going to be a $35 million facility, is this correct?

Mr. LOW. Yes. Now the equipment is R. & D. equipment, it is equipment that is very similar to Apollo and Gemini spacecraft plus instructor's consoles. It is like the procedures trainer that we used in Project Mercury which you may have seen at Cape Canaveral. It is a mockup of the spacecraft, tied into the control center, tied into an instructor's console in which all possible normal and abnormal missions can be simulated on the ground.

Colonel GOULD. Has the $33 million, roughly, already been obligated?

Mr. LOW. One specific number I know about, which is a subcontract from North American for the Apollo mission simulator, this

contract was just let 1 week ago. The Gemini mission simulator subcontract was probably let about 6 months ago.

Colonel GOULD. Would you provide for the record, please, the total cost of the simulators now under procurement or intended to be procured and how much has been obligated to date?

(The information referred to is as follows:)

The estimated cost of flight crew training simulators now under procurement, or intended to be procured, totals $48 million in fiscal years 1963, 1964, and 1965. As of May 1, 1963, $10.754 million of this total has been expended.

What are the design and construction leadtimes on this project, please?

Mr. DIAZ. We expect to start design in May. The design criteria are already under development. Completion of construction is expected in May of 1965.

Colonel GOULD. Apparently you will use——

Mr. DIAZ. $147,000 advance funds.

Colonel GOULD. Is that included in the 241,000?

Mr. DIAZ. Correct.

Mr. HOLMES. I would like to point out, Mr. Chairman, that this does not mean that we have extra money. The Corps of Engineers has placed a great deal of pressure on us indicating that we are operating inefficiently by not doing advance design early enough. So the reprograming, such as it has been necessary to get these funds, doesn't mean that then this engineering money we are asking for in this budget isn't needed.

It is not as though it is extra money, it means that we have to accommodate this by operating within our 1963 budget in order to be most efficient, but it doesn't mean that this is extra engineering design money, which could be the conclusion as we hit each one of these. I would like to point that out.

Colonel GOULD. As a followup question, would more liberal use of advance design funds benefit your program?

Mr. HOLMES. I think very much so, Colonel Gould.

Mr. GURNEY. Mr. Chairman?

Mr. DADDARIO. Yes, Mr. Gurney.

Mr. GURNEY. I notice these are all separate buildings, mission simulation and training facility, et cetera. Is that necessary? Do you always have to have separate buildings, or can you combine these under one roof? Is there any saving if you should do so?

Mr. LOW. Mr. Gurney, I am certainly not an expert in this area. We did have architect and engineering firms planning in detail the Houston site and the buildings for the most economical use of facilities, of people in the facilities, proper grouping of people and this master plan——

Mr. GURNEY. I am sure that answers the question. In other words, all of these were in one master plan?

Mr. DIAZ. They are according to the master plan.

Mr. GURNEY. Thank you.

Mr. DADDARIO. May we proceed to the Project Engineering facility?

Mr. LOW. The Project Engineer Facility listed on page CF 8–32 through page 8–35 is essentially an office building to house the personnel from the Gemini and Apollo project offices. We are requesting for this building sufficient space for 560 personnel.

The total dollar amount requested for this building is $2,761,000.

Mr. DADDARIO. Colonel Gould.

Colonel GOULD. Yes, sir.

In the fiscal year 1962 program, I believe, a Project Management Building was authorized, now under construction, and according to the justification will accommodate 930 personnel, is this correct?

Mr. LOW. There is a typographical error here. It is 940.

Colonel GOULD. 940.

You also indicated that the fiscal years 1962 and 1963 items as now authorized will permit you to release about 282,000 square feet of leased space; is that correct?

Mr. DIAZ. That is correct.

Colonel GOULD. Now the balance between this 282,000 square feet to be released and the total under lease somewhere around 360,000 square feet, I believe, will this building accommodate the balance of those people now in leased space?

Mr. DIAZ. This building will accommodate 560 people and will essentially accommodate the balance of the people in leased space.

Colonel GOULD. In other words, if this is built, you will be able to eliminate all leased space; is this correct?

Mr. DIAZ. I will have to check that and provide it for the record.

(The information requested is as follows:)

When the MSC Project Engineering Building is constructed, it will accommodate 560 people. This one facility would not enable MSC to release the balance of leased space. However, when all the buildings requested in this program are constructed, all leased space could be terminated.

Mr. LOW. This is our intent, certainly.

Colonel GOULD. What impact would occur on your program if this building were deferred for a year?

Mr. LOW. I think we would be back in the same kind of inefficient operation that Mr. Holmes was describing a few moments ago. It would take the core of the people, the project officers, and leave them situated away from the main center where all the work is going on.

Colonel GOULD. But with the facilities authorized in 1962 and 1963, would it not be possible after they are completed, to accommodate all of your personnel at the Manned Spacecraft Center and at Ellington Air Force Base without the necessity of continuing leased space in Houston?

Mr. LOW. Certainly, we could accommodate people at Ellington, but even so, Ellington is sufficiently far away that the operation would be an exceedingly inefficient one.

I know from personal experience that every time I am now in Houston and Dr. Gilruth or Mr. Williams or Mr. Elms wants to call a meeting with any one of their people, they have to come from six or seven different locations. It takes about half an hour for them to get there and this is a half an hour cut—for important people, cut out of the time of the lunar program. It is a most inefficient operation. I certainly would not encourage carrying it on any longer than necessary.

Colonel GOULD. In developing administrative or engineering facilities of this nature, what criteria do you use for the size?

Mr. DIAZ. We use a factor of 120 feet net space per man.

Colonel GOULD. What would the gross be?

Mr. DIAZ. Pardon?

Colonel GOULD. What would be the gross?
Mr. DIAZ. 145.
Colonel GOULD. 145 feet per person.
That is all I have.
Mr. DADDARIO. May we proceed to the Spacecraft Control Technology Laboratory, please.
Mr. LOW. The Spacecraft Control Technology Laboratory is a facility required for the developmental testing and evaluation of the major electronic subsystems in our manned spacecraft.
In particular, it will include a laboratory for inertial components, a laboratory for the computer elements of the guidance and control system and for the optical elements of the guidance and control system, a laboratory for the entire guidance and control systems working together as a system and finally a laboratory for the systems working within an entire spacecraft module.
On page CF 8–40 and 41 we are requesting $6,106,000 for this facility. This is broken down into $116,000 for site development and utility installations; $1,702,000 for facility construction and modifications; $3,897,000 for equipment, instrumentation, and support systems; and $391,000 for design and engineering.
Mr. DADDARIO. Colonel Gould.
Colonel GOULD. I note in the project description that the astronauts will be brought into this facility to perform simulated mission control operations. It would appear that these same operations could easily be conducted in the mission simulation and training facility included in this program. Would you comment on this, please?
Mr. Low. There is a basic difference between these two facilities. In the mission simulation facility, we will have mission simulators that duplicate exactly the existing spacecraft and their display systems and their control systems. If an astronaut in the mission simulation and training facility makes a certain movement with his hand controller, for example, there will be exactly the same display outside his window or on the gages and dials and needles as there would be in the actual spacecraft.
The Spacecraft Control Technology Laboratory, on the other hand, will be a development facility, rather than another training facility. It will be used to help solve problems as they are bound to arise in a program like Apollo. For example, if, on the first orbital mission, we find that the spacecraft does not react exactly in space as we had hoped it would, that the reaction to a certain control movement is different, that the displays don't give the proper information, then we have to go back to this facility, which is a laboratory-type facility where we can make changes in the systems, changes in displays. It will have a very flexible computer complex associated with it, where we can then try out these changes before we incorporate them in the actual spacecraft and in the mission simulation and training facilities.
Colonel GOULD. Doesn't this duplicate to a certain extent some research along these lines being performed at Langley or at other NASA installations?
Mr. Low. I don't believe it does in that this facility is geared as a developmental test facility rather than a research facility. It will take an existing piece of hardware and change it, develop it, do with it what is necessary to make it useful, if it is not completely useful at any given point in time.

The Langley facilities lead the state of the art by a period of time. They research and develop new equipments that would be used 5 or 10 years hence.

Colonel GOULD. Back to the research laboratories, if something goes wrong with equipment do you not bring it back and put it through the cycle again for further research?

Mr. HOLMES. Not usually, no. Usually the research in these other centers is not that directly applied to the development hardware. In the manned space program, we are not getting any significant amount of development of hardware from the other centers, other than Houston and Huntsville, and LOC.

Colonel GOULD. We were told that the function basically of the Manned Spacecraft Center was primarily one of operations and training, but there appear to be quite a few research activities being conducted.

Mr. LOW. I call them development activities.

Colonel GOULD. Development, not research?

Mr. HOLMES. It is to my mind the Center we are establishing in the United States that has the U.S. capability to develop manned spacecraft, and secondary to that, although perhaps just as equally important, secondly to that we are establishing a flight training operation. But there really are two distinct missions and functions for Houston, and both are very important, I think.

Mr. GURNEY. Mr. Chairman.

Mr. DADDARIO. Have you finished?

Colonel GOULD. Yes, sir.

Mr. DADDARIO. Yes, Mr. Gurney.

Mr. GURNEY. I expect in the Mercury program we did a great deal of the same work and effort which this Control Technology Laboratory is going to do; is that correct?

Mr. LOW. Not to nearly the scale we will have to do it in Apollo, because Apollo and Gemini, for that matter, will have a guidance system as we did not have in Mercury. As we pointed out earlier, the Apollo spacecraft and the Gemini will be able to fly through their own propulsion systems along guided trajectories that can be changed in the mission, while Mercury flew along a fixed path, a fixed path in space. This facility is geared primarily for the further development of these guidance and control systems that did not exist in Mercury.

Mr. GURNEY. And isn't there any equipment available which you used in the Mercury program which could accomplish this?

Mr. LOW. No, sir.

Mr. GURNEY. This is entirely new?

Mr. LOW. There was no guidance equipment in the Mercury program.

Mr. WAGGONNER. This item of $1.75 million for simulated space scenery, is this for development of space scenery or for purchase?

Mr. LOW. This is for a development contract. I don't particularly like the word "scenery."

Mr. WAGGONNER. That is what it says, though.

Mr. LOW. I know it does. That is a mistake in our preparation. It is for displays of what astronauts would see out the window, the particular relationship of the Moon, the Earth and the stars, for example, by which he will navigate.

Mr. WAGGONNER. In other words, this is really for training?

Mr. Low. No, it is for the development of the guidance equipment that will be used by the astronaut in making his navigation corrections.

Mr. WAGGONNER. That is all.

Mr. DADDARIO. Colonel Gould.

Colonel GOULD. As a followup on Mr. Waggonner's question, I notice that like equipment in the mission simulation and training facility is only $238,000. What is the difference between these two items?

Mr. Low. The out-of-the-window displays, as we call them, for the mission simulation and training facility are part of the $33 million item that I mentioned before, the simulators and trainers, themselves.

What page were you on before, Colonel Gould, when you had the——

Colonel GOULD. I will have to look it up now. Test equipment recording instrumentation, which includes scenery, according to the justification on page CF 8–31.

Mr. Low. No, the test equipment and recording instrumentation on 8–31 is equipment used to maintain checkout, and so on, on the simulator. It is not the simulator.

Mr. PATTEN. Why not take out the word "scenery" and call it something else right now?

Mr. Low. Yes, sir.

Mr. PATTEN. You said you didn't like it. We didn't like it.

Mr. Low. It is actually simulator space display equipment. The word can be left out. I will take it out.

Colonel GOULD. Has the design been initiated on this project?

Mr. LILLY. No, design has not been initiated on this project.

Colonel GOULD. Do you intend to initiate it prior to the end of the fiscal year?

Mr. LILLY. Yes.

Colonel GOULD. How much in advance design funds will be used?

Mr. DIAZ. $278,000.

Mr. GURNEY. One further question. In facilities like this launch environment and mission simulator and spacecraft control—are we planning for the future or is this simply a one-show Apollo equipment? Are these buildings going to be used for further missions in space?

Mr. Low. These buildings will be able to be used for further missions in space.

Mr. GURNEY. And are they being designed with that in mind?

Mr. Low. Yes, sir.

Mr. GURNEY. That is all.

Mr. DADDARIO. Gentlemen, those bells indicate a quorum call. I have just one quick question of Mr. Holmes. Could you give us the present status of the Cooper flight, when do you expect it will be going off?

Mr. HOLMES. I have the information, Mr. Chairman, but could I do it privately? NASA has only announced mid-May, even though it has been reported in the press as being on certain days like May 7, and so forth. If I say publicly what it is, I would obviously be announcing it.

Mr. DADDARIO. We will leave it in that area, somewhere around mid-May.

Mr. HOLMES. Yes.

Mr. DADDARIO. The meeting will adjourn until 10 o'clock Friday in room 356 in the Old House Office Building. At that time I would like everyone to keep in mind that we have a great number of items to go through, and we will try to proceed with a little more haste than we did this morning. Thank you, gentlemen.

Mr. HOLMES. Thank you, sir.

(Whereupon, at 12:05 p.m. the subcommittee adjourned, to reconvene at 10 a.m., Friday, April 26, 1963, in room 356, Cannon Building.)

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1964 NASA AUTHORIZATION

HEARINGS

BEFORE THE

SUBCOMMITTEE ON MANNED SPACE FLIGHT

OF THE

COMMITTEE ON SCIENCE AND ASTRONAUTICS

U.S. HOUSE OF REPRESENTATIVES

EIGHTY-EIGHTH CONGRESS

FIRST SESSION

ON

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1964 NASA AUTHORIZATION

FRIDAY, APRIL 26, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON MANNED SPACE FLIGHT,
Washington, D.C.

The subcommittee met, pursuant to recess, in room 356, Cannon Building, at 10 a.m., Hon. Olin E. Teague (chairman of the subcommittee) presiding.

Mr. TEAGUE. The committee will come to order. Please proceed Mr. Holmes.

STATEMENT OF D. BRAINERD HOLMES, DEPUTY ASSOCIATE ADMINISTRATOR AND DIRECTOR, OFFICE OF MANNED SPACE FLIGHT, NASA; ACCOMPANIED BY WILLIAM E. LILLY, DIRECTOR, PROGRAM REVIEW AND RESOURCES MANAGEMENT; GEORGE M. LOW, DEPUTY DIRECTOR (PROGRAMS); R. A. DIAZ, ASSISTANT DIRECTOR FOR FACILITIES, PROGRAM REVIEW AND RESOURCES MANAGEMENT, AND STANLEY SMOLENSKY, DEPUTY DIRECTOR, OFFICE OF LAUNCH VEHICLES AND PROPULSION

Mr. HOLMES. Yes, sir. We are prepared to start, Mr. Chairman. I believe in the last session we reviewed almost all of the Facilities for the Manned Spacecraft Center in volume IV, part 2 of "Construction of Facilities."

Mr. TEAGUE. I think Colonel Gould has one or two more questions.

Mr. HOLMES. Fine. I believe that we stopped at CF 8-42, the ultrahigh vacuum chamber facility.

Colonel GOULD. I have a few more questions, Mr. Holmes, on the project for the Spacecraft Control Technology Laboratory.

Mr. HOLMES. Yes, sir.

Colonel GOULD. One has to do with something that Mr. Fulton mentioned and that is the cost of the facility which is indicated at $37.49 per square foot. Do you have any information with you that would give us some of the structural characteristics that might support $37.49 per square foot.

Mr. HOLMES. Yes, I think that Mr. Diaz can discuss this, Colonel Gould.

Mr. DIAZ. Yes. The building is a three-story structure 45 feet high. Certain areas within the building will have 45-foot clear ceiling heights, other areas will have 30-foot clearance. Special seismic foundation also will increase the cost. These are some of the special features that we have in the structure.

Colonel GOULD. All right. I would also like to know what is included in the Special Projects Laboratory equipment for $646,000, please?

Mr. LOW. The special projects laboratory is one of several laboratories within this building. As we discussed before the facility is used first for component testing, then complete system testing, and then complete guidance and control system testing within spacecraft modules.

This total testing will be done in the Special Projects Laboratory. The equipment within this laboratory includes such things as static control systems test stands, general purpose electronic test equipment, control equipment to tie this facility in with the thermochemical test area, so that we can run hot tests on reaction control systems, and at the same time they can check out the reaction in the guidance system and similar types of equipment.

Colonel GOULD. Has the design been started on this facility?

Mr. DIAZ. It will start next month.

Colonel GOULD. What funds are you going to use?

Mr. DIAZ. $278,000 advanced design funds from fiscal year 1963.

Colonel GOULD. Is that in addition to the $301,000?

Mr. DIAZ. It is included therein.

Colonel GOULD. Included?

Mr. DIAZ. Yes.

Colonel GOULD. That is all I have, Mr. Chairman.

Mr. LOW. The next facility, Mr. Chairman, is listed in volume IV, part 2 of the budget requests on pages CF 8–42 to 8–44. It is an ultrahigh vacuum space chamber facility to test mechanical components of Apollo spacecraft under higher vacuum conditions than is possible in the larger space chambers. We are requesting for this facility a total of $2,685,000 which includes $68,000 for site development and utility installations, $240,000 for facility construction and modifications, $2,051,000 for equipment, instrumentation, and support systems, and $326,000 for design engineering.

The facility is scheduled to be ready for use in March of 1965.

Mr. TEAGUE. Colonel Gould.

Colonel GOULD. In fiscal year 1962, a project for an Environmental Testing Laboratory in the amount of $26.5 million was authorized which included a vacuum space chamber. According to a recent press release by NASA, I believe, RCA has been awarded a contract for two vacuum chambers at Houston. I assume these are for that fiscal year 1962 project; is this correct?

Mr. LOW. RCA got the contract for the solar simulators within those two chambers in the fiscal 1962 project.

Colonel GOULD. I understand that these vacuum chambers and the solar simulators will be installed by the end of calendar year 1964; is this correct?

Mr. DIAZ. That is correct.

Mr. LILLY. That is correct.

Colonel GOULD. What is the relationship between the Ultrahigh Vacuum Space Chamber Facility and the 1962 project?

Mr. LOW. The fiscal year 1962 project consists of two large space chambers for testing. One of these is very large and will be able to test the complete Apollo command, service, and lunar excursion modules as a unit. It has a vacuum capability of 10^{-4} millimeters of mercury. This is not a very severe vacuum. It will allow us to do much of the testing that has to be done for the Apollo mission.

The smaller chamber in the fiscal year 1962 project has a similar vacuum capability and allows additional testing of men in the command module, environmental control systems testing, and so on.

The fiscal year 1964 request is for a smaller chamber, only about 6 feet in diameter. It will have a capability of going to a vacuum that is about four times as high as the fiscal year 1962 project facilities. We need this to test the mechanical components, for example, the landing gear on the lunar excursion module, because materials tend to change in these very high vacuums, and the new phenomenon that we might get into there must be checked out before we can accomplish the mission.

Colonel GOULD. I noticed recently that the Bethlehem Corp. is going to build a simulator at Goddard in the near future. This facility is supposed to be 9 feet in diameter by 15 feet long, and with pressures of 10^{-8}. Why couldn't this facility at Goddard be used to meet this need?

Mr. LOW. In order to get into the vacuum welding and other phenomena that we have found in very small chambers like bell jars, one has to get to vacuum levels of 10^{-12} to 10^{-15}, while the Goddard chamber, as you pointed out, only goes to 10^{-8}. I would like to point out that, before we decided to request this facility, we surveyed all existing facilities, either existing or being built, which included 25 chambers within the Government, 77 within industry, and not one of them meets the criteria that we must have for this chamber.

Colonel GOULD. Mr Chairman, a recent inventory of thermovacuum facilities indicated that there were a total of 23 in existence both in industry and in the Government agencies. In addition to that, there are eight which will come into being by the end of calendar year 1964, I believe, which will have a solar capability.

I would like to present this inventory to NASA, and ask that they indicate why these facilities will not meet their requirement at Houston. This information could be supplied for the record.

Mr. TEAGUE. Without objection, it is so ordered.

(The information requested is as follows:)

Comparison of Existing or Planned Vacuum Chambers With MSC Ultra-High-Vacuum Space Chamber Facility

Each of the 31 facilities listed in the attached inventory was examined with regard to its capability for fulfilling the Apollo spacecraft development requirement. None of the 31 chambers examined has the ultra-high vacuum capability which is essential for testing the Apollo spacecraft components under the extreme vacuum conditions that will be encountered during the Apollo mission. The testing capability provided by the MSC ultra-high-vacuum space chamber facility is absolutely essential in order to insure satisfactory performance of the Apollo spacecraft components under prolonged exposure to the translunar and lunar environment.

Inventory of major thermal vacuum facilities (without solar simulation)

Location	Size (feet) (diameter by height)	Operational
1. Aeronutronic, Newport Beach, Calif.	8 by 21	
2. Airesearch, Torrance, Calif.	15 by 15	
3. Arnold Engineer Development Center, Tillahoma, Tenn.	7 by 12 19 by 32	
4. Ball Bros. Research, Boulder, Colo.	10 by 15	
5. Beach Aircraft, Wichita, Kans.	10 by 20	
6. Bell Telephone Laboratory, Whippany, N.J.	9 by 13	
7. Bendix Systems Division, Ann Arbor, Mich.	20 by 27	
8. Chance Vought, Dallas, Tex.	12 by 16	
9. Convair, San Diego, Calif., Dallas, Tex.	12 by 20 12 by 16	
10. Douglas MSSD, Huntington Beach, Calif.	30-foot sphere	Mid-1963.
11. Fairchild, Syosset, N.Y.	15 by 13 by 14	
12. General Electric, Valley Forge, Pa.	(3) 30-foot sphere	
13. Grumman Aircraft, Bethpage, N.Y.	15 by 20	
14. Hughes Aircraft	15 by 28	Mid-1963.
15. Lockheed, Sunnyvale, Calif.	20 by 20	
16. McDonnell Aircraft, St. Louis, Mo.	20 by 36	1963.
17. NASA, Goddard Space Flight Center, Greenbelt, Md.	35 by 60 18 by 30 12 by 15	1963.
18. NASA, JPL, Pasadena, Calif.	7 by 12	
19. NASA, Langley Research Center, Langley, Va.	58 by 63	
20. North American Aviation, El Segundo, Calif.	15 by 27	Mid-1963.
21. RCA Space Center, Princeton, N.J.	26 by 20	
22. Republic Aviation, Farmingdale, N.Y.	13 by 18	
23. Wright-Patterson AFB, Dayton, Ohio	8 by 25	

Inventory of major space simulators (with solar capability)—solar simulation capability

Location and dimensions	Type of system	Objective beam size, intensity	At present size	Status remarks
1. AEDC, Air Force, Tullahoma, Tenn.; 42 feet diameter by 75 feet high.	Horizontal beam, modular carbon arc system has been investigated by RCA for Air Force.	20 feet wide by 40 feet high; 130 watts per square foot.	Not built yet.....	Basic facility contract did not include solar. Final solar system has not been selected. Estimated availability, calendar year 1965.
2. General Electric Co., Valley Forge, Pa.; 32 feet diameter by 54 feet high.	Vertical down beam, off axis, virtual source, quadrisected parabola, 148, 5-kilowatt xenon lamps.	20 feet diameter; 130 watts per square foot.	20 feet diameter; 80 watts per square foot.	Plan to upgrade primary mirror sections to improve intensity and uniformity. Estimated availability, late calendar year 1963 or early 1964.
3. Hughes Aircraft, Culver City, Calif.; 15 feet diameter by 28 feet high.	Similar G.E. system, off axis, 2.5-kilowatt xenon or mercury-xenon lamps.	8 feet diameter; 130 watts per square foot.	Not built yet.....	Initial contract terminated with Spectro Laboratory because inability to meet performance. Estimated availability, calendar year 1964.
4. NASA Goddard SFC, Greenbelt, Md.....	Vertical down beam, modular projection, about 1,251 modules each 2.5-kilowatt mercury-xenon lamp.	18 feet diameter; 130-plus watts per square foot.	.....do.....	Recent M–H prototype tests very encouraging. Earliest contractors estimate is November 1963. Estimated availability for operation, calendar year 1964, 1st quarter.
5. NASA Jet Propulsion Laboratory, Pasadena, Calif.	Vertical down beam, off axis, virtual source, 131 2.5-kilowatt mercury-xenon lamps (modified from on-axis system).	10-foot diameter, 200 watts per square foot.	5 feet diameter, 170 watts per square foot.	Plan to upgrade in next 6 to 12 months to obtain 270 watts per square foot or more and increase size to 8 to 10 diameter with 130 to 200 watts range.
6. NASA Manned Spacecraft Center, Houston, Tex., chamber A, 65 feet diameter by 120 feet high.	Vertical down beam and horizontal beam RCA modular carbon arc projection system.	13-foot diameter, 13 feet wide, by 40 feet high, 130 watts per square feet.	Not built yet.....	Contract recently awarded to RCA. Being designed. Installation schedule is December 1964. Estimated operational schedule calender year 1965.
7. NASA Manned Spacecraft Center, Houston, Tex., chamber B, 35 feet diameter by 45 feet high.	Horizontal beam and vertical beam ultimate RCA modular carbon arc projection system.	Initial beam 6-foot diameter, 130 watts per square foot.	.....do.....	Same status as chamber A. (10^{-6} torr). Note: An ultra-high-vacuum chamber for 10^{-12} to 10^{-13} torr with 6-foot solar beam is in CF fiscal year 1964 budget.
8. Space Technology Laboratories, Los Angeles, Calif.	Modular carbon arc system with parabolic collimate mirrors inside chamber.	4 feet by 8 feet, 130 watts per square foot.	.....do.....	Design details not released. Awaiting development smaller system using same principle. Estimated availability calendar year 1964.

Inventory of major space simulators (with solar capability)—solar simulation capability

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6. NASA Manned Spacecraft Center, Houston, Tex., chamber A, 65 feet diameter by 120 feet high.	Vertical down beam and horisontal beam RCA modular carbon arc projection system.	13-foot diameter, 13 feet wide, by 40 feet high, 130 watts per square foot.	Not built yet.....	Contract recently awarded to RCA. Being designed. Installation schedule is December 1964. Estimated operational schedule calender year 1965.
7. NASA Manned Spacecraft Center, Houston, Tex., chamber B, 35 feet diameter by 43 feet high.	Horisontal beam and vertical beam ultimate RCA modular carbon arc projection system.	Initial beam 6-foot diameter, 130 watts per square foot.	.....do.....	Same status as chamber A. (10^{-6} torr). Note: An ultra-high-vacuum chamber for 10^{-13} to 10^{-15} torr with 6-foot solar beam is in CF fiscal year 1964 budget.
8. Space Technology Laboratories, Los Angeles, Calif.	Modular carbon arc system with parabolic collimate mirrors inside chamber.	4 feet by 8 feet, 130 watts per square foot.	.....do.....	Design details not released. Awaiting development smaller system using same principle. Estimated availability calendar year 1964.

Colonel GOULD. Has the contract for construction of the Environmental Testing Laboratory authorized in fiscal year 1962 been awarded?

Mr. DIAZ. The contract for the laboratory itself has not been awarded as yet.

Colonel GOULD. When do you anticipate that it will be awarded?

Mr. DIAZ. It is anticipated that it will be awarded this summer.

Colonel GOULD. What is the construction lead time?

Mr. LOW. Our scheduled operational date for fiscal year 1962 facilities is February 1965, with joint occupancy starting in September 1964.

Colonel GOULD. If this facility is approved as part of the fiscal year 1964 program, will this be constructed as a modification to the fiscal year 1962 project or as a separate contract?

Mr. DIAZ. That has not been determined as yet, but it very likely will be constructed as a modification to the contract for the fiscal year 1962 project that will be under construction at that time.

Colonel GOULD. This is an addition to the building?

Mr. DIAZ. That is correct.

Colonel GOULD. Has design started on the fiscal year 1964 item?

Mr. DIAZ. It has not, we will start next month.

Colonel GOULD. Do you intend to use fiscal year 1963 advance design funds?

Mr. DIAZ. Correct.

Colonel GOULD. How much?

Mr. DIAZ. $307,000.

Colonel GOULD. Is that included in the total of $326,000 shown on page CF 8–4?

Mr. DIAZ. It is included.

Colonel GOULD. That is all I have on that project, Mr. Chairman.

Mr. LOW. The next facility I would like to discuss, Mr. Chairman, is listed under various locations on page CF 13–36 and following pages. It is a lunar excursion module test facility at the White Sands Missile Range.

Mr. TEAGUE. CF 13–36?

Mr. FUQUA. What book is that in?

Mr. LOW. Volume IV, part 2, CF 13–36, under "Various Locations."

As you know, Mr. Chairman, using fiscal year 1963 funds we have started construction of a facility at White Sands to test the propulsion system of the service module of the Apollo spacecraft. Adjacent to this facility in the same area we are requesting funds to build a facility to test the propulsion systems of the lunar excursion module.

For this facility we are requesting $15 million, including $1,732,000 for site development and utility installations, I am now on page CF 13–41.

As I mentioned $1,732,000 for site development and utility installations; $6,982,300 for facility construction and modification; $5,019,700 for equipment, instrumentation, and support systems; and $1,266,000 for design engineering, for a total of $15 million.

This facility and the facility in the 1963 budget for the command and service modules are being constructed under the auspices of the Corps of Engineers.

Mr. TEAGUE. Any questions, Colonel?

Colonel GOULD. Yes, sir.

In the fiscal year 1963 program, a Lunar Landing Simulation Facility was authorized in the amount of $6.5 million. Subsequent, to the enactment of the law, I understand, it was deleted by NASA. I assume that this deletion was occasioned by your change from Nova to the LOR concept, is this correct?

Mr. Low. This facility was planned for Houston and our further planning, including the lunar orbit rendezvous design, dictated that we should delete this facility.

Colonel GOULD. Since the $6.5 million that was justified is more or less analogous to the type of facility that is proposed, why couldn't this previous authorization be applied against the $15 million requirement for fiscal year 1964.

Mr. Low. It was an entirely different facility. This is a propulsion test facility. The fiscal year 1963 requirement was a flight simulation facility for astronaut training.

Perhaps Mr. Lilly would like to add to this answer.

Mr. LILLY. As you know, Colonel Gould, we in the Office of Manned Space Flight were faced with the situation of an authorization from this committee of approximately $582 million against which we had cash to apply of approximately $535 million. The $6.5 million for this facility was applied to other facility requirements that we had, such as the Mission Control Center, the S–II stage facilities, and other items that had not been budgeted.

Colonel GOULD. During a briefing by the North American Aviation Co. in California recently, this committee learned that approximately $10 million of R. & D. funds under North American's contract is being spent for the construction of test and ancillary facilities at the White Sands Proving Grounds. Is this $10 million the same funds that you referred to as 1963?

Mr. Low. Yes. And since that time we have changed our method of operation in that this facility will not be constructed under North American's contract, and North American supervision, but will be constructed under Corps of Engineers supervision, directly for NASA.

Colonel GOULD. Well, in a paper released by NASA on February 21, 1963, there was an indication that the North American organization had already proceeded with some of this construction. How much was spent before you made the determination to change the method of getting this work done?

Mr. Low. The work that was done, I will have to get the exact number for the record, but the work that was done under North American subcontract was done by the Parsons Co. Engineering Services. This contract has now been transferred to the Corps of Engineers.

The Corps of Engineers is managing this contract now. It is a continuation of the same subcontract, though.

Colonel GOULD. This would just be a change in contracting officers, then, rather than a termination of one contract and award to another?

Mr. DIAZ. That is correct.

Mr. Low. That is correct, a change in the contracting management and supervision.

Colonel GOULD. Are there any facilities still included in the North American contract?

Mr. Low. Not at White Sands.

Colonel GOULD. Are there at Downey?

Mr. Low. Yes, at Downey.

Colonel GOULD. Would you repeat again, please, how much of these R. & D. funds are being transferred for this construction at White Sands?

Mr. LILLY. The figure is $9,084,000.

Colonel GOULD. And that is in addition to this $15 million that is being requested from construction funds for fiscal year 1964?

Mr DIAZ. That is correct.

Mr. Low. This is for two different parts of the facility, though, the fiscal 1963 funds at White Sands were for the command and service module test facility. The fiscal 1964 funds are for the lunar excursion module test facility.

Colonel GOULD. Do you happen to have a large blowup of the site area so you can explain this to us, please? It is a little confusing as to what is to be done with the $15 million you are requesting, and what work is already underway.

Mr. Low. I don't have such a blowup with me.

Mr. HOLMES. We can provide one if you would like one. It would show them separately located, of course, but I think that the main point is that in our present plan and funding that is authorized we are trying to test the service module, which as you know is the module which lets us deboost into lunar orbit and also take off from lunar orbit, whereas this facility request is for the bug in the testing of both, its descent and ascent engines.

Colonel GOULD. Would you provide for the record a statement that will show the relationship of these two facilities in detail?

Mr. HOLMES. Yes, sir.

(The information requested is as follows:)

Two propulsion testing facilities in support of the Apollo lunar landing program are planned to be constructed at the White Sands Missile Range. The first, or phase I facility, will be used for the service module engine tests and the second, or phase II facility, will be used for the lunar excursion module engine and vehicle hover tests.

These two facilities are planned to be constructed on White Sands Missile Range property located on the western side of the San Andres Mountain Range, approximately 8 miles north of Organ, N. Mex. This property consists of an area approximately 10 miles by 8 miles and by a NASA/DOD agreement has been assigned to NASA for use as a propulsion testing area.

The phase I facility was funded in fiscal year 1963 for $9,084,000 and includes a test area and administrative area. The test area will include two test stands for testing the service module engine; one control center for controlling the tests on both stands; two ground control centers, one adjacent to each test stand to house certain control equipment; a preparation building for preparing the spacecraft modules for delivery to the test stands; a propellant and cryogenic storage area for efficient storage and transfer of propellants and cryogenics to the test stands; and supporting utilities: water, sewage, electrical roads, parking. The administrative area will include an office building for use by NASA and contractor personnel, a fire station for protection of the entire area, a cafeteria, and certain other support buildings for storage and maintenance.

The phase II facility is the proposed fiscal year 1964 lunar excursion module (LEM) test facility at an estimated cost of $15 million. This facility will be located approximately 1 mile from the phase I facility to enable simultaneous testing on both the phase I and phase II test stands. This facility will provide a LEM propulsion testing area and an area for conducting tethered and hover flight tests of the LEM. The propulsion testing area will include four test stands for testing the lunar touchdown engine and the lunar takeoff engine, along with combined systems testing when in a mated position; a control center for controlling the tests on all stands and the flight tests; four ground control centers, one adjacent to each test stand to house certain control equipment; a preparation building for preparing the lunar excursion module for delivery to the test stands; flight testing

area to be used for testing the lunar excursion module in restrained flight; supporting utilities, extension of the propellent system and the cryogenic system from the phase I storage area to the test stands; additions to the phase I administrative area to accommodate additional phase II personnel; and requirements for phase II storage and maintenance.

The phase I and phase II test stands will be designed for the specific engines and configuration of the respective modules; that is, the service module and the lunar excursion module. The test stands are sited to permit concurrent tests to be conducted on all stands. The total area and total operational and testing requirements have been studied in determining the minimum facilities to be constructed and in arriving at the most economical arrangement. These studies have resulted in a common propellent and cryogenic storage area; a common administrative area; common security, storage, and maintenance areas; common fire protection system; and minimum integrated road and utility systems.

Colonel GOULD. How many NASA personnel and how many contractor personnel will operate these facilities for which you are requesting $15 million this year?

Mr. LOW. The total personnel expected to be in the White Sands area is 321 at the end of this calendar year, 985 at the end of calendar year 1964, and about 1,000 in 1965 and 1966. The NASA complement there will be relatively small, 70 people in 1963, building up to 100 or 150. The remaining people will be contractor people for North American, for Grumman, and from General Dynamics, Convair Division, who will launch the Little Joe II launch vehicle in another area at White Sands Missile Range.

Colonel GOULD. I reviewed this estimate and it appears that it was very preliminary in nature when it was put into the book. Do you have a more refined estimate at this time?

Mr. LILLY. We do not at this time. The criteria for this facility will not be completed until next month.

Colonel GOULD. Have you started design on this $15 million requirement?

Mr. DIAZ. No, sir, we have not.

Colonel GOULD. Do you intend to before the fiscal year 1964 program is acted upon?

Mr. DIAZ. Yes, sir, we intend to start design about the middle of June.

Colonel GOULD. Using fiscal year 1963 advance planning funds?

Mr. DIAZ. We have $500,000 advance planning funds for this facility.

Colonel GOULD. Is that $500,000 included in the $1,266,000 shown on CF 13-42?

Mr. DIAZ. Yes, sir.

Colonel GOULD. What is the latest date that this facility is needed?

Mr. LOW. October 1964.

Colonel GOULD. What are your construction and design leadtimes?

Mr. LOW. We figure on 12 months for construction.

Colonel GOULD. It is going to be tight, isn't it?

Mr. LOW. It is. Very tight.

Colonel GOULD. The Control Center is estimated at $66 a square foot. Can you explain the reason for that high cost or do you have enough information yet to analyze this cost?

Mr. DIAZ. We do not have enough information at the present time to——

Mr. HOLMES. I would like to correct that. If we are putting it at $66 there must be some basis for it and I would like to see the basis in the record, either that or change the estimate.

Mr. LILLY. The apparent high cost per square foot is due to the blast protection construction that is required and the specialized mechanical filtering system.

Mr. HOLMES. Isn't this a thick wall?

Mr. DIAZ. It will be a heavy blast wall.

Mr. FULTON of Pennsylvania. Before you leave that, Mr. Chairman, at our last meeting I asked NASA to provide for the record an explanation of the costs per square foot of all the buildings and to justify the differences. That should apply to every such facility, not just the ones I mentioned previously.

Mr. HOLMES. Yes, Mr. Fulton. You did request that data and we will provide the information.

Mr. FULTON of Pennsylvania. If we could have that for the record, I would appreciate it.

(The information referred to is contained in appendix A.)

Colonel GOULD. You are asking for an addition to the administration building; does an administration building exist at the present time?

Mr. LOW. This is additional floor space to the administration building currently planned in the fiscal year 1963 budget.

Colonel GOULD. Does this $15 million requirement constitute the total cost of all known requirements for this activity?

Mr. LOW. To the best of my knowledge, yes.

Colonel GOULD. In other words, there will be no requirements beyond fiscal year 1964 as you see it now?

Mr. LOW. We have not identified any as yet.

Colonel GOULD. That is all, Mr. Chairman.

Mr. DADDARIO. Any questions?

Mr. FULTON of Pennsylvania. Yes.

Mr. DADDARIO. Mr. Fulton.

Mr. FULTON of Pennsylvania. When we are talking of construction costs we should have comparable cost figures as to the type of building, the area, and the wage costs for the area. Likewise, we should have comparable cost figures on fencing, electrical systems, sewerlines, and things of that type, so that we have a method of comparison and correlation of these figures.

Mr. DADDARIO. Is it possible for you to take into consideration the kind of buildings involved to arrive at these comparisons, so to speak? There are no similar type buildings in the area, are there?

Mr. LILLY. This will be possible in certain cases on such structures as administration buildings and warehouses, but I don't think it will be possible on test stands and other structures of this nature.

Mr. DADDARIO. But you could prepare comparisons probably by following Mr. Fulton's suggestions involving wage scales, and that kind of thing. We could then figure out pretty well what the situation is. Would you agree with that?

Mr. FULTON of Pennsylvania. Yes, that is fine.

Mr. FUQUA. Along the same lines, here is one for a warehouse building at $15 per square foot. I am no builder, but from my knowledge of building this seems to be a little excessive even for a home. I think you should have these things in here so we can compare it. It seems to me the cost is a little excessive in these areas that I am familiar with.

Mr. LILLY. We will be glad to.

Mr. FUQUA. The administration building and warehouse.

Mr. LILLY. This particular one was based on the cost of other warehouses built at the White Sands Missile Range.

Mr. LOW. One of the problems at many of these facilities is that we must provide humidity control, dust control, and so forth, to control the entire environment and this makes the building somewhat more expensive.

Mr. FULTON of Pennsylvania. Those things should be separated. Simply to call it a warehouse building——

Mr. HOLMES. I think if we do what you asked and justify throughout the dollars per square foot, that it ought to answer most of these questions.

Mr. FULTON of Pennsylvania. Yes; I think it would, and that is why I have asked for it.

Mr. TEAGUE. Any further questions?

Mr. BELL. No questions.

Mr. TEAGUE. Colonel Gould?

Colonel GOULD. No, sir; that is all.

Mr. LOW. Mr. Chairman, there is one additional facility used in the spacecraft testing and development, and this is a spacecraft checkout facility located at the Launch Operations Center at Cape Canaveral. I would prefer to defer discussion of this facility until we cover the Launch Operations Center complex and then treat this as one of the facilities within that complex, if that is all right.

Mr. TEAGUE. It is all right.

Mr. FULTON of Pennsylvania. As a person interested in mathematics, it always has struck me as unusual when you come up with so many items and hit an exactly even figure of $15 million with six zeros. Who is the genius that computed that? Might they have started with the $15 million and gone back, or is it just a general estimate? If this is so, I think we should know it.

Mr. LILLY. This particular estimate, as I said a while ago, was prepared without any advance design information. Therefore, the estimate is based on engineering judgment. We will always find that the last three numbers in the budget book are zeros, since all estimates in the budget are rounded to the nearest thousand.

Mr. FULTON of Pennsylvania. Yes; but this really is hitting a peak when you get six zeros in so many figures.

Mr. TEAGUE. All right.

Mr. HOLMES. I would suggest, Mr. Chairman, that we return to the R. & D. part of the fiscal year 1964 budget book. I believe we have finished the manned spacecraft systems, both R. & D. portion and supporting facilities, with the exception of those located at the Launch Operations Center, and I believe we are then at page RDO2–1 which will start the justification of the request for funds for launch vehicle and propulsion systems. That is in volume II of our fiscal year 1964 budget book.

Mr. YEAGER. Mr. Chairman, may I ask a question before we go to that?

Mr. TEAGUE. Mr. Yeager.

Mr. YEAGER. I have a question on the supporting research and technology table that you had on page 4 of volume V.

Mr. Holmes. Yes, sir.

Mr. YEAGER. The fourth item from the bottom is meteorites and micrometeorites and the figure of $100,000. Now scattered throughout, in the other offices such as the Office of Space Science and Office of Advanced Research and Technology, there are seven or eight different items amounting to around $8 million or $9 million which also deal with meteorites and micrometeorites. Can you explain what is the difference between your $100,000 program and those being handled by the other offices? The day before yesterday in the Office of Space Sciences, Dr. Newell indicated that this was something that they would probably take over and do for you, and that you are now in discussion with them.

Mr. HOLMES. There are various aspects of meteorites and micrometeorites. There is, of course, the aspect of determining just the density of meteorites is, their energies, and we are doing various things to determine these factors. But also particularly related to the spacecraft technology, and Mr. Low may want to add to this, is the study of what does one do to protect a spacecraft against the impact of these micrometeorites. There are techniques such as having an absorbent protective coating that would absorb the shock rather than penetrate the shell.

There are studies of making the protective shell strong enough so that it will prevent penetration. There are studies as to what kind of a blast one might get if one of these high-speed particles penetrated a pressure shell that had an environment of oxygen.

Would you like to add to that, Mr. Low?

Mr. LOW. No; this is exactly the answer. Under the supporting technology tasks we are carrying specific tasks to test, in this case, Apollo or Gemini spacecraft structures with meteorite impacts, as opposed to the general effect to determine what is the meteorite environment.

Mr. YEAGER. Are you certain in your own mind that this is not something that is being handled in the other offices under their micrometeorite-meteorite program?

Mr. LOW. Absolutely, in that before we start any one of these tasks, we must get a signoff from the Office of Advanced Research and Technology, which is the focal point for all the meteorite studies. They are comparing this with all other studies.

Mr. YEAGER. There are two other items on this page that I would like to ask you about; that is, the item on space chemistry in the amount of $250,000, and also the item on geodesy and celestial mechanics in the amount of $590,000. The Office of Space Sciences is devoting $1,232,000 to space chemistry and something like $6,500,000 to geodesy and celestial mechanics. Can you describe how your activities differ?

Mr. LOW. The item on space chemistry for $250,000 is a study of the interaction of materials in the Apollo spacecraft, or external to the Apollo spacecraft, interactions of these materials with the space environment, how do these particular materials react? Under geodesy and celestial mechanics we have a number of contracts for the preparation of lunar charts and displays to be used by the astronauts in the spacecraft. This is the actual preparation of the mapping charts, star charts, lunar charts, that will form part of the displays, part of the map system that the astronauts will carry on the missions.

We found, for example, in Project Mercury, even though there are untold numbers of maps of the Earth, we had special maps prepared for the astronauts to carry for their purposes in Earth orbit. This is a similar type task here.

Mr. YEAGER. That is all, Mr. Chairman, thank you.

Mr. TEAGUE. All right. We go to RDOC–1.

Mr. HOLMES. Mr. Chairman, we have Mr. Stanley Smolensky with us here this morning. He is the Deputy Director of our Office of Launch Vehicles and Propulsion in the Office of Manned Space Flight, and he is prepared to testify on this particular section of our request.

(The biography of Mr. Smolensky follows:)

STANLEY M. SMOLENSKY

Stanley M. Smolensky has been Deputy Director of Launch Vehicles and Propulsion, Office of Manned Space Flight, NASA Headquarters, since August 27, 1962.

Prior to joining NASA he was general manager of a division with Thiokol Chemical Corp., Bristol, Pa. From 1957 to 1959, Mr. Smolensky was Hawk program coordinator and Hawk field support manager for Raytheon Co., Andover, Mass. He was with U.S. Army Ordnance from 1941 to 1956 and from 1949 to 1956 Smolensky was assigned to guided missile activities with Army Ordnance. He holds the rank of lieutenant colonel.

Mr. Smolensky was born April 29, 1918, in Cleveland, Ohio. He attended schools at Garfield Heights, Ohio, and studied at the Massachusetts Institute of Technology from 1938 to 1941, receiving a bachelor of science degree in 1941. He returned to MIT from 1946 to 1948 and received a master's of science degree.

Mr. Smolensky's military service includes campaigns in North Africa, Salerno, Anzio, and southern France. He holds the Bronze Star and Commendation Ribbon. His postwar Army service includes 2 years spent in Yugoslavia.

Mr. Smolensky has specialized in servomechanisms and fluid mechanics. He is a member of the Institute of Radio Engineers, American Rocket Society, American Management Association, Army Ordnance Association, and Air Force Association.

Mr. Smolensky is married to the former Clare Lamb. They have two children and live at 832 South Royal Street, Alexandria, Va.

Mr. SMOLENSKY. Good morning.

Mr. Chairman, prior to starting this group I have a chart which indicates the configurations of the various vehicles. Mr. Gurney had asked for that at one time.

Mr. HOLMES. May we submit this as part of the record, Mr. Chairman?

Mr. TEAGUE. Yes.

Mr. HOLMES. I think it would be interesting.

Mr. TEAGUE. Without objection, it will be so included.

Mr. SMOLENSKY. Mr. Chairman, I would like to call the attention of the group to this chart, which indicates the new nomenclature. It also will serve to orient you throughout the hearings. The Saturn I was previously designated the C–1; the Saturn IB, was previously called the C–1B, and the Saturn V was termed the Advanced Saturn.

Mr. FULTON of Pennsylvania. Will you say that again, please?

Mr. BELL. A little slower.

Mr. FULTON of Pennsylvania. The Saturn I configuration is what?

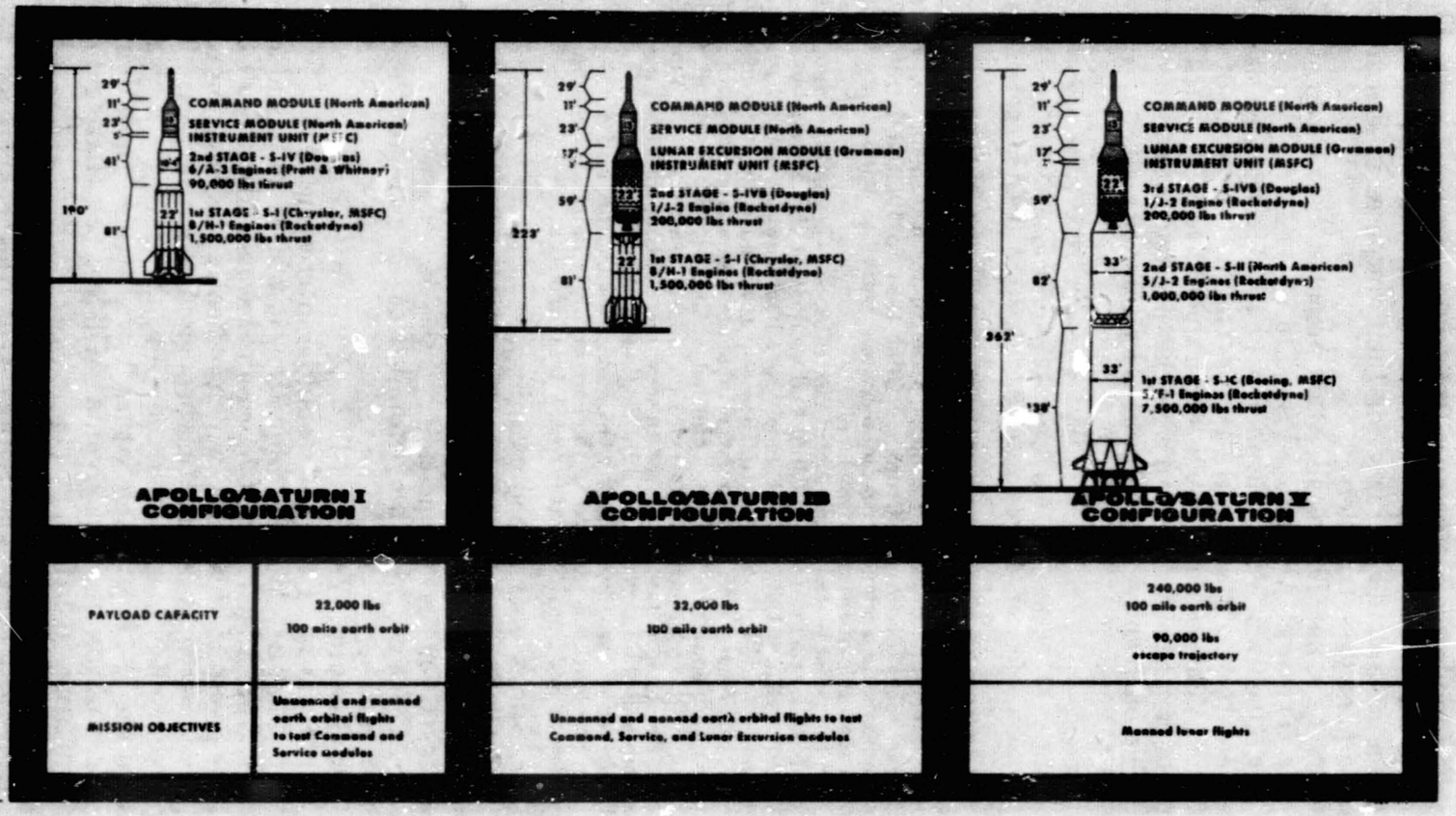
Mr. SMOLENSKY. The Saturn I on this chart used to be called the C–1.

Mr. BELL. What is it now?

Mr. SMOLENSKY. It is now the Saturn I.

Mr. HOLMES. This is merely a change in terminology in order to, we feel, clarify the situation.

APOLLO SPACECRAFT & SATURN LAUNCH VEHICLE CONFIGURATIONS



PAYLOAD CAPACITY	22,000 lbs 100 mile earth orbit	32,000 lbs 100 mile earth orbit	240,000 lbs 100 mile earth orbit 90,000 lbs escape trajectory
MISSION OBJECTIVES	Unmanned and manned earth orbital flights to test Command and Service modules	Unmanned and manned earth orbital flights to test Command, Service, and Lunar Excursion modules	Manned lunar flights

Mr. SMOLENSKY. The Saturn IB used to be called the C–1B.

Mr. FULTON of Pennsylvania. And the Saturn used to be what?

Mr. SMOLENSKY. The Saturn V used to be the C–5.

Mr. HOLMES. It also used to be the Advanced Saturn.

Mr. SMOLENSKY. Yes; it was also called the Advanced Saturn.

Mr. HOLMES. We are trying now to get people to drop the C, which merely stood for configuration 1 and to use this simpler terminology. By "people," I mean the people in our own office.

Mr. SMOLENSKY. I would now like to turn to page RDO2–1, which will be presenting the fiscal year 1964 estimates for the launch vehicle and propulsion systems. The objectives of the program are the launch vehicle and propulsion systems program supports, through the development of the required vehicle and propulsion systems.

The current goal is to achieve manned lunar landing and return in this decade. The program, as currently approved, consists of the development of the three Saturn launch vehicles previously mentioned.

Progress of the launch vehicle and propulsion program is indicated by the launch of the fourth Saturn (SA–4) on March 28 of 1963. The launch was completely successful, as were the others. The progression planned in the development capabilities of the vehicles is indicated by the weight-carrying capabilities of the vehicles.

Saturn I will place approximately 11 tons in Earth orbit; Saturn IB will place 16 tons in Earth orbit, and the Saturn V will place in excess of 100 tons in Earth orbit and will have a capability of over 40 tons on escape missions.

In the fiscal year 1964 budget estimates we are requesting $1,168,500,000 in direct R. & D. costs.

This amount is broken down into launch vehicle supporting technology for $16,900,000; propulsion supporting technology, $22,500,000; launch operations supporting technology, $7,600,000; Saturn I, $93,800,000; Saturn IB, $68,600,000; Saturn V, $733 million; for the M–1 engine development, $45 million; the H–1 engine, $5,200,000——

Mr. FULTON of Pennsylvania. Mr. Smolensky, could we suggest that as you come to the various engines you describe how they fit into the program, so that we have them by designation?

Mr. SMOLENSKY. Certainly.

Mr. FULTON of Pennsylvania. All right.

Mr. SMOLENSKY. The M–1 engine program does not support any of these particular vehicles. It is a separate engine development program.

Mr. FULTON of Pennsylvania. So it is not shown on your chart at all?

Mr. SMOLENSKY. It is not shown on the chart, correct.

Mr. DADDARIO. Mr. Chairman?

Mr. TEAGUE. Mr. Daddario.

Mr. DADDARIO. Well, it did rightfully belong within the manned lunar landing program when it actually was a part of the Nova vehicle, did it not?

Mr. HOLMES. I think that the M–1 does, Mr. Daddario, belong as part of our launch vehicle and propulsion system request in the Office of Manned Space Flight. However, it does not appear here as a part of the Apollo program, per se. We have in the past in our manned space flight budgets and our NASA budgets, included engine

developments which usually precede stage developments by several years.

Mr. DADDARIO. If you didn't put it here, where would it go, since the goal under this section is the achievement of the manned lunar landing and return? If it were placed under another category, what would that category be?

Mr. HOLMES. It is true that our budget for manned space flight includes any and all requests of NASA for manned space flight. For instance a manned space station, separate from going to the Moon, would appear within this budget and the engines for such a mission as the manned space station would appear here, if new ones were required. The only other placed that it could logically go would be in the Office of Advanced Research and Technology, and indeed, it does not fit that application.

Mr. DADDARIO. Where did you have it last year?

Mr. HOLMES. Last year we had all of the engines, including the F–1 and H–1 engines, under the budget of the Office of Advanced Research and Technology. The reason was that the reorganization of NASA had not caught up with the presentation of the budget books.

Therefore, we have all of our engines, both for the lunar program as well as other engines for manned space flight or any other projects for manned space flight in our manned space flight budget request.

Mr. FULTON of Pennsylvania. Would you yield?

Mr. TEAGUE. Mr. Fulton.

Mr. FULTON of Pennsylvania. The M–1 engine is an upper stage liquid hydrogen and oxygen engine in the process of development; that means it is beyond technical research. My question is: What is the mission for the M–1 engine? If it does not fit in the Apollo space flight programs, where does it fit?

Mr. DADDARIO. Mr. Fulton, before we go into that, I would like to ask Mr. Yeager a question just to clear something up.

Is it my understanding, Mr. Yeager, that we will be going into this particular engine at greater length on Wednesday of next week?

Mr. YEAGER. I was assuming that it would be about May 2. If we start right down the list with these various items we will come to the M–1 engine. It is about six items away, so I assume we will cover it at the meeting next Wednesday.

Mr. FULTON of Pennsylvania. I am simply asking where does the M–1 engine fit, with what other booster, and for what mission?

Mr. HOLMES. Yes. The M–1 fits into our present planning for follow-on programs for larger boosters; it does not today have a requirement for a specific launch vehicle stage.

Mr. FULTON of Pennsylvania. Nor a mission?

Mr. HOLMES. Nor an approved mission.

Mr. FULTON of Pennsylvania. Nor a time limit when the M–1 engine must be ready?

Mr. HOLMES. That is correct. I think the justification for the M–1 is the same justification as we had for the F–1, started several years ago. We know that the leadtime required for development of an engine is many years more than that required for a booster stage. If we wish to have this continued growth capability, we must be working on the engines today.

Mr. FULTON of Pennsylvania. Outside of your in-house development of the M–1 engine, you have had no contract, and don't have one today?

Mr. HOLMES. We do have a contract for the M–1, which is a letter contract with Aerojet General Corp., to develop this engine. It was to be developed as a 1.2-million-pound-thrust engine for use in the second and third stages of the Nova vehicle. With the deferral of Nova development, we deemed it wise to achieve a more advanced concept, not just a double Saturn, as far as payload capability is concerned.

Mr. FULTON of Pennsylvania. Does the letter of intent have within it the full $233 million proposed development expenses on the M–1 engine?

Mr. HOLMES. No, sir; it does not. I would have to obtain the total amount authorized in the letter contract. However, we are reviewing the contract for definitization right now.

Mr. WAGGONNER. Mr. Holmes, if we have no Nova vehicle now and we have no mission for this particular engine, why spend the money at this time? We have kept the Air Force out of the space program in times gone by because they didn't have a mission. So why does NASA propose this expenditure when we have abandoned the Nova program as such? Several days ago before this committee you testified that the Nova program would never be developed as it was originally planned. If Nova was pursued further, it would be a 1970 model or 1970 version of Nova, rather than the 1963 version. Aren't we wasting $45 million here still talking about a 1963 or 1964 version of an M–1 engine which doesn't have a mission?

Mr. HOLMES. No, sir; I don't think so. We have reoriented this contract with Aerojet General to make this a more advanced engine of a capability of about 1.5 million pounds of thrust, instead of 1.2 million, so that as we continue to move ahead in space we will have the necessary propulsion power.

As you know, a limiting factor in our space operations, as contrasted to Russia's, has been their capability to accelerate masses at higher speeds than we could by the order of about 5 to 1. If we had not started the development of the F–1 engine—with no immediate mission in terms of a specific booster—several years ago, our whole Apollo mission would be delayed today by several years. Based on the concept of how long it takes to develop an engine, we believe that there is justification in starting today on a hydrogen fuel engine of that power.

Mr. WAGGONNER. When do you feel that we will have a mission for this M–1 engine?

Mr. HOLMES. In the seventies.

Mr. WAGGONNER. What has been the average engine development time on other engines since the inception of this program?

Mr. HOLMES. The average development time is about 8 years.

Mr. WAGGONNER. Haven't we learned anything in this period of time which has shortened the interval of this development, and we aren't we able to apply any of the technology to shorten the development time?

We started from nothing, and with all that we have learned, it still takes the 8 years?

Mr. HOLMES. I wish I could answer that we had learned how to shorten the cycle. I think we have learned many things, but when you consider that we are now using an entirely different fuel (liquid hydrogen) from kerosene, the concepts are quite different. This is a huge

engine, using hydrogen fuel. To date, we have only developed one hydrogen fuel engine which has operated effectively—the A–3, with 15,000 pounds of thrust. Here we are talking about one and a half million pounds of thrust. I think it is logical to conclude that an engine of this type would require a 7- to 8-year development period before it is used for operational flights.

Mr. Smolensky may want to comment.

Mr. SMOLENSKY. That is the comment I wanted to make. We require at least 8 to 10 years to develop a new type of engine.

Mr. WAGGONNER. Go ahead.

Mr. SMOLENSKY. I was just going to comment on the amount of testing of the various components that have to go into a new engine. We have not come to the point where we can come up with a new engine configuration in a much shorter time.

Mr. TEAGUE. Will you speak a little louder, please?

Mr. SMOLENSKY. Yes.

Mr. HOLMES. I think, Mr. Chairman, that Mr. Yeager indicated that the committee might want at a later date to explore in detail the M–1 engine and I think we could, if you would like, talk about it in terms of our systems planning, that is how it would fit into the overall growth of the program at that time better than I am qualified to do today. Dr. Shea, our Deputy Director for Systems, would be happy to discuss these aspects with you. It might give a better perspective to the total discussion.

Mr. TEAGUE. We might do that next Wednesday.

Mr. HOLMES. Whenever you say.

Mr. TEAGUE. Mr. Riehlman.

Mr. RIEHLMAN. I think that pretty much answers what I was going to ask about this project. In fiscal year 1962 we authorized $16 million, in fiscal year 1963, $35 million, and you are asking for another $45 million for fiscal year 1964. If this engine will not be developed before 1970, I would like to have them project what the development cost of the M–1 engine will be. You can do that when we discuss this next Wednesday.

Mr. HOLMES. Yes, sir.

Mr. RIEHLMAN. I think it is important to know what the projected cost is going to be, Mr. Chairman.

Mr. DADDARIO. Something in the order of $263 million, isn't it?

Mr. RIEHLMAN. It will be more than that if we continue at this rate.

Mr. HOLMES. The estimate of the Aerojet General Corp.'s definitive contract is of that order, yes. I am not sure of the exact figure, but it is over $200 million.

Mr. TEAGUE. All right.

Mr. SMOLENSKY. The next engine development program for which we are requesting funds is the H–1 engine. Eight H–1's are used in the Saturn–I first stage and in the Saturn–IB first stage. We are requesting $5,200,000 for the H1– engine in the fiscal year 1964 budget estimates.

The next line item is RL–10 engine program, for thich we are requesting $32,600,000. Six RL–10 engines are used in the second stage (S–IV) of the Saturn–I.

Next is the F–1 engine development program, for which we are requesting $54,100,000. As you recall, five F–1 engines are clustered in the first stage (S–IC) of the Saturn V.

The next line item is the J–2 engine for which we are requesting $48,200,000. One J–2 engine of course, appears in the S–IVB stage of the Saturn–IB. The J–2 is also used in Saturn V upper stages. The second stage (S–II) of the Saturn–V uses five J–2's and the third stage (S–IVB) of the Saturn V uses one J–2 engine.

The next area is range instrumentation, for the instrumentation at the Launch Operations Center of $20 million, and the next item is range support at LOC for $21 million.

Mr. WAGGONNER. Range support where?

Mr. SMOLENSKY. Range support at the Launch Operations Center for $21 million. The subtotal of direct R. & D. costs is $1,168,500,000.

If we add to that subtotal for personnel costs of $82,243,000 and operation of installations costs of $68,711,000, we arrive at this total requirement of $1,319,454,000.

Mr. WAGGONNER. How much of this range support money will be transferred to the DOD?

Mr. SMOLENSKY. Are you referring to this $20 million figure?

Mr. WAGGONNER. Yes, could you give some indication how much of it?

Mr. HOLMES. There is a breakdown of this item on RDO 2–31. It shows Air Force-related expenses of $1 million and range contractor support of $10 million. Some of this amount will probably go through DOD for range contractor support.

Mr. SMOLENSKY. Starting with the breakdown of launch vehicle supporting technology for $16,900,000, this group is broken down into all supporting technology studies related to our launch vehicles. It is broken down into launch vehicle studies for $2 million; launch vehicle aerothermodynamic studies for $800,000; launch vehicle loads and structures for $6 million; and space vehicle design criteria studies for $2 million.

Mr. YEAGER. On page 7?

Mr. SMOLENSKY. I am breaking down the launch vehicle supporting technology request.

Mr. YEAGER. On page 7 of volume V?

Mr. SMOLENSKY. In volume V, page 7, you have a breakdown of what I am presenting.

Mr. HOLMES. I would give them a feel for what this does and then answer their questions.

Mr. SMOLENSKY. This launch vehicle supporting technology area covers our efforts to advance the technology required to support the design, development, and manufacture of our launch vehicles and to solve technical problems. It also includes studies of advanced design concepts and vehicle systems. We conduct a number of launch vehicle studies. We have about three or four where we are devoting effort to studying the aspects of reusable launch vehicles and reusable cargo carriers which fit into some of the long-range studies that Dr. Shea will be talking about.

Under the launch vehicle aerothermodynamics portion we are continuing our studies of the aerodynamic heating of various space vehicle configurations and the investigation of the use of high temperature metals as they may apply to the launch vehicle structures.

The next area, which is a very important one, is the launch vehicle loads and structures area, in which we have a group of about 25 to 30 various tasks and studies, dealing with such things as our zero leakage

problem. This is the problem of studying all the flanges and piping and tubing to minimize the leakage problem of some of these high-energy fuels.

We also study the important area of welding techniques for large vehicles, and this, incidentally, is a tremendously important area for us to make sure that we do develop the proper fabricating techniques that will assure us the reliable welding structures for our large vehicles.

Under the space vehicle design criteria, we have about 12 or 13 studies planned, where we want to get into the aspects of the cost relationships, the cost reliability relationships of some of our programs. We are trying to arrive at the costs of expendable structures versus the cost of reusable structures. We are also trying to make comparisons that may be of value to us in evaluating proposed future concepts.

Under the guidance section are all studies related to our launch vehicles guidance problems? One particular area of interest is the matter of high accuracy, long-life gyros—that is, trying to increase the accuracy and reliability. We are investigating the area of ceramic bearings, which, of course, is a very interesting and promising one.

Under the navigation end of it, we have four or five studies projected. We are, for instance, trying to develop special-purpose devices to be used in the simulation of some of our flights. We also want to study methods of speeding up our flight evaluation studies.

In other words, right now it takes a considerable length of time to process all the data on which we evaluate each one of our flights. As our program progresses there will be many more launches and the need for automating some of our flight evaluation information is of utmost importance.

The next area has to do with control systems related to the launch vehicles. One area in particular we are looking at is the emergency detection studies for manned space flight launch vehicles. We are studying all of the possible areas that might cause us trouble. We are trying to develop means and sensors for detecting possible incipient problems and to develop means by which we can correct any deficiencies that occur.

In the communications area we are conducting studies relating to communications and particularly telemetering problems in connection with our launch vehicles.

Mr. YEAGER. Question, Mr. Chairman.

Mr. TEAGUE. Mr. Yeager.

Mr. YEAGER. You have these same items of guidance systems, navigation control, communications, also in your manned spacecraft systems breakdown, in the same supporting item. How are these different? Is it just that one applies to the spacecraft per se and the other to the launch vehicle?

Mr. LOW. That is correct.

Mr. SMOLENSKY. That is correct. And I think you will find——

Mr. YEAGER. There are different problems in actually different areas?

Mr. SMOLENSKY. Correct. We attempt to focus our attention on the problems in these areas that relate to our launch vehicles. You have different parameters to work with, different designs and the studies are justified as specifically assigned to the launch vehicle.

Mr. YEAGER. They are in fact entirely different, separate systems?

Mr. SMOLENSKY. Separate systems, yes.

Mr. YEAGER. Thank you.

Mr. SMOLENSKY. This is also true of the micrometeorite problem and everything else.

The next area is the propulsion supporting technology area for which we are requesting $22,500,000. That is broken down into two areas, one for liquid propellant programs and one for solid propellant programs.

We have about 12 or 13 different studies planned under the booster propulsion systems in liquid propellants and we have 7 or 8 different studies planned for the spacecraft propulsion system studies.

Under the liquid propulsion system studies we are looking into such things as the combustion instability of LOX and LOX-hydrogen. We have had this problem with most of our engines. We do feel that we should be doing quite a bit of analytical work to avoid this problem in some of the LOX-hydrogen engines.

We are also looking at such things as advanced nozzle developments, which will be most important in determining the feasibility of the type of nozzle to be used for any advanced launch vehicle. In spacecraft propulsion systems, under liquid technology, we are looking into the cryogenic propellant storage problem for possible applications to future spacecraft propulsion systems. We are looking into all the attendant problems of possible use of cryogenic fuels at some point in the spacecraft propulsion.

The next area is solid propellant programs. We are requesting $6,500,000. In this area we are essentially backing up the effort that is now going on in the Air Force. The Air Force has conducted feasibility studies for the large solid-propellant boosters to meet our requirements. Our studies in this area are mainly along the lines of trying to determine how we can then adapt such large boosters for launch vehicles for manned space flight.

We have about 25 studies broken down to categories such as systems reliability studies, manufacturing facility requirements, system safety studies, and system control studies.

We also look into the hazard classification of using large boosters in our large launch vehicles and studying the very important area of acoustical and vibration effects as they might affect the launch vehicle from the use of solid boosters.

The next area in supporting technology is that of launch operations supporting technology for which we are requesting—and this is on page RDO 2-7 of volume II—a total of $8,621,000.

These studies are broken down into three categories which are listed in your book V: launch facilities, GSE studies, operation techniques, site hazard, and space fragment studies.

These studies are most important from the standpoint of preparing ourselves to launch larger space boosters. In the launch facilities study we investigate such problems as jet impingement on water, which is contantly with us, facilities for large solid boosters, and the solid propellant, jet erosion problems, which will differ from the problems with the liquid fuels. Under the launch GSE studies we have the enormous problem of investigating all of the attendant ground-support equipment that might be used in any new launch-vehicle concept.

I might also point out that the launch-site hazards area is a very vital one to us. We have a number of studies to assess the launch-site hazards that we would encounter with any of the large, solid boosters or any of the new booster configurations that we might adopt.

Acoustic measurements is another example of a very important area. Here we must at all times be aware of the acoustic effects of any of the large boosters as it may bear upon the safety of the people and the safety of the launch vehicle. In the space fragment area, hazard studies are also of great significance from the standpoint of gaining knowledge as to what happens to the various fragments that may be coming back into the atmosphere and what can we do in terms of possible designs to overcome these problems.

Mr. YEAGER. A question here, Mr. Chairman.

Mr. TEAGUE. Mr. Yeager.

Mr. YEAGER. On personnel costs, page 2–7, the figures indicate a per capita increase of about $2,200. Isn't that a little high? Do you have any ready explanation for that? You show 25 people last year being paid $177,000; this year 33 people are being paid $307,000.

Mr. LILLY. These figures, Mr. Yeager, are end-year employment figures. The 25 people were not employed during the full year.

Mr. YEAGER. They weren't full time in 1963?

Mr. LILLY. Not 25 of them; no, sir.

Mr. SMOLENSKY. The next portion of our budgetary request is for the Saturn I. Here, for fiscal year 1964, we are requesting a total of $93,800,000 direct R. & D. costs, plus personnel costs of $32,107,000 and operation of installations of $32,722,000, for a total cost of $158,629,000.

The objective of the Saturn I development program is to develop a two-stage vehicle capable of 22,000 pounds in low Earth orbit. This payload is more than five times the weight of the Project Mercury capsule. Saturn I flights will test the escape abort system, command module and service module in Earth orbit and during reentry to verify the Apollo spacecraft and subsystems reliability.

Saturn I will be the first vehicle to orbit a manned Apollo spacecraft. The first stage of the Saturn I will also be used as a booster for the Saturn IB vehicle. In addition, Saturn I will be used in the development tests of the Saturn V guidance system and the initial development phase of the automatic checkout system.

Saturn I, as you can see from your configuration chart, is a two-stage vehicle using a cluster of engines for each stage. The vehicle stands about 122 feet, is 22 feet in diameter, and has a fin span of approximately 40 feet. It carries the equivalent of more than 10 tank cars' load of propellant.

The first stage (S–I) is now under development at the Marshall Space Flight Center. That Center will produce a total of eight of these stages. Production of two additional development stages and all the operational stages is under contract to Chrysler Corp., Space Division.

The Chrysler S–I effort will be accomplished at the Michoud plant in New Orleans, La. These S–I stages use eight H–1 engines, which provide 1.5 million pounds of thrust.

The second stage (S–IV) is being developed and produced by the Douglas Aircraft Co. in Santa Monica, Calif. This stage utilizes a

cluster of six RL–10 engines which are liquid hydrogen-liquid oxygen engines producing a total of 90,000 pounds of thrust. The Saturn I development flight schedule consists of a total of 10 launches with 2 configurations designated block I and block II. Four block I vehicles were flight tested using a live first stage and an inert upper stage. The six block II flight vehicles will fly with live stages. Four block I vehicles have been flight tested to date.

Mr. Low. Yes, four block I flight tests have been conducted to date.

Mr. SMOLENSKY. In fiscal year 1964, four block II flights will take place. The first of these flights (SA–5) will make the initial use of a lox-hydrogen engine in a Saturn-type vehicle. During the fiscal year orbital testing of the first Apollo boilerplate spacecraft and the acceptance firing of the first Chrysler-produced stage will be accomplished.

Mr. TEAGUE. Mr. Daddario has a question.

Mr. DADDARIO. Can you tell us how the two additional development stages, and all operational stages, which are under contract to Chrysler Corp., Space Division, were brought about? Was there competition and if so, who were the other companies involved?

Mr. SMOLENSKY. I am sorry. I missed that question.

Mr. DADDARIO. On RDO–2–9, second paragraph from the bottom, you refer to the production of two additional development stages and all operational stages which are under contract to the Chrysler Corporation, Space Division. How was that contract brought about, was it competitive or negotiated? If there were other companies involved, who were those companies?

Mr. SMOLENSKY. This was a sole source evaluation as a logical extension of the previous NASA contract with Chrysler. In the original contract 38 contractors were invited to bid. Seven responsive bids were received from Chrysler, Boeing, AVCO, Chance Vought, Northrop, Lockheed, and Ford.

Mr. LILLY. I think I might add to Mr. Smolensky's statement about the extension of Chrysler's contract for producing S–I stages for the Saturn I vehicle. The first contract for the S–I stage was awarded on a competitive basis. Thirty-eight companies were invited to submit bids and seven companies did submit bids.

Mr. DADDARIO. We are referring now to the two additional development stages. In the first instance, the S–I was the one in which the other companies were involved, is that correct?

Mr. HOLMES. I think that I can clarify this point for you, Mr. Daddario. The original contract which we awarded to Chrysler provided for 10 production stages.

Mr. DADDARIO. And you juggled the stages?

Mr. HOLMES. We juggled the stages around in order to phase Chrysler into the picture earlier at the Michoud plant.

This adjustment was at Marshall's instigation. We believe that it is a more efficient way of getting the contractor into production earlier. As a result, we will be flying Chrysler-built stages prior to completing flights of all of the Marshall-built stages. In other words, it is not an increase in the scope of the contract; it is an adjustment of the award that Chrysler won competitively.

Mr. DADDARIO. We discussed this in the past, Mr. Holmes.

Mr. HOLMES. Yes, sir.

Mr. DADDARIO. And I had understood this to be the case. I do think, however, it is a subject of inquiry when we have an expert here.

Mr. HOLMES. Oh, yes.

Mr. DADDARIO. It is not really a logical extension of a capability so much as it is an adjustment within a program which more suits your convenience and which in the final analysis, as I understand it, telescopes the program a little bit. Juggling the moneys around does not, in fact, add to the total amounts in question in this instance, it is just a question of taking money from one place and putting it in another. That is correct, isn't it?

Mr. HOLMES. I think that is exactly correct, yes, sir.

Mr. DADDARIO. These two additional stages do not reflect additional money?

Mr. HOLMES. They do not reflect additional money.

Mr. DADDARIO. Just an adjustment of the program.

Mr. HOLMES. Yes; it is a reduction in the total production vehicles by Chrysler by two, but an increase from zero to two for the development vehicles by Chrysler.

Mr. DADDARIO. And a reduction of two at Marshall?

Mr. HOLMES. Yes. The total number stays the same, just as you have stated.

Mr. DADDARIO. It all adds up to the same total.

Mr. HOLMES. Yes, sir.

Mr. DADDARIO. The only thing is that Chrysler winds up with a little bigger contract?

Mr. HOLMES. Not really. Chrysler is producing two development stages which it did not have originally. However, Chrysler's original contract for 10 production stages has been reduced to 8 production stages.

Mr. DADDARIO. I see. It evens itself off all the way around.

Mr. HOLMES. Yes, sir.

Mr. DADDARIO. Fine. Thank you, Mr. Chairman.

Mr. SMOLENSKY. As I mentioned before, the second stage of the Saturn—the S–IV stage—is being developed and produced by the Douglas Aircraft Co. in Santa Monica, Calif.

Mr. TEAGUE. May we take about a minute here and have a little conference as John Daly calls it. You have to go to the Senate this afternoon, do you not?

Mr. HOLMES. Yes, sir.

Mr. TEAGUE. How about your other people, Mr. Low and——

Mr. HOLMES. I plan to ask Mr. Low and Mr. Lilly to accompany me.

Mr. TEAGUE. In that case, this committee will not meet this afternoon.

Mr. DADDARIO. You can't break that combination up, Mr. Teague.

Mr. HOLMES. Off the record, please.

(Discussion off the record.)

Mr. TEAGUE. There will be no committee meeting this afternoon. Go right ahead.

Mr. HOLMES. Where are you, Mr. Smolensky?

Mr. SMOLENSKY. I am on page RDO 2–10.

Mr. HOLMES. Mr. Chairman, am I right in suggesting that Mr. Smolensky give the committee a feel for what is involved rather than an item by item coverage?

Mr. TEAGUE. That is right.

Mr. HOLMES. We have covered the S–I stage. Have we discussed the S–IV stage development yet?

Mr. SMOLENSKY. No, we have not.

Mr. HOLMES. Let's continue with that area.

Mr. SMOLENSKY. We are requesting $25,500,000 for the S–IV stage in fiscal year 1964. The first successful hot firing of the RL–10 engine cluster for the S–IV stage occurred in August of 1962. Full-duration hot firings occurred in October of 1962. We have been having a series of battleship firings all along.

As of last week we had the 11th successful battleship testing. In fiscal year 1964 the first live flight of an S–IV stage, in the SA–5 flight, will mark a significant milestone in manned lunar landing. This flight test of the liquid hydrogen/liquid oxygen-powered stage of the Saturn I is the initial step toward the development of large size vehicles required for later mission use.

Design improvement of the S–IV stage, along with associated design modification, is being conducted by the Douglas Aircraft Corp.

Component material and spare part deliveries for four stages produced in fiscal year 1964 and procurement for two stages to be delivered in fiscal year 1965 will be made. At the same time we will be continuing the off-system testing at the Sacramento field station and acceptance testing, as the S–IV stage is needed for four vehicles. This is scheduled for fiscal year 1964.

Large quantities of propellants and high-pressure gases will be procured and consumed to support an extensive hot firing program. We will also be modifying and replacing special test equipment, assembly and structure fixtures, and other associated tooling will be accomplished.

Final assembly checkout and acceptance testing of three vehicles will be accomplished prior to shipment to the Launch Operations Center. Assembly and checkout of two additional vehicles is to start during fiscal year 1964.

Mr. TEAGUE. Any questions?

Mr. FUQUA. What is a battleship firing or testing?

Mr. SMOLENSKY. Battleship testing is essentially the propulsion systems testing, as it is configured in the stage. The battleship stage is a special stage that has heavier tankage, which permits us to fully test out the propulsion system.

Mr. HOLMES. We can start out much earlier by not having the tooling and facilities for flight weight hardware. Further, this approach is a safe one. Even if the engine blew up, the tank propellants wouldn't come out and explode.

Mr. SMOLENSKY. The next area for which we are requesting funds is the vehicle instrument unit. The instrument unit houses the guidance and stabilization systems, telemetering equipment, power supply batteries and inverters, and inflight air-conditioning equipment.

During fiscal year 1963 a major part of the development testing will be completed. This testing involves the use of three hardware assemblies—the system development unit, the dynamic test unit, and the structural test unit.

During fiscal year 1964 a major part of the fabrication assembly and checkout of units for five Saturn I's will be accomplished. The

program also covers the development, vibration, and structural testing of units for the eight Saturn and later instrument unit configurations.

Mr. TEAGUE. Any questions?

(No response.)

Mr. SMOLENSKY. The next item, which goes along right with the vehicle instrument unit, is that of the guidance system. We are requesting $2 million for this item. Vehicles up to the seventh Saturn will use the ST–90 inertial platform, modified Jupiter equipment, with the new ST–124 as a passenger on the third through the sixth vehicle. The guidance and stabilization system for the seventh Saturn and later vehicles will consist primarily of the new ST–124 inertial platform. The procurement of additional hardware is taking place in fiscal year 1963. The ST–124's will be produced for vehicles through the 10 th Saturn. In fiscal year 1964 funds are requested to support the stage engineering effort for hardware deliveries, complete guidance system procurement for vehicles through the 10th, with incremental coverage on spare parts, and funding for flight evaluation reports.

Mr. HOLMES. I think that the committee understands the function of this guidance system in the instrument unit. It is the device which generates signals to tell the four gimballed outboard engines in the first stage which way to direct their thrust. After staging, the guidance system continues to give commands, in this case, the six RL–10 engines in the S–IV stage how to move in order to guide the launch vehicle to a proper trajectory for Earth orbit.

Mr. TEAGUE. Any questions?

(No response.)

Mr. SMOLENSKY. The next item is for the H–1 engines required for the stages used in the Saturn I development program. We are requesting a total of $2,800,000. All engines for the Saturn I vehicle development will be delivered during this current year.

The funding in fiscal year 1964 is required to provide contract field engineering, spare parts, and associated services to Marshall, Michoud and the Launch Operations Center. In addition, these funds will provide for engineering change modification kits and will be necessary for solution of development problems experienced in R. & D. testing and improvements generated through the continued engine development program.

Mr. TEAGUE. Any questions?

Mr. YEAGER. What does this buy for you? This, and also your figure on the RL–10? It says "engine procurement."

Mr. SMOLENSKY. I must go back to fiscal year 1963. We requested $7.9 million for the H–1 engine for the completion of 47 engines.

Mr. YEAGER. Forty-seven?

Mr. SMOLENSKY. That is correct. Eight H–1's for each Saturn I from SA–6 through SA–10 and seven spares, plus the propellant, for the acceptance testing. The funds requested in fiscal year 1964 are needed for spare parts for the 47 H–1 engines, plus the field service functions that I just mentioned, which means engineering change modification kits and general field engineering support. Do you want to cover the RL–10 now?

Mr. YEAGER. You could cover the RL–10 now, or you could cover it when you get to it in the book.

Mr. SMOLENSKY. For the RL–10 engine procurement to support the Saturn I development program we are asking $3,400,000. All RL–10

engines to be procured for the Saturn I development program will be delivered during fiscal year 1963. The funding for fiscal year 1964 is required for contractor field engineering, spare parts, and associated services. It is essentially the same requirement that we have in the H–1 engine program. I can give you those figures if you wish.

Mr. YEAGER. I would be interested in them.

Mr. SMOLENSKY. In fiscal year 1963 we requested $12,650,000, which provided for the fabrication of 67 engines, including 6 for the S–IV battleship stage, 12 for the S–IV all-systems test—do you want the breakdown?

Mr. YEAGER. No, the same explanation.

Mr. SMOLENSKY. That is correct, Mr. Yeager. Propellant for acceptance testing amounted to $4 million.

Mr. GURNEY. Question.

Mr. TEAGUE. Mr. Gurney.

Mr. GURNEY. Is RL–10 another designation for A–3?

Mr. SMOLENSKY. Yes, it is, Mr. Gurney. RL–10A–3 is the modification of the RL–10 engine being used in the S–IV stage.

Mr. GURNEY. Thank you.

Mr. SMOLENSKY. The next area is that of systems integration for which we are requesting $30,600,000. This area involves all of the integration testing that must be performed. By the end of fiscal year 1963 the major portion of design integration and early system integration testing will have been performed. In fiscal year 1964 emphasis will be placed on system integration and testing of the vehicle, including both the S–I and S–IV stages, and the guidance system and the instrument unit, as well as the engines and the Apollo command and service modules.

In fiscal year 1964 the funding provides for engineering services, ground support equipment, replacement and refurbishing of the firing accessories, the propellant servicing hardware, the launcher arms and the deflectors, which may be damaged in even the most successful flights. In other words, we do provide for the refurbishing of the launchers at LOC.

Mr. YEAGER. Question, Mr. Chairman.

Mr. TEAGUE. Mr. Yeager.

Mr. YEAGER. Is any of this going to be part of the General Electric integration and checkout program?

Mr. HOLMES. No, sir.

Mr. YEAGER. That is all separate from that?

Mr. HOLMES. Yes, it is.

Mr. TEAGUE. Any further questions. Proceed.

Mr. SMOLENSKY. The next portion of the budget is the development program for the Saturn–IB vehicle. In fiscal year 1964 we are asking for a total of $68,600,000, with additional personnel costs of $4,457,000 and operation of installations $2,911,000, for a total cost of $75,968,000. I am referring to volume II, RDO 2–12 and 2–13.

The objective of the Saturn–IB development program is to develop a two-stage vehicle capable of placing approximately 32,000 pounds in low Earth orbit. That payload is about one and a half times the payload capacity of the Saturn. The Saturn–IB will provide a reliable launch vehicle to meet our intermediate Apollo spacecraft development requirements. The Saturn–IB vehicle will be capable of placing the Apollo spacecraft in Earth orbit for systems testing

and for rendezvous testing of the lunar excursion module and the command modules. The second objective of the Saturn–IB is to advance by approximately 14 months flight tests for the S–IVB stage and the Apollo spacecraft.

We are requesting the necessary funds to provide for the completion of criteria and specifications for the Saturn–IB vehicle requirements. Engineering design effort will be completed to accommodate this stage to the S–IVB stage and the necessary instrumentation, electrical networks, and other systems. Procurement of all structural and electrical items for the dynamic stage and the first two development flight stages will be initiated. In addition, long leadtime structural components will be procured for vehicles 3 and 4.

For the S–IVB stage we are requesting a total of $19,100,000. In fiscal year 1964 we plan to provide for the design and development of the S–IVB stage and to complete the procurement of all structural and electrical items for SA–201 and 202. Assembly hardware procurement will be 75 percent complete for SA–201 and initiated for SA–202.

We will be initiating long-lead structural procurements for Saturn–IB vehicles SA–203 and 204.

Mr. HOLMES. We might clarify that by indicating that our first Saturn–IB flight is called SA–201; the second one is SA–202. The designations follow in sequence. We hope on the fifth one, SA–205, to have the Saturn–IB man-rated.

Mr. SMOLENSKY. In the case of the instrument unit we are requesting $6 million, which will provide for the procurement of long leadtime components for SA–201. The basic design, major testing, major tooling, and specialties equipment come under the Saturn–V development program. In addition, we are requesting $5,200,000 for the guidance system for the procurement of ST–124 inertial platforms for Saturn–IB vehicles SA–201 through SA–204, as well as the procurement of guidance computers and guidance signal processors for SA–201 and 203.

Under H–1 engine procurement we are requesting $3,700,000 for fiscal year 1964. This request represents incremental funding for long leadtime hardware for 15 flight engines and 2 spare engines to be delivered in fiscal year 1964.

Included in the costs are such items as support services, spare parts, field engineering, training, ground support equipment, modification and/or retrograde. A total of $300,000 of that amount represents funding required for the acceptance tests for the 17 engines to be delivered in fiscal year 1964.

The next item is the J–2 engine procurement to support this program. We are requesting $4,200,000 in fiscal year 1964; including $3.9 million for incremental funding of two J–2 test engines and one flight engine to be delivered in fiscal year 1964, and incremental funding for long leadtime hardware for one test engine, three flight engines, and one spare to be delivered in fiscal year 1965.

This amount requested also provides for spare parts, ground support equipment, field services, and training. The remaining $300,000 represents requirements for acceptance testing.

Under systems integration we are requesting $16,900,000, which is broken down into hardware procurement of control computer and associated components, range safety and tracking equipment, telemetering equipment, electrical network and power supplies, and environmental control equipment.

We are also procuring ground support equipment items for launch operations to bring pad A at launch complex 37 to an operationally ready date of early 1965. This also includes funds for the plan and design criteria and specifications for the use of pad 37–A as a launch pad for the vehicle.

Mr. FUQUA. Mr. Chairman.

Mr. TEAGUE. Mr. Fuqua.

Mr. FUQUA. Back just a bit you had $30 million for systems integration; then you just mentioned another $16 million for the systems integration. Add to this the GE contract, from which this is separate, of about $25 million for this year, and that is considerably more than $50 million we are spending just on integration?

Mr. HOLMES. Yes. The terminology is a little misleading in that the integration shown under the launch vehicle budget requests does include that study and relationship. However, it also includes equipment and hardware. For instance, it includes propellant-servicing hardware, launcher arms, and other devices intimately tied to the vehicles.

The General Electric contract, for which there was $25 million in fiscal year 1963, included reliability analyses checkout studies, and integration studies. This study effort covered such questions as: Do these various stages properly mate with the spacecraft? Does the spacecraft properly mate with overall checkout equipment at the cape? Although the words are the same, the work is really quite different.

Mr. TEAGUE. Any further questions?

I think, Mr. Holmes, we will stop right there.

Mr. HOLMES. Yes, sir.

Mr. TEAGUE. Unless there are questions on the Advance Saturn, I would like to ask the status of the F–1 engine?

Mr. HOLMES. In terms of combustion instability and so forth?

Mr. TEAGUE. Yes.

Mr. HOLMES. We have had numerous F–1 engine runs now without experiencing combustion instability. I am not certain of the exact figure now, but I would like to get it for you because I have a paper that gives a more detailed report.

We have a major effort at the F–1 contractor plant, Rocketdyne, in investigating and resolving the combustion instability problem. We also have experts from Princeton, experts from Marshall, who were in charge of following the development, and experts from Lewis devoting an intensive effort to this problem. I obtain a monthly status report and transmit that report to my superiors. I think we are doing everything possible. Rocketdyne feels very optimistic that we can have the instability problem essentially resolved or under control by the end of this calendar year.

(The information requested is as follows:)

As of May 1, 1963, the F–1 engine, 5 of which will be used in the first stage of the Saturn V, has undergone a total of 305 tests. Approximately half of these ground tests were conducted at the full thrust of 1.5 million pounds; 20 test runs were conducted for the full duration of 2.5 minutes.

Since earlier reports to the committee on the F–1 status, various steps have been taken to overcome the problem of combustion instability. We have been investigating different designs for the injector system, which feeds the liquid oxygen and kerosene propellants from the turbopump into the combustion chamber. One of the several injector systems that was designed to combat

combustion instability has been tested with great success. The new injector system isolates the vibrations in the turbopump from those in the engine's combustion chamber. As a result, the vibrations or oscillations are not carried through to the combustion chamber. The fact that combustion instability has not been encountered with the new injector system bears out the thesis that the phenomenon, although it tends to be inherent, occurs only when it is triggered from another source. The new injector system has operated successfully 25 times for durations in excess of 100 seconds. Two of these tests were conducted at full thrust and full duration. This progress increases our confidence that the powerful F–1 engine will be available when needed.

NASA is sparing no effort in overcoming the problem of F–1 combustion instability. The contractor, Rocketdyne, is devoting an intensive effort to a timely solution of the problem. The contractor effort is supplemented by the analysis and advice of outstanding propulsion experts, including representatives from the Marshall Space Flight Center and the Lewis Research Center, and scientists from universities and industry. The status of F–1 engine development is commanding the attention of each level of NASA management, including the Associate Administrator, the Director of the Office of Manned Space Flight, and the Director of the Marshall Space Flight Center.

Mr. TEAGUE. Any other questions?

Mr. TEAGUE. Mr. Bell.

Mr. BELL. Are we going to continue from this point at our next meeting?

Mr. TEAGUE. Yes; next Wednesday.

Mr. BELL. What other areas do we cover?

Mr. TEAGUE. Aerospace medicine is the next one; we will go right through the book.

Mr. BELL. I see. That is all, Mr. Chairman.

Mr. HOLMES. Shall we be prepared to start with aerospace medicine?

Mr. TEAGUE. I think Mr. Bell may have some questions on the Advanced Saturn.

Mr. HOLMES. Start with the Advanced Saturn.

Mr. TEAGUE. If there are no questions, we go right on to aerospace medicine.

Mr. YEAGER. And the M–1 engine.

Mr. TEAGUE. We will discuss the M–1 engine.

Mr. YEAGER. Mr. Holmes, on Wednesday NASA put out a press release saying that Langley was requesting studies on a manned orbiting research laboratory.

Mr. HOLMES. Yes.

Mr. YEAGER. Does this represent a major decision to go for the manned orbiting space station? The second part of the question is: How was this funded in the space budget, or is it funded?

Mr. HOLMES. On the first part of the question, I think the right answer is "No." Langley's effort is merely a continuation of the studies that we have been doing in terms of feasibility, and the way in which one should approach a manned space station. There is an existing agreement between Mr. Webb and Mr. McNamara that neither the Department of Defense nor NASA would inaugurate hardware development without agreement between the two parties. It will be a continuation of the type of studies that Langley has done. These studies involve the use of a Saturn vehicle to launch a cylindrical stage. A space station capable of housing four to six men might be resupplied using the Gemini vehicle. At any rate, the studies are of a conceptual type and investigate the feasibility of such a project. Since a manned space station is an advanced study

effort, it falls into the systems engineering area in the manned space flight budget.

Mr. YEAGER. Thank you.

Mr. TEAGUE. Any other questions?

(No response.)

Mr. TEAGUE. Mr. Holmes, in the Texas papers yesterday there was a statement by Mr. Meyer at Houston. He says that "A several months' delay in the two-man orbital flights for Project Gemini has been disclosed by the project's chief administrator." Then it quotes him as saying that "It will be at least the summer of 1964 before we can launch the first manned Gemini flight."

Would you care to comment on that?

Mr. HOLMES. Who is the chief?

Mr. TEAGUE. Mr. Andre Meyer, Jr., Chief of Project.

Mr. HOLMES. Yes. It is an unfortunate statement because it has been given far too early before we have actually completed our studies of the difficulties we have in Gemini. We have not, in my office, changed our official schedule, which calls for the first Gemini flight, a suborbital flight, this December, and follow it with a manned flight in the first quarter of next year.

However, I would be less than straightforward if I did not indicate that our evaluation of Gemini, in terms of where we stand today, does give us some concern. We are studying whether we should commit men to the Gemini spacecraft before we have had two unmanned flights—one to check out as early as possible the structural and aerodynamic integrity of the Gemini spacecraft and the Titan II, and the other to check out all systems, as we did in Project Mercury, without the man aboard.

It is too early for us to state that we have changed the schedule, since our evaluation studies have not been completed.

Mr. TEAGUE. He says that delay is caused by subcontractors not delivering the hardware and a delay in the fabrication of the spacecraft by the prime contractor.

Mr. HOLMES. I see.

Mr. TEAGUE. I will give it to you.

Mr. HOLMES. Thank you very much.

Mr. TEAGUE. The committee will be adjourned.

(Whereupon, at 11:55 a.m. the subcommittee adjourned.)

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1964 NASA AUTHORIZATION

MONDAY, APRIL 29, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON MANNED SPACE FLIGHT,
Washington, D.C.

EXECUTIVE SESSION

(The following testimony of Gen. Bernard A. Schriever, Commander, Air Force Systems Command, was taken in executive session because of the classified nature of the material presented. The classified portion of the testimony has subsequently been deleted from the record by the Department of Defense, and the testimony as shown below is unclassified.)

The subcommittee met, pursuant to adjournment, in room 356, Cannon Office Building, at 10:10 a.m., Hon. Olin E. Teague (chairman of the subcommittee) presiding.

Mr. TEAGUE. The committee will come to order.

Our witness this morning is Gen. Bernard A. Schriever, Commander, Air Force Systems Command, Department of the Air Force.

(The biography of General Schriever is as follows:)

GEN. BERNARD A. SCHRIEVER, U.S. AIR FORCE

Gen. Bernard Adolph Schriever was born in Bremen, Germany, on September 14, 1910. His parents emigrated to the United States in 1917, and he became a naturalized citizen in 1923. He received his early schooling in San Antonio, Tex., and was graduated from Texas A. & M., College Station, Tex., in 1931 with a bachelor of science degree.

General Schriever's military career began in 1931 when he accepted a Reserve appointment in the field artillery after graduation from Texas A. & M.

Entering flight training at Randolph Field, Tex., in July 1932, he earned his wings and commission as a second lieutenant in the Air Corps Reserve in June 1933 at Kelly Field, Tex.

First assigned as a bomber pilot at March Field, Calif., General Schriever later was stationed at Hamilton Field, Calif., and Albrook Field, C.Z. In September 1937, he reverted to inactive Reserve status, and accepted a position as pilot with Northwest Airlines.

While flying for Northwest he married Dora Brett, daughter of Lt. Gen. and Mrs. George H. Brett, U.S. Air Force retired, whom he had met in Panama, while assigned to Albrook Field.

Reentering the service as a second lieutenant in the Regular Army in October 1938, General Schriever was assigned to the 7th Bomb Group, Hamilton Field, Calif. One year later, he was assigned to test pilot duties at Wright Field, Ohio. While at Wright Field, he attended the Air Corps Engineering School, specializing in aeronautical engineering subjects, and was graduated in July 1941. He then entered Stanford University to pursue an advanced course in aeronautical engineering and in June 1942 was awarded a master's degree in mechanical engineering (aeronautical).

In July 1942, General Schriever joined the 19th Bomb Group in the southwest Pacific. While in that theater, he participated in the Bismarck Archipelago, Leyte, Luzon, Papua, North Solomon, South Philippine, and Ryukyu campaigns.

In January 1943, he became Chief of the Maintenance and Engineering Division, 5th Air Force Service Command. He held this position until August 1943 when he was appointed Chief of Staff, 5th Air Force Service Command. In September 1944, he assumed command of the Advanced Headquarters, Far East Air Service Command, and supported theater operations from bases in Hollandia, New Guinea, Leyte, Manila, and Okinawa.

General Schriever was assigned to Air Force Headquarters in January 1946 as Chief, Scientific Liaison Section, Deputy Chief of Staff, Materiel. He held this position until August 1949 when he entered the National War College. Following his graduation in June 1950, he returned to Headquarters, USAF, to become Assistant for Evaluation, Office of the Deputy Chief of Staff, Development. His next assignment in January 1951 was Assistant for Development Planning (an outgrowth of the Evaluation Office). In June 1954, he became assistant to the commander, Air Research and Development Command, Baltimore, Md. In July 1954, though retained as assistant to the commander, ARDC, General Schriever assumed command of the Air Force Ballistic Missile Division, ARDC, Los Angeles, Calif.

In this capacity, he directed the Nation's highest priority project, the development of an intercontinental ballistic missile. He was responsible not only for pushing forward research and development on all technical phases of the Atlas, Titan, Thor, and Minuteman ballistic missiles, but for concurrently providing the launching sites and equipment, tracking facilities, and ground support equipment necessary to these missiles. The propulsion, guidance, and structural techniques developed for the Air Force's ballistic missile program have contributed substantially to the Nation's aerospace capability.

In April 1959, General Schriever was named commander of the Air Research and Development Command (ARDC) with the rank of lieutenant general.

On April 1, 1961, he became commander for the newly created and expanded Air Force Systems Command. AFSC is responsible for research, development, procurement, and production actions required to place a complete aerospace system in operational use.

General Schriever's management responsibility includes monitorship of more than 6,400 research and development contracts. Currently, about 1,500 major contractors are engaged in work on Air Force weapon systems, materiel, equipment, and special projects.

A. Personal data:
   1. Born September 14, 1910, Bremen, Germany. Father: Adolph Schriever (deceased). Mother: Elizabeth Schriever.
   2. Married January 3, 1938. Wife: Dora Brett Schriever. Children: Brett Arnold, born 1938; Dodie Elizabeth, born 1941; and Barbara Alice, born 1949.
   3. Hometown address: San Antonio, Tex.

B. Education:
   1. Texas A. & M., College Station, Tex. (construction engineer) B.S. degree, 1931.
   2. Stanford University, Palo Alto, Calif. (aeronautical engineering) M.S. in mechanical engineering (aeronautical), 1942.
   3. Primary and Basic Flight School, Randolph Field, Tex., 1933.
   4. Advanced pilot training, Kelly Field, Tex., 1933.
   5. Aeronautical engineer (1 year), 1941.
   6. National War College (regular course), June 1950.

C. Decorations and medals: Purple Heart, Asiatic-Pacific Ribbon, Unit Citation (1 Oak Leaf Cluster), American Defense Ribbon, Air Medal, Legion of Merit, Distinguished Service Medal (1 Cluster), Philippine Liberation Medal, American theater, National Defense Service Medal, Guided Missile Insignia, Air Force Longevity Service Award (1 Silver Oak Leaf Cluster).

D. Promotions: Second lieutenant, November 28, 1931; first lieutenant, June 29, 1933; captain, April 15, 1942; major, June 25, 1942; lieutenant colonel, August 5, 1943; colonel, December 21, 1943; brigadier general, June 19, 1953; major general, December 13, 1955; lieutenant general, April 25, 1959; and general, July 1, 1961.

STATEMENT OF GEN. BERNARD A. SCHRIEVER, COMMANDER, AIR FORCE SYSTEMS COMMAND, DEPARTMENT OF THE AIR FORCE

General SCHRIEVER. Do you want me to read the statement?

Mr. TEAGUE. Y s.

General SCHRIEVER. Mr. Chairman and members of the subcommittee, it is appropriate to review past progress and future plans periodically in order to validate or, when warranted, redirect the objectives and path we have set for ourselves. Your committee's keen interest in the U.S. space program and the results of your efforts have been extremely beneficial in this connection. I appreciate this opportunity to appear before you and am happy to assist your review in every possible way.

I believe you are well aware of my feelings regarding the importance of an adequate military space effort as part of the national space program. I have also often stated my belief that the civilian and military portions of the national space program must complement each other, with closest possible relationships at all working levels. This is why I have taken management and organizational steps such as establishing General Ritland as my Deputy for Manned Space Flight.

I believe it is timely, however, to reiterate the reasons which I have identified on various occasions in support of an integrated military space development program. Such a military program necessarily will differ from the civilian effort in certain respects if our national security objectives are to be met in a timely and satisfactory manner.

The fundamental differences are: First, the relative urgency of the national security mission; second, the contrast between many military operating characteristics and those of civilian operations; third, the technical considerations which are dictated by this contrast; and fourth, the management concept which is necessary if we are to satisfy the military mission and the operating requirements which characterize it.

The military has looked to space as an avenue through which to achieve two broad types of national security objectives. The first of these is to provide means of better accomplishing traditional passive military functions such as communications, observation, warning, mapping, and meteorology. All of these are urgent in that space offers significant improvements over presently available means of performing these tasks which are important to our national security.

The second category of activity in which we consider military space development to be urgent is that which will provide advantageous means of countering any hostile threat. I include here such military space operations as inspection and negation of hostile systems, and means of defending or reducing the vulnerability of our own space systems.

In addition to differences in urgency, military missions such as those which I have mentioned lead to operating requirements and characteristics which can differ significantly from civilian operations. The possibility of operating in a combat environment is the most conspicuous, and speaks for itself.

Not so evident are the differing characteristics which are dictated by the military needs for routinely repetitive, fast-reacting, and eco-

nomical operations. It is this type of requirement which has led us to emphasize strongly the need for a standard launch vehicle such as the Titan III system.

For effective military space capabilities, we also will need maneuvering capabilities—both in orbit and during reentry to recovery sites—which will not for some time be as critical a requirement in civilian operations. Another example of operatng requirements which are unique to military systems is the need for antijamming capabilities and secure ground terminals in a military communications satellite.

There is also a critical military requirement for a kind of reliability which differs from present civilian space effort. The achievement of reliability in routine, fast-reacting, and economical operations is a greatly different problem than achieving it for individual scientific or exploratory projects or for civilian missions in which launch readiness or continuous operation are not crucial.

The urgency, operating, and technical considerations which I have mentioned all contribute to what I consider to be the major factor which differentiates the military from the civilian space effort. I have earlier referred to this factor as being management, and I mean this in the context of what is required in a complete weapon system.

To most people a weapon system is the hardware that flies. The fact is that it represents only the top of the iceberg. Military systems acquisition involves very much more; namely, it also involves training the operating and maintenance personnel; providing training devices; establishing the logistic sources and pipeline of replenishment spares; designing and installing ground facilities and developing related equipment; and validating technical procedures and manuals for "blue-suit" skill levels, and so forth.

Departing from my statement a moment here, many of you gentlemen are familiar with the details of the development of the ballistic missiles. Concerning what I have just said, one of our big problems today is getting all of these pieces working together in an effective manner. The R. & D. program that we see at Cape Canaveral is only one small element of the total development effort that is involved in bringing a weapon system into the operational inventory. This is often overlooked and I have stressed this quite often here in the Congress in the past years.

Now back to the statement: The initiation of these added activities comprising the total weapon system cannot wait for delivery of hardware from a development and production agency if systems are to be fully operational in a reasonable time and at least cost. This is particularly true in a period of technological conflict in which the advantage can lie with the nation best able to compress leadtimes while not sacrificing significant technological improvement of its weapon systems.

All of these related weapon system considerations must be taken into account from the very initiation of development programs, and must be more and more closely integrated in our program management as development progresses.

With this background of concepts and factors which characterize the military's space missions for national security, I would like to discuss the current Air Force program of military space development and how it has been formulated.

For some years the Air Force has been engaged in numerous development activities pointed at various individual objectives. By now our development activities, coupled with the applicable results of NASA activities, have provided a strong technological foundation upon which we can base increased development efforts toward selected operational capabilities of value and importance.

Air Force progress and technical experience to date has been remarkable, particularly when measured against the short period of time since entering a field of such great challenge and complexity. You are aware of the impressively large number of space launches that have taken place—roughly 200 since the United States started its space activities.

A large portion of these have involved Air Force responsibilities. Reliabilities have been improving, significantly, as demonstrated in recent months by near 100 percent successful performance of Thor standard launch vehicles and Agena-D upper stages. In our satellite development program in 1962 we experienced 100 percent success of onboard orbital experiments which attained orbit. Only one launch attempt failed to achieve orbit, and we had approximately an 0.800 percent batting average in the complex operation of deorbiting and recovering the capsules which were planned for recovery.

We have also accumulated valuable experience with various sensor devices, auxiliary power supplies, stabilization mechanisms, et cetera. On the ground, there has been a successful record of large, solid-motor firings over the past 2 years. In short, in these and other ways we have developed a number of technological building blocks which are essential to the development of operational systems.

Our attempts to plan an integrated space program for national security started shortly after the first Soviet space launch. Our planning has been on a continuing basis ever since. Secretary McNamara's memorandum of February 23, 1962, was in response to certain of these planning efforts. Mr. Rubel has already discussed that memorandum with you.

Some of the more important elements of our early space planning were approved and are underway. Examples are the Titan III, the X–20 Dyna-Soar, and classified programs associated with satellite communications, inspection, and early warning.

While conducting these and other space development programs and projects, we have continued to refine our plans toward more soundly integrated and promising objectives. In April of 1962 a group was convened at our Space Systems Division to work on a new long-range military space program incorporating a number of technical objectives. In June of 1962, a representative Air Force-wide task force was established to translate the results of this group's effort into the Air Force 5-year space program.

The elements of this program are aimed at achieving useful military capabilities in space, some of which can be realized in the near future and others of which are dependent upon further technological progress. For the latter, the program includes exploratory and advanced development projects to provide the required technological advances. This program was forwarded to the Secretary of Defense in November 1962 by the Secretary of the Air Force, along with recommendations for approval of specific programs.

The Secretary of Defense has directed the Air Force to review its space development effort and, in effect, determine what revision may be warranted to direct greater attention to the achievement of certain specific military mission requirements. Although he expressed particular interest in contributions to these missions by the X–20 and Gemini programs, the Air Force's current review necessarily will include all technological efforts which are pertinent.

There is one program which is of fundamental importance to achieving various military capabilities in space, both manned and unmanned. This is the military orbital development system (MODS), which would build from the technology and techniques developed in Dyna-Soar and Gemini. This program would provide a space laboratory which will greatly assist us in resolving uncertainties concerning military applications in space. Some of these can be resolved in no other way, or only by expensive and time-consuming techniques. It will be able to demonstrate the ability of man to perform functional missions for extended periods in space, and to serve as a test station for the operation of military equipment and the development of operational techniques in space.

Off the statement here, I might say this is one of the things we are looking at very much in detail in connection with the Gemini, how we might be able to build in a modular fashion a space station for conducting experiments. Undoubtedly, whatever comes out of this would be a joint military-NASA effort.

In closing, I will mention a concept which the Air Force believes to hold great promise for military space applications in the more distant future. Here again, when I say "distant future" I mean that. I mean that we are talking about the period in the seventies, more likely in the latter part of the seventies, when I speak of this. I refer to the Aerospace plane concept, which the Air Force and industry have been studying for some time.

Attainment of the Aerospace plane objectives of multipurpose, fully recoverable and reusable manned vehicles is essential to our acquiring the economy and versatility of military space operations which inevitably will be required. The Air Force places strong emphasis on its research and development activities toward these goals.

Gentleman, this concludes my statement, and I will be happy to answer any questions you may have.

Mr. TEAGUE. General, on page 7 of your statement, you say that the Secretary of Defense has directed the Air Force to review its space development effort and, in effect, determine what revision may be warranted to direct greater attention to the achievement of certain specific military mission requirements.

As far as I am concerned, that is merely a delay.

Would you care to comment on that or would you rather not comment?

General SCHRIEVER. Well, it could be looked upon in one way as a delay, yes. We have, of course, made certain recommendations in the past, particularly in connection with our 5-year program, which were not accepted specifically at that time.

On the other hand, I think it is fair to say that the space program is getting to be an extremely costly one from the standpoint of the overall national effort and every effort needs to be made to bring our efforts as closely together with those of NASA as we possibly can.

The Secretary's objectives are sound in that he is attempting to bring the Air Force together with NASA in the Gemini role. The Gemini and Dyna-Soar programs will cost roughly a billion dollars a piece and although both of them are costed out at slightly less than that now, I am sure they will run about that.

And both the programs combined have a tremendous potential for advancing technology in rendezvous, docking, transfer, carrying out experiments in space, reentry and so forth.

So from his position I think he is justified in insisting that we bring these things together as closely as we can.

This is in fact what we are doing now and the Gemini planning board has this as its major objective.

It might be perhaps that we should have gotten on with this sooner. So in that regard I think there has been a delay. But in terms of pulling it together now, I think it is quite appropriate.

Mr. TEAGUE. Any further questions?

Mr. Fulton?

Mr. FULTON of Pennsylvania. How much delay would you imagine there has been in the Gemini program?

General SCHRIEVER. Delay in the Gemini program?

Mr. FULTON of Pennsylvania. Yes.

General SCHRIEVER. Is this in connection with the press——

Mr. FULTON of Pennsylvania. I am speaking with reference to your comment that there has been a delay.

General SCHRIEVER. What I had reference to when I said a delay, I think that we probably could have gotten and should have gotten together at the working level sooner.

Mr. FULTON of Pennsylvania. That is the Air Force and NASA?

General SCHRIEVER. NASA and ourselves. I think all of you are aware of the fact that I have had a continuing effort going on to accomplish this over the past several years and I have always felt that the relationship just at the top, the AACB, was not adequate, and that we had to have an across-the-board getting together right on down to the working level.

The creation of General Ritland's office was a first step. I think that we could have moved faster in this regard and should have moved faster, but as far as the Gemini program itself is concerned there is no delay in the Gemini program associated with this organizational matter that I discussed.

Mr. FULTON of Pennsylvania. There has been a delay in getting the organizational form set up rather than a delay in any specific program?

General SCHRIEVER. Yes, sir.

Mr. FULTON of Pennsylvania. Either in NASA or Air Force, is that what you mean?

General SCHRIEVER. Yes, sir.

Mr. FULTON of Pennsylvania. That is what I wanted to make clear. The NASA proposed budget for fiscal year 1964 is $5.7 billion. The Air Force proposed budget is $1.65 billion, approximately. That would make a total U.S. combined effort in space for the coming fiscal year of $7.35 billion. My questions are:

First, is this necessary? Should the people of the United States spend their hard-earned tax money for this purpose?

Second, is it enough, or is it too much?

And, third, concerning the proportionate amount being spent by NASA and the Air Force, is it proportioned correctly to give us the best possible results on space efforts so that the United States will become preeminent in space?

General SCHRIEVER. Well, that is a very difficult question to answer. I can just——

Mr. FULTON of Pennsylvania. Is $7.3 billion necessary for the U.S. space effort?

General SCHRIEVER. I can give you my personal views on this. I think it is necessary to spend money in this order of magnitude for space activities.

Mr. FULTON of Pennsylvania. If you had the decision to make originally, and if you were going to recommend to the American people an amount to be spent for space, you would recommend the full $7.3 billion?

General SCHRIEVER. Well, I could not unequivocally say that, because I have not had the opportunity to review in detail the program as presented. In terms of an order of magnitude of cost, I certainly feel that in the light of the objectives of our space program, which I think are sound, this is a figure that one would expect to be spending now.

I stated this several years ago; that I expected the total space budget to build up into a magnitude of this order.

Further, that I felt that the overall ballistic missile program dollars would be coming down and they will be, I think, in the next few years.

So that the overall spending for ballistic missiles and space combined will not be much different than what it has been over the past several years. It will go up slightly, I think, but not to an extent that we cannot afford in this country.

Mr. FULTON of Pennsylvania. So this is about the same order of magnitude that you would expect to find in the budget for fiscal years 1965 and 1966 as well, not that the budget will go up higher but that it will be about this particular level?

General SCHRIEVER. Well, I would expect that it will probably go a little bit higher than that.

Mr. FULTON of Pennsylvania. Would you care to venture your ideas on what the general magnitude might be 2 or 3 years from now?

General SCHRIEVER. Several years ago when I attended a meeting at the Arden House, I made some calculations with respect—I think both of you were there——

Mr. FULTON of Pennsylvania. Yes, both Mr. Daddario and I were there and talked with you at the time?

General SCHRIEVER. I don't recall for certain but my calculations were that the space budget would probably go up into the order of $6 to $8 billion and possibly slightly higher.

Mr. FULTON of Pennsylvania. Is this manned trip to the Moon necessary in your judgment?

General SCHRIEVER. I've always felt that a lunar program was an essential objective for the overall national space effort.

Mr. FULTON of Pennsylvania. As far as the gain in our scientific community and the progress of the United States in space, this Moon trip is worthwhile and is an asset rather than a liability?

General SCHRIEVER. Well, certain of the assets must be in the intangible category now, that is, the prestige factor. Exactly the extent to which you get scientific advancement from this is a matter of judgment.

Certainly there will be a tremendous advance in science and technology, but as you have seen in the paper recently, there is a difference of opinion as to whether or not this is good or bad with respect to certain other areas.

Mr. FULTON of Pennsylvania. We are trying to obtain your overall judgment based upon your vast experience in research and development.

General SCHRIEVER. My overall judgment is that it definitely will be on the plus side.

Mr. BELL. Would the gentleman yield at that point?

Mr. FULTON of Pennsylvania. Let him finish and I would be glad to yield.

General SCHRIEVER. I just don't feel that our capabilities in this category are saturated to the extent—I am talking about our scientific and technological capabilities—that certain of these people indicate that they are.

Mr. FULTON of Pennsylvania. Then there is both a civilian as well as a military gain or benefit from this research and development for the manned lunar landing?

General SCHRIEVER. Yes, definitely. Here again it is a little bit difficult to develop a laundry list of specific items and say these all have applications to the military mission. However, we can point out certain things.

The Gemini program, for example, certainly has tremendous contributions to make in the objectives of that program.

The whole matter of the man and creating an environment for man to operate in is absolutely essential from a military point of view.

The near Earth activities are of greater interest to us than the ones that are essentially involved with a lunar orbit and the lunar part of the job. That does not mean at some future date this will not also interest us.

Mr. FULTON of Pennsylvania. You are interested, in the military, in manned space flight, aren't you?

General SCHRIEVER. Absolutely.

Mr. FULTON of Pennsylvania. Go right ahead, Mr. Bell.

Mr. BELL. I think you answered the question I was going to ask concerning the military value of the manned lunar flight. I believe that you said there would be some gains militarily?

General SCHRIEVER. Yes.

Mr. BELL. In the lunar orbital flight?

General SCHRIEVER. Yes.

Mr. BELL. As I understand, you believe that an Earth orbital flight would be of greater value militarily. Therefore, I assume that if you were to select the mode for reaching the Moon you might try an Earth orbital flight first?

General SCHRIEVER. Well, I hate to say, because I am sure they made their decision on very good reasons. What I said was that those activities associated with the near-Earth orbital activities are of more immediate interest to us than those aspects that relate to the lunar activity—that is the landing on the Moon, and the lunar orbit.

Now, the Gemini and certain other aspects of Apollo in the near-Earth orbit all have applications to the military missions as I have pointed out.

Mr. RIEHLMAN. Mr. Chairman?

Mr. DADDARIO (presiding). Yes, Mr. Riehlman?

Mr. RIEHLMAN. That gets into some of the questions I wanted to ask about the interest of the military in the Gemini program.

There was an article in the Sunday Star yesterday written by Mr. William Hines which deals quite a bit with this. The inference that I get from the article, which concerns an interview that he had with Mr. Webb, is that there is a possibility of lack of interest on the part of NASA in the Gemini program. My feeling would be that NASA is willing to turn this over to the military, and that NASA's great interest is in the Apollo program?

General SCHRIEVER. Well, this——

Mr. FULTON of Pennsylvania. Have you seen the article?

General SCHRIEVER. Yes, I have seen the article. I think this could be inferred from the article.

However, in my associations with NASA on the Gemini planning board there has been no lack of interest in the Gemini program and I can well understand why there should not be a lack of interest in aachieving the objectives that they have, which are rendezvous, docking, transfer, and putting a man up in space for an extended period of time.

These are just some of the objectives in the program that have to be achieved——

Mr. RIEHLMAN. It certainly is true——

General SCHRIEVER (continuing). Before they can go to the Moon.

Mr. RIEHLMAN. And have a lunar operation there?

General SCHRIEVER. NASA has a 12-flight program now as their total Gemini effort and I am not sure of what their interest in this program is beyond that 12th flight. They are taking a look at this. We too will have an interest beyond that and we also are working on that area.

Mr. RIEHLMAN. Well, I was keenly interested in this statement because the inference is certainly there that there could possibly be a lack of interest in the Gemini program as far as the NASA is concerned. As you stated, General, the Air Force has a great interest in this type of program because of its low orbital capability, rendezvous techniques, and all the rest that is going to be a part of the Gemini program.

General SCHRIEVER. That is right.

Mr. RIEHLMAN. I would expect that this would be of tremendous interest to this commitee. If this is going to be a completely military project and NASA is going to support it, then the question arises as to whether or not we can use some of this information when we go before the House this year for the authorization to carry on this type of program.

How much can we attach to the military's interest in the Gemini program which is actually being financed through NASA, that is, outside of the Titan II?

General SCHRIEVER. Well, we have defined certain experiments that we would like to conduct during the 12-flight program, the present 12-flight program, that are in addition to what NASA is going to do. This is still in the process of being shaken down in detail. We have to

submit such a plan to Mr. Webb and Mr. McNamara by about the 15th of May.

We are also looking beyond the 12-flight program—at the direction of the Secretary—as to what can the Gemini do beyond that in the other areas that I have talked about such as the module approach to building a space station and other experimental things.

We are studying this very carefully with NASA. NASA does have the overall management responsibility for Gemini. They have not shown a lack of interest in it in any of our meetings. Therefore I was a little surprised at Mr. Hines' article.

Mr. RIEHLMAN. I am sure they may not have shown a lack of interest. The point I am trying to make is that here might be the opportunity for the military to at least show a greater interest as far as the public is concerned with the Gemini program.

Mr. TEAGUE. Will the gentleman yield?

Mr. RIEHLMAN. Yes.

Mr. TEAGUE. In Texas newspapers last week there was an article from the Associated Press which quoted Mr. Meyer who is project manager of Gemini at Houston, as saying that the Gemini program slipped many months because of the failure to deliver hardware by the contractors.

Mr. RIEHLMAN. This says it will possibly be a year.

Mr. TEAGUE. Brainerd Holmes said the statement was very premature.

General SCHRIEVER. Well, based on our meetings to date I think the statement is premature. There is no question but that we have some development problems that we have to lick in the TITAN II on this vertical longitudinal oscillation problem, called "Pogo-Stick."

We have laid out a program to lick this. There is no queston in my mind but that we can do it. I think there will be some delay in the first flight, but I think it is premature to make statements such as that you report.

I did not see this particular report.

Mr. FULTON of Pennsylvania. Mr. Chairman, could we have both those articles put in the record?

Mr. TEAGUE. I don't have the one I mentioned since I gave it to Mr. Holmes, but if it is all right with Mr. Riehlman, we can have this article put in.

Mr. RIEHLMAN. It is all right.

Mr. DADDARIO. What purpose will it serve?

Mr. RIEHLMAN. I don't know that it serves any real purpose because it is not official; this is just speculation on the part of a writer for the Sunday Star.

Mr. TEAGUE. I think that when Mr. Holmes comes here, we should clarify this whole matter. He told me that it was premature.

Mr. RIEHLMAN. I would like to keep the article and if it is necessary we ought to include it in the record.

Mr. DADDARIO. I don't think we ought to make the record a matter of general speculation. We have heard from two of the outstanding people in the program that any such speculation is premature.

Mr. TEAGUE. We will clear it up with Mr. Holmes on Wednesday.

Mr. FULTON of Pennsylvania. Could I just be heard a minute?

The article has been referred to in the testimony so anybody reading the testimony would, of course, want to see what the article was.

There are certain indefinite statements made that have inferences, and I believe that a person reading the record would like to see the article himself to see what the inferences are that the general testified to.

I have no particular feeling about it one way or the other. Whatever the chairman wants to do is fine, but I felt that if it were a legal hearing, we would certainly have the article put in the record.

Mr. TEAGUE. Do you have objection?

Mr. RIEHLMAN. I have no objection on the basis of what Mr. Fulton has explained.

Mr. FULTON of Pennsylvania. I would include it merely for reference.

Mr. DADDARIO. You would establish a precedent of putting in the record every single article to which anybody ever refers.

Mr. TEAGUE. He quotes the Administrator of NASA.

Mr. FULTON of Pennsylvania. That is the trouble.

Mr. RIEHLMAN. Mr. Hines quotes Mr. Webb on two or three occasions, and he also refers to the military.

Mr. FULTON of Pennsylvania. Unless somebody sees the article to get the inferences we are talking about, it becomes meaningless to have the discussion.

Mr. TEAGUE. Any objection?

Mr. DADDARIO. I withdraw my objection.

Mr. TEAGUE. We will put it in the record.

(The article referred to is as follows:)

[From the Sunday Star, Washington, D.C., Apr. 28, 1963]

TWO-MAN GEMINI AGAIN PUT OFF, GIVING RUSSIA NEXT PRIZE

(By William Hines, Star science writer)

The two-man Gemini project has missed its latest target date and will not reach the manned flight stage for at least a year, Space Administrator James E. Webb said yesterday.

In the meantime, he declared, the Russians can be expected "at any time" to launch a Vostik-type capsule containing a multimanned crew. Thus, the Soviet Union would beat the United States to the next big space milestone by at least 12 months.

The additional delay in Gemini, widely rumored throughout the space business, was conceded by Mr. Webb in an interview following a talk to Princeton University alumni here. He charged the slippage to "some difficulty with the utilization of Titan II" and the fact that "we have run into problems" with the Gemini capsule itself.

"No one can forecast now when we will fly Gemini," Mr. Webb said.

DENIES PLANS COMPETE

Mr. Webb's acknowledgement of the additional delay is certain to add fuel to the fire of speculation about Gemini's future as a part of the National Aeronautics and Space Administration's program.

NASA cooked up the two-man program as a stopgap between the 1962–63 one-man Mercury project and the 1965–70 three-man Apollo program leading to lunar flight.

The latest delay in Gemini pushes its first mission date back to within a matter of months of the first scheduled Apollo Earth orbital flight.

Mr. Webb denied that Apollo and Gemini would be "competing" for attention in the 1964–65 time period. However, it is already widely recognized that Gemini is being deemphasized, financially and in all other ways to clear the decks for Apollo. Some observers believe a recent agreement between NASA and the Defense Department, cutting the Air Force in on Project Gemini, is a part of this deemphasis.

OTHER PROGRAM PACE

Mr. Webb and Defense Secretary McNamara lunched together yesterday following the NASA Chief's appearance at the Princeton meeting. The Space Administrator took part in a panel discussion on space, along with Princeton Profs. Harry Hess, Courtland Perkins; and Charles Conrad, Jr., Gemini-Apollo astronaut trainee, a 1953 Princeton alumnus.

The first indication that Mr. Webb was prepared to admit a further slippage in the Gemini flight schedule came when he was asked by a Princeton alumnus what dictated the pace of space programs. Explaining that both money and trained manpower entered into the matter, Mr. Webb turned to the question of Soviet-American competition.

"With their existing rockets, they will probably be able to do a multimanned flight around the Earth a year before we will do that," he said.

After the meeting, a reporter asked what this meant with respect to Gemini, officially scheduled to enter the manned-flight stage in the first quarter of 1964. Mr. Webb said such a target date could not be met and added that "no one can forecast" a Gemini flight date at this time.

RECENT RECOVERY

While acknowledging that the $750 million Gemini program has failed to meet crucial development milestones, Mr. Webb insisted that reporters quote him as saying, "We can solve every single one of our problems." He added that the integrated mission control center now being built at the manned spacecraft center outside Houston, Tex., would be able to handle up to four flights simultaneously, either Gemini missions, or Apollo missions, or a combination of both.

The Titan II trouble Mr. Webb mentioned, has been discovered in recent launchings of that rocket. Vibrations after takeoff, while regarded as acceptable in a weapons system, are thought to be excessive for manned space launchings.

Less is known about the trouble in the Gemini capsule itself, but this is understood to consist of a number of "bugs" of sorts normally encountered in the development cycle.

RENDEZVOUS LATER

When Gemini originally was announced as a part of the space program late in 1961, NASA officials were hopeful of first manned orbital flights in the fall of 1963, with more complex rendezvous missions starting as early as mid-1964.

Delays, some blamed on funding, officially threw the first flight into 1964 as early as last November.

With an initial manned flight now possible no earlier than May or June of next year—barring further slippages—it now seems highly unlikely that rendezvous missions will be flown before 1965. Such missions, bringing together the manned Gemini spacecraft and an unmanned Agena propulsion unit, are regarded as essential training flights for the 1968–70 Moon-landing adventure.

Mr. TEAGUE. Any questions, Mr. Daddario—excuse me, were you through, Mr. Riehlman?

Mr. RIEHLMAN. I have one or two other questions but go ahead.

Mr. DADDARIO. General, there is no conflict as to what we should achieve as a nation or what we are capable of achieving. Rather, doesn't the conflict exist over how we should achieve it?

General SCHRIEVER. I am not sure I understand exactly.

Mr. DADDARIO. Let me carry it through.

In your statement you referred to setting up the initial management and organizational steps through the liaison of General Ritland with the Office of Manned Space Flight. When you talk about the reasons why the military must do certain things and why there is an urgency to your program, doesn't this boil down to the fact that there are in fact two space programs? Isn't it a fact that we have a military program and a civilian program, and we have not been able to reconcile the differences between them?

General SCHRIEVER. I think it is true to say that there are two programs. It is essentially, however, because of the overlap in tech-

nology that the "how," as you have mentioned, will be constantly worked on to insure that these programs are completely complementary. There is a great deal that NASA will do, particularly in the technology area, that will have direct application to military operations or military development.

Mr. DADDARIO. This has been a subject of constant concern to the members of this committee and, as I understand your testimony, you also have been concerned. Do you believe that we are taking steps to reconcile these differences. Are we bringing together the proper people, and are we developing the capabilities so that we are molding one team to achieve our objectives?

General SCHRIEVER. Well, I feel that a great deal of progress has been made. I have stated before that I felt that the contact at the top was not enough. You need the contact at the top from the standpoint of policy and overall program approval, but when you get down into the details of working out the specifics with respect to a project or specifics with respect to facilities, technical facilities, for example, it is absolutely essential that you go clear down to the working levels. It is only there that you can really get the kinds of information necessary to determine whether there is duplication or whether there is not duplication.

And here I think we still have a way to go. I think one must remember that NASA is a new organization. They have expanded rapidly. They have problems, and we have had problems in the space business. I think good progress has been made. I think the Gemini planning board is another indication of it because this does, in fact, provide the kind of grassroots, across-the-board activity that I am talking about in this area of manned space flight.

Now, I think more of this in other areas is called for.

Mr. DADDARIO. Some time ago there was an indication that the Air Force was losing people because of the greater opportunities in NASA and in industry. Has this slowed down as a result of the Air Force playing a greater part in the space program so that these people can see that their future opportunities lie with the Air Force rather than some other agency?

General SCHRIEVER. Well, first of all, Mr. Daddario, I think that this concern or this reported raiding, as you might call it, has been somewhat taken out of perspective.

We have been keeping very close records on the people that we have lost to NASA as well as to industry, and I can say that our attrition or our losses to NASA have been what I would consider to be normal. They have not been abnormal.

NASA has cooperated with the Defense Department in this regard. I can frankly say I was concerned about it a couple of years ago, but my concern just has not materialized. We have lost some people to NASA, that it right; but that is to be expected and we do have a normal turnover.

Our normal turnover of civil service personnel has not changed in the last several years, we have stayed just about on the same percentage level. So I cannot complain that we are losing people to NASA at an abnormal rate.

Mr. DADDARIO. This would be a good indication then, if it is a normal situation?

General SCHRIEVER. Yes.

Mr. DADDARIO. It would show me at least that there is a statement in the program?

General SCHRIEVER. That is right. Of course, these people are not necessarily just people in space technical work—they may be in other areas of specialized activities—in the procurement field, the quality control field, such things as that.

So we have a broad spectrum of technical and management people. We have lost people clear across the board, but, as I say, I would consider it just normal.

Mr. RIEHLMAN. Would the gentleman yield?

Mr DADDARIO. Yes.

Mr. RIEHLMAN. General, in some areas there has been a question raised as to whether or not we should go into the Gemini program at all.

Some people feel that the Gemini program is not necessary, and this probably rests on the decision to employ the EOR or the LOR approach. If we had decided that we could have accomplished the manned lunar landing by the EOR approach, would it have been necessary to have both the Gemini and the Apollo projects going at this time?

General SCHRIEVER. Well, I think this is a question that really NASA needs to answer.

I can give you some basic, fundamental reasons why it is necessary for NASA to have the kind of information that they are going to get out of the Gemini.

Mr. RIEHLMAN. Let me just back up a moment so that you will know what I am thinking about. Couldn't NASA have gotten the very same inormation out of the Apollo program if it had decided on an EOR approach?

General SCHRIEVER. NASA could have gotten the same information but at a later date and at a considerably greater expense, because the Apollo costs a great deal more per launch than will the Gemini.

They have got to have this basic, fundamental information of how does a men respond to 7 days in orbit.

What about the rendezvous and the docking, and so forth?

So really this is aimed at achieving those steps, those building block steps at a considerably lower price than they would have had to do it in the Apollo. I think they are completely justified in the program. They would have had to do it, I think, under either circumstance, but they will get this information much sooner and much cheaper.

Mr. DADDARIO. Mr. Bell?

Mr. BELL. General, in answer to Mr. Daddario's question, you inferred that you can compete satisfactorily for personnel with NASA and industry. You do have a problem, though, do you not, as to salary levels and benefits as far as your personnel are concerned?

General SCHRIEVER. I did not say we could successfully compete with industry. I said that our losses had not been abnormal. We do lose a lot of good people to industry, more than I would like to lose. And we cannot compete with industry from a salary standpoint or even, I would say, a fringe benefits standpoint.

Mr. BELL. How about NASA, can you compete with them?

General SCHRIEVER. With NASA, yes. Of course, there is always an advantage when you have a growing organization when people have an opportunity to move up the ladder faster, that sort of thing.

Our organization is pretty stable. There has been some growth but it is a slow growth, whereas NASA is building up quite rapidly and has over the past couple of years.

Mr. BELL. Also in answer to Mr. Daddario's question, you mentioned coordination and eliminating some of this duplication which you say may exist.

General SCHRIEVER. Well, I said to insure that we do a better job.

Mr. BELL. Just visualizing this coordination at the top level for a minute, and I don't mean to ask embarrassing questions, but I am curious as to the line of command. Is Secretary McNamara the one that deals with Mr. Webb or do you deal with Mr. Webb, or do both of you? How does this operate? For example, if you get into a problem as to what NASA or the Air Force does, whom do you deal with?

General SCHRIEVER. On all formal dealings between the Department of Defense and NASA, it is Mr. Webb dealing with Mr. McNamara. They have established the AACB, the Astronautics and Aeronautics Coordinating Board.

Mr. BELL. Who is the Chairman of that?

General SCHRIEVER. Dr. Brown and Dr. Seamans are the co-Chairmen. They also have a number of panels.

The representatives on those panels covering the various technical areas of common interest between NASA and DOD are from the DOD as well as the services and the NASA. This Board and the panels meet periodically.

Mr. BELL. Are the panels equally divided as far as representation is concerned?

General SCHRIEVER. I think they are equally divided between NASA and the Department of Defense.

Mr. BELL. The Air Force?

General SCHRIEVER. Not the Air Force.

Mr. BELL. You are talking about Department of Defense and NASA?

General SCHRIEVER. Yes, sir.

Mr. BELL. So actually when you get to the top you have it pretty well evenly divided. If there were a difference of opinion between the departments, you would have sort of a Mexican standoff?

General SCHRIEVER. At that level——

Mr. FULTON of Pennsylvania. What is that?

Mr. BELL. Where neither side can win nor outvote the other.

General SCHRIEVER. Well, in that case it would be brought up to Mr. Webb on the part of NASA and Mr. McNamara on the part of the Department of Defense for resolution.

Now you asked me about dealing at my level. Actually I have had delegated to me from the Department of Air Force, both from the Secretarial level and from the Air Staff, very considerable authority for dealing with NASA.

Most of the dealings between NASA and the Air Force are done at the Systems Command level; in other words, my command.

On matters where policy has already been established and programs are under way, I deal directly with Dr. Seamans and Brainerd Holmes with respect to the resources that may be applied.

Mr. Daddario. But when it concerned a matter of which agency was to have a certain project such as Gemini, or who was to do a particular thing, it would probably have to be resolved between the Secretary of Defense and the Administrator of NASA; is that correct?

General Schriever. That is correct; but that is not at my level.

Mr. Bell. I probably should not be asking you this question, but has there been to your knowledge any definite difference of opinion in any of these areas?

General Schriever. Well, certainly there have been differences of opinion and you would expect that.

Mr. Bell. Yes.

General Schriever. After all, we are dealing with tremendous programs, tremendous resources, many people, many facilities, so there are certainly differences arising from time to time.

Mr. Bell. That is true.

General Schriever. They have all been worked out to the best of my knowledge.

Mr. Bell. May I ask one more question?

Mr. Daddario. Yes.

Mr. Bell. General Schriever, I understand that the Nuclear Systems Office in NASA is having a little trouble with Project Rover. I also understand that the Department of Defense has budgeted for nuclear propulsion, and that many people feel there has not been an adequate increase to take care of the leadtime necessary to build up nuclear propulsion.

Would you consider this reasonably accurate?

General Schriever. Well, the development of nuclear propulsion, that is the boosters has been assigned to the NASA.

In other words, the Department of Defense does not work with AEC in booster fields, directly.

Now we do work in the auxiliary power field. Here we have a very considerable interest. We fund for it and work directly with the AEC. As a matter of fact, we have furnished Air Force officers who are assigned to AEC and they are actually the program directors of the SNAP and several other projects.

Mr. Bell. Orion, SNAP, and two or three other programs?

General Schriever. That is right. But in the Rover program and in the nuclear-booster area this is a NASA–AEC tie. We are interested in it, of course, but we have not funded for any of this and I cannot at the moment give you any details as to the status of that project because I am just not up to date in this matter at the moment.

Mr. Bell. Thank you.

Mr. Daddario. It is your feeling then, General, that the line of communications between NASA and the Air Force is better now than it has been before, and that it seems to be improving all the time?

General Schriever. It is better and it has been improving; yes, sir.

Mr. Daddario. In your opinion, it is important that we have the best possible coordination because, through this means of communication, we will have a more efficient program and obtain better dollar

effectiveness? Consider this in light of the statement you made that this program is an expensive one.

General SCHRIEVER. Yes, sir.

Mr. DADDARIO. I am pleased to hear that. I often have my doubts, frankly.

General SCHRIEVER. Well differences do arise, but then I have differences among my own people. I have 17 commanders and I can assure you sometimes I almost tear my hair out in frustration because wherever you have an overlapping situation among programs and among areas of responsibility, you are bound to have differences arise.

So you can expect that these will arise and there will continue to be problems between NASA and the Air Force, but I think this is to be expected.

Mr. DADDARIO. In the area of the large solid motors we have programs involving 120-, 156-, and 260-inch motors.

Do we need all of these programs at the same time or could we gain the requisite knowledge by going ahead with just the smaller ones, taking into consideration what you have said regarding the cost per shot of the Apollo and Gemini programs?

I wonder if we could not defer the 260-inch program until we have learned as much as we probably can out of the 120- and 156-inch solid motor programs.

General SCHRIEVER. Well, I think that this large solid motor program has probably been under more scrutiny than any other program that we have ever undertaken. It has been about 2 years in really evolving into something that has been agreed to by both the Department of Defense and NASA and we have just selected the contractors.

The program really is what you might call an experimental or technical feasibility program involving a number of experiments to prove the feasibility of these various rocket motors. I think it does not commit the Department of Defense or NASA to very large-scale facilities or to very large-scale testing.

It is not going to be a very expensive program; not nearly as expensive as visualized earlier.

I think it is necessary to actually carry out experiments in the 260-inch-diameter region because you simply cannot extrapolate from 156 to 260 with any degree of certainty.

The program has been very carefully developed. We have had our best technical people in it. We have had the best technical people from NASA involved and I think it is a very sound program. It is one of the few programs that, now, everybody, I think, is in complete agreement.

Mr. DADDARIO. How large is the 260-inch program? When you say it is experimental, how many firings will take place?

General SCHRIEVER. I will have to furnish that for the record.

The fiscal year 1964 budget, I think, is $35 million. I can furnish this for the record for you.

We have a very detailed development plan which gives exactly the number of firings and precisely what is involved in each of these.

The 120-inch, of course, is tied to the Titan III.

Mr. DADDARIO. Yes.

General SCHRIEVER. We are talking about the 156-inch and the 260-inch.

Mr. DADDARIO. Could we have that, and would you project the costs for the future, too?

General SCHRIEVER. Yes; I can give that to you.

Mr. DADDARIO. The reason I go into this is because it has been indicated to this committee that all the necessary information could be obtained from the smaller programs. Furthermore, to conduct a 260-inch program would necessitate 100 firings to bring it to perfection and these 100 firings will cost millions of dollars?

General SCHRIEVER. Well, I don't know; you can probably get a number of different opinions on this.

All I can say is that we have had our very best technical people on this. We have scaled the program way down with objectives that are considerably less than those which were earlier established in terms of actually achieving a 260-inch capability.

The program now calls for establishing the technical feasibility of such an engine. We are not talking about 100 firings or anything like that; we are talking about just a small number of firings, not involving the total length of the rocket.

So what you say is true; if we went into a very large-scale program it would be a very expensive one for the 260-inch-rocket motor.

You can get a lot of people who will voice opinions on these solids. The fact is, that, I have to take the word of my technical experts and they are the best in the business. We know, I think, more about solids than any other establishment.

We moved from the smaller rockets into the Minuteman based on just this kind of feasibility program that we are now undertaking in the large solids.

Mr. DADDARIO. These figures you provide will set out the program and its cost?

General SCHRIEVER. I will provide you with what I think you want in terms of the magnitude of the program, both in dollars and in firings, and I will add a few specifics as to why we feel that we need to go both 156- and 260-inch routes.

(The information referred to is classified and may be found in the committee files.)

Mr. FULTON of Pennsylvania. Would you yield?

Mr. DADDARIO. Yes.

Mr. FULTON of Pennsylvania. To get more detail, could you divide it between research and technical development and engine development so that we can see which is research and which is actually engine development? Is that possible?

General Schriever, I understand that most of the expenses of these programs when they get to a certain point are engine development. However this large solid program is not aimed at engine development at all in terms of what I think you have reference to.

Mr. FULTON of Pennsylvania. That is what I am trying to get clear. This is really just research and technical development on the program rather than engine development.

General SCHRIEVER. That is right.

Mr. FULTON of Pennsylvania. Thank you.

(The information referred to is classified and may be found in the committee files.)

Mr. DADDARIO. How far in the future must we look before we can reach the point where nuclear engines can become somewhat smaller?

When can we develop a nuclear capacity, for example, while reducing the size of the engine and still accomplish some of these objectives?

It seems that, eventually, we must reach that point because a 260-inch motor is an awful big piece of equipment. Can we look forward to the time when we will develop a nuclear capacity with a more efficient engine?

General SCHRIEVER. Well, if you are calling for very high thrust you are not going to have very small engines. As a matter of fact, the present nuclear approach, using the resupply technique, which uses hydrogen; it is a very, very large tank. So I cannot visualize a small powerplant having a very large thrust capability. I think if you are talking about a large thrust capability, you are going to talk about a relatively large engine.

Now, from a military standpoint, I think we will move more slowly toward these large engines; that it is to our advantage to stay as small as possible because of the logistics and operational aspects involved and also the cost involved.

That is another reason why we are so anxious to develop the rendezvous, docking, and transfer techniques, because it is entirely possible that rather than sending something up in one package, we would prefer to send it up in several smaller packages and assemble it in space.

These are some of the things that are still ahead of us in our experimental work.

Mr. DADDARIO. Are we preventing that from coming about by not going ahead with Gemini type programs before we go into Apollo and Nova?

Are we eliminating the development of techniques to put smaller payloads into Earth orbit and then moving from there?

General SCHRIEVER. No. The Gemini program will, in fact, meet this requirement. We have, of course, the satellite inspector program which we are attempting to work into the overall Gemini-Dyna-Soar situation.

There are specific developments of sensors and other equipments involved and there are certain differences in techniques of rendezvous, such as with a hostile or noncooperative object rather than a cooperative target, but all of these can be worked into an expanded Gemini type program.

Mr. TEAGUE. Mr. Bell?

Mr. BELL. General, I have a series of questions that perhaps have been asked you before but are somewhat more detailed.

NASA has a Life Science Research Facility in its budget for about $4,800,000. I understand that the Air Force has a large facility and a technical capacity in the bioastronautics area which has been offered several times to support NASA programs, but that NASA has not accepted these offers. Are you aware of this?

General SCHRIEVER. Well, we have discussed with NASA on—when I say "we"——

Mr. TEAGUE. Before you answer that, would you yield for a second?

Mr. BELL. Yes.

Mr. TEAGUE. Would you include the Navy School of Medicine at Pensacola, Fla., in your answer? We were down there and they told us something about the coordination that is going on. Likewise, we

talked about an agreement between NASA and the DOD last year, and we understand that the agreement has never been reached.

Please review the whole area for us because we will be going into this with NASA one day soon. Mr. Bell was [illegible] subcommittee last year, so give us an overall résumé of this [illegible] aerospace medicine.

General SCHRIEVER. Well, I will see what I [illegible]

(The information requested is as follows:)

USAF BIOASTRONAUTICS RESOURCES

As you know the Air Force has been painstakingly investigating the complex problem of injecting human beings farther and farther into the hazardous reaches of the aerospace environment since 1918. Highlights of this effort include the establishment of the predecessor of the present School of Aerospace Medicine in that year; the founding of the nucleus of the present Aerospace Medical Research Laboratories at Wright-Patterson Air Force Base (to do bioengineering in connection with manned aircraft development) in 1935; and the creation of a group of other system design and test support groups beginning in 1951, shortly after the Air Research and Development Command was founded to bring order and scientific management into the research and development business and provide the USAF with qualitatively superior weapon systems.

The word "bioastronautics" is what we use to describe the research, development, and test programs needed to explore the capabilities and limitations of man in space environments and promote the safety and effectiveness of man in space flight operations. It consists not only of contributions made by life scientists but also of knowledge and skill which their associates in the physical, chemical, and engineering sciences and technologies can bring to bear on the common goal of assuring the successful protection and performance of aerospace crewmen.

The recent establishment of the Aerospace Medical Division located at Brooks Air Force Base, San Antonio, Tex., established a focal point for the overall management and implementation of the bioastronautics program. Its prime mission is to manage and direct research and development programs in support of Air Force systems development, including basic and applied research, advanced technology, operational support and direct system support programs. This is our headquarters for our aerospace medicine and bioastronautic research and we have a large part of our research facilities located there. Under management of the Aerospace Medical Division we have the research laboratories of the School of Aerospace Medicine located at Brooks AFB, the Aerospace Medical Research Laboratories located at Wright-Patterson AFB, the Aeromedical Research Laboratory located at Holloman AFB, the Arctic Aeromedical Laboratory located at Fort Wainwright AFB, Alaska, and the Personnel Laboratory located at Lackland AFB. These laboratories constitute our major facilities for bioastronautics research and development.

They are not only an Air Force asset but a unique national resource and represent a considerable investment in funds and scientific effort. For example, the replacement value for the real estate and research tools of these organizations would amount in excess of $50 million. Additionally, our highly trained scientists constitute one of the most valuable national assets in the race for space. Among the personnel assigned to these organizations are 283 scientists, military and civilian, owning a doctorate degree in one or another of numerous scientific and medical specialties and devoting full time to such research. Approximately 143 more hold a master's degree and 399 with a bachelor's degree fall in the same category.

Now moving on to our relationships with NASA—the Secretary of the Air Force and the USAF Chief of Staff declared in the summer of 1958 that it would be the Air Force policy to give full and enthusiastic support to NASA in its space flight programs. This policy has been reaffirmed on many occasions since, and this command has given complete cooperation to the NASA in all requests for assistance. The following represent some of the NASA requests and Systems Command cooperation with respect to research and development associated with bioastronautic research:

(a) Astronaut physical screening and physiological stress testing.

(b) Astronaut training and indoctrination in weightlessness, acceleration, use of protective equipment, etc.
(c) Evaluation of competitive full pressure suit designs.
(d) Mercury capsule impact testing.
(e) Chimpanzee training and flight test support.
(f) Chimpanzee holding facility expansion, and baseline data collection.
(g) Radiobiological applied research and instrumentation development.
(h) Proposed cosmic radiation space flight program (Thor-Agena B vehicles, highly eccentric orbits).
(i) Consultative assistance from Air Force laboratory and staff levels.

General SCHRIEVER. We do not have an agreement between NASA and the military that I am aware of with respect to the utilization of our resources in support of the NASA manned space flight programs. Nor do we have any mechanism for coordinating at the working level on facility resources that are being asked for by NASA or underway in one form or another for this type of work.

Mr. TEAGUE. Why not? If my memory is correct, last year both the Air Force and NASA told this subcommittee that you expected to have an agreement very soon.

Mr. DADDARIO. Mr. Rubel and Dr. Dryden told us that within 2 weeks after the close of the hearings they would come to that agreement.

Mr. FULTON of Pennsylvania. Yes.

Mr. TEAGUE. If you will forgive us for getting into your question, Mr. Bell.

Mr. BELL. No, that is all right.

General SCHRIEVER. There were communications between the Department of Defense and NASA on this subject. To the best of my knowledge an agreement has not been accomplished.

Mr. TEAGUE. Is there a reason? Is it a point of difference, or is it a lack of initiative to have an agreement? What is behind it?

General SCHRIEVER. I think there has been a point of difference. I don't know exactly where it stands at the moment.

Mr. TEAGUE. Thank you.

Mr. BELL. General, I understand that NASA's Langley Research Center has a program costing approximately $1,700,000 for a Vehicle Antenna Test Facility. I also understand that the Air Force as a capability in this area at Wright-Patterson Field. Is that correct?

General SCHRIEVER. Yes, we have certain antenna development capabilities both at Rome, N.Y., and at Wright Field. I am not able to comment specifically on the need for the NASA vehicle antenna test facility because I am not familiar with their requirement. Our capabilities at the Rome Air Development Center and Aeronautical Systems Division are oriented toward radar, electronic counter-measures (ECM) and aircraft communications.

Mr. BELL. Has NASA offered to make any kind of arrangement for your facilities at either Rome or Wright-Patterson?

General SCHRIEVER. To the best of my knowledge we have not made any offer of our test facilities in these areas nor have there been any requests made upon us. But I couldn't guarante this 100 percent because I don't see all the correspondence.

Mr. BELL. In the NASA budget there is a request for a "Launch Environment Antenna Test Facility" for $7 million. The Air Force—I suppose this is much the same thing—has a similar facility, again at Wright-Patterson.

General SCHRIEVER. We have facilities that would appear similar to that description, but whether or not they are necessarily in all respects, facilities suitable to solve NASA's needs, or whether these facilities with modifications could be made to serve NASA, it would be very difficult to say. The NASA facility in question will simulate the noise, vibration, and other environments that would be characteristic of a launch site. There are no facilities at Wright Field specifically designed or currently capable of simulating this environment.

(The following information has been submitted for the record:)

USAF VIBRATION AND COMMUNICATIONS TEST FACILITIES, WRIGHT-PATTERSON AFB, OHIO

1. *Vibration facility (building No. 93), $100,000; five technicians.*—Model C-82 calidyne, 12,500 pound force, provides a massive vibration table for medium and high weight class of equipment.
2. *Random vibration facility (building No. 93), $120,000; seven technicians.*—Output force of 3,500 pounds, frequency five—2,000 cycles per second for equipment weighing less than 90 pounds.
3. *High intensity acoustic test facility, $300,000.*—Fifty-four feet long by twenty-six feet wide by thirteen feet high. Capable of subjecting electronics, materials, structures, to sound pressure levels up to 174 decibels. Maximum frequency range 20—10,000 cycles per second. This facility is located at Cambridge.
4. *Sonic test facility, $13 million (under construction).*—Seventy-foot by fifty-six-foot by forty-two-foot chamber; 1 million watt acoustic power; progressive wave field 174 decibels; random noise field 160 decibels. Most advanced and largest capacity test facility of its kind in existence.
5. *Communication receiver facility, $675,000; four technicians.*—Building 836 and 103-acre plot of land provides an experimental test site for communications systems operating in frequency bands above 2 gcs. This shares acreage with building 835 (flight test radar repeater facility) 5 miles east of Wright-Patterson AFB.

Mr. TEAGUE. Would you tell what the AACB is and who is on it?

General SCHRIEVER. It is the Aeronautics and Astronautics Coordinating Board. Dr. Brown and Dr. Seamans are the co-chairmen of this and it consists of a number of panels.

Mr. BELL. General, getting back to the launch operations again, there is a Central Instrumentation Facility costing about $31 million in the NASA budget. I understand this facility appears to provide NASA with an excess capability, in view of the DOD capability existing at the Atlantic Missile Range. The AMR is updating the telemetry center and there is an additional amount of money for the NASA program; I wonder if you think there is anything that could be be coordinated in this area?

General SCHRIEVER. Well, this is one area in which I believe detailed coordination is taking place at Cape Canaveral now. You see we have a completely separate agreement with respect to the operation of the Atlantic Missile Range. This agreement was some months in developing and it does require that the people on location specifically coordinate in detail on all technical facilities.

The Atlantic Missile Range is presently updating the telemetry center. The AMR telemetry program for expansion and updating was jointly planned with NASA. However, NASA's requirement for additional telemetry was not made known at that time. At this point I would like to emphasize that complete assessment of the possible extent of duplication involved can be accomplished only by a comprehensive study and comparison of present and proposed facili-

ties and projected workloads by the operating personnel at AMR. As I have said earlier, this detailed coordination is presently going on now at the Atlantic Missile Range.

Mr. TEAGUE. If there is no objection from any member of the committee, I would like to offer you a chance to revise your remarks on those questions on which you do not have the detailed information. You might want to add some comments later for the record.

General SCHRIEVER. Do I understand that where I do not have the detailed information, you are asking that I fill in the details?

Mr. TEAGUE. Correct.

Mr. FULTON of Pennsylvania. For example, I think you should make some very definite statements in regard to coordination.

General SCHRIEVER. Well, I would prefer to do this because we are covering a very broad field here.

Mr. TEAGUE. I would certainly hope the record would not indicate that we were ducking these questions or bypassing them. That is the reason I would like your staff to take the record and go through it and put in anything on which you would like to elaborate.

General SCHRIEVER. All right, I will be glad to do that, I do not have the details on many of the facilities that you have brought up. I am familiar with them in general, but I do not have the specific details.

(The following information has been submitted for the record:)

I have appreciated the opportunity to amplify my description of the Air Force technical facilities and capabilities about which Mr. Bell has inquired. More detailed technical indentification of the Air Forces' resources, of course, have been made available to NASA. The question of extent of NASA/DOD coordination or potential duplication of facilities, however, can only be examined in the context of total projected workload requirements for each of the agencies at each of the facilities concerned. The specific nature of the tasks and objectives which are involved also must be reviewed.

In other words, close coordination or mutual exchange of information regarding planned R. & D. efforts is a prerequisite to effective coordination of planning of technical facilities. To be most effective and timely, this coordination and interchange must be initiated at the working levels at which adequately detailed technical understanding can be found regarding specific R. & D. tasks. As the subcommittee knows, there has been extensive coordination and cooperation with the NASA by the Air Force, particularly in the bioastronautics area. Examples are listed at the conclusion of my discussion.

The total magnitude of the NASA and DOD space research and development effort has almost inevitably mushroomed at a rate greater than improvement in some of our management and procedural arrangements for optimum effectiveness of interagency coordination. This statement in no way detracts from the highly beneficial results of work in many areas by the AACB and its subsidiary panels. The task of assuring adequate coordination in the field of technical facilities planning is one requiring significant further improvement, but, by the inherent nature of such planning, the problem must be recognized as being one of the most challenging we face.

Planning and design of advanced technical facilities constitute major R. & D. jobs in themselves, complicated not only by their own leadtimes and unforeseeable obstacles, but also by the unknowns and variables of the R. & D. objectives for which the facilities are required. Over and above these complications are those involved with budgetary and funding leadtimes and uncertainties.

In view of these abbreviated summaries of the difficulties involved, it is evident that it is virtually impossible within a brief time period for me to furnish an accurate analysis in valid overall perspective concerning the extent to which undesirable duplication may exist in connection with planned or existing technical facilities of the NASA and DOD.

With respect to fiscal year 1964, an ad hoc committee to the AACB is currently charged with determination of appropriate balance between NASA and DOD existing and planned technical facilities. I also understand that as a

result of a request by the Senate Committee on Aeronautical and Space Sciences during his appearance on April 29, 1963, Deputy Secretary of Defense Gilpatric has promised to furnish the Congress information on this subject.

I believe that at times the great savings which can result in major R. & D. programs costs by virtue of availability of adequate laboratory and test facilities is not adequately recognized and taken into account. Although I am admittedly influenced by my responsibility for R. & D. matters, I am personally concerned about vital accomplishments which may be missed due to nonavailability of a laboratory or test capability just as much as I am concerned about the extent unwarranted or apparent duplication may exist. It is difficult in today's circumstances not to keep carefully planned technical facilities fully and constructively utilized.

With respect to later years, I believe that we are now in position to improve our procedures for interagency coordination, commencing earlier in the cycle and from most knowledgeable levels, while allowing for more deliberate sorting and sifting of matters which will require higher levels of review and decision.

LIST OF USAF–NASA COORDINATION/PARTICIPATING ACTIVITIES IN BIOASTRONAUTICS

Since August 15, 1962, there has been a full-time specialist in bioastronautics assigned to the Deputy to the Commander AFSC, Manned Space Flight, for interface activities with the NASA Office of Manned Space Flight. In addition to the Office of Manned Space Flight, the scope of his work with NASA has included the Directorate of Biotechnology and Human Research in the NASA Office of Advanced Research and Technology and the Directorate of Biosciences Programs in the Office of Space Sciences. These interface activities include continuous liaison with the above-mentioned NASA offices; procurement of a wide variety of USAF bioastronautics information for the NASA; arrangement of augmented programs of cooperative research by the USAF bioastronautics laboratories and appropriate NASA program offices and centers; visits to various NASA activities outside the Washington area; participation in numerous NASA technical and managerial briefings and conferences. A chronological list of samples of cooperative NASA–USAF activities follows and illustrates typical types of joint undertakings which result in coordination at the working level:

June to August 1962

The NASA Manned Spacecraft Center, Houston, Tex., requested the Air Force to perform the medical evaluations of additional astronauts selected for future manned space flight projects. The requested evaluations were performed at the USAF School of Aerospace Medicine, Brooks AFB, Tex., during July and August 1962. Each examination required approximately 5 full working days unless some finding required further additional studies. Dr. George B. Smith, Jr., from NASA's Houston facilities, participated in the evaluation program as the NASA liaison officer for the first 2 weeks of the program. The examinations proceeded on schedule with no apparent complications or difficulties.

The 6570th Aerospace Medical Research Laboratories, Wright-Patterson Air Force Base, an element of the Aerospace Medical Division, and the Manned Spacecraft Center, Houston, of the NASA, initiated a joint research program to study the dynamics of human restraint and support systems. Frost Engineering Co. is the contractor for this effort. Mathematical models developed during this program will be validated by in-house experimentation, using human subjects.

The Aerospace medical evaluations for 32 NASA astronaut candidates were completed in August 10, 1962, by the USAF School of Aerospace Medicine, Brooks AFB, Tex.

September 1962

The USAF School of Aerospace Medicine conducted the aeromedical examination of the 32 astronaut candidates for Project Gemini. NASA has informally indicated that this support was exceptional. At the request of NASA, the Aerospace Medical Division arranged to train 15 Manned Spacecraft Center personnel in aerospace physiology and pressure suit indoctrination techniques. The trainees included engineers, scientists, and contractors. A total of 13 NASA personnel have already received this type of training. This was representative of support which, while important to NASA, has not been considered reimbursable.

Close liaison was maintained with the Director of Bioscience Programs, NASA Office of Space Sciences with respect to two fields of endeavor. The likelihood and extent was examined for AFSC support of a research program to conduct biological experiments in orbiting satellites, in which the Director of Bioscience Programs had a keen interest. Also, AFSC's Aerospace Medical Division was requested to submit research proposals to the Director of Bioscience Programs with the intent of initiating a modest participating program to exploit USAF in-house laboratory capabilities for basic experiments in the aerospace biomedical sciences.

October 1962

During the week of October 14, Capt. Neville Clark of the Aerospace Medical Research Laboratories, AMD, presented the results of completed lateral impact studies to NASA MSC. This was, and still is, a part of a continuing, high priority acceleration effects series which is being supported by the NASA MSC.

Arrangements were made by the Behavioral Sciences Laboratory of the Aerospace Medical Research Laboratories, AMD, to provide orientation training for the Gemini and Apollo astronauts in certain aspects of weightlessness by flights in the KC-135. Drinking and eating during weightlessness were parts of the program.

A total of 78 USAF Medical Service personnel participated in the direct support of the Mercury MA-8 flight of October 4, 1962, on an additional duty basis. This number did not include USAF Medical Service personnel assigned to the NASA.

AMD submitted 14 research proposals in response to a request from the NASA Director of Biotechnology and Human Research OART. The Air Force Special Weapons Center submitted three research proposals to NASA Director of Bioscience Programs, OSS, for inclusion with the proposed NASA biosatellite program.

Arrangements were made for interested NASA specialists to attend the semiannual Air Force-Navy symposium on simulation and training research.

November 1962

In response to earlier NASA invitations, the Aerospace Medical Division submitted 13 additonal research proposals for the NASA/OSS Director of Bioscience Programs, making a total of 16 and 5 additional for the NASA/OART Director of Biotechnology and Human Research, making a total of 19. Collaborative effort resulting from NASA funding of any of the proposals represents a form of USAF support of NASA programs.

The Aerospace Medical Research Laboratories understood research on integrated passive techniques for pressurization and thermal control in a space worker's garment and head enclosure, pursuant to NASA Order T-12059 received in November 1962, in the amount of $40,000.

NASA Order R-43 was augmented by $33,140 during November to support additional Aerospace Medical Research Laboratories studies on human reactions to acceleration, emphasizing cardiovascular, and respiratory systems effects.

December 1962

During the month, the Commander, AMD and key members of his staff paid a formal visit to the MSC to meet members of Dr. Gilruth's organization and to become more familiar with MSC's bioastronautics program and problems.

The Commander and the Chief Scientist of the Electronic Systems Division's Operational Applications Laboratory (OAL) briefed the NASA/OART Director of Biotechnology and Human Research on the program and capabilities of the OAL. As a result, members of the Directorate of Biotechnology and Human Research scheduled a visit to ESD to become more familiar with the OAL program and to consider possible additional research of interest to OART.

January and February 1963

By invitation of NASA, AFSC submitted experiment and hardware development proposals for the proposed biosatellite program, and also requested AFSC members to serve on the Biosatellite Program Steering Committee.

During January and February, the 6571st Aeromedical Research Laboratory, Holloman AFB, N. Mex., accomplished a total of 70 runs on the "Daisy" deceleration track. Twenty-seven human subjects and forty-three animals were de-

celerated in oblique positions to study deceleration problems which may be encountered in Apollo.

During the annual educational event, "Lectures in Aerospace Medicine," given from February 4 to 8, 1963, at the School of Aerospace Medicine, several conferences and laboratory visits were held for NASA life scientists attending the lectures. The conferences served to familiarize the NASA visitors with ongoing research and scientific capabilities of the Aerospace Medical Division, with a view toward increasing the amount of cooperative research and development between the USAF and the NASA.

On February 14, 1963, the NASA Director of Aerospace Medicine (Office of Manned Space Flight) presented a special briefing on the MA–9 aerospace medical support program to several Washington, D.C. area USAF bioastronautics specialists.

The Aeromedical Laboratory at Holloman AFB was host during February for a visit by a representative of NASA's Office of Advanced Research and Technology. The visit will probably result in development of one or more animan experiments by the Holloman group for participation in the NASA biosatellite program.

Scientists and staff officers of the Aerospace Medical Division and the Aerospace Medical Research Laboratories visited the Crew Systems Division, Manned Spacecraft Center, Houston, during the month to discuss NASA's problems and requirements in several areas of interest including oxygen toxicity and space flight food technology, and to report progress on the impact research being done at the Aeromedical Research Laboratory for NASA.

The NASA Director of Bioscience Programs, Office of Space Sciences initiated support of a School of Aerospace Medicine research task, "A study of the ecological relationships between bacteria and algae in photosynthetic gas exchangers." NASA support will be a total of $35,900 for 2 years.

The NASA Director of Bioscience Programs, Office of Space Sciences invited the Aerospace Medical Division to submit a research proposal for the NASA biosatellite program involving comparative studies of animals in orbit with and without artificial gravity.

On February 26, 1963, Headquarters AFSC arranged for life scientists of the NASA Headquarters to visit the new Armed Forces Radiobiology Research Institute located at the National Naval Medical Center, Bethesda, Md. This unique, triservice facility has exceptional potential for radiobiological investigations of interest to NASA's space flight programs.

March 1963

Aerospace Medical Division (AMD) representatives visited NASA's Manned Spacecraft Center (MSC) to negotiate specific research and development tasks to be done with $500,000 which MSC transferred to AMD in the fourth quarter of fiscal year 1963. The funds are tentatively allocated as follows: Approximately $248,000 for research and test on aerospace medical techniques for astronaut selection; $75,000 studies on habitable atmospheres; $32,000 on thermal balance; $110,000 on lateral impact tolerance; and $35,000 on vibration effects in the supine position.

On March 8, 1963, nine USAF bioastronautics specialists attended a special briefing presented by the Director of Biotechnology and Human Research, OART, NASA. The purpose of this half-day session was to inform key USAF bioastronautics managers regarding the 5-year planned program so as to facilitate interagency coordination and to foster an increase in NASA-USAF cooperative R. & D.

A series of preliminary discussions were held with NASA bioastronautics officials to evaluate possible NASA interest in using the Titan IIIA flight tests for orbiting some biological payloads.

Two scientists of AMD's Aerospace Medical Research Laboratories participated in a working conference on extravehicular protective systems sponsored by NASA's OART. Four additional 1-day conferences on this subject are scheduled during the following 4 months.

April 1963

Three USAF specialists assisted the NASA Office of Manned Space Flight in preparing a list of measurements and tests to be made in manned space stations in order to predict human responses to long-term zero gravity. The lists will be used in contractor's work statements.

The Aerospace Medical Division (AFSC) agreed to continue during fiscal year 1964 at no additional expense to the NASA, a research project on the biological effects of high energy protons. Fiscal year 1963 NASA support of this project was $200,000.

Tarce Aerospace Medical Division (AFSC) scientists visited the NASA Manned Spacecraft Center to start plans for a cooperative study on the water requirements of man in the Apollo pressure suit.

The following events and activities took place involving personnel and facilities of the 6570th Aerospace Medical Research Laboratories, Wright-Patterson AFB:

(a) Two representatives of the Manned Space Flight Center visited the Biacoustics Laboratory for consultation concerning construction of NASA research facilities to investigate acoustics and communication problems in Apollo.

(b) A capsule to test air regeneration was built, tested, and delivered to MSC for use in the MA–10 flight.

(c) Nine Gemini astronauts were briefed on procedures for eating under zero gravity conditions.

(d) The same astronauts were given flight indoctrination in both the KC–135 and C–131B aircraft.

(e) Vibration and impact studies with human subjects continued in support of Gemini.

(f) The simulated Apollo escape tunnel was modified to permit escape studies under zero gravity conditions.

(g) The Manned Space Flight Panel of the DOD–NASA Aeronautics and Astronautics Coordination Board recommended that the Dynamic escape simulator, presently under construction at Wright-Patterson AFB, will be used by NASA for a total of 3 months during calendar years 1964 and 1965.

Mr. BELL. Shall I continue?

Mr. TEAGUE. Yes.

Mr. BELL. There is a Mission Simulation and Procedures Training Facility costing $2,200,000 in the NASA budget. I understand that the Air Force Aerospace Research Pilot School at Edwards Air Force Base has a similar facility. Is that correct?

General SCHRIEVER. I don't believe that is true. I don't think we have a facility of that type, the type that I am sure NASA is thinking about here. This is a mission simulator, I would presume, at Houston, is this right?

Mr. BELL. No, it is at Edwards Air Force Base in California that you have, or are you speaking of the one that NASA has?

General SCHRIEVER. The one that NASA is asking for.

Mr. BELL. I assume so, yes.

General SCHRIEVER. I would assume that this is a considerably more elaborate facility aimed at extended flights in Gemini- or Apollo-type capsules, whereas our capability out there is rather a stick and wire affair by comparison tied in with high performance airplane testing and we are just updating it, but it certainly won't be adequate for the NASA requirements.

Mr. BELL. I see. These are detailed items and if you don't have the information, General, I would appreciate it if you would supply it for the record.

General SCHRIEVER. All right.

Mr. BELL. I understand that the NASA proposes an Atmospheric Reentry Materials and Structure Evaluation Facility in its budget for $2,800,000. The Air Force has a facility at Arnold Engineering Development Center, and I understand there is a similar facility at Wright-Patterson Field in Ohio. I have had the pleasure of going down and seeing the Arnold Engineering Development Center facility. It is a very good, very well run operation.

I was wondering if they could be——

General SCHRIEVER. Well, we of course have a very outstanding materials research capability, both in personnel and in facilities, but here again precisely how this will be responsive to the NASA requirement I couldn't say.

The Air Force facilities at the Arnold Engineering Development Center and Wright Field have considerable capability for research and development in the area of hypervelocity and reentry. I do not recall the specific details on these facilities and at this juncture I would submit this information for the record.

(The information referred to is as follows:)

USAF ATMOSPHERIC REENTRY MATERIALS AND STRUCTURES EVALUATION FACILITIES

ARNOLD ENGINEERING DEVELOPMENT CENTER

1. AEDC has several facilities for research and development in the area of hypervelocity and reentry. These facilities are—

(*a*) 50-inch mach 8 tunnel.
(*b*) 50-inch mach 10 tunnel.
(*c*) 12-inch hypersonic tunnel mach 5–8.
(*d*) 50-inch hypervelocity tunnel mach 20.
(*e*) 100-inch hypervelocity tunnel mach 20.
(*f*) 100-foot hypervelocity range with a capability of 32,000 feet per second with a ½-gram model.
(*g*) 1,000-foot hypervelocity range in shakedown period now. Can accelerate models up to 2½-inch diameter to velocities of 25,000 feet per second; smaller models in excess of 30,000 feet per second.
(*h*) Plant cost of all above, $15.8 million.
(*i*) Personnel, 229.

2. Type of tasks and research projects:

(*a*) Drag forces were measured on a nose cone model for a proposed space system operating at over 60 miles simulated altitude.

(*b*) Aerodynamic testing in the 50-inch mach 8 tunnel defined the safe maneuvering limits for the Nike-Zeus missile.

(*c*) In 4 days' time from delivery of the test model, final reduced data was furnished for a Martin-Marietta model of their 608–N lifting reentry vehicle tested in the 50-inch mach 10 tunnel.

WRIGHT-PATTERSON AIR FORCE BASE, OHIO

1. *Electrogas dynamic facility (4 megawatt); $1,112,000; 27 scientists and technicians.*—Located in building 254. Consists of one 4-megawatt arc-heated facility and control room. Facility has a 2-foot diameter test section and is capable of simulating transient or steady state reentry into terrestrial or extraterrestrial atmospheres. This facility will simulate reentry aerodynamic and heating conditions over a range of altitudes from 100,000 to 280,000 feet at velocities up to 26,000 feet per second.

2. *Electrogas dynamic facility (50 megawatt); $9 million; under construction.*—To conduct aerodynamic, structural, and materials testing on large-size models and full-scale components of aerospace vehicles at extremely high enthalpies (15,000 British thermal units per pound) and velocities (25,000 feet per second). Includes an effective test section up to 6 feet in diameter. This facility will be capable of simulating the hypersonic aerodynamic and thermodynamic environment for reentry conditions and advanced propulsion devices.

3. *High temperature hypersonic gas dynamic facility; $1 million; 36 scientists and technicians.*—Simulates flight conditions at hypersonic speeds for aerodynamic investigation and research. This is an intermittent operating wind tunnel capable of operation at mach numbers up to 14, with stagnation temperatures and pressures up to 4,500° R. and 40 atmospheres, respectively. Includes a test section 24 inches in diameter for model testing.

Mr. BELL. General, are those operations like the Arnold Engineering facility terribly busy so that they could not be coordinated? Is the facility busy with the Air Force projects and could not be utilized for other operations?

General SCHRIEVER. The facilities are quite busy. We put propects in there on a priority basis, particularly in the tunnels. But we serve all of the Defense Department and industry there, as wall as NASA. We have supported NASA at the Arnold Engineering Development Center on a number of projects, as well as the Navy.

In other words, it supports the whole Defense Department, other Government agencies, and also industry. That was the whole philosophy of those facilities. They are so large, so expensive, that they are really a national resource. We operate them, but consider them to be a national resource.

Mr. BELL. There is a question in my mind whether another agency of the Government should build such a facility.

General SCHRIEVER. Again I don't know specifically what facility they are talking about. Just because one Government agency has a particular facility doesn't mean that another Government agency doesn't need a similar facility to support their activity. Like facilities don't always mean that you have duplication. For instance, in industry, each major company requires facilities of its own to operate because it is a matter of having the resources available and also, for the most part, the resources in other organizations are saturated with work they have to do in their own support.

Mr. BELL. This will be the case of your ultra-high vacuum space chamber facilities, too?

General SCHRIEVER. Yes; these, of course, are new facilties. NASA needs facilities of this type, and I think the Department of Defense also needs facilities of this type.

Mr. BELL. But you already have some, don't you?

General SCHRIEVER. We have a small one.

Mr. BELL. At AEDC?

General SCHRIEVER. We have a small facility there called the Mark I which is now under construction and which will be completed in the summer of 1964. For some time we have had under study and are planning a much larger facility called Mark II, which we now have requested in the fiscal year 1965 military construction program. So, here again, there isn't any question in my mind that you are going to need more than a single facility for this sort of thing.

Mr. BELL. You think there may be a reason for having them?

General SCHRIEVER. Yes, sir.

Mr. BELL. NASA wants to build in the Marshall Space Flight Center an Acceleration Test and Calibration Facility, and I understand you have considerable facilities again at Wright-Patterson, and Edwards Air Force Base in California, and at Holloman in New Mexico.

General SCHRIEVER. They may be referring to a sled-rack type of facility.

Mr. BELL. I believe so, yes.

General SCHRIEVER. Yes, we have a——

Mr. BELL. Can you see any reason why NASA should not use the Air Force facility or do you think NASA should build their own?

General SCHRIEVER. Again, I would be unable to answer that in view of the fact that I don't know what their requirement is based on. We do have a facility and it is used by other agencies. The AEC and industry, for example, operate on our track at Holloman, as well as the Air Force.

(The following information has been submitted for the record:)

The Air Force has considerable resources in the acceleration test and calibration test work area. A list of these facilities follows:

USAF ACCELERATION TEST AND CALIBRATION FACILITY

HOLLOMAN AFB

1. Track test facility

(*a*) 35,000-foot test track provides a component and system test bed for conducting tests on parameters such as onset, acceleration, high velocity, vibration, and deceleration.

(*b*) Plant cost, approximately $35 million.

(*c*) Personnel, 200.

(*d*) Examples of past contributions:

(1) Sled testing of the Thor, Titan, Minuteman prevented flight test failure. Minutemen sled guidance system test disclosed several problems. Among these were two major deficiencies which required redesign: The caging amplifier for the redundant gyro and VM-4 digital resolver, either of which would have caused inflight failure.

(2) Saturn guidance system problems defined which would have caused inflight failure: (a) servo power supply could not meet all electrical load requirements under dynamic conditions, (b) accelerometer output electronics had a tendency to saturate under extreme dynamic conditions, (c) gyros had a tendency to oscillate under very high vibration output.

2. Precision centrifuge

(*a*) The precision centrifuge is now under construction and will be capable of subjecting inertial guidance systems and components to controlled accelerations which simulate the operational environment. Radial accelerations up to 100 g.'s will be available and the centrifuge will have a double gimballed platform. The facility can handle packages up to 600 pounds.

(*b*) Plant cost, $1,500,000.

(*c*) Personnel, 8.

3. Accelerator, 100-inch centrifugal

(*a*) This facility is a precision centrifuge with radium arm of 100 inches capable of extreme accuracy in measuring acceleration forces over a range from 1.0 to 12.5 g.'s with a payload of 400 pounds.

(*b*) Plant cost, $165,000.

(*c*) Personnel, 2.

WRIGHT-PATTERSON AIR FORCE BASE, OHIO

1. Centrifugee

(*a*) *Equipment centrifuge; $300,000 five technicians.*—Produces 30 g. acceleration on loads up to 15,000 pounds; 12 feet in diameter; equipped with 8 cubic feet detachable altitude chamber (stimulating up to 100,000 feet; also electromagnetic vibrator generating 600 pounds force and frequency up to 2,000 cycles per second.

(*b*) *Instrument centrifuge; $90,000; five technicians.*—Under radial load up to 20 pounds, operates with maximum acceleration of 100 g.'s and maximum weight of 100 pounds. Horizontal arm type with an optical viewing for observing static image of specimen during rotation.

2. Chambers

(*a*) *Systems humidity chambers; $100,000 (building No. 22).*—Capable of any humidity condition between 20 and 95 percent in temperature range +350° to +200° F.

(*b*) *Altitude chamber; $225,000 (building No. 22).*—For altitudes up to 165,000 feet; temperature range −90° to +212° F.

(*c*) *Reach-in environment chambers (four each); $120,000 (building No. 22).*—Consisting of: Arctic altitude chamber; heat, cold, and altitude chamber; systems and components climatic humidity chamber. These are all small facilities.

(*d*) *Environmental chambers (10 each) (building No. 45); $790,000.*—Consisting of: Walk-in arid chamber; walk-in fungus chamber: walk-in humidity chambers (two each); walk-in low temperature chamber; walk-in salt fog and rain chambers; walk-in sunshine chamber; walk-in high-low temperature chamber; reach-in temperature/altitude chamber.

(e) *Stratosphere chamber (building No. 22); $128,000.*—Temperature range from −125° to +175° F.; altitude range up to 120,000 feet.

(f) *Temperature shock test chamber (building No. 22).*—Temperature range from −125° to +127° F. Temperature in one-half of chamber can be raised from −75° to +160° F. in 12 minutes.

(g) *Vibration facilities (building No. 93) (seven each) $350,000.*—Includes: one each vibration exciter, 1 to 2,000 cycles per second, force output 3,500 pounds; two each vibration exciters, 1–59, 500 cycles per second, force output 2,400 pounds; two each vibration machines, 6–60 cycles per second automatic cycling, maximum acceleration ± g., vertical and lateral; two each vibration machines, 5–2,000 cycles per second frequency range, medium acceleration ±60 g.

CAMBRIDGE MASS.

1. High intensity acoustic test facility; $300,000, four technicians.—54 feet long by 26 feet wide by 13 feet high; maximum frequency range is 20 to 10,000 cycling, maximum acceleration ±10 g., vertical and lateral; two each vibration

Mr. BELL. At the Mississippi Test Facility, NASA has budgeted for equipment for electronics instrumentation and materials laboratory of over $2 million; I understand that you have a laboratory of this type in Ohio, is that correct?

General SCHRIEVER. Well, again, I think that falls into the category of that type of facility you will find in many places in the United States, in industry and in the Government. I think it is a question of specific need and workload.

Mr. BELL. This may be a question of——

General SCHRIEVER. Specific need and workload, I am pretty sure.

Mr. BELL. Well, that generally covers some of the points that I had in mind.

General SCHRIEVER. I would prefer to take a look at my comments here and correct the record a little because I have tried to be general in my responses.

Mr. TEAGUE. Mr. Casey?

Mr. CASEY. General, I would like to know if the disarmament conference is causing you any concern for the future of your program or your future regarding participation in the NASA program?

General SCHRIEVER. Disarmament talks?

Mr. CASEY. Yes.

General SCHRIEVER. As far as disarmament talks or arms control is concerned, as a military man my concern is simply to insure that any action taken has enough safeguards that we are absolutely certain that we don't get hornswoggled in some fashion.

Mr. CASEY. Of course, that is what I am concerned about too. I just wondered if you had been following these closely enough to know whether there was any threat to the curtailment of your program or your participation in the NASA program?

Mr. TEAGUE. Would the gentleman yield?

Mr. CASEY. Yes.

Mr. TEAGUE. May I amend his request to include the meetings in Rome between Dr. Dryden and the Russian representatives on the exchange of information on weather, communications, and other things?

General SCHRIEVER. Well, I feel that in the area of space discussions that there is certainly room for cooperation in the space field. What I am concerned about is perhaps a misinterpretation by the public, perhaps, that space will always be a domain for peaceful purposes. I feel very strongly and I have stated many times in the past that it is

also necessary to develop those things in space which will provide us the capability of keeping the peace, maintaining the peace.

So I like to add this connotation, because I don't believe that there is any guarantee that the Soviets are going to develop only those things for peaceful purposes in space. I have never believed anything they have said yet and I never will unless there is a complete change.

Mr. CASEY. Right now, then, you have no concern other than you are watching it, I presume?

General SCHRIEVER. Well, I have concern; yes, sir. I have great concern. I feel that the only thing they respect is strength, and I think we have to maintain our strength at the highest level. The lack of information with respect to the Soviet Union which has been brought about by the Iron Curtain and their constant abrogation of all agreements that they have ever made gives me little hope that an arms agreement or disarmament that is meaningful—or let's say which can be provided with the proper safeguards—is just around the corner. I just don't think it is.

Mr. CASEY. Are you consulted concerning these discussions?

General SCHRIEVER. No, sir.

Mr. CASEY. You are not?

General SCHRIEVER. No, sir. I am speaking just purely as a military man, my own personal concern.

Mr. GURNEY. Will the gentleman yield?

Mr. CASEY. General, what brought this to mind this morning was that I heard one of our representatives who has been working on the arms control and disarmament talks, and his concern was what he could sell the U.S. Senate, not what he could sell, or insist upon with Russia. It concerns me very much.

Mr. FULTON of Pennsylvania. Who is this? I didn't hear you.

Mr. CASEY. Jim Boyd. I certainly think it is very important that a man who holds the position that you hold regarding the defense of this country should be consulted.

General SCHRIEVER. Well, I am not consulted, but, of course, the Joint Chiefs are. There is an arrangement between the Department of Defense and the Arms Control and Disarmament Agency which brings the Joint Chiefs of Staff into the picture. They are consulted.

Mr. GURNEY. Will the gentleman yield?

Mr. CASEY. Yes.

Mr. GURNEY. That is the question I was going to ask. Does the Department of Defense have men who are actually present at these disarmament discussions, and know what is going on and report back?

General SCHRIEVER. There are Department of Defense personnel actually assigned to the Arms Control and Disarmament Agency. I am not sure exactly how many. Any major policy matters that are considered by the Arms Control and Disarmament Agency do have Joint Chiefs of Staff input. I can't quite give you the total organizational and procedural arrangement, but the Secretary of Defense and the Joint Chiefs of Staff are consulted in major areas of policy and programs that are developed by the Arms Control and Disarmament Agency.

Mr. GURNEY. What about this point the chairman brought up about the discussions in Rome between NASA and the Soviets so far as weather and communications satellites are concerned? Does the De-

partment of Defense have a representative attending these meetings, and do you know what is going on?

General SCHRIEVER. I do not know what is going on and I am not sure whether the Department of Defense has a representative at those meetings or not.

I believe that these are handled through the United Nations and the State Department is the official governmental agency that is involved, other than the NASA.

Mr. GURNEY. Do you think——

Mr. FULTON of Pennsylvania. Can I answer for you on that? I have been at several of the meetings.

General SCHRIEVER. Yes; well, there is no Defense Department representative there.

Mr. GURNEY. Do you think there should be one?

General SCHRIEVER. Well, I think that the objectives of these meetings are such that it would make it very embarrassing to have a Defense Department representative there.

Mr. TEAGUE. Mr. Fulton in on that committee.

Mr. FULTON of Pennsylvania. It is the Committee on Peaceful Uses of Outer Space under the United Nations. The meetings in Rome have been between Dr. Hugh Dryden and Dr. Blagonravov.

Mr. TEAGUE. Who is a Russian general.

Mr. FULTON of Pennsylvania. Who is quite a high scientist, and I might say agreed very promptly that the meetings be held in Rome rather than some place in the Soviet Union, which was a great indication to me that it was the scientific approach and not the military approach. These meetings have been under the correspondence between the President of the United States and Premier Khrushchev of the Soviet Union which have been made public.

The meetings have resulted in no joint programs but, rather, in the giving of information from each side from their separate facilities. So it is coordination or giving information rather than a joint program. In the release of classified information, of course, the Department of Defense as well as every other agency of the Government has participated, so there is that protection.

Mr. TEAGUE. Last year, a few of us were interested in this thing and asked to meet with some people to discuss it. Mr. McGeorge Bundy of the White House came down, but we did not feel that we received a satisfactory answer.

Later, Mr. George C. McGhee, Under Secretary of State for Political Affairs, appeared and we asked him who the representatives were from the Department of Defense that have this kind of a thing as their responsibility. As I remember, there was a captain and a major or major and lieutenant colonel sitting in on a conference with the very high-level Assistant Secretary of State. Personally, I wasn't at all pleased with the representation of the Defense Department at these meetings. I thought I sent you a brief on that.

Mr. GURNEY. I read it. That is one of the reasons I asked the question now.

Mr. TEAGUE. General Schriever has a slide that he wants to show us. If we are going to get to it, we had better give him a chance to show it now.

General SCHRIEVER. I hadn't planned to show it. I think it would be better to give it to you as a matter for the record.

Mr. TEAGUE. All right.

General SCHRIEVER. It gives a listing of the different projects in fiscal year 1964 that fall into the space area.

(The information referred to is classified.)

Mr. TEAGUE. All right. I would like to have about a 5-minute executive meeting before 12 o'clock.

Mr. RIEHLMAN. Of the subcommittee?

Mr. TEAGUE. Yes; the subcommittee.

Mr. FULTON of Pennsylvania. Because the question has come up, and because I have been to the meetings at Geneva and actually sat in on the negotiations with Dr. Hugh Dryden and Dr. Blagonravov of the Soviet Union, I can say of my own personal experience that there was nothing done which would in any way endanger the security of the United States of America. I actually say that publicly.

Mr. GURNEY. May I ask two questions?

Mr. TEAGUE. Yes.

Mr. GURNEY. These may have been covered. What is the status of Dyna-Soar? Has that been asked?

Mr. TEAGUE. No.

General SCHRIEVER. The status of Dyna-Soar is just as it has been. We have a program, the level of effort about $135 million a year. We have $131 this year, and next year it is $125 million, although we hope to get a little bit more to bring it up to about a $135 million program. There has been no change to the program over the past 6 or 8 months.

We do have, under study at the present time, in response to the Secretary of Defense's memorandum of last month, the relationship of Dyna-Soar and Gemini for the accomplishment of certain mission-oriented jobs, such as inspection and negation; reducing the vulnerability of our satellites; reconnaissance systems; and the possibility of offensive systems.

So, therefore, I might say that the Dyno-Soar program is under study and analysis at this time, but there has been no change in the program.

Mr. GURNEY. Is there any question about its being continued? Is it being reevaluated now as to whether it should be continued?

General SCHRIEVER. I think it is fair to say to say that it is being evaluated with respect to a possible change in status. We feel very strongly in the Air Force as to the necessity of the Dyna-Soar program. We have been supported strongly in this by NASA.

We feel that the Gemini and Dyna-Soar are complementary programs. We need to develop the capability of having the ability to maneuver and it gives us much greater flexibility from a military standpoint in reentry. We can select time of reentry. It gives us much greater flexibility because we can reenter on a number of orbits, we can land where we want to land, we can achieve great flexibility because of the size of the footprint area.

Furthermore, we need to explore its reentry corridor, with speeds ranging from something in the order of mach 25 to mach 5. Mach 5 is about where we stand now with the X–15. From a technological standpoint it is important, and from a military effectiveness standpoint, it is important.

So we feel that the Dyna-Soar and the Gemini are complementary. We are getting strong support from NASA and we hope that there is no change in the status.

Mr. GURNEY. As a matter of fact, if the Dyna-Soar program is cut out, it cuts the heart out of the Air Force space effort for this coming year, doesn't it? I mean, isn't this the major dollar item?

General SCHRIEVER. Well, the major dollar item is the Titan III.

Mr. GURNEY. Dyna-Soar is next?

General SCHRIEVER. Dyna-Soar would be next.

Mr. GURNEY. How much money has been devoted in your budget for the military orbital development system?

General SCHRIEVER. There is no money in the fiscal year 1963 budget. I don't believe there is any in the fiscal year 1964 budget at the moment. One of the things that we are looking at now in connection with the Gemini program and Dyna-Soar is their application to the so-called MODS. We consider MODS very important.

I think the same is true at the Department of Defense level, but I think it is clear that this should be and probably will be a joint NASA-Air Force program. We do not have anything in the budget as of now for that program.

Mr. GURNEY. Yet you do, from your statement, consider this one of the most important things you should be doing; isn't that correct?

General SCHRIEVER. Yes, sir.

Mr. GURNEY. Do you think the Department of Defense or the Air Force is moving too slowly on it?

General SCHRIEVER. I would like to see it move faster and I think that something will evolve out of this present review to bring about some sort of a program. Again, I think it will probably end up being a joint effort of some kind.

Mr. GURNEY. Do you know whether NASA is looking into this concept?

General SCHRIEVER. Yes, they are.

Mr. GURNEY. I learned in Florida just yesterday that NASA was looking into it.

General SCHRIEVER. Yes, they are.

Mr. GURNEY. I talked to some people who are now about to give proposals on this sort of thing.

General SCHRIEVER. This is right.

Mr. GURNEY. For NASA.

General SCHRIEVER. Right.

Mr. GURNEY. Do you think the Air Force should be in it, or NASA should be in it?

General SCHRIEVER. I think we should both be in it.

Mr. GURNEY. Do you think that NASA is moving faster than the Air Force is?

General SCHRIEVER. Well, they at least have asked for proposals from industry. We haven't gotten quite that far.

Mr. GURNEY. Why is that?

General SCHRIEVER. Well, we simply haven't been given the authority to do so; we haven't had it funded.

Mr. GURNEY. That is all.

Mr. TEAGUE. Mr. Fulton mentioned a number of points. In your statement on page 6, for example, you say "A group was convened

at our Space Systems Division." Could we have who and what that group was?

General SCHRIEVER. Yes.

Mr. TEAGUE. "In June a representative Air Force-wide task force?"

General SCHRIEVER. We can give you that.

(The information referred to may be found in the committee files.)

Mr. TEAGUE. At the bottom of the page you say "along with recommendations for approval of specific programs," could that be identified?

General SCHRIEVER. Yes, sir.

Mr. TEAGUE. Over on page 7 you refer to the "Aerospace-plane concept, which the Air Force and industry have been studying for some time." Is that Dyna-Soar?

General SCHRIEVER. No, no.

Mr. TEAGUE. Would you let your staff spell it out a little more clearly for the record so that an ordinary old common country boy can understand it?

General SCHRIEVER. All right.

(The information referred to is classified and may be found in the committee files.)

Mr. TEAGUE. Mr. Daddario has one more question.

Mr. DADDARIO. General Schriever, in line with the information that you are going to get together for some of Mr. Bell's questions, and because of the fact that we are having General Roadman come here to set out the aerospace medicine program, I wonder if you might be able to provide for the record the development plan for the School of Aviation Medicine at Brooks Air Force Base, and if that plan has in any way been slowed down in the last few years?

General SCHRIEVER. Here are you talking about the plan for the facilities?

Mr. DADDARIO. For the facilities.

General SCHRIEVER. Not the development program?

Mr. DADDARIO. No, the plan for the facilities at the School of Aviation Medicine at Brooks.

General SCHRIEVER. Yes, sir.

(The information requested is as follows:)

DEVELOPMENT PLAN FOR THE RESEARCH FACILITIES, BROOKS AIR FORCE BASE

The initial military construction program was approved and funds appropriated during 1957 and 1958. Construction of facilities began early enough to permit occupancy of six major research laboratories during 1959. The laboratories completed and occupied during 1959 are Flight Medicine Laboratory, academic building, research institute, Altitude Laboratory, Research Laboratory, heating and cooling plant.

Additional funds were appropriated during 1960-61 to permit construction and occupancy of six laboratories during 1963. These new buildings are professional building, library, Bioastronautics-Biodynamics Laboratory, vivarium, Bionucleonics Laboratory, 176 dog kennels.

A toxic materials storage building and a Biosystems Laboratory is now under construction with a planned date of occupancy during early 1964.

The Air Force Systems Command military construction review committee has recently approved the following for formal presentation in succeeding years. If approved by all authoritative channels, we would add these facilities during the fiscal year indicated: 1965: Electronics Science Laboratory, vivarium addition, Epidemiological Laboratory; 1966: Science Laboratory, Medical Aeromedical Dynamics Laboratory, records repository; 1969: germ-free Biological Laboratory.

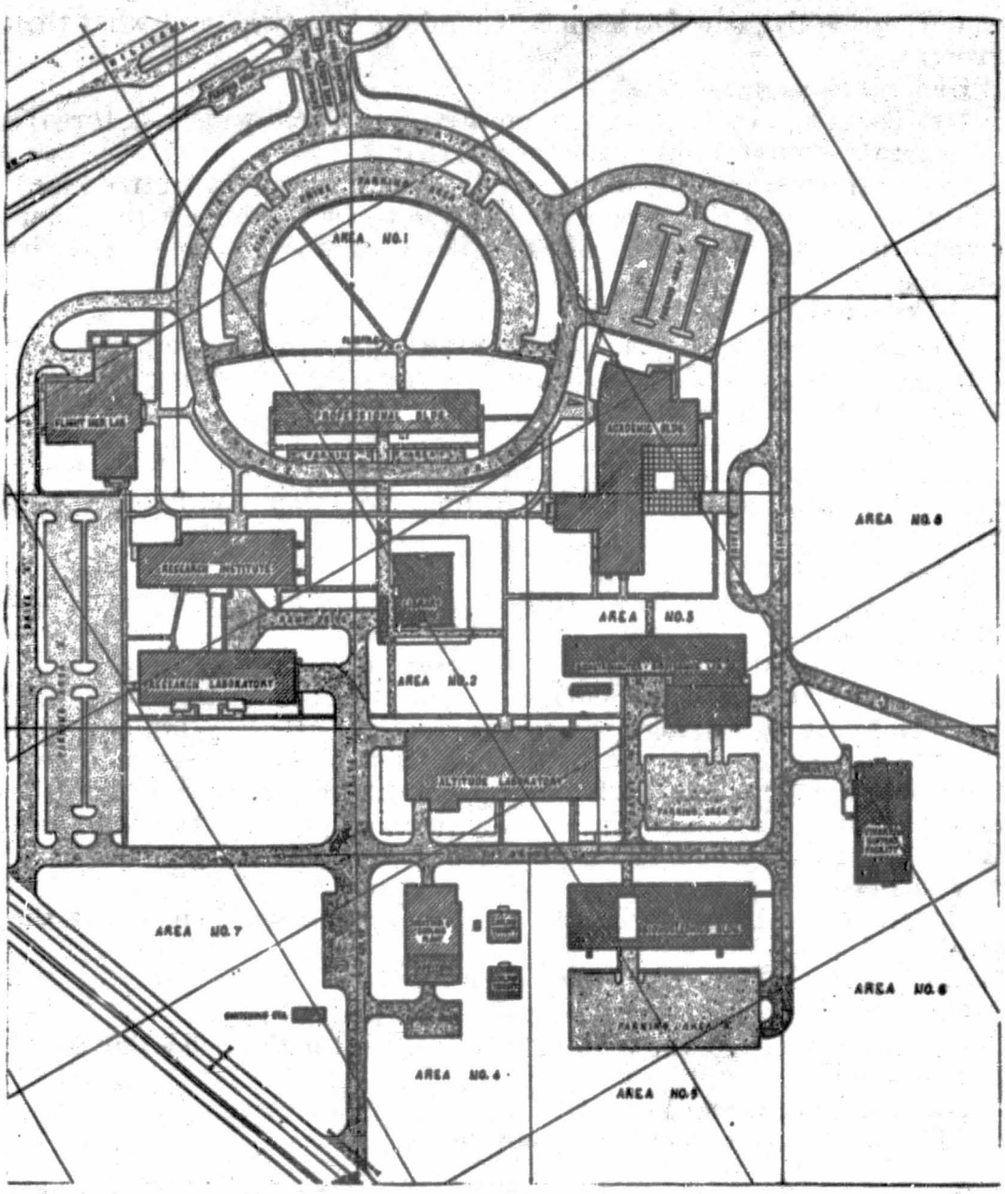

FIGURE 163a

Mr. TEAGUE. Any further questions?

Mr. Yeager?

Mr. YEAGER. I have six questions which I would like to submit and get the answers for the record?

Mr. TEAGUE. All right.

QUESTIONS FOR GENERAL SCHRIEVER

1. Question. Can you provide a brief summary of the Air Force 5-year space program referred to in your testimony?

Answer. In April 1962, a space technical objectives task group was convened at Space Systems Division (AFSC), Los Angeles, Calif. Lieutenant General Estes, then Deputy Commander, Aerospace Systems, AFSC, was in charge of this group. Their objective was to formulate a technical plan of exploratory, advanced, and engineering development for establishing a broad technical base for future space efforts. This technical base would allow the timely development of space capabilities as requirements were validated and approved. The task

group was organized into panels which outlined the technical objectives required in the areas of launch vehicles, in-space propulsion life support, reentry vehicles, spacecraft, space surveillance, weapons, space communications equipment, guidance, sensors, space vehicle power, data processors, and environmental data.

In June 1962 the Air Force organized a space task group to determine what the future military capabilities in space should be for the time period fiscal year 1963–68. This group used the results of the space technical objectives task group and the desired capabilities of the Air Force using commands in specifying the exploratory, advanced, and engineering programs needed to achieve useful military capabilities in space. The program included capabilities which can be realized in the near term and outlined the technical advances or base required in order to achieve more advanced capabilities. The USAF 5-year space program was published in October 1962. The program structure included descriptions, cost summaries, program milestones, and current status for each of the program elements and was arranged in Hitch line item format.

The program included—

(*a*) *Exploratory development.*—The total required cost was presented for technical development and studies and analysis through fiscal year 1968.

(*b*) *Advanced development.*—Program elements were presented for 42 individual efforts in the areas of propulsion, flight control, structures, materials, aerodynamics, nuclear propulsion, auxiliary power, in-space propulsion, boosters, guidance, sensors, reentry, weapons, command and control, environmental monitoring and mapping, and surveillance.

(*c*) *Engineering development.*—Program elements were presented for 21 efforts to achieve useful military capabilities for near and far term time periods. These capabilities included warning, satellite interception and inspection, standard first and upper stage launch vehicles, reconnaissance, meteorology, communications, military development and testing, environmental monitoring, standardardized components, training, detection, and tracking.

Question 2: In view of the Air Force's interest in Gemini and of the experiments which NASA plans to carry on in Gemini on behalf of the Air Force, should not the Air Force fund a part of Project Gemini prior to fiscal year 1965?

Answer: (*a*) In developing an experimental program for DOD participation in Project Gemini the joint ad hoc study group was goverened by the paramount guideline that the program is to be conducted "so as to satisfy, first, the essential objectives of the manned lunar landing program." Thus, the experiments were designed to fit in "space available" not to interfere with current NASA mission programs.

(*b*) It is true that the results of the NASA Gemini flights are regarded as contributory to DOD space objectives. It is also true that the experiments proposed to DOD for performance in that program are considered to be for the most part in support of NASA objectives as well. The ad hoc study group jointly determined that 60 percent of the proposed Air Force work was in direct support of NASA goals, 20 percent was of interest to NASA and none were detrimental to the NASA objectives.

(*c*) As an additional restriction, the Air Force experiments are in the proposal stage, subject to approval by the Manned Spacecraft Center in-flight experiments panel, and are therefore subject to exclusion in deference to NASA on any specific flight.

(*d*) In view of the above comments the Air Force expects to fund only the additional costs resulting from its participation in the program. The Gemini program planning board (GPPB) has asked the Joint DOD/NASA ad hoc committee to examine various alternatives for participation in the Gemini program. On May 6, 1963, the GPPB decided the extent of the participation by the Air Force in the program would be limited to providing experiments on a "space available" basis only. The Air Force would expect to fund only the additional costs resulting from that participation, and on the time-phased basis required to cover these costs.

Question 3. The subcommittee has heard from various quarters that the Titan III appears to be an almost untenable scientific and engineering effort—that is, in the attempt to marry the complicated solid strapons to the liquid storable system. Would you comment on this?

Answer. (*a*) All problems associated with the use of solid rocket booster stages in conjunction with liquid stages are well within the present state of technology. The basic physical phenomena are understood and subject to rational engineering methods. The evaluation of a vehicle such as Titan III which de-

pends upon this combination is basically a matter of conducting an effective engineering development program.

(*b*) Specifically the use of a storable propellent system offers a degree of conservatism as opposed to a cryogenic system. This is chiefly reflected in the sensitivity of a cryogenic system to the local thermal environment. The thermal environment consists of both aerodynamic heating and the combination of conduction and radiation for the exhaust plumes of the boost stage solid motors. Of most significance, however, in establishing the feasibility of the Titan III approach is recognition of the history of successful accomplishments involving parallel staging. The Navajo vehicle achieved successful staging on some six flights under more severe conditions than those encountered by Titan III. At least four other guided missiles have successfully utilized the paralled staging of multisolid motor boosters. These are summarized in the chart of attachment 2. (Bloodhound, British Thunderbird, Sea Slub, French Parca).

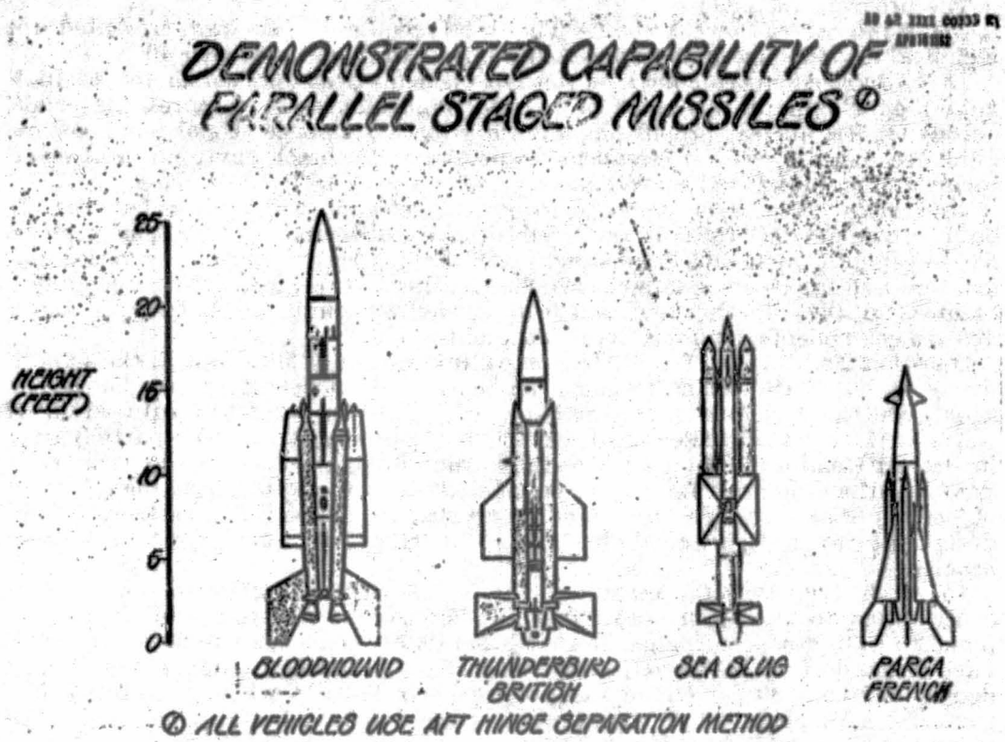

FIGURE 168b

(*c*) An even more significant and direct confirmation is afforded by the recent success in March of this year of the "Improved Thor" vehicle. This consisted of a Thor LV-2A, a core stage with three solid motor boosters clustered about it as a lower stage. It is interesting to note that the Thor is also a cryogenic vehicle. The staging and separation of the solid motors was eminently successful. It is presently planned to launch additional Improved Thors which will provide additional corroboration and useful information applicable to the Titan III.

(*d*) The Thor success highlights two additional considerations. The staging technique used depended purely upon areodynamic loads to achieve separation under more stringent conditions than those encountered by Titan III. Additionally, the Thor configuration utilized available hardware with minimal modification. An additional handicap existed in the use of a developmental Thiokol solid motor. Despite these limitations, the scheme was successful.

(*e*) In summary, it is useful to examine the Titan III approach which by comparison has had the advantage of systematic analysis and integrated design. In selecting a staging technique, consideration was carefully given to simplicity, conservatism, and reliability. The lateral translation technique being utilized provides flexibility in both the direction and magnitude of the forces used to stage the motors. Further these lateral thrust forces are produced by small

solid motors which are well within the established state of solid motor technology.

Question 4. Is the Titan III on schedule?

Answer. Yes. There have been and will probably be further changes in some of the minor milestone dates which is normal in a program of this magnitude; however, the planned launch schedule is that established when the program was approved by the DOD and progress on the pacing items including development of the large solid motor, the new liquid engine for the transtage and construction of static firing and launch facilities is satisfactory to support this schedule.

Question 5. When do you expect that Titan III will be ready for useful work?

Answer. Configuration A, the core, can be ready to support payloads within its performance capability on pad 20 at AMR anytime after May 1965. Titan III C configuration will be usefully employed when it launches the first unmanned Dyna-Soar glider with an R. & D. launch vehicle. It is scheduled to launch the first manned Dyna-Soar glider a few months later with a production vehicle.

Question 6. Do you believe that the Titan III may be useful in the assembly of manned orbiting space stations in the future?

Answer. Yes. For payloads in the vicinity of the maximum capability of the Titan III C in low orbit, the Titan III offers a cost effective vehicle which is extremely competitive with any vehicle currently programed and under development. For payloads less than the maximum capability for the Titan III, its cost effectiveness in rapid launch capability will make it very competitive.

Mr. YEAGER. Also, is it all right to release General Schriever's statement?

Mr. TEAGUE. He said it wasn't classified.

Mr. FULTON of Pennsylvania. Off the record.

(Discussion off the record).

Mr. TEAGUE. We will have an executive subcommittee meeting. Thank you General Schriever; you have been very helpful.

(Whereupon, at 11:52 a.m., the subcommittee proceeded into an executive meeting.)

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1964 NASA AUTHORIZATION

WEDNESDAY, MAY 1, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON MANNED SPACE FLIGHT,
Washington, D.C.

The subcommittee met, pursuant to adjournment, in room 356, Cannon Building, at 10 a.m., Hon. Olin E. Teague (chairman of the subcommittee) presiding.

Mr. TEAGUE. The committee will come to order.

STATEMENT OF D. BRAINERD HOLMES, DEPUTY ASSOCIATE ADMINISTRATOR AND DIRECTOR, OFFICE OF MANNED SPACE FLIGHT, NASA; ACCOMPANIED BY WILLIAM E. LILLY, DIRECTOR, PROGRAM REVIEW AND RESOURCES MANAGEMENT; GEORGE M. LOW, DEPUTY DIRECTOR (PROGRAMS); AND DR. JOSEPH F. SHEA, DEPUTY DIRECTOR (SYSTEMS); ADELBERT O. TISCHLER, ASSISTANT DIRECTOR (PROPULSION); AND STANLEY M. SMOLENSKY, DEPUTY DIRECTOR (LAUNCH VEHICLES AND PROPULSION)

Mr. TEAGUE. I believe that we were first going to discuss the lag in the Gemini program.

Mr. HOLMES. Anything you wish to discuss.

Mr. TEAGUE. We have heard everybody discuss it but you. Let us hear your opinion. This story is evidently in the newspapers all over the country. It quotes different sources, including Mr. Webb, as saying that the Gemini program is in trouble, and that it is behind schedule a number of months.

Mr. HOLMES. Yes, I had read some of these stories. It is unfortunate, I think, that somehow or other this information gets into the press, in my mind, prematurely. The program people who are working with the problems—and there are always problems in a program of this magnitude—haven't really had a chance to evaluate the difficulties to the point where they can speak to them.

We have, however, evaluated these problems now. In fact, it is only this morning that I have formal approval for a new schedule for Gemini. I don't think Gemini is in serious trouble. I think that the present Gemini is a different program than the one with which we started. It had two fundamental purposes originally, which we have not given up and which we still consider to be of paramount importance—to gain experience in prolonged weightlessness, and to gain experience in rendezvous, before Apollo. The advantage, as you

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realize, is that the results of Gemini may be applied as necessary to Apollo design.

However, as we developed the Gemini program, we found it was not wise to have only an updated Mercury spacecraft. We found as we developed the subsystems for Gemini that it was much wiser to incorporate technology known today, not something that was early developmental technology of the past. This concept would lead us step by step toward Apollo, and we would reap tremendous benefits from it. In addition, as we developed the Gemini program it became quite apparent to us that this would be a very useful Earth orbital spacecraft. It would be more economical than the Apollo spacecraft would ever be, since Apollo is designed for a different mission. Gemini may be economically used, for instance, in ferrying supplies to a space vehicle or space station in orbit, or for rendezvous of many kinds.

In developing the Gemini subsystems, we find that they are better and more sophisticated than initially conceived, and that the spacecraft is much more sophisticated than anticipated. Therefore, the costs tend to be higher and the time scales longer.

I would like to comment on the Gemini schedules, since it seems to me that we should place this in proper perspective. We do presently plan to launch the first Gemini spacecraft at the end of this year, as previously announced.

Mr. TEAGUE. In December of 1963?

Mr. HOLMES. Yes, sir. We do plan, however, to have this flight be primarily an aerodynamic and structural test of the launch vehicle-Gemini spacecraft combination. Therefore, we will not be carrying some of the subsystems that we had originally planned. We don't want to delay that flight, because we have learned from experience that you can't design a building block program and assume that it will work.

As you recall, we had aerodynamic and structural failure with the Atlas and we had to have a thick skin in order to carry the Mercury. We have learned that it is wisest to test out the aerodynamic and structural characteristics.

Mr. RIEHLMAN. How does that differ in time, Mr. Holmes, from your specific schedule?

Mr. HOLMES. Exactly the same time as we have been saying ever since we had discussions earlier concerning the funds and the rate at which we should establish the program.

Mr. TEAGUE. A quote in the Houston paper said differently, and Mr. Webb said differently today in the press.

Mr. HOLMES. I haven't finished the whole story, and I think they were probably referring to the part I am about to come to, Mr. Chairman.

Mr. FULTON of Pennsylvania. Would you tell us what subsystems are left off this first Gemini flight? That might clear it up.

Mr. HOLMES. With your indulgence, if I could continue, it will become clearer. Then I can come back and answer that question specifically, if you would like. We had planned to have the first manned Gemini flight, the second flight, during the first quarter of 1964. Our present plan is that the first manned flight in the series would not be until the fourth quarter of 1964. Our current plan grew in part from the advisability of having more sophisticated subsystems, which requires more time, and in part from a reorienta-

tion of the program to include a second unmanned flight before the manned flight.

In our previous thinking, for example, we were going to fly the integrated guidance system of the spacecraft, as well as the guidance system of the booster, so that you could use either one in guidance during propulsion on the first manned flight. Now we don't think that this approach is a wise one. With our greater experience, we have concluded that the best approach is to have a structural flight at the end of this year, followed by a second structural flight, possibly orbital, with all systems aboard. These systems would include an integrated guidance system that would apply to both the launch vehicle and the spacecraft. We believe that two qualification flights are desirable before we have a manned mission.

In view of an extra structural flight, as well as delays in some of our subsystems, we are now planning to have our first manned Gemini flight about 6 months later than the original schedule.

I think that this is a sounder approach. I have not mentioned the Titan II, but it has had some developmental problems over and above what we had anticipated. However, the problems are always encountered in a developmental program. In our opinion it will be safer to use the Tital II for manned flights if we have two structural missions. We will have more time to eliminate the developmental problems.

Mr. FULTON of Pennsylvania. Is there a second unmanned flight, or just one?

Mr. HOLMES. We are planning an unmanned flight at the end of this year and about the middle of next year and we plan to have a manned flight in the last quarter of 1964.

Mr. FULTON of Pennsylvania. Does that increase the total number of Gemini flights previously planned?

Mr. HOLMES. No, sir; we still plan to have 12 Gemini flights.

Mr. FULTON of Pennsylvania. What flight are you leaving off?

Mr. HOLMES. The first unmanned flight will be a boilerplate flight. We have ordered 15 boosters and 12 Gemini spacecraft. Mr. Low, what one are we leaving off?

Mr. LOW. In the rest of the program we are also reevaluating the mission assignments for each flight. With the increase in the number of systems to be flown in the unmanned flight just prior to the manned flight, we believe that we will achieve our goal of a long duration flight with a fewer number of steps leading up to that in the manned flight program.

Mr. FULTON of Pennsylvania. So you are not so brave. You are really scheduling 13 Gemini flights.

Mr. HOLMES. We can reuse spacecraft, which is one reason we are purchasing 15 boosters and only 12 flight-article spacecraft. I would like to emphasize that while we are behind a few months today, we are not behind by 6 months today.

Also, we have a much more sophisticated Gemini system than originally conceived and we are producing a useful, flexible program for the country. The Gemini system is going to be a very operational vehicle.

Mr. GURNEY. Admitting all this is true, why is it, for example, that NASA's leading witnesses have stated within the last few months that the flight schedules on Gemini are: One, an unmanned craft in

December, and, two, a manned flight early in 1964. These statements have been made before this committee, I think as recently as a month ago?

Mr. HOLMES. You cannot run a project involving a large number of people and have the head of the project change the schedule or intimate any weakness in the schedule until there has been a thorough evaluation. I regret this. But if we operate in any different fashion. I am afraid the entire operation would come unglued, organizationally.

Mr. GURNEY. I would simply make the comment that it would be wise to try to alleviate some of this uncertainty about these things that are embarrassing both to you and to the committee.

Mr. FULTON of Pennsylvania. Mr. Chairman?

Mr. TEAGUE. Mr. Fulton.

Mr. FULTON of Pennsylvania. Assuming this is the policy of NASA which Mr. Webb made without explanation, did not the policy work as a joint policy for everybody at the top of NASA? When these statements came out without explanation by two of the top men in NASA, certainly it gives credence to the reports circulated in the newspapers. Why didn't the word get to both Mr. Meyer and Mr. Webb?

Mr. HOLMES. As you know from your experience, Mr. Fulton, it is sometimes difficult to address a group and not become trapped by a certain statement that you have made. I don't know the circumstances surrounding Mr. Meyer's statement. I can say that we are looking into the matter.

I do know in the case of the Administrator that I had briefed Mr. Webb only a few days before on the details of the Gemini situation. I had alerted him to the problems a few weeks before the briefing.

Mr. Webb was at Princeton, talking to a group about the program. I believe that he was questioned sharply following his briefing to this group, and I think he himself felt that it was premature, by a few days, for any announcement to appear in the press. Mr. Webb and I discussed this point as recently as within the hour.

Mr. Webb has established in NASA the fundamental policy that we must complete our evaluations of problems before we announce changes. If a problem is encountered, there are many possible solutions, such as increasing the manpower or shifting the approach. Therefore, we have to complete our analysis so that we know what we are talking about. Mr. Webb believes very strongly in this policy.

Mr. FULTON of Pennsylvania. We all should follow it, shouldn't we?

Mr. HOLMES. Yes, sir.

Mr. FULTON of Pennsylvania. These statements by Mr. Webb and Mr. Meyer corroborate each other and were made in two different parts of the country, even though, as you seem to indicate, they were made spontaneously. However, statements of a policy nature which, as Mr. Gurney has pointed out, contradict testimony given by NASA witnesses before the Manned Space Flight Subcommittee, cause us a real concern. We are likewise concerned about the aspect this gives the program in the eyes of the country. If the program is not being well managed, and it is slipping badly, I think the country should know it.

Does any slip in the Gemini program equally or equivalently cause a slip in the Apollo program? Will this slip in the Gemini program now result in a slip in the Apollo program?

Mr. HOLMES. No, it will not affect the Apollo schedules today. However, I should add, to be forthright, that it is important for us to experience longer duration flight and to develop the rendezvous technique at the earliest possible time. If there are any negative aspects that might affect the Apollo design, the sooner we find out, the better.

Mr. FULTON of Pennsylvania. What portion of this is due to the Titan II slippage, and what portion to the NASA program slippage on Gemini?

Mr. HOLMES. I would say that about one-half of the 6 months is due to development problems with the Titan II and to delays on the Gemini spacecraft subsystems. The other half, in my opinion, is no slippage at all, but rather a reevaluation of what we should do to have a sound and better program.

Mr. TEAGUE. Are there any other questions concerning Gemini?

Mr. DADDARIO. Mr. Holmes, this discussion about Gemini compels me to ask: Do we have a space program which is too ambitious—not just Gemini, but the whole program? There seems to be the same kind of slippage in almost every aspect of it. I understand that you have management problems that you have to face as you go along, but are we in the first instance, as a committee, told that you can achieve certain goals which cannot be achieved? Are you too ambitious in the first place?

Mr. HOLMES. I don't think so, Mr. Daddario. If we look at any developmental program of this nature, many of the intermediate goals are not met, partially because successful program management really requires optimistic scheduling of milestones.

Mr. DADDARIO. Why?

Mr. HOLMES. If the program manager is not optimistic the total group of people working with the schedule won't work any faster than the established schedule even though it would be possible to do so. I am convinced, going back to any one of the systems on which I have worked, that if we had added a year to the schedule, we would have met it a year later; no sooner.

Mr. DADDARIO. It is this goal which is the most important, not the achievement of certain objectives within the program, but the idea that you must push people to achieve these even though this is not within a management capability. Is that your idea?

Mr. HOLMES. Yes, I think that is particularly well stated, especially for the intermediate goals. We are, of course, working very hard to accomplish each step in a timely fashion. However, we must keep the intermediate goal in proper perspective and not react emotionally if we complete one step next month instead of this month.

Now, I ought to interpret that statement. It is very important to the people who are working hard to finish a job as soon as possible to complete these milestones. However, the significant point is when do we get to the Moon, or when do we achieve the necessary operational capability to accomplish this goal. This objective should establish our perspective.

Our program is somewhat unique in that everyone knows almost everything that is going on. In view of this openness we should avoid placing so much emphasis on each step or milestone. We should keep in mind the end dates and have confidence that we are going to meet them. I know that it is very difficult to do, but if we

look at the weapons system programs where we predicted certain flights of missiles and certain tests of missiles, the intermediate milestones were often missed. This was true even in the very successful programs.

Looking at my recent experience with the ballistic missile early-warning system BMEWS, that program went into effect on time, and within its budget. But there were certainly intermediate milestones that we missed. I can recall having had a group of people work extremely hard, in a highly concentrated period to get tons of steel for antenna fabrication on ships. You could only ship to the Arctic, during the 3-months open season, otherwise you had to rely on air transportation. After the steel was all tagged in pieces like a big erector set, after all the special-purpose steel was stored up on the site in the darkness and under snow, we discovered that 10 percent of the steel was not heattreated properly for the cold temperatures. In the darkness the men had to sort out all this steel, fly it back, and heat-treat it. When we heattreated the steel, the welds went brittle and it had to be rewelded.

But the end date was met. Had BMEWS not been a classified program, the trouble would have been in all the papers—with implications that the program was not being well-managed.

I cannot draw a direct analogy to the kind of problems that we have today, but I think the situation is similar, and I think the program is well managed and under control. I am not patting myself on the back. I am talking about my subordinates.

Mr. DADDARIO. We have experience in the development of weapons systems and programs of this kind, and I recognize the psychological requirement of having goals for your people to work on. However, don't we learn from those programs how to better manage en route to the achievement of the final goal, so we can avoid the wastefulness and inefficiencies which are involved?

Mr. HOLMES. I think that we do learn. I think that we tend to be optimistic. I would like to point out that the initial schedule for Gemini and the initial funding request was introduced about 18 months ago. Yet it is not 2 years ago that we flew the first suborbital flight of Alan Shepard. I think people lose sight of the tremendous maturity that this country has gained in space flight in such a short period.

Today we are much wiser than we were then. We are going to be wiser in the future than we are now. I don't think, personally, that it is a negative action to reorient a program such as Gemini to make it a better and safer program at this point in time. I firmly believe that we will have a sounder, safer Gemini program by deciding to have an additional unmanned flight before our first manned flight.

Mr. DADDARIO. What we are really talking about is that you learn as you go along, and you have better programs as a result. You begin changing those which you have originally conceived and brought before us—this is how it should be. But in the process of doing it, there are steps taken along the road which then become changed, and these are the places within which the inefficiencies occur. I think we are achieving great things.

At the same time, we are spending a great deal of money, and we seem to be following the path we followed on many occasions of setting goals which we then change, and it is in these places, certainly, where the wastes occur.

Mr. HOLMES. Yes. I think that goals that are changed merely because of slippage should be distinguished from goals that are changed to incorporate technology and to foster program growth. As I mentioned, in Gemini it is a mixture of these two factors.

Mr. GURNEY. Isn't this really another thing? I am sure that no one on this committee disagrees with the way you at going about this program, or the wisdom of it.

The thing which troubles me and which I think is completely unwise in a program of this sort, particularly where we are in competition with the Soviet Union, is to announce that you are going to do a dramatic thing like orbiting two men in space on a particular day and knowing perfectly well that this schedule may not be met because of changes that may be necessary.

To announce that you are going to do something on a certain day, and then within a month's time suddenly say it is going to be 6 months later, is the thing that I would think the committee would agree is unwise.

It would be better to say: "Yes, we are going to have a manned flight of Gemini in 1964." Then when the date is reasonably ascertainable, announce that it is going to be done in the fourth quarter, or November, or December, or some such thing.

Mr. HOLMES. I would welcome such a thing, Mr. Gurney. However, in our program the total pressures have been in the opposite direction. That is, to run an open program and to state even more specifically than the quarter, as NASA has been stating, when these events should occur. We have had no choice but to make these announcements, given the ground rules under which we have been working nationally.

Once having announced a date, I think it would be very inappropriate for anyone in the project management to indicate a change before comprehensive studies are completed and a change is definitely required.

I do think that the program could run more soundly, from a project management standpoint, if it were not quite so open. From a national standpoint, I don't know whether that is true or not. Our policy leaders have felt that we gain more by having it completely open, even exposing problems when we shift dates, than having a closed program.

Mr. GURNEY. My only comment would be that I see no demand on the part of any reasonable person to have you pinpoint a year or a year and a half in advance of when you are going to do something. No person expects the impossible. I don't see how you can accurately predict a year in advance the quarter or the month that you are going to do something in, and I don't think you should be expected to.

Who would demand it? Who is demanding it? Certainly not this committee, are they?

Mr. HOLMES. I am not so sure about that.

Mr. TEAGUE. What amazes me is that NASA does as well as it does.

Mr. Daddario?

Mr. DADDARIO. Mr. Holmes, you established a philosophical approach to this this morning by saying that the important achievement is the final achievement, and the steps in between are adjustable in accordance with the situation as it comes about to finally effect that objective. Are you of the opinion that you have the management

capability, or you are developing the capability, to see these changes in time to reorganize and redirect at the quickest possible time in order to effect the greatest savings of expenditures?

Mr. HOLMES. My answer is a very affirmative one, Mr. Daddario. I would like to point out that this is a typical example of what I consider sound management. We didn't approach the first quarter of 1964 and then a month before say to the committee or to the public, "We didn't make it." What we have done is to say 1 year ahead that we ought to reorient this program. In my opinion, this is a straightforward and honest way to do it. To let you know as soon as we know with any soundness and can predict what we think we should do. We are telling the committee as soon as possible. We couldn't do it any earlier.

Mr. DADDARIO. You think in this instance you caught it at the earliest possible time?

Mr. HOLMES. Yes, sir; I do.

Mr. DADDARIO. I hope you can say this about other programs as well.

Mr. HOLMES. In terms of management capability, it is worthwhile to note that a year and a half ago we had an organization that certainly was nowhere near the size it is today, or nowhere near the maturity. The procedures by which the organizational entities worked together weren't defined. It has taken a full year to establish scheduling and cost procedures whereby the responsible people must approve a schedule monthly. That schedule is built up step-by-step, until you have an overall flight program, such as Apollo and Gemini.

It is this kind of procedure that brings out what are real dates and what are fictitious. It was this kind of procedure that really brought us to grips with Gemini earlier than we would have without an effective scheduling system.

On the other hand, I wouldn't want to mislead the committee. It is a long process to consolidate a group of 12,000 people in Government and 150,000 in industry to work in concert with a schedule. It will probably be another year before the schedule system is the way I want to see it, but it is a good deal better today than it was. It is on a sound footing to predict exactly where you are going, and then have the guts to change the schedule, if you really believe it should be changed.

Mr. DADDARIO. That brings us to another point. Are you receiving more money than you are capable of spending, taking into consideration that in developing this kind of a management team we are again learning from the experience of the past?

You had the weapons system development program which indicated that you could not go too fast. You do have to develop the team and management capability.

Now, are these keeping pace—the development of the management team and the expenditures of funds necessary to achieve objectives? Are these working hand in glove in such an efficient manner that we should continue at this pace?

Mr. HOLMES. Yes. In my opinion, it would be less efficient to go any slower, but, as I stated previously, partially I didn't think we should go much faster, due to this limitation of putting people together to manage such a large endeavor efficiently.

It is my considered belief, however, that to go any slower would lead to a more expensive and less efficient program. We are not

going as rapidly, anywhere near, as one does go in certain military systems, and I think for a very good reason. It is a different kind of program.

I do believe we are going at a rate that is efficient. I believe that we could go somewhat faster and still be efficient. I think to go slower we would start to lose efficiency.

Mr. WAGGONNER. Mr. Holmes, we have given considerable thought in the last few days to a statement which a fellow scientist of yours from Carnegie Institute has made with regard to the overall space program. He denounced the worth and value of the space program, and classified it as a public works program, and not much else.

I would like to have your comments on this statement, and I would like to know if you feel his view represents any sizable segment of the scientific community. What is your general appraisal of this statement?

Mr. HOLMES. I think it is a completely fallacious statement that shows a lack of understanding of the basic precepts of the program. I don't think that it is a coincidence that these negative statements concerning the space program usually come from the people who have made absolutely no attempt to talk to us to learn what we are doing. They make certain assumptions and believe they know what we are doing. I don't question their integrity, but the fact remains that they haven't bothered to find out exactly what we are doing. This includes many writers who have made negative comments. When they talk with the people on the program, and try to understand what we are doing, they often leave with an entirely different attitude.

Rather than a public works program, I believe that this program is leading our Nation away from falling into a weak position. It is enhancing the ability of our Nation to continue in world leadership. It is my personal opinion that this program, more than any other, stimulates and gives inspiration to the growth of America. To call it a public works program just makes me plain angry.

Mr. WAGGONNER. Don't you feel that maybe his statement and those of others who have spoken out on this subject is to some extent our fault, and I refer to this committee as well as NASA, because we have failed to communicate with them about this program? Haven't we fallen a little bit short in actually letting people know what this program is? Haven't we been just a little bit too smug about it, and we assumed that people knew about the program? Haven't we just gone in our own direction without trying to really tell the story in layman's language that the average individual could understand?

Mr. HOLMES. I think it is a matter of degree. I couldn't give you a straight "No." I don't believe it is the case. There is always some gray area, and I am certain that we haven't done as good a job as we could have done. However, I do know that we have tried very hard through our public information office and through talks to various groups to keep people informed. I might add that this committee has contributed greatly to presenting the facts about our program—both in giving talks and bringing out these facts in the testimony.

I believe that we can do more. As a matter of fact, we were discussing this matter yesterday, and I will indicate some of the discussion that we had. We normally make documentary film on all aspects of our program, since it is an excellent way of keeping management informed. Usually the films are silent and the appropriate program director provides the commentary during a presentation.

We had a Manned Space Flight Management Council meeting yesterday and saw a good deal of this film. Our discussion centered on whether it wouldn't be a good idea—and I would welcome your comments—to take a rather inexpensive approach and use this film, which we need for program purposes, to produce a bimonthly presentation for the Congress and the public. We would not just show the types of pictures on going to the Moon which are seen in many magazines today, nor just a group of models. We would show spacecraft being droptested on land and water; or we would show a spacecraft with its escape rocket undergoing certain tests. In other words, the film would reflect the status of the actual hardware that America is building as part of its manned space program. This is one thought that we had.

Mr. TEAGUE. Mr. Roudebush.

Mr. ROUDEBUSH. Mr. Holmes, I think the committee will remember—and it won't serve any purpose to dig into the record—that I asked you a series of questions about a month ago in this same room in which I expressed concern about the reliability of Titan II. I was assured at that time that it was completely reliable in your opinion. I also expressed amazement that only one unmanned Gemini flight was scheduled, and I was assured by either you or Mr. Low that you had gone into this thing, and that only one unmanned shot was necessary in the case of Gemini.

What has happened in the last 30 days that caused a complete reevaluation of the program? Do you re all that series of questions that I asked at the time?

Mr. HOLMES. I recall your discussing it. I don't recall the specific questions, but I do recall our discussing it here.

I didn't mean to indicate that we didn't have certain development problems with the Titan II. I did intend to indicate, however, and I still feel, that the Titan II will be an extremely reliable launch vehicle. But it does have these development problems.

As far as flying men on a third spacecraft instead of a second, all I can say is that in a program of this type, one really cannot be sure when a manned mission can be conducted until the preceding steps have been taken.

If indeed—and God hope it doesn't happen—at the end of the year when we have a structural test, it should fall apart, as happened on Mercury, we would not commit men to go on the third one. I have confidence in the scheduling we have laid out today. However, one cannot be completely certain, since it is a development program. Mother Nature often has a way of being a little wiser than the human being.

Mr. ROUDEBUSH. On this first—what you referred to as boilerplate—flight in December of 1963, the first Gemini unmanned shot, are we launching it at that time just to meet a publicly announced schedule, or do we actually need this shot in December? Couldn't you combine the first and second unmanned shots by delaying the program a few weeks, which I would be perfectly compatible to?

Mr. HOLMES. No, we looked into all the approaches and studied the possibilities very carefully. We believe that it is absolutely essential to check the aerodynamic and structural compatibility of the Titan II and the Gemini spacecraft as soon as possible. Despite

all the simulation on the ground, we really won't know until we have launched it, as was the case in the Mercury program.

Dr. Shea might want to comment on this, or Mr. Low, because they feel strongly, as I do, that it is absolutely essential to conduct this test at the earliest possible time.

Dr. SHEA. What Brainerd says is exactly true. We began to find difficulty in getting all the systems aboard the first flight, and then were faced with two alternatives—dropping the flight back, and essentially having the first flight contain all the systems we had originally intended, and then proceeding to a manned shot. That was our first inclination. We studied the physical configuration of the craft itself. The launch vehicle would be available to be fired in December and we could mate that launch vehicle with a somewhat simpler spacecraft. We did want to get the launch vehicle test under our belts to verify the soundness of changes that have been made in the launch vehicle and to assure that there are not going to be problems in flight. As a result of our analyses, we were led to conclude that we should keep the launch vehicle shot as originally scheduled.

Mr. ROUDEBUSH. My reason for asking the question ties in with previous questions asked by Mr. Gurney and Mr. Daddario. We have publicly announced that we intend to have our first unmanned shot in December of 1963, and I was concerned over the fact we might just be trying to meet a schedule for public consumption, let's say.

One last question. We do, I think, at this time acknowledge that slippage has occurred in the Gemini program for a multitude of reasons. Has that delay in any way, Mr. Holmes, been caused by lack of funds authorized by this committee?

Mr. HOLMES. The 6 months' delay to which I addressed my remarks today, and which I split somewhat arbitrarily between development difficulties and reevaluation, is not related to funds, although we are tightly pressed for funds.

The previous adjustment of the program was directly related to funds, and I think I indicated clearly at the time—before the fact, not after the fact—that I had no alternative except to adjust the schedules unless we were going to spend at a higher rate in that fiscal year than we were able to with the funds allotted.

An overall decision was made by the agency and by the Government that this was the reasonable rate at which to go. We established the program on that basis.

Mr. ROUDEBUSH. I am happy to have that answer. I will conclude by saying that I hope if we have further delays in our space program that no one gets on television or radio and starts blaming Congress because we have reduced funds, and so forth. I am most concerned with the responsibility of this committee. I don't want to be charged with lack of interest, or incompetence, in the case of the space program, and I don't want to see the committee of which I am a member charged in that way. I am glad to hear that any delay we have experienced was not caused by a lack of funds.

Mr. HOLMES. That is certainly a factual statement, sir.

Mr. RIEHLMAN. You said in your statement, Mr. Holmes, that this 6 months delay was partially due to Titan II and partly the Gemini capsule, itself.

The other day General Schriever was before this committee and I discussed with him the reliability of the Titan II, and whether it

would be available by the time the Gemini capsule was ready for test. We were assured that this was a good possibility; that any problem you are having with the Titan II would be eliminated and it would be ready when the Gemini project itself is ready.

Mr. HOLMES. I wouldn't argue with that statement. I think it is possible. I think the Air Force is doing everything they can to eliminate problems they have with the Titan II. We are very close to General Schriever on this, and I think he also indicated I said it was premature to discuss the schedule at that time because we hadn't completely established it. However, the development program for making certain corrections in Titan II is nip and tuck with that first flight, and certainly it is more conservative to schedule the way we are.

I would like to make it perfectly clear, if nothing were "wrong" with the Titan II in its development program, and I don't see anything wrong other than normal development problems, we still would be changing our schedule. I am not trying to blame the Titan II.

However, the Titan II was one consideration in our thinking, because of certain difficulties we are having. I would feel very bad, for instance, if it came out that NASA was saying this is the Air Force's fault because of the launch vehicle. That is not the case.

Mr. RIEHLMAN. How serious do you really feel the problem is with the Titan II?

Mr. HOLMES. I feel that the difficulties we are having do not affect the weapons system, which is the purpose for which the Titan II was initially designed. The Air Force says it is fine, and we agree with them. For manned flight, however, there are certain corrections that must be made. I have every confidence in the present development program with certain testing to establish modifications. I firmly believe that we will have an extremely reliable and good vehicle in the Titan II when we need it.

Mr. TEAGUE. Mr. Fulton.

Mr. FULTON of Pennsylvania. Would you tell us what effect this change will have on the budgeted funds? Will this delay, or so-called change of policy, of about 6 months cause an increase in costs, and therefore an increase in the space budget?

Mr. HOLMES. Yes, sir; it will.

Mr. FULTON of Pennsylvania. Could you estimate how much that will be, and what this committee should look for on budgetary requirements?

Mr. HOLMES. It is my opinion that the total Gemini probram will be several hundred million dollars more than was initially anticipated. Now, this refers to the estimated runout costs and does not mean several hundred million dollars more than is being requested in our current budget.

Mr. FULTON of Pennsylvania. Give us the starting figure originally expected so we can have something as a foundation on which to add the $200 million.

Mr. HOLMES. I am trying to relate it to our current budget request. To tie it to the philosophy of the fiscal year 1964 budget request in addition to 1963 and what we anticipate in the future, the figure would have been somewhere between $700 and $800 million. Several hundred million dollars more may be needed.

Mr. FULTON of Pennsylvania. In what budgetary year can we expect the added costs because of the delay?

Mr. HOLMES. In fiscal 1965 and fiscal 1966.

Mr. FULTON of Pennsylvania. Divided pretty equally between the 2 years?

Mr. HOLMES. I would think so; yes, sir.

Mr. FULTON of Pennsylvania. Having some experience as a newspaper publisher, I don't think we can blame the newspaper people for being avid on getting an announcement of this great significance to our space program, because, after all, we are in a very dramatic race with the Soviet to get to the Moon first.

My own criticism is that there was a casual announcement of great significance given by officials of NASA at the highest policy level. Secondly, that NASA did not have the announcement made in conjunction with its public relations personnel. If I were the public relations officer, I would be running around with a paddle at the present time.

The third point is that these announcements were made at two different places under two different circumstances. One was made to a group of students during a question-and-answer period after an address by Mr. Webb at Princeton, and the other one was really on his own motion by Mr. Mayer, a prominent official at Houston. That doesn't look like good agency coordination, and I would criticize the method rather than the newspapers.

Another point I would like to make is this: NASA is certainly making the Soviet program look good, because the Soviet program has already had a dual launch done on precision terms, the second one occurring almost exactly 24 hours after the first. The Soviets have shown the capability of rendezvous 7 or 8 months ago. On the dual launch the orbits were within one and a half to 2 miles perpendicularly between the interfaces, and longitudinally about 2 to 3 miles, so that that was a terrific accomplishment.

When would we have a dual-launch capability such as the Soviets accomplished last year?

Mr. HOLMES. I would like, before answering that question, to add to my comment about the press. I think the ladies and gentlemen of the press are doing just about what I would do if I were in their position. All I am saying is that they have a good way of getting news, and if you are a program manager only halfway through your decision, you would prefer some time to complete your evaluations. I wasn't being critical of them, except to say that premature publicity does complicate your work. Other than that I certainly agree with what you said.

Mr. FULTON of Pennsylvania. Why hasn't an explanation been made, or could I ask for it, so at least it correlates or conforms to what you say. After having talked within the hour to Administrator Webb, you are certainly leaving both Mr. Webb and Mr. Meyer clear out in orbit on their statements. They don't agree; they don't correlate.

Mr. HOLMES. Well, Mr. Webb, I think, feels that anything he indicated was consistent with what I am saying today.

Mr. FULTON of Pennsylvania. Well, could I ask for a statement to the chairman from Mr. Webb and Mr. Meyer, at least trying to correlate what has been going on here in these public statements?

Mr. HOLMES. I could get a statement from Mr. Meyer because he is a subordinate of mine. I cannot promise one from Mr. Webb. He is my superior.

(Mr. Webb's statement follows:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION,
OFFICE OF THE ADMINISTRATOR,
Washington, D.C.

Memorandum for: Subcommittee on Manned Space Flight, Committee on Science and Astronautics, House of Representatives, Washington, D.C.

Subject: Current status of Project Gemini.

The statement of Mr. D. Brainerd Holmes, Director, Office of Manned Space Flight, before the Subcommittee on Manned Space Flight, May 1, 1963 (pp. 1382–1386) represents the position of the National Aeronautics and Space Administration on the Gemini program and its relationship to the Apollo program. As Mr. Holmes said, he had reviewed this matter the morning of May 1 with Dr. Dryden, Dr. Seamans, and myself.

As far as I am concerned, there are no substantive discrepancies between Mr. Holmes' statement and any comments I have made regarding this program. Mr. Holmes' remarks are, of course, much more detailed than any similar statement I have made recently.

The newspaper article referred to in your letter contains the author's own remarks and predictions. In light of Mr. Holmes' approved statement, I do not find it necessary to comment further upon the article. I can only say that we are continuing work on Project Gemini with increasing emphasis toward attaining the goals set for the program.

Sincerely yours,

JAMES E. WEBB, *Administrator.*

Mr. FULTON of Pennsylvania. Maybe the chairman can get it.

I want to see how far we are behind the Soviets on our program. To me it looks like a year and a half already. Then when you add to this another 6-month delay in the Gemini program, it looks like the gap is lengthening rather than diminishing.

Mr. HOLMES. No, sir, I don't think so. To answer your earlier question, we do not plan to follow the Russian example of putting two men in orbit in separate spacecraft and have them pass close together and not rendezvous. That is not in our program.

Mr. FULTON of Pennsylvania. When will you have the capability of the twin launch and the ability to come within 2 miles?

Mr. HOLMES. I think we have it today, as long as one would say that we were doing it with a spacecraft with much less mass than theirs. If we compare Mercury orbits, we have precisely duplicated them.

Mr. FULTON of Pennsylvania. Of course, you haven't done it in timing so that you have the orbital velocities within a range that you can have a possible rendezvous. We haven't done anything like that.

Mr. HOLMES. Let me say that out last launch in predicting timing, and so forth, was such that we could have performed precisely the same kind of mission. Of course, one can't really say that we would have been able to do it, and do it twice, unless we had done it.

I think the significant point is to remember that we should not necessarily parallel in what the Russians do with their different booster and their different start in manned space flight. We should concentrate on running a sound program designed to achieve efficiency in space. I think that we are running an efficient and sound program and I do not think that we are falling behind the Russians.

Mr. FULTON of Pennsylvania. Well, how far in time—1 year, 2 years, and does this new 6-month delay push us an additional 6 months behind the Russians?

Mr. HOLMES. I am not sure that we aren't ahead of the Russians.

Mr. DADDARIO. There is a good possibility that the Russians have some of these slippage problems themselves, isn't that so, Mr. Holmes?

Mr. HOLMES. It is impossible to compare the two programs without detailed knowledge on what the Soviet Union is accomplishing on the ground in terms of developing new engines and boosters. If the Soviet Union is only doing what has been demonstrated publically, which I doubt, it is behind us. That is why I do not think it proper to compare what they have shown and say they are ahead. They need different vehicles and different spacecraft to get to the Moon, or to gain this proficiency in space.

Mr. FULTON of Pennsylvania. This is the first time I have ever heard anyone officially say that the United States is ahead in the space program and the race to the Moon. As a casual observer in space myself, I would judge that we were about a year and a half behind, and this 6 months now makes the gap 2 years. I am not placing the blame on anyone. I am just trying to assess where we stand today.

Mr. HOLMES. I don't believe that I said that. What I did say, which I think is a factual statement, is if all they were doing in the development of equipment is what they have demonstrated, then they are behind us. I have no knowledge about what they are doing on the ground.

Mr. FULTON of Pennsylvania. But it was a terrific accomplishment when they launched the two Vostoks.

Mr. HOLMES. It was very impressive.

Mr. FULTON of Pennsylvania. And within a 24-hour period and close enough that you could almost call across and ask for a sandwich. I think it was pretty good.

Mr. HOLMES. Yes, sir, I agree with you.

Mr. TEAGUE. Are there any questions?

(No response.)

Mr. TEAGUE. Good.

If my memory is correct, we left off in volume 2, research and development, page RDO 2–16.

Mr. FULTON of Pennsylvania. Could I have for the record later the answers to some of the questions that I had spoken about earlier, go line by line?

Mr. HOLMES. Yes, sir.

Mr. FULTON of Pennsylvania. There has been a charge made that the space programs use 10 percent of the scientific and engineering talent available in this country for all research programs, and that this is too much use of the natural resource for this one area. I would like the agency to answer that.

Mr. HOLMES. Yes, sir.

(The information requested is as follows:)

NASA has seen no evidence to support the statement that it is using 10 percent of the Nation's scientific and engineering manpower. At the beginning of 1963 approximately 4 percent of the country's scientific and engineering manpower was involved in the space effort. According to current estimates, the percentage will reach approximately 6 to 7 percent by next year. NASA's grants to colleges and universities are aimed at fostering the graduate training of both scientists and engineers. Over a period of time this graduate study support will increase the scientific and technical resources of this Nation.

Mr. FULTON of Pennsylvania. The other was a charge that the scientific gains now to be expected from the Apollo Moon flight in the U.S. space program are not enough to warrant this expenditure of money, and to warrant going further with such a program.

If you would answer those two, I would appreciate it.

Mr. HOLMES. Yes, I certainly will.

Mr. TEAGUE. For the record.

(The information requested is as follows:)

PROJECT APOLLO—STEPPINGSTONE TO SPACE

Our Nation has made steady progress in manned space flight since 1961, when the President recommended, and the Congress endorsed, the goal of manned lunar landing and return within the decade. The record of Project Mercury has confirmed the engineering reliability of the flight hardware and the efficiency of the launch, flight, and recovery operations. The unbroken series of successes in Mercury missions have pioneered our development of the operational skills to sustain man in space flight. Mercury's successor, Project Gemini, will expand this base of knowledge and skills. In turn, Project Apollo will lead us to the historic objective of landing highly trained men on the Moon, and returning them safely to Earth, and will write the prolog for further manned exploration of space.

The objectives and benefits of our program embrace many fields. To judge a program of this scope and growth potential in narrow terms is to view it through the wrong end of the telescope. The program is designed to advance the welfare and security of the Nation and NASA firmly believes that the results of the manned space flight program, established and executed on a sound engineering basis, will achieve these goals. The facts dispute the charge that the scientific and technological gains from Project Apollo will be slight. The development of Saturn-class launch vehicles, for instance, will provide power to conduct a variety of manned space flight activities, including Earth orbital and lunar and planetary missions. The development of operational techniques, such as rendezvous and docking, can be applied to numerous uses in space flight.

Although Project Apollo is not geared to scientific ends alone, certain aspects of the current mission plan will certainly enhance scientific knowledge. The two Apollo astronauts who descend to the Moon's surface will play an invaluable scientific role in this pioneering venture. The first U.S. crew to land on the Moon will perform vital tasks, which cannot be accomplished as fully by any other authorized or planned unmanned program. As examples, after the Apollo astronauts observe the lunar surface, they will be expected to—

(*a*) Select the location for a detailed examination of lunar surface characteristics, perform these studies, and record the results.

(*b*) Select the optimum location for obtaining sample material from the lunar surface, extract samples, and package them for return to Earth.

(*c*) Choose the location for implanting scientific instruments into the lunar surface; insert these devices in special physical or geometrical relationships to the lunar surface; properly adjust or energize these instruments which are designed to gather data about the composition and characteristics of the Moon's surface.

Each task demands the unique abilities of carefully trained, on-the-spot observers. Our experience to date has proved that instruments cannot analyze or compensate for the unexpected. His judgment and analytical powers will be indispensable in proper exploration of the lunar surface.

Even the early stages of manned lunar exploration will yield data that will increase our insight into a variety of unsettled scientific questions. Since the Moon lacks atmosphere and escapes the erosive effects of weather, it may well provide a key to the formation and early development of our solar system. The scientific data may also add significantly to our knowledge of chemical or biological evolution.

Eloquent defenses of the human motivations behind Project Apollo have already been presented. Man, since time immemorial, has accepted the challenge of the unknown. This historical urge has been a measure of society's vitality, and, ultimately, has determined the course of civilization. This same urge, which changed the face of this Nation from a group of coastal settlements to a mighty industrial and technological force, is at work in our program. We can assume that the long-range impact of Apollo, in the tradition of exploratory achievement, will repay many times over the energies and resources devoted to it. We can already point to the increased knowledge of new sources of power, such as the fuel cell, and to the development of heat-resistant materials, and microminiaturization that have come from space technology.

We started in second place in space and now we are moving ahead with a manned space flight program that is established on a sound engineering basis, with emphasis on safety, reliability, and judicious use of resources. Project Apollo, as well as its predecessors, stimulates both the pioneer spirit and the economy of our Nation. It exemplifies our urge to act, to discover, and to excell.

The objectives are broad and challenging. If we are unwilling to continue to accept the challenge, we must be satisfied with second place in space exploration and, eventually, a secondary role in world leadership. Project Apollo is an effort worthy of a nation built by pioneers who were willing to confront the unknown. The program is designed to achieve a definite goal, but this goal stands as a milestone toward deeper penetration of space and greater scientific knowledge. In pursuing the goal of Project Apollo, we will carry many areas of knowledge to a higher level and will develop operational skills that can be applied to a variety of space missions. whether scientific, exploratory, or defensive. As with all pioneer efforts, the potential is limitless, bounded only by the range of our vision.

Mr. HOLMES. Yes, sir. Mr. Chairman, I believe we were starting the Advanced Saturn, which we now call the Saturn V, and we will review this project in any manner you see fit. As I recall from your last statement, you indicated that you might prefer to have questions asked rather than have us describe each item.

Mr. TEAGUE. Unless there is some question, we will just insert the material from the budget book on the Advanced Saturn into the record. The members may ask questions on any item, but I see no reason to just repeat what is printed in the book.

(The information referred to is as follows:)

Advanced Saturn

	1962	1963	1964
S-1C stage	$22,575,000	$144,500,000	$291,600,000
S-II stage	19,284,000	92,500,000	181,400,000
S-IVB stage	2,500,000	32,100,000	82,300,000
Vehicle instrument unit	---	2,600,000	17,000,000
Guidance system	7,590,000	11,000,000	16,000,000
F-1 engine procurement	3,400,000	21,600,000	53,100,000
J-2 engine procurement	1,700,000	9,800,000	16,600,000
Support	326,000	14,500,000	75,000,000
Subtotal, direct R&D costs	$57,375,000	$328,600,000	$733,000,000
Personnel costs	7,213,000	24,859,000	39,013,000
Operation of installations	4,901,000	14,906,000	27,730,000
Total costs	$ 69,489,000	$368,365,000	$799,743,000
Total personnel	822	2,524	3,601

The Advanced Saturn is the most powerful launch vehicle now under development. It will have capability to perform manned orbital operations;

manned circumlunar navigation and lunar landing; unmanned earth orbital operations; and unmanned instrumented lunar and deep space exploration. It is now being developed to land a man on the moon in this decade.

With the Advanced Saturn the payload capability for earth orbital missions will be increased more than 50 fold (i.e., in excess of 100 tons). The vehicle will also develop sufficient thrust for achieving escape trajectories for payloads exceeding 40 tons.

The enormity of the Advanced Saturn can be understood by comparisons. The vehicle is as tall as a 35 story building and weighs as much as a Navy destroyer. It is filled with 100 railroad tank cars of fuel, 80 percent of which is consumed in 2½ minutes. The Advanced Saturn is being developed by a logical extension of techniques and principles already developed. However, metals and insulation must be improved to meet increased heat and vibrations conditions. New design of advanced ground support equipment steps off from the experience gained during preceding launch vehicle projects. New tooling is required to meet the larger size and weight of the new stages. Proven fabrication methods will be used to develop improved methods of forming the thicker metals of the advanced stages. Altered methods of assembly are being devised since this must be accomplished in the vertical position to prevent the stages from deforming due to their own weight. Studies and experiments will determine how the advanced stages will be handled, transported, and assembled at the launch sites. Because of the vehicle's bulk, additional safety procedures must be developed, telemetry stations must be expanded, and improved ways must be found to protect and service the vehicle after assembly.

Prior to the first manned vehicle flight a tremendous research, development and test effort will be required because of the immense size, complexity, and high reliability and safety requirements. To accomplish this, many tasks never before undertaken in this size and scope must be done. Ground static firings of stages and systems; dynamic testing of the entire vehicle; reliability testing of stages, systems, subsystems and components; and structural testing of the propellant tankages and interstages are prime examples.

The Advanced Saturn project was initiated in fiscal year 1961 through establishment of conceptual and preliminary design studies. In fiscal year 1962 all major contracts were placed. During the current year the program moved forward with the establishment of manufacturing and testing resources, and the beginning of fabrication and testing of components and subassemblies. Fiscal year 1964 activities will increase as ground stages are delivered and the testing program develops.

S-IC stage

The Advanced Saturn is designed as a three-stage vehicle to support the primary mission of manned lunar landing and return.

The first or booster stage, the S-IC, will be 138 feet high and have a diameter of 33 feet. Five F-1 engines will provide a total sea level thrust of 7.5 million pounds. The propellants will be liquid oxygen (LOX) oxidizer and RP-1 (Kerosene) fuel. The engines will be arranged in a square pattern of four gimballed outside engines for vehicle flight control, and one fixed engine located in the center. The weight of the stage without propellants will be about 300,000 pounds. The propellant capacity will be 4,400,000 pounds.

The Boeing Company, Aero-Space Division, was selected as the stage development and production contractor, and awarded a contract in February 1962. Marshall Space Flight Center is developing the preliminary design criteria and will assemble and test the first ground test articles at Huntsville, Alabama, with Boeing assistance. Boeing is fabricating the components for the ground test and flight articles and will assemble one of the ground test stages, in addition to the flight stages, at the Government-owned-contractor-operated Michoud Plant near New Orleans, Louisiana.

Development draws heavily upon test facilities now available at Marshall, and upon new facilities planned for the Michoud Plant in Louisiana and the Mississippi Test Facility at Pearl River, Mississippi.

During fiscal year 1962 and continuing into fiscal year 1963, preliminary design concepts were prepared by Marshall Space Flight Center. Boeing's major emphasis was on detail design, facility planning, tooling and test equipment acquisitions, supporting research studies, initial component testing and qualification of various stage components. Certain hardware items have been procured for the ground test articles and for the first and second flight test vehicles. Fabrication has commenced for static, dynamic and structural test vehicles.

In fiscal year 1964 emphasis will continue on the completion of detail design of ground and first flight vehicles. As a result of the tests performed with the ground test stages, redesign and modification will be accomplished on structures, propulsion, electrical instrumentation and control for the flight stages. The static test stage and structural test stage will be assembled and testing operations will be initiated. Fabrication of the dynamic test stage will be complete and structural assembly essentially completed. Fabrication of the systems checkout stage and first flight stage will be nearly complete, and work on the second flight stage will be initiated. Hardware procurement for the third and fourth flight stages will be accomplished.

S-II stage

The second stage, the S-II, will be 81.5 feet high and 33 feet in diameter. Five J-2 engines will provide a total thrust of one million pounds at altitude. The high energy propellants will be liquid oxygen (LOX) oxidizer and liquid hydrogen (LH_2) fuel. The dry weight of the S-II stage will be approximately 75,000 pounds, and the propellant capacity will be

930,000 pounds. The five J-2 engines will be mounted with their center lines parallel to the stage center line. Four movable control engines will be arranged concentrically and equally spaced about a fixed center engine.

North American Aviation (NAA), Space and Information Systems Division, was selected as the second stage contractor, and was awarded an initial contract in October 1961 for the S-II stage. NAA will design, develop, fabricate, test and checkout nine flight stages, 1 non-operative (dummy) stage and 6 ground test vehicles. The major manufacturing and assembly activities for the S-II stage are being conducted at NAA's Seal Beach, California facility.

During fiscal years 1962 and 1963 major effort related to preliminary and detailed designs, procurement of special tooling and test equipment to support the assembly operations, procurement of components to support the test program for design verification and qualification, procurement of hardware and initiation of fabrication for all ground test articles, one dummy flight stage and the first flight test vehicle.

In fiscal year 1964 design, fabrication drawings and procurement specification will be completed. Fabrication, assembly and installation on test stands and initiation of testing operations will be accomplished for battleship and structural test stages. Final assembly will be completed on the static test stage and dynamic test stage, with the latter having been delivered to Marshall. The facilities checkout vehicle and the second, third, and fourth flight vehicle will be in various stages of manufacture. Initiation of procurement for long lead time items will be accomplished through the sixth flight vehicle.

S-IVB stage

The third stage, the S-IVB, will be 58 feet high and 260 inches in diameter. One J-2 engine will provide a thrust of 200,000 pounds at altitude. The dry weight of the S-IVB stage will be about 21,000 pounds, and the propellant capacity 230,000 pounds. The single J-2 engine will be gimbal mounted to provide flight control.

Douglas Aircraft Company (DAC) was selected in December 1961, as the developer for the third stage since the S-IVB was a modification of the S-IV stage, which was under contract with DAC. DAC will furnish eight flight stages, two non-operative (dummy) stages and five ground test vehicles. The major manufacturing and assembly activities are being conducted at DAC's Santa Monica, California plant.

The funding in fiscal years 1962 and 1963 provides for detail design, facilities planning, and hardware procurement for three of the five ground test articles and the first flight test vehicle. Structural testing for qualification of components is being accomplished.

In fiscal year 1964 structural design will be refined, and the ground test program will be underway. The structural facilities checkout and dynamic vehicles will be complete, with the latter ready for shipment to Marshall Space Flight Center. Basic structural assembly of the all-systems vehicle will be complete, with structural assembly of the first flight vehicle nearing its midpoint. Fabrication of parts on the second flight vehicle will be complete and will be initiated for third flight vehicle.

Vehicle instrument unit

The vehicle instrument unit houses the guidance and stabilization units, telemetering equipment, power supplies, and an unpressurized cooling system. It is located between the S-IVB stage and the payload.

The fiscal year 1963 funding provides for initial design, procurement, and testing efforts on the instrument unit. To prove the design, various ground test units are required, namely a structural unit, a vibration test unit, a dynamic test unit, and a systems development test unit. By the end of the fiscal year, the design of the structure will be completed and vibration testing of subassemblies started.

The fiscal year 1964 effort will result in completion of design of additional items such as the unpressurized cooling system, the electrical system for the ground test units, and ground support equipment. Design of the electrical system for the first flight vehicle will be approximately 75 percent complete. Fabrication of the structures for the ground test units will be completed. Installation of the electrical and unpressurized cooling systems in the systems development test unit will also be completed. Procurement of hardware for the first flight will be initiated and procurement of all tooling and special test equipment completed for fabrication, assembly, and testing of all instrument unit components and systems.

Guidance system

The guidance system consists primarily of an inertial platform, a digital computer, a guidance signal processor, and a control computer. This equipment is housed in the instrument unit.

The fiscal year 1963 funds provided for the continuance of guidance system research and development based on previous work accomplished under the Saturn program. 75 percent of the design changes to the ST-124 inertial platform and the ASC-15 digital computer, imposed by Advanced Saturn requirements, will be accomplished and procurement of this hardware initiated for the systems development test unit. Design, development and improvement of the function and reliability of guidance components such as a guidance signal processor, control computer, control signal processor, azimuth alignment package, accelerometers and rate gyros will be accomplished.

The fiscal year 1964 program will result in completion of the design changes and modifications on the ST-124 inertial platform dictated by

Advanced Saturn requirements. Design of the modified ASC-15 digital computer will be completed except for modifications resulting from system experience. Design, development, and prototype testing of guidance components and instrumentation will continue. The inertial platform and the digital computer equipment for the system development test unit will be delivered and tested. Procurement will be initiated for the inertial platform, the digital computer, and backup spares for the first flight vehicle. Guidance instrumentation components for the ground test units will be procured, and procurement will be initiated for long lead items and spares for the first Advanced Saturn flight. Procurement of tooling and special test equipment will be completed for production and testing of the inertial platform, guidance computer, guidance signal processor, and ground support equipment.

Principal participants in the program are International Business Machines at Owego, New York for the digital computer and guidance signal processor, and Bendix Corporation at Teterboro, New Jersey for the inertial platform.

F-1 engine procurement

Both the F-1 and J-2 engines are being developed by the Rocketdyne Division of North American Aviation, Inc. under separate contracts and are to be supplied to the respective stage contractors for the ground test and flight articles as Government furnished equipment. Production facilities will be provided at Canoga Park, California.

In fiscal years 1962 and 1963, four "hard" mockups were delivered and long lead time hardware procurement for 14 engines initiated, twelve of which are in the process of fabrication. In fiscal year 1964, one additional "hard" mockup together with 10 engines are to be delivered. Long lead time hardware procurement will be initiated for 23 additional engines. Twenty F-1 engines will be in various stages of fabrication. Also included in fiscal year 1964 are costs of modifications and retro-fitting of previously delivered engines as a result of experience gained during pre-flight rating tests. Propellants for engines delivered in fiscal year 1964 will also be procured.

J-2 engine procurement

In fiscal year 1964 five "hard" mockups and 15 J-2 engines will be delivered, procurement of which was initiated in prior years. Long lead-time hardware will be procured for 10 engines. Twenty-six of the engines for which procurement was initiated in current and prior fiscal years will be in various stages of manufacture. Propellants for engines delivered in fiscal year 1964 will also be procured.

Support

In fiscal years 1962 and 1963, studies and investigations were conducted and hardware procured to support experimental test programs. In fiscal year 1964 design development will continue for vehicle system ground support equip-

ment. Design development and prototype testing of telemetry and range safety equipment will continue. Design of universal transporter hardware will also be in process.

Hardware for evaluation and ground test stages will be procured. Procurement will be completed for component equipment and services to support Advanced Saturn and analytical investigations in ground test programs. Equipment will be secured to support full-scale dynamic tests at the Marshall Space Flight Center.

A marine vessel will be procured and modified for transportation of upper stages from the west coast to the Mississippi Test Facility, Marshall Space Flight Center, and the Launch Operations Center. Transportation support for bulky hardware and major subassemblies from Wichita to Michoud and Huntsville, and from Michoud to Huntsville will be required. Marshall Space Flight Center will provide for local transportation of ground test components.

Wind tunnel studies will continue at Arnold Engineering Development Center (Tennessee), Langley Research Center, and Cornell Aeronautical Laboratories (New York) with specific investigations concentrated on critical vehicle areas. The reliability program effort will continue, as will product improvement of liquid hydrogen propulsion components. Studies will be initiated for advanced structural applications and more detailed aerodynamic analysis and follow-up effort will begin for programs already established.

Mr. TEAGUE. Are there any questions?

Mr. YEAGER. May I ask one question about the table shown in volume V on the Advanced Saturn?

Mr. HOLMES. Volume V?

Mr. YEAGER. Page 10 of volume V. There is an item under each category for tooling and special equipment. Could you give us a brief explanation of that?

Mr. HOLMES. Mr. Smolensky will do that.

Mr. SMOLENSKY. This refers to the tooling and special equipment that would be going into the actual contractor's plant. It includes both the inspection, quality control special test equipment, as well as necessary fixtures and holding devices required for the S–II stage.

Mr. YEAGER. Do you have any estimate of the amount of R. & D. money in this Advanced Saturn which will be expended for contractor's facilities, just a rough percentage is all I am after.

Mr. LILLY. It is not our present intent to put any of the R. & D. funds requested for fiscal year 1964 into contractor brick and mortar facilities. There will, no doubt, be money in facility contracts because of procurement practices of putting certain tooling and equipment in so-called facilities contracts, but no brick and mortar facilities are planned.

Mr. YEAGER. Thank you. That is all I had.

Mr. FULTON of Pennsylvania. I have a question.

Mr. TEAGUE. Mr. Fulton.

Mr. FULTON of Pennsylvania. On the justification of the Saturn and various types of vehicles, will you tell us in the current fiscal year what there might be on the Nova program? Is there any part of the Nova program listed among these various Saturn-type vehicles?

Mr. SMOLENSKY. The answer is no, sir.

Mr. FULTON of Pennsylvania. Where is what we will call the remains of the Nova program after this committee had done its work last year?

Mr. SMOLENSKY. Systems Engineering is where that will be covered when Dr. Shea appears before the committee.

Mr. FULTON of Pennsylvania. That is not under your shop at all?

Mr. HOLMES. Dr. Shea is in my Systems Engineering office.

Mr. FULTON of Pennsylvania. It is not mixed with the Saturn programs?

Mr. HOLMES. The only place it is mixed in at all, to my knowledge, is the M–1 engine, which we indicated we would discuss toward the end of this session.

Mr. FULTON of Pennsylvania. Yes, we expect that, but there is no other line item, nor is there anything within design and development of the Saturn type vehicles that is actually also Nova? There is no mixture?

Mr. HOLMES. No, sir, to my knowledge, in our total manned space flight program the only Nova funds are the funds associated with the M–1 engine, or the systems studies which Dr. Shea is doing on a new advanced launch vehicle.

Mr. FULTON of Pennsylvania. They will appear as funds under something like systems engineering or design and development headings, is that correct?

Mr. LOW. Mr. Fulton, they will appear in the section of volume II entitled "Systems Engineering" starting on RDO 5-1.

Mr. FULTON of Pennsylvania. But we can say with assurance that every one of these funds justified for the Saturn program and vehicles are actually Saturn, and are not looking ahead to the Nova program, so there is no mixture of funds?

Mr. HOLMES. Absolutely none.

Mr. FULTON of Pennsylvania. Is there any overlap between the purposes of the H-1 engine and the J-2 engine? Do you need those two programs?

Mr. HOLMES. There is no overlap. We very much need the two engines. The H-1 is a kerosene engine, which is used in the first stage of the Saturn I. The J-2 is a hydrogen engine, which is used in the upper stages of the Saturn IB and V.

Mr. FULTON of Pennsylvania. I think we want that on the record, that we are not duplicating.

Does the M-1 engine duplicate the purposes of either the H-1 or the J-2?

Mr. HOLMES. We will discuss that in more detail later, but it is a more powerful engine. The M-1 is a million and a half pound-thrust hydrogen engine, whereas the highest hydrogen engine we are presently developing is the J-2. They are a different category of engine so far as thrust.

Mr. FULTON of Pennsylvania. So there is no duplication on these projects. Each one of these engines is necessary?

Mr. HOLMES. Yes, sir, that is a correct statement.

Mr. FULTON of Pennsylvania. On your hardware procurement, how is that done? Is that done by public bid, or is that done just by negotiation? Is that components, or is that design and engineering construction?

Mr. SMOLENSKY. First of all, we have the various stages and each stage contractor has his prime contract which includes development and engineering, and actual hardware procurement. A certain amount is procured from various vendors.

Mr. FULTON of Pennsylvania. It is research, as well, not just ordinary off-the-shelf components?

Mr. SMOLENSKY. That is correct. First he has to go through the development program, design the specifications for it and determine what he wants to buy, and in many cases have it developed by some subcontractor and then bring it inhouse for qualification testing and checkout.

Mr. FULTON of Pennsylvania. In your fiscal year 1963 budget on design and development, how closely are you coming in actual fact to your preliminary estimates for each item in the budget? What is your correlation? Are you close to your original figures?

Mr. HOLMES. Within the total manned space flight, any change of funds between those projects is within about 10 percent, as a total. There is some deviation, but the average range is no greater than 10 percent.

Mr. FULTON of Pennsylvania. On assembly and checkout, how do you fare on those funds? Is there good correlation between original estimates so that we can gage 1964?

Mr. SMOLENSKY. I would say yes, sir.

Mr. FULTON of Pennsylvania. Within what range of percentage?

Mr. SMOLENSKY. I would say in that case, too, we are on schedule and within the funding that we had available for 1963.

Mr. FULTON of Pennsylvania. How do you describe stage support as an item?

Mr. SMOLENSKY. These are all the studies and evaluations that have to go on to evaluate, for instance, our actuators we use in the program.

Mr. FULTON of Pennsylvania. Will you speak a little louder?

Mr. SMOLENSKY. This is the stage support the contractor has for the evaluation of various hardware that is delivered by the various subcontractors. It also includes studies on base heating and radiation characteristics, and it includes investigations and tests of electrical connectors, and circuit connection techniques under extreme environmental conditions.

Mr. FULTON of Pennsylvania. Is that done by the contractor, by NASA, or by the General Electric Co. under its contract?

Mr. SMOLENSKY. Under each stage, sir, this is part of the prime contract with the stage contractor.

Mr. FULTON of Pennsylvania. Where does the General Electric contract fit into the listing that we have, for example, on page 10 of volume V?

Mr. HOLMES. It does not, Mr. Fulton.

Mr. FULTON of Pennsylvania. So that is——

Mr. HOLMES. I would like to address myself to a statement I made when I stated the overall average of 10 percent. I was talking about between the major items, such as Apollo, or Gemini, not between things like design and engineering versus assembly.

Mr. FULTON of Pennsylvania. But on the Apollo-Saturn programs you are not starving the general programs of NASA of research and development in order to do the design, engineering, and construction work that are necessary in the Apollo program? I think that should be answered, because there has been some charge made of that.

Mr. HOLMES. No, sir; I don't think we are starving any part of NASA.

Mr. FULTON of Pennsylvania. There have been no funds transferred from NASA's research and development programs through reprograming for the Apollo and Saturn programs?

Mr. HOLMES. There have been absolutely no dollars flowing through the manned space flight programs to the detriment of other programs in NASA, within my knowledge.

Mr. FULTON of Pennsylvania. That is all.

Mr. TEAGUE. Mr. Waggonner.

Mr. WAGGONNER. Mr. Holmes, concerning the Advance Saturn, the S–1C is the booster stage of the Advance Saturn. In fiscal year 1964, you are asking for more than twice the amount of $144 million requested in fiscal year 1963—$291,600,000.

In fiscal year 1964, you say that the emphasis on this S–1C booster stage is going to be on completion of detail design and ground testing.

If we are going to have a cost of $291,600,000 in a year when we have placed emphasis on the detail design and ground testing, what is going to be the procurement cost when we really start paying for these booster stages?

Mr. HOLMES. The total runout?

Mr. WAGGONNER. Yes, what is the projected runout?

Mr. HOLMES. For the development part of the programs, the funds shown here, that runout estimate is just over a billion dollars for the first stage, the S–1C.

Mr. WAGGONNER. You have already let contracts for about $485 million of that first stage, am I correct?

Mr. SMOLENSKY. $418 million, sir.

Mr. WAGGONNER. Is this a comparable situation to the S–2 stage? We have a request this year for about twice the amount of money that you were using in fiscal year 1963, and I am talking about the projected budget for fiscal year 1964.

Are you going to use that money for the same phase of the S–2 stage as you are for the S–1C stage, and what is the projected runout of the S–2 stage?

Mr. HOLMES. I would like to say that $418 million was followed by the contract to Boeing, so the $480 million is right, or near that figure.

The runout on S–2 is around $630 million.

Mr. WAGGONNER. NASA has let no firm contracts on the S–2 stage?

Mr. HOLMES. We have a firm contract with the North American Aviation to build the S–2.

Mr. WAGGONNER. The other item I am concerned about is the increase in the support expenditures. In 1962 the initial request was $326,000, and now for fiscal year 1964 you are requesting $75 million, and requesting this when we are in the detail design stage. Where are we going to expend that amount of money as a support item in detail design, and what is going to be the runout of the support item when we become fully operational?

Mr. HOLMES. I would ask Mr. Smolensky to answer that, if he would, please.

Mr. SMOLENSKY. Certainly. This support item is the same item that is involved in systems integration on the other vehicles, for instance, covered under Saturn I and Saturn I–B. In the case of Saturn V, it is called support, and this involves the whole effort on the part of Marshall, through the contractors reporting to it, working on the various problems having to do with the integration of the stages for the large vehicle. In the case of Saturn V, this means working on the problems involved in integrating the first stage and the second stage and the third stage.

They are also involved here with paying for transportation costs. They are also involved here in paying for the development of the ground support equipment that they need in order to check out the reliability of the various stages and the interface connections that they have.

This also covers wind tunnel studies and evaluation, actually, of the various subsystems that are used in each and every one of the stages and the vehicle, itself.

Mr. WAGGONNER. Are there any outside management contracts to further and speed the integration of these different stages considered in this support item?

Mr. SMOLENSKY. There are outside contracts that come under this particular area, yes.

Mr. WAGGONNER. Would you tell me what the fiscal year 1964 overall cost of all management contracts would be, or if it is a single contract, what would be the proportion in dollars?

Mr. SMOLENSKY. I wouldn't want to say management contracts, but engineering support contracts.

Mr. WAGGONNER. Could you give me what proportion that represents, for the record?

Mr. SMOLENSKY. I will supply that.

(The information requested is as follows:)

Forty percent of the $75 million requested for Saturn V support in fiscal year 1964 is required for engineering support, covering design, development, and testing.

Mr. TEAGUE. Mr. Gurney.

Mr. GURNEY. May we take one engine here, the F–1 engine, and I might point out that in volume V you show the figure as $54.9 million—one figure must be in error.

Can you give us in capsule form how you got the figure in the budget, what does it consist of, when did you arrive at it, what discussions did you have to arrive at that figure so we can get some idea of what it represents?

Mr. SMOLENSKY. In the 1964 budget, that figure of $53.1 million represents the F–1 engine support that we are giving to the launch vehicle development program. In other words, this applies to engines that must be supplied to the S–1C stage. The breakdown we have for that is that it provides the funds for and delivery of a hard mockup so that people in the development program can work with a model of the engine as it may affect the various interrelationships of other systems, and it completes the fabrication and delivery of 10 engines under the 1963 funding program. We are also ordering long leadtime items for 23 engines and fabrication work on 20 engines.

Mr. GURNEY. Does it include testing?

Mr. SMOLENSKY. It includes the cost of modification and retrofit of previously delivered engines, and it would include the acceptance testing.

Mr. GURNEY. How many firings does that include, and how much will they cost?

Mr. SMOLENSKY. For each of these engines in the acceptance test?

Mr. GURNEY. Incidentally, is it $53 million or $54 million?

Mr. SMOLENSKY. $53.1 million.

Mr. LILLY. The figure of $54.1 million is for the F–1 engine development program, not the procurement of hardware engines for use on the Saturn V.

Mr. GURNEY. So what you have——

Mr. SMOLENSKY. I am talking essentially about engines that must be supplied to the development stages.

Mr. GURNEY. Can you also cover the engine development program and give us an idea how you arrived at that $54 million figure?

Mr. SMOLENSKY. We are actually then discussing the RDO 2–26 where we had a total of $54,100,000?

Mr. GURNEY. Right.

Mr. SMOLENSKY. In that case, we are talking about using 12 completed engines and 10 equivalent engines, that is all their components, which will be part of the research and development program, and these moneys will be used, then, for the development work that has to do with developing the engine system, the turbopumps, the thrust chambers, the controls, and the gas generators. Each and every one of these items will include a certain amount of tests, and we are projecting about 250 engine tests here in order to assure ourselves of the reliability of the components of the subsystems in this particular program.

This is a separate R. & D. program, whereas the engines that we are talking about under the vehicle program are part of the production contract.

Mr. GURNEY. How does that compare with this year, so far as testing is concerned?

Mr. SMOLENSKY. In 1963?

Mr. GURNEY. Yes.

Mr. SMOLENSKY. I can get it for the record, sir.

(The information requested is as follows:)

The F-1 engine has undergone 142 tests from July 1, 1962, through May 1, 1963

Mr. GURNEY. In arriving at that figure for testing, who makes the decision? Do you make it together with Rocketdyne, or do you tell them how many to test?

Mr. SMOLENSKY. This is a joint requirement that is worked out among the technical management at Marshall, ourselves, and the contractor, Rocketdyne, depending on what the problems are, and the requirements both from our standpoint and theirs.

Mr. HOLMES. Excuse me, Mr. Gurney. We have Mr. Tischler here who heads our engine development operation. I had hoped at the end of the session today, with the chairman's permission, to have him describe this F-1 instability problem. I think he will then address himself to this testing as to what part we and Marshall play. It will be an excellent example. I didn't do an adequate job in talking about the F-1 instability at the last hearing. I didn't realize that Mr. Tischler was behind me then, and I think it would be of interest to this committee to hear about that significant and important element of the program.

Mr. GURNEY. All right, that is fine, but one other question. You have 250 tests scheduled, and I suppose there must be a fairly accurate way of arriving at that number. Do you have 10 tests to test the carburetor, 10 tests for the nozzle, or how do you arrive at the 250?

Mr. HOLMES. Mr. Tischler can explain that for you.

Mr. TEAGUE. Mr. Tischler, will you identify yourself for the record.

Mr. TISCHLER. My name is Adelbert O. Tischler. I am Assistant Director for Propulsion in the Office of Manned Space Flight.

(The biography of Mr. Tischler follows:)

A. O. TISCHLER, ASSISTANT DIRECTOR FOR PROPULSION, OFFICE OF MANNED SPACE FLIGHT

A. (Adelbert) O. Tischler was appointed Assistant Director for Propulsion, Office of Manned Space Flight, National Aeronautics and Space Administration, in November 1961. He first joined NASA as Chief, Liquid Rocket Engines, when NASA was established on October 1, 1958. Before joining NASA, he was Head of the Rocket Combustion Section at the Lewis Research Center in Cleveland, Ohio. In his present assignment he is responsible for management of engine projects for both launch vehicles and spacecraft which are being developed for manned space flight applications.

Mr. Tischler joined the National Advisory Committee for Aeronautics, the predecessor of the NASA, as a chemical engineer on the staff of the Lewis Laboratory, in 1942. He remained at this research center until he was named to his position of Chief, Liquid Rocket Engines, in Washington, D.C. Throughout his scientific career, he has specialized in combustion research, with particular emphasis on turbojet and rocket engines.

A native of Cleveland, Mr. Tischler earned a Bachelor of Science degree in 1940 and a Master of Science in Chemical Engineering degree in 1946 from the Case Institute of Technology.

Mr. Tischler is a fellow member of the American Institute for Aeronautics and Astronautics, and the Combustion Institute. He is chairman of the Liquid

Rocket Committee of the A.I.A.A. He is the author of numerous technical papers, and has frequently discussed rocket developments before various professional organizations.

Mr. and Mrs. Tischler and their three children, Craig G., 9, Marc A., 7, and Sandra L., 6, live at 8404 McGruder Mill Court, Bethesda, Maryland.

Mr. HOLMES. I would also like to introduce Capt. Robert A. Freitag, my Director of Propulsion and Launch Vehicles, who is also present.

Mr. TEAGUE. Mr. Tischler.

Mr. TISCHLER. The answer to your question, Mr. Gurney, I believe lies in the fact that with the test stands we have available at Edwards and at the Santa Susana facility at Rocketdyne, we can conduct a limited number of tests. That limit is in the order of one test per day on engine testing. This is not the sum total of testing by a long shot. Of course we have to supplement the engine testing with component testing, much of which is done in the Santa Susana facility.

The projection of 250 tests then represents an aggressive program approaching the limit of our testing capability.

Mr. GURNEY. Well, that is a good answer. In other words, you run as many tests as you can with the facilities you have got available?

Mr. TISCHLER. That is exactly right.

Mr. TEAGUE. If there are no other questions, I believe we had agreed to go to the detailed discussion of the M–1.

Mr. HOLMES. Yes, sir, and I would like Mr. Tischler to comment on the F–1, also.

Mr. TEAGUE. All right, Mr. Tischler.

Mr. TISCHLER. With your permission, I will stand.

I believe two questions were asked by this group last week. The first of these had to do with why we are developing the M–1 engine, and I would like to address myself to this question, first.

As you know, we are not presently building a vehicle which is designed to use the M–1 engine. Funding limitations in fact prevent us from building such a vehicle at this time. However, as Mr. Holmes brought out in the discussion last Friday, the development of an engine takes several years longer than the development of an airframe, and we clearly recognize as a matter of history that our payload lifting capability has been limited by the thrust capability of the engines that we have on hand. Therefore, we at NASA think it is sound philosophical judgment to develop the M–1 engine.

If I can refer to this historical pattern that I have just mentioned, the F–1 used in the first stage of the Saturn V vehicle was initiated in 1958 without a clear definition of a vehicle requirement. The F–1 engine was based on existing technology and conservative design. Since our experience at that time was largely limited to the ICBM and IRBM vehicles, we employed liquid oxygen and kerosene as the propellants. That F–1 engine has permitted us to forge ahead with our assault on the Moon.

The F–1 engine, on the other hand, is not a high performance engine. It is intended to be used in the launch stage and is not suitable for use in the second stage.

For the second stage of the same Saturn V vehicle, we have initiated the development of the J–2 engine, with which you are quite familiar.

Again, however, in 1960 when we undertook this development we did not have a vehicle requirement. At the same time, we recognize now that the use of the high performance J–2 makes possible the land-

ing on the Moon in this decade. Thus, in spite of the absence of a defined requirement for either the F–1 or J–2 at the time the engines were started, we can say in retrospect we could not endeavor to land men on the Moon in this decade had we not proceeded with these developments.

Their initiation was based on the philosophical judgment that engines of a geometrically spaced thrust-level would be needed in this space race. This building block concept was strongly endorsed by the President's Scientific Advisory Committee.

On June 5, 1961, the Ad Hoc Booster Panel of the President's Science Advisory Committee issued a report which recommended in part:

> * * * action should be taken immediately to develop two new liquid hydrogen-oxygen engines with thrusts of approximately 1 and 4 million pounds. These engines together with the J–2 would constitute a family with proper ratios of thrust to be used for building block stages. Such engines have possibilities for use in first stage boosters and are essential for second and third stages for very large payload missions.

This is the end of the quotation.

Mr. FULTON of Pennsylvania. Is that the M–1 engine you are referring to?

Mr. TISCHLER. This statement is in reference to two engines that were not identified at that time. NASA undertook the development of the first of these, the 1-million-pound-thrust engine in early 1962, and this became known as the M–1 engine.

Mr. FULTON of Pennsylvania. And what is the other one known as?

Mr. TISCHLER. The other has no designation. We have not undertaken this development.

Mr. FULTON of Pennsylvania. That is a 4-million-pound hydrogen engine?

Mr. TISCHLER. Yes, approximately.

Mr. FULTON of Pennsylvania. Why couldn't you get the same amount of thrust by clustering?

Mr. TISCHLER. That would be our intent at this time.

Mr. FULTON of Pennsylvania. Then what is the need of the 4-million-pound-thrust engine? If the M–1 is going to cost $233 million for development at the million-pound level, I would say it would look as if the undesignated 4-million-pound-thrust engine would have an astronomical cost for engine production.

Mr. TISCHLER. It would undoubtedly be significantly higher in cost. We did not go ahead with this 4-million-pound-thrust engine and have no plans to go ahead with such an engine immediately.

Mr. FULTON of Pennsylvania. Why couldn't you cluster five J–2 engines and get the same effect as an M–1?

Mr. TISCHLER. I think I can answer that question in a moment, if I may.

The M–1 is the largest of a stable of three hydrogen-oxygen engines that are under development in this country.

May I have the first slide (fig. 164), please?

These are the A–3 engines which develop 15,000 pounds of thrust, the J–2 which we have just mentioned, and the M–1 engine which is planned to have one and a half million pounds of thrust. I must say that this drawing is out of proportion.

FIGURE 164

The M–1 engine is significantly larger than it appears here on this slide with respect to the other two engines. My significant point is the fact that the thrust levels of these engines are approximately a factor of 10 apart from each other. All of these hydrogen-oxygen engines will provide specific impulse values greater than about 420 seconds per pound of propellant, which is approximately one-third greater than can be obtained with oxygen and kerosene. It is the high specific impulse of the hydrogen-oxygen combination that makes this combination attractive in the upper stages of our space vehicle.

Mr. GURNEY. The M–1 has the same thrust as the F–1, is that right?

Mr. TISCHLER. Yes.

Mr. GURNEY. Is it more reliable, or not quite as large?

Mr. TISCHLER. This engine is physically bulkier than the M–1. When we say it has the same thrust level, there is a small shade of difference. The thrust rating of the F–1 is a rating at sea level—that is at takeoff.

Mr. HOLMES. Could you explain the difference?

Mr. TISCHLER. The M–1 is an altitude rating. In other words, the M–1 engine is a second or third stage engine which will operate in a vacuum environment. However, this difference is not the significant point.

The significant point is that the M–1 is a hydrogen-oxygen engine which has a much higher specific impulse than oxygen-kerosene. The specific impulse in this case is analogous to miles per gallon. That means that with the same loading of propellants in a given stage, we

could burn approximately 30 percent longer, and this has great significance in range and velocity.

Mr. FULTON of Pennsylvania. In what time period are you looking ahead to the M–1 development?

Mr. TISCHLER. I will come to that in a moment, too, if I may again defer your question.

Let's illustrate the advantages of using hydrogen in the second stage, if I may have the next slide (fig. 165).

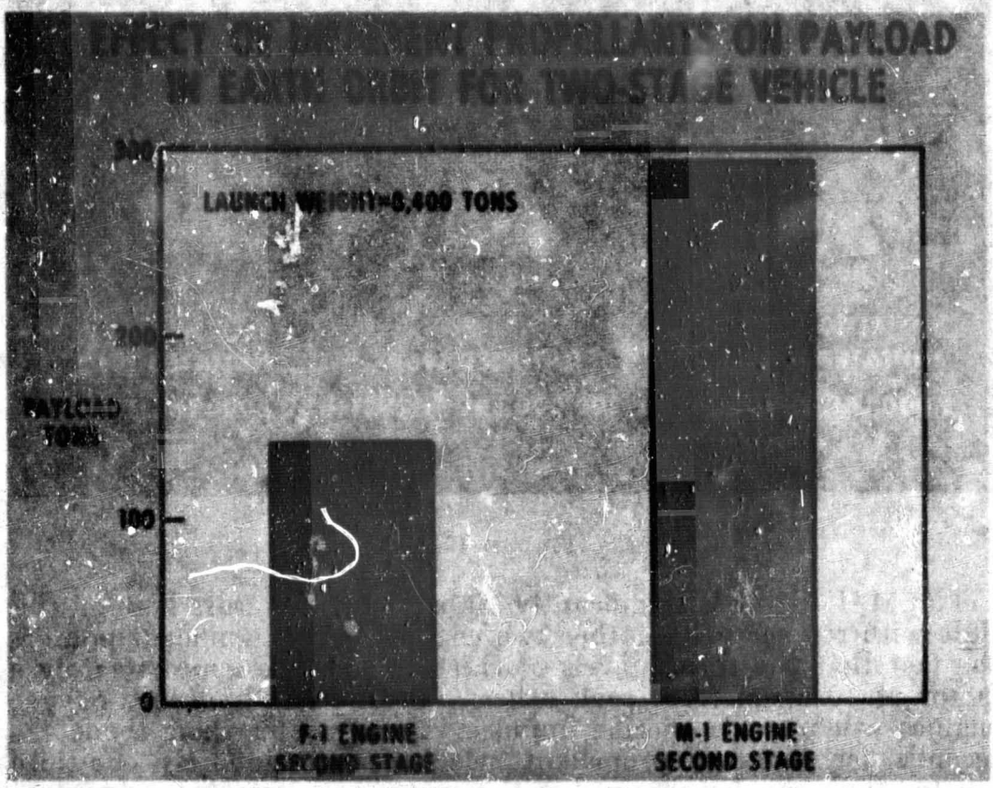

FIGURE 165

Here is a completely hypothetical vehicle using the F–1 in the second stage and using an M–1 in the second stage, the first stage for both vehicles being identical.

As you can see, using hydrogen in the second stage picks up the payload capability by more than a hundred percent.

Mr. HOLMES. Mr. Gurney, I think that answers your question.

Mr. GURNEY. Yes, it does.

Mr. TISCHLER. Now, to understand the significance of the M–1 engine in the NASA programing thinking, I think we must turn to what Mr. Fulton mentioned, our development schedules.

The next slide (fig. 166) will show a typical large thrust propulsion equipment development schedule. It is in fact the schedule for the F–1 which was initiated in late 1958, and which will be flown in early 1966. The F–1 will be flown in an operational status in 1967.

Now, the principal point I wish to make here is that from the point of initiation to the point of operational capability is nearly 9 years.

F-1 ENGINE DEVELOPMENT HISTORY

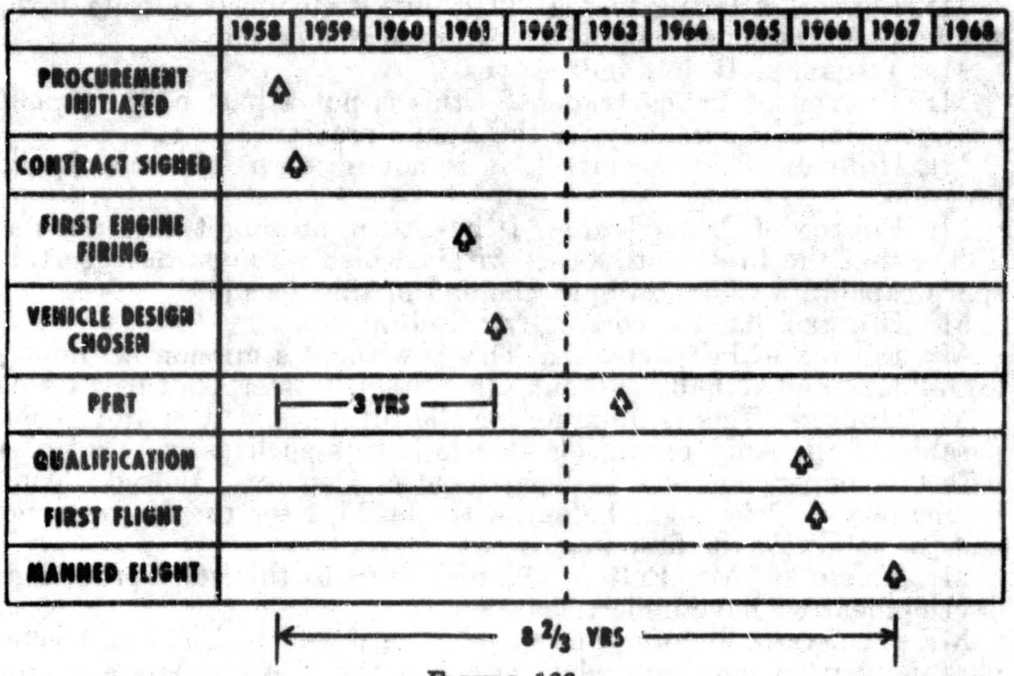

FIGURE 166

On the basis that the F–1 engine—which we are pushing very aggressively—will take 9 years, I think the schedule that will be shown next (fig. 167) for the M–1 schedule is very reasonable.

We initiated procurement of the M–1 in January of 1962. Upon our decision to go to the Moon by lunar orbit rendezvous instead of direct flight, we changed the concept of this engine, uprated the thrust,

M-1 SCHEDULE

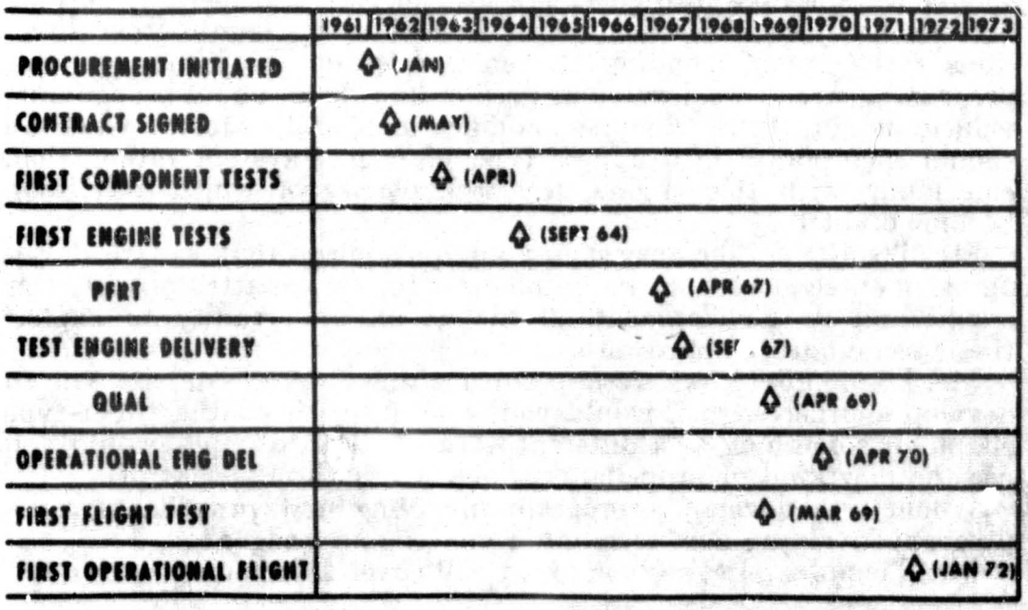

FIGURE 167

and made it a higher performance engine, and we ought to allow at least a year for this. This would give us operational status in 1972.

Mr. FULTON of Pennsylvania. That puts it obviously outside of the Apollo program or landing on the Mo n in this decade.

Mr. TISCHLER. It does indeed; yes.

Mr. FULTON of Pennsylvania. So this is not a part of the Apollo program, nor is it necessary for the Apollo program?

Mr. HOLMES. That is correct, it is not necessary for the Apollo program.

Mr. FULTON of Pennsylvania. It has, then, no target date, such as a date that the President has set within which we must have certain space capabilities; for example, the end of this decade?

Mr. HOLMES. That is correct, Mr. Fulton.

Mr. FULTON of Pennsylvania. This is without a mission, without a target date, and actually without a first-stage booster, isn't that right?

Mr. HOLMES. This is building for the future, and it is quite comparable to the solid propulsion developments such as we are doing with the cooperation of the Department of Defense. Indeed a complementary vehicle might be one with the M–1 for the second stage and the solids for the first stage.

Mr. TISCHLER. Mr. Fulton, if I may turn to this solid propellant development we have undertaken——

Mr. DADDARIO. Before you get off this, if you had shown a comparable chart a year ago when you had the Nova program in the budget, how would it differ from that you have before us at the moment?

Mr. TISCHLER. I think I can answer that question in part. I think that the M–1 engine, which was part of the Nova schedule, would have been pushed much more aggressively than we are pushing it at the present time, in funding and in progress. As a result, we could have shortened this time period to operational flight by several years.

We would have had to do it.

Mr. DADDARIO. Does that make any difference in your planning for the future? You are now projecting this program ahead, and should we not take into consideration that we will learn something between now and then which might divert our efforts into other directions rather than spending the enormous sum of money on this program? Aren't we developing greater knowledge about propellants, vehicle design, thrust chamber modifications, and so forth, which we should incorporate into a new type of engine system rather than continuing with this engine, the technologies of which may soon become obsolete?

Mr. TISCHLER. The answer to your question is that we are developing new techniques as we go along, and, as a matter of fact, this engine and its development affords us an opportunity to exploit these techniques in hardware.

Mr. DADDARIO. If we were to cut out this program and ask you to develop another engine, would you come up with another M–1-type engine or something of a different nature? For example, would you use the new kind of propellants which Mr. Fulton speaks of?

Would you develop a program involving new propellants, or a program involving new techniques and engine designs?

Mr. TISCHLER. Let's go on and I will cover these points.

Mr. GURNEY. Let me ask you this before you continue, I don't understand your statement to the effect that if you had more money, the time limit would be different. It seems to me the schedule on the M–1 engine is quite similar to the F–1 engine. I understand from the testimony on the F–1 engine that NASA is spending as much money as it can on development. To put it another way, if NASA spent more money on the F–1 engine, the engine wouldn't be developed any faster, and the time schedule on the M–1 engine is almost identical to the F–1 engine.

Mr. HOLMES. If I might address myself to that, I don't think it is a fair statement to say we were spending money at a rate that would give us the maximum possible production of the F–1 engine a few years ago. I think that part of the program from 1958, on, could have been compressed somewhat by higher spending.

Related to that, but also related to Mr. Daddario's question, the M–1 engine we will obtain with this program is a more sophisticated M–1 engine than if we had had to crash it through for the Nova program on a shorter time scale. For the dollars spent, we will get more in this manner than had we had to produce it for the Nova vehicle.

Mr. TISCHLER. Indeed, and one more important point is had we pursued the Nova concept, we would have based this engine on a more conservative technique, a somewhat more antiquated engine in the light of our present concepts. This approach would have permitted us to shorten the time undoubtedly, but we would have ended up with an old-fashioned engine.

Mr. DADDARIO. You are still not using high-energy fuels or developing a high-pressure engine.

Mr. TISCHLER. This engine runs at a chamber pressure of 1,000 pounds per square inch. It is the highest pressure engine being built in the country, or it is at least the match of any high-pressure engine with which I am acquainted, and I think I know them all.

Mr. DADDARIO. It is difficult for me to understand the criteria you have established. To say that we should not be concerned about the development of these engines because in the past we have developed engines which have had no vehicle concept, and therefore since we have done it in the past we should continue to do it, seems to me to be an unhealthy type of criteria. I recognize the need of developing this kind of engine, but I would be much happer if we knew what we were going to use it for. I would also hope that by 1972 or 1973, considering that it has been the habit to have a certain amount of slippage, that we would have diverted our efforts in another direction. I ask again, if we were to scrap this whole program, aren't we developing techniques and new fuel knowledge which might bring us to a better engine than the M–1 engine?

Mr. TISCHLER. The answer to that question is very difficult, but I think I can try to answer it in a moment. I doubt very much that we could change the fuel, because liquid hydrogen is a fairly expensive fuel, but nevertheless available in unlimited quantities by nature. To use exotic fuel propellants would run us into a severe problem of propellant supply for a large thrust engine.

Secondly, liquid hydrogen and liquid oxygen is an excellent specific impulse combination. It is very difficult to beat.

Let me turn briefly to the solid propellant program.

Mr. FULTON of Pennsylvania. Before you leave that, I have read the NASA technical notice of February 1963, which mentions the increased percentage gain of up to 10 to 20 percent on using high energy propellants, and recommending that there be further research and development done along those lines.

I agree with Mr. Daddario. Here we are going into larger and larger vehicles, which is simply engine and design development as distinguished from the research and development of higher energy fuels. One is a scientific program, the high energy fuels, and the other is engine development. NASA can get much more for its money in research and development than it can in engine development. To spend $233 million on a program that has no end result makes me question the necessity of it.

Mr. TISCHLER. But there is an assumption which I must dispute, and that is that this program has no end result. I would point out this engine is available about 5 years after the operational date of Saturn V.

Mr. ROUDEBUSH. But what is the end result? That is what we are trying to get at. What kind of a mission have you planned for the M–1 engine?

Mr. HOLMES. Let me address myself to that. My feeling is this. The way we are running the M–1 program, to obtain a more advanced engine, is entirely consistent with running a solid propellant program, because we think solid propellants or larger vehicles are a logical follow-on to the present program. The end result is to go farther into space, to go to the planets, or make a more detailed exploration of the Moon. This is the end result. I think the most logical one could apply to this, and you may consider this in your judgment of whether you think the funds are necessary or not, is that in any one of these programs that we are carrying on, and I think it is true of a small program in industry or of a huge program such as this, a certain percentage of your money ought to be spent to produce hardware that will be useful and usable for that period than when the present hardware is becoming obsolete.

How much is a matter of judgment. It is our judgment that this is about the right amount to spend on this hydrogen or high-energy type engine. It is also our judgment that the amount we are spending for the development of 260-inch and 156-inch solids. which are funding by the Department of Defense to carry that out for us, is the right amount for that.

I think they have to be taken in that concept, thought of that way and then judged as to whether it is the right amount, is it too much or is it too little?

Mr. DADDARIO. One of the problems here, Mr. Holmes, is that this committee was sold this program with the understanding that the M–1 engine would be ready in this decade. That was considered in the first instance last year when it was part of the Nova program.

Mr. HOLMES. Yes, sir, that is correct. I don't think "sold" is perhaps the right word—but it was explained to you that way; yes, sir.

Mr. DADDARIO. Maybe it is too harsh a word, but the fact remained I think we were sold on it. If we had been advised a year ago that this program would go into the next decade, it is my opinion that this committee would not have voted to authorize the funds.

Mr. ROUNDEBUSH. I think that is true.

Mr. DADDARIO. When we look at it in the concept of an engine which is being developed for some kind of use, the nature of which at the moment is unknown, I think this committee has to shift gears insofar as its thinking is concerned.

Mr. HOLMES. NASA, too, has had to shift gears. We did initiate the program in all sincerity on the concept that we hadn't decided whether to use the direct flight mode and needed Nova or not. Our funding request is less, certainly, than it would be had we stayed with the original plan to use it for a Nova vehicle within this decade, that is true.

Mr. DADDARIO. We are not even talking about a funding request being higher or lower. We are talking about a better use of the knowledge which we are developing. The committee has been of the hope that somewhere along the line we would be getting into other phases. For example, let's say that somewhere between now and 1972, or 1973, 1974, or 1975, that we develop a nuclear engine capability to have an upper stage engine which can do more than anything we can conceive of at this time. Would we need an engine such as the M–1? Aren't we going to learn rendezvous techniques, perhaps through the placing of a space platform in orbit which can be used as a launching pad to accomplish more in space. It just seems to me that we are cutting out the possibility of developing the knowledge which will obviate the need for an engine of this tremendous size and cost.

Mr. HOLMES. Could I ask Dr. Shea, who, as you know, heads our total system engineering effort in the manned space flight operation, and who therefore knows more than any of the rest of us on this, to make a few comments to your point?

Mr. ROUDEBUSH. Before you go into that, what is this $5.7 million being spent on the M–1 engine for special test equipment? Specifically, what is that?

Mr. TISCHLER. The special test equipment is the equipment which covers instrumentation, recording equipment, and the like, on the test facility. It is equipment that can be used elsewhere and is not considered part of the facilities.

Mr. GURNEY. During Dr. Shea's comments, could he comment on this? Is the F–1 engine and the M–1 engine put in combination actually sufficient to carry us on a mission to Mars, or is there a specific use for this in mind?

Dr. SHEA. The decision not quite a year ago to rely on the lunar orbit rendezvous technique for Apollo carried with it the implicit decision that the Saturn V launch vehicle would be the large workhorse booster vehicle for the NASA and U.S. space program essentially throughout this decade, and probably on into the early part of the 1970's.

As we look at the future missions we talk about doing, whether it is a space station or extended lunar operations up to and including the lunar base, it appears that most of those programs can be done within the framework of the Saturn V vehicle itself. Therefore, the pressure for a new launch vehicle will really come about either when we define new missions as yet unthought of for man in near Earth space or military uses of space, or will come about when we do the planetary program. We can't say at this point in time what that schedule is, or even what it should be.

Mr. TEAGUE. Didn't you tell us last year that regardless of the approach used for the manned lunar landing, that you had to have an engine of this kind to launch heavy space laboratories in Earth orbit? Wasn't that the testimony last year?

Dr. SHEA. An engine of this kind makes sense for advanced chemical boosters with payload capabilities to Earth orbit in the order of half a million pounds to a million pounds—roughly two to four times the size of the Saturn vehicle.

Now, as I look at it from where we sit trying to define the advanced programs and what the advanced vehicles ought to be, it is going to be several years, in the order of 3 or 4 years, before we really understand the missions that we want to do and the schedule on which we are going to want to do them. Only then will we know exactly when to bring the new vehicles into the national inventory.

Mr. TEAGUE. Is there any question that you are going to put heavy laboratories up in orbit?

Dr. SHEA. No, sir. We are going to do that, but the Saturn V can put up a fairly heavy laboratory with a single shot. The connection of two or more such payloads is not a difficult task, even though we didn't choose to use Earth orbit rendezvous technique for Apollo. In that case we decided that we did not have to use it rather than that we were afraid of doing it.

The point I would like to make is that around 1965 or 1966 we will face a national decision as to what the next generation of boosters will be.

At this point in time, there are many possibilities that are competitive. Both chemical and nuclear stages are competitive. We are doing extensive study work, paperwork, looking at recoverable vehicles. We are looking at solid vehicles. When we come to the point of making the decision as to what the next generation of launch vehicles shall be, we must have the necessary data available. If we don't have available—not just in chemical technology, but also in nuclear technology, in the understanding of airframes, and so on—the fundamental data that says we can in a given time frame, proceed along this path of technology or that path of technology, we will, in effect, be limiting ourselves to a much narrower spectrum of choices, than would be the case if we keep fundamental developments going along in several areas. We really look at the M–1 engine as one of a series of complementary developments that ought to go forward in the country, so that when we come to defining the next missions we will know the state of advanced chemical propulsion, and we will have readily available potential chemical building blocks that we can use. I would hope that we would also have nuclear propulsion available as a possible competitor for the advanced vehicles.

Mr. FULTON of Pennsylvania. NASA first gave an estimate of $90 million for the overall cost of the M–1 engine program. Now you say that it is going to cost in the range of $230 to $233 million for the same program.

When I hear that you have changed your mind on timing, on size, and on costs, I think this committee deserves an explanation. Certainly the $90 million M–1 engine program which we first looked into is not the same thing as the $233 million engine development program for the M–1 which you now estimate. What is the difference? How could you be that far off on your estimates within a 2-year period?

Mr. TISCHLER. First, if I may answer that question, the $90 million figure was the contractor's estimate or proposal of what it would take to develop an engine of 1.2 million pounds of thrust. NASA's immediate reaction on seeing the proposal was that this estimate was not an adequate development plan, that it would take much more work than the contractor had proposed to do this job and do it right. At no point did we really accept the $90 million figure as the real price of developing the engine.

Mr. FULTON of Pennsylvania. At that time what was your figure in relation to the $90 million?

Mr. TISCHLER. I believe it was $179 million for the R. & D. work alone.

Mr. FULTON of Pennsylvania. It has gone up tremendously when it hits $233 million for engine development.

Mr. TISCHLER. The $233 million figure includes the cost of the facility development, as proposed by the contractor to date.

Mr. FULTON of Pennsylvania. Could you spend that money better on research and development rather than on engine development, which is the most costly element of all?

Mr. TISCHLER. That is a very difficult question to answer, because it involves the answers to the question which Dr. Shea discussed. These considerations are: When in fact are we going to have a mission requirement that demands the use of this engine or an alternate, and when in fact can we have such an alternate available? These are very difficult questions to answer because they lie in the future.

Mr. TEAGUE. Mr. Riehlman.

Mr. RIEHLMAN. Last year you requested $35 million for the M-1 engine. How much of that has been obligated?

Mr. TISCHLER. NASA headquarters office has allocated all of that money to the Lewis Research Center. The Lewis Research Center has obligated—well, I am sorry I can't give the figure.

Mr. LILLY. $18 million of the R. & D. funds was obligated as of March 31.

(The information referred to is as follows:)

Status of M-1 engine obligations as of Apr. 30, 1963

[In thousands of dollars]

	Amount programed for fiscal year	Amount obligated
Fiscal year 1962:		
Research and development	16,705	16,694
Construction of facilities	166	166
Total	16,871	16,860
Fiscal year 1963:		
Research and development	35,000	21,022
Construction of facilities	13,000	9,640
Total	48,000	30,662

Mr. RIEHLMAN. This came in this morning and was just handed to me, Mr. Chairman. It shows the amount of money that has been obligated, to whom it has been obligated, and for what purposes.

The other question I have is just a general one, and I am sure the answer is very simple. It is my understanding that we do not have at the present time a program in being, or planned, for which we would use the M–1 engine. We do not have a present requirement for the engines. Now, would the cancellation of the M–1 engine program at the present time have any effect whatsoever upon any existing NASA program?

Dr. SHEA. None of our existing programs, that is right, sir.

Mr. HOLMES. I think although that is correct, if one goes back in the history of development, whether it be an Atlas to fly a Mercury, or whether it be a large plane to act as a tanker or jet aircraft that led to our commercial 707, there wouldn't be any of these programs without advance planning.

I don't say this to disagree with you, but I do disagree with some of the philosopy expressed in this country that one must look at things strictly on a budgetary basis and shouldn't develop anything that doesn't have a specific mission. I think the way one should look at it is to try to judge how much money should be spent—zero is the wrong amount for this kind of thing, but a large amount is not the right level either.

Mr. RIEHLMAN. We have the national goal of a manned lunar landing to accomplish in this decade, and we have in being at the present time the engines and the equipment to accomplish that.

Mr. HOLMES. That is correct.

Mr. RIEHLMAN. Now, what we are talking about is beyond this decade. I am disturbed, and I am sure every other member is, about the amount of money we are spending on this program. Somewhere we are going to have to curtail expenditures, there is no question about it. We have to face this reality. My feeling is that between now and the end of this decade there may be some new concepts and new discoveries such as has been suggested by other members of the committee, that will give us a greater advance than we could have possibly anticipated that we would have before the end of this decade. I really feel that we should take a very careful and sharp look at the development of the M–1 engine before we decide to continue the program, unless we have some definite program that we are going to use it for.

Mr. TISCHLER. Mr. Riehlman, may I address myself to this particular issue, by running through a series of slides here?

Mr. TEAGUE. How long will it take you?

Mr. TISCHLER. About three minutes.

Mr. TEAGUE. All right, we will run through the slides.

Mr. TISCHLER. This slide showing a solid propellant development schedule represents an alternate way of launching vehicles (fig. 168) We have not used solid propellants. You will notice that the operational date for this possibility is also 1972, which gives us along with the M–1 the complete propulsion equipment.

Going on to the next slide (fig. 169), here are some of the configurations proposed by the solid propellant contractors, and they all use M–1 engines in the second stage.

Going to the next one (fig. 170), here are some concepts which lie behind the M–1 engine. On the right is the clustered solid motors configuration we have discussed, and I won't discuss in detail these new concepts.

SOLID PROPELLANT DEVELOPMENT SCHEDULE

	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
BEGIN FEASIBILITY DEMONSTRATION	◇ (MAY)										
FIRST DEMO FIRING		◇ (SEPT 64)									
CONTRACT AWARD		◇ (JULY 64)									
FIRST DEVELOPMENT FIRING			◇ (JAN 66)								
PFRT						◇ (SEPT 68)					
FIRST LAUNCH							◇ (JULY 69)				
FIRST OPERATIONAL FLIGHT									(JULY 72) ◇		

FIGURE 168

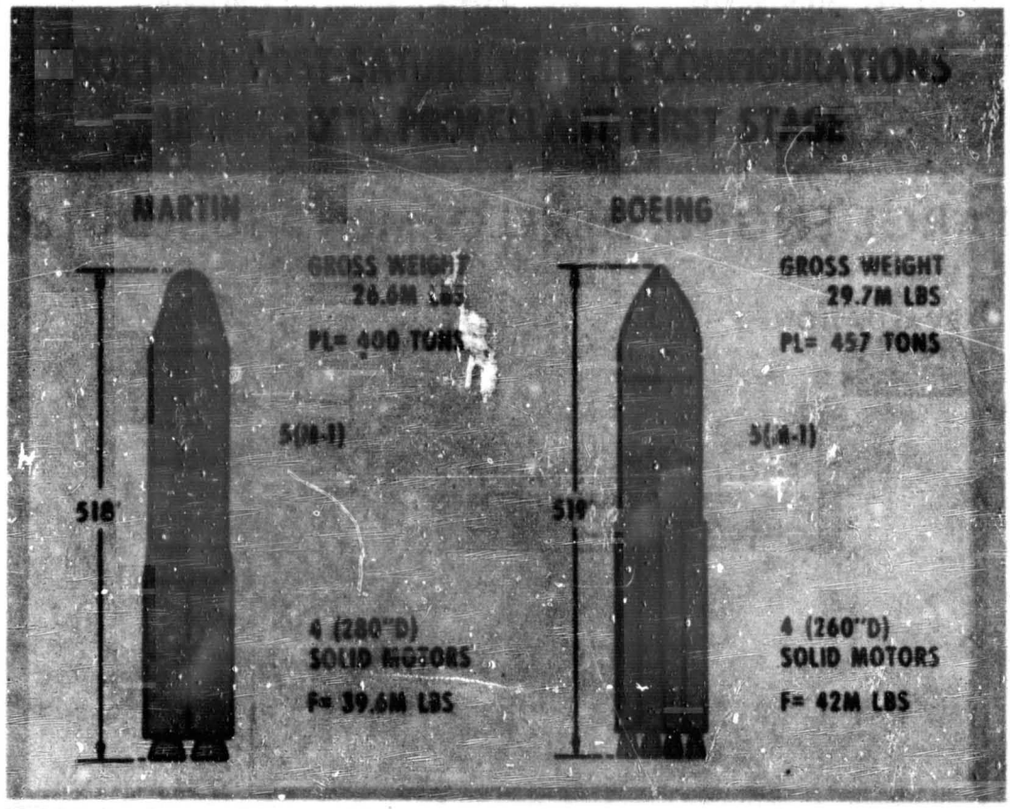

FIGURE 169

The particular point I want to make about these new concepts is that we are not really ready yet to start the design and development of an engine of this type, and if we laid out a 10-year schedule for that kind of development we would find ourselves in the operational period lying beyond 1957 (fig. 171).

LARGE ENGINE CONCEPTS

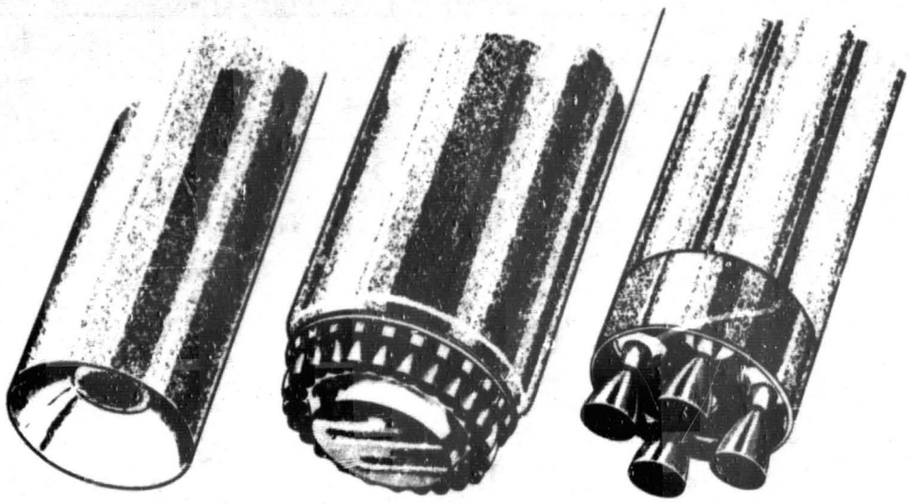

FIGURE 170

LARGE ENGINE DEVELOPMENT SCHEDULE

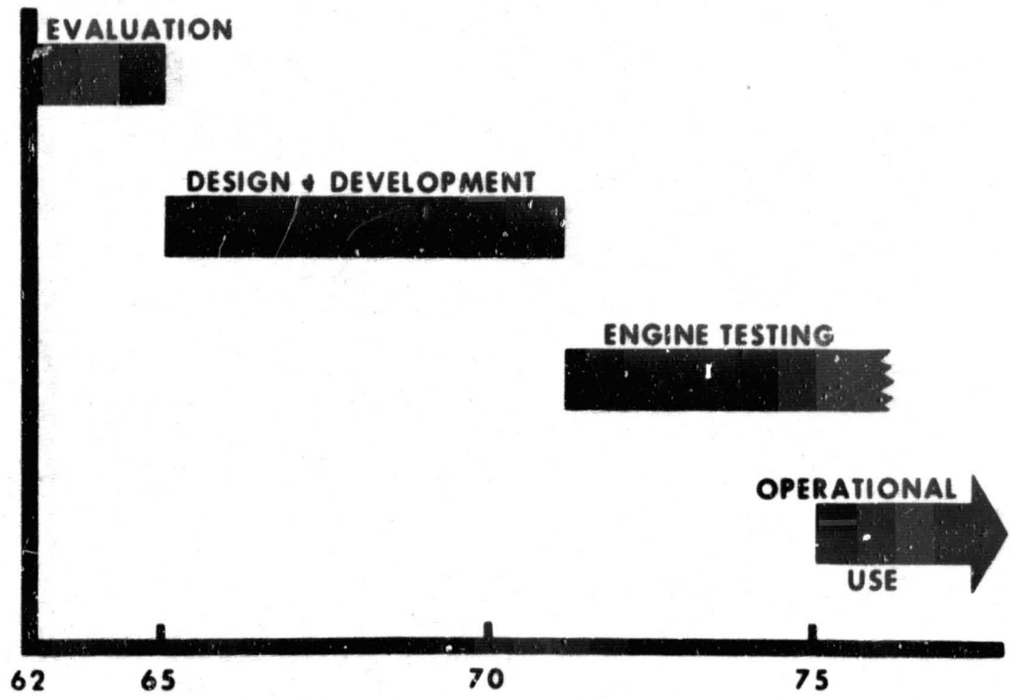

FIGURE 171

If we place the F–1, M–1, and the advanced concept engine I just mentioned on a time schedule, we find that if we wait for this advanced concept engine (fig. 172), we have a period of between 9 and 10 years in which we have no greater capability than we will have with the Saturn V. This is a long dry spell.

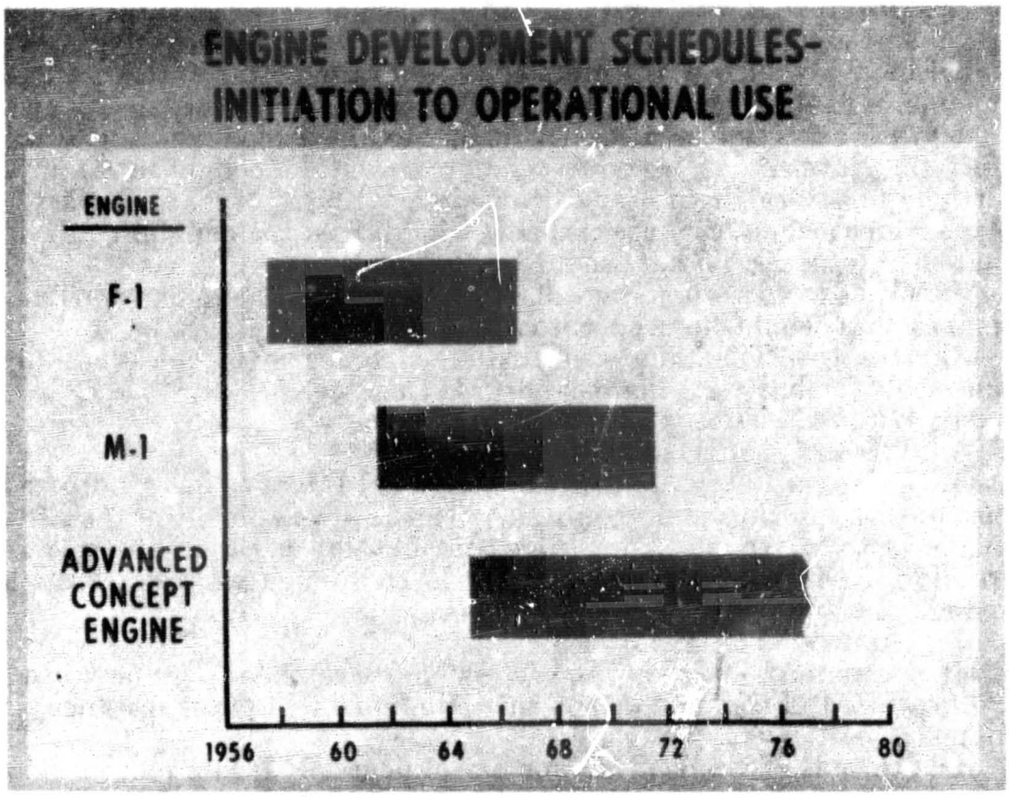

FIGURE 172

Mr. FULTON of Pennsylvania. But it brings up the question, is this Dyna-Soar type necessary?

Mr. TISCHLER. That is an important and pertinent question that can only be answered by looking to our mission requirements as they define themselves. We can't answer it right now.

Mr. FULTON of Pennsylvania. If any of these possibilities develop, such as solid propellant engines, advanced research, or the high-energy fuels which your own technical papers indicate are successful, then the M–1 concept is not necessary.

Mr. TISCHLER. Conceivably we have to grant this, this is admitted. On the other hand, the most promising alternative is a nuclear rocket, which is a hydrogen rocket, and for that we do have to have the hydrogen technology, nonetheless.

Mr. HOLMES. We might learn to lace it with boron and make it more efficient.

Mr. FULTON of Pennsylvania. Boron, beryllium, aluminum—is that right?

Mr. HOLMES. Yes, sir.

Mr. GURNEY. Certainly no one would quarrel with the wisdom of your going ahead with the F–1 engine. It is quite clear that the

power of the F–1 engine is much greater than we had before. Can you tell us this, though. Exactly what greater capacity or capability will you have with the M–1 engine together with the F–1, which I presume you will still use? If you can point out dramatically what greater capability you would have, that might make some sense to the committee. I haven't heard that yet.

Mr. HOLMES. If you assume solid propellants are used in the first stage, and assume the M–1 engines are used in the upper stages, we would have a vehicle with three to six times the power of the Saturn; capable of launching three to six times the payloads of the Saturn. Today we are very pressed just going to the Moon and exploring with the Saturn. It certainly is not powerful enough to go into further planetary flight if we want to do that. We are initiating plans which, when they are utilized, will give us the capability to do that in the future. That would be the need.

Mr. GURNEY. In what stage of development are the solid propellant engines that would be used with the M–1?

Mr. HOLMES. The time scale indicated to us is shorter than the time scale for having a flight-ready M–1 engine.

Mr. GURNEY. That is all.

Mr. TEAGUE. Mr. Daddario.

Mr. DADDARIO. Mr. Holmes, both you and Dr. Shea have indicated that one reason we should continue with the development of the M–1 engine is to widen our knowledge and develop a capability in this area for the future, is that correct? Even though we don't have a mission for the M–1 engine?

Mr. HOLMES. Yes, sir.

Mr. DADDARIO. And yet, as I follow your arguments, we now have a different M–1 engine concept than we had in the first instance, is that correct?

Mr. HOLMES. I think it is a matter of degree. It is a matter that not having to rush it, we are upgrading it and treating it in a more advanced fashion than we would have otherwise.

Mr. DADDARIO. If this is the case and if the M–1 engine program continues to be put off for a bit, and if a nominal amount of money is given so that the door can be kept open, it is conceivable that you will change its design in the future so that you will have then a better engine than is now conceived? You have admitted that the present M–1 engine is better than the first one which you brought before this committee.

Mr. HOLMES. Yes, sir; I believe that is correct. I think we must say with honesty that it is a matter of judgment as to the proper spending rate for such developments when you don't have a definite goal to meet. This is our best judgment.

Mr. DADDARIO. So somewhere within the broad concept of the whole space program, knowledge is constantly being generated which can be used to advantage, and this has been demonstrated in the change of design of the M–1. Furthermore, it is conceivable that the design will continue to change in the future providing this knowledge keeps being reflected and generated in this direction.

Mr. HOLMES. Yes, sir.

Mr. FULTON of Pennsylvania. This looks to me as if the M–1 engine has become an orphan. It was first presented as a part of the Nova program, and when this committee knocked out the Nova vehicle,

the M–1 became an orphan because the mission went out, isn't that right?

Mr. HOLMES. I don't consider it an orphan, no.

Mr. FULTON of Pennsylvania. At least the mission went out. It isn't that you didn't have a mission, because with the M–1 engine you did originally have the Nova mission.

Mr. HOLMES. That is correct.

Mr. FULTON of Pennsylvania. And now you don't have a mission because NASA doesn't think the Nova is a correct approach.

Mr. HOLMES. Well, I don't think you really meant that last statement. The Nova as we think of it today, of being an advanced vehicle rather than a vehicle using the old state of the art, we think that is a correct approach.

Mr. FULTON of Pennsylvania. Much later in time.

Mr. HOLMES. Yes.

Mr. FULTON of Pennsylvania. This committee must present a tight budget to the Congress this year. If there must be some cut in the budget, when you look your various programs over that have specific missions in manned space flight, which would you rather cut—the ones with the specific missions or the ones with no mission? I think you should put them in order of priority for us.

Mr. TEAGUE. If I might have one final comment——

Mr. HOLMES. I wish you would.

Mr. TEAGUE. I think everyone agrees that there was a period of time when the Soviets were considered to be ahead of us in the space race. Would you agree that the reason the Soviets were ahead of us was because we only built engines for which we had a known mission? If we had gone ahead and built a big engine even though at that moment we didn't see a mission for it, the Russians wouldn't have been ahead of us?

Mr. HOLMES. I completely agree. I think the philosophy of "don't build any equipment unless you have a special mission" is a disastrous one and has gotten us in trouble in the past.

Mr. TEAGUE. Isn't the M–1 engine just one step up?

Mr. HOLMES. In our opinion it is, and in our opinion it is the proper level of funding.

Mr. TEAGUE. You do not do yourselves credit, I don't think, by not saying you are going to use the M–1 engine to launch heavy space laboratories into orbit. There really is a mission, if you will admit it. You may not have it defined, and the vehicle hasn't been built, but you do have a mission for it.

Mr. FULTON of Pennsylvania. But that isn't quite the problem.

Mr. TEAGUE. Let him answer that.

Mr. HOLMES. Yes, sir; we have a mission for it——

Mr. TEAGUE. Then why do you say there isn't any mission for it?

Mr. HOLMES. I thought I said the mission is to go into space to the planets, to put heavier masses——

Mr. TEAGUE. And the M–1 is one step up.

Mr. HOLMES. One step up, supported by our solid development program that exists today; yes, sir.

Mr. GURNEY. This is what I was trying to get.

Mr. DADDARIO. Mr. Holmes, the chairman has drawn an analogy to the past, and I think it applied at that time very well. I can remember Chairman Teague years ago asking why NASA did not have a

million-and-a-half-pound-thrust engine program, and he was told it was unnecessary. But as of the moment, this is not an alternative to just one other engine. We have other programs being developed in the solid propellant area. We have nuclear programs. If we were to eliminate the M–1 engine, that would not leave us without an alternate large thrust possibility for the future in many other ways. If the M–1 engine were to be eliminated, it would not mean that we do not have programs which aren't an advance of the Saturn-type vehicle.

Mr. HOLMES. We would not have a high-energy engine for second stage use, with much lower energy solids for first stage use. Where the thrust per pound per second is much lower they are suitable for the launch or first stage, but not for the upper stages, unless one just wants to build a giant vehicle, all solid, like 50 million pounds of thrust. I don't think there is any question but what the M–1 fits that pattern of the other things we are developing. The question only involves how much money this Nation should be committing to these things that are not in the specific program.

Mr. DADDARIO. Let's say we have a nuclear capacity by the early 1970's. Would you use a nuclear rocket engine in the upper stages or would you use the M–1 engine?

Mr. HOLMES. Our present thought, I believe, is that the nuclear stage in that time will be used primarily for the escape stage. And you would need the M–1 to accelerate it as a second stage.

Mr. FULTON of Pennsylvania. The same problem came up on the development of the Nova program of whether at this point in time you were going to just have a bigger and better Saturn, or whether you would go into the next generation of vehicles. I think that our concern is that this just looks like a bigger or better J–2 in this current generation of hydrogen fueled engines.

Now, there is a problem as to alternatives. Mr. Daddario has adequately pointed out the nuclear competition, and we have had testimony on the solid fuel competition in the same specific impulse and size. Likewise, we have the competition in chemical fuel field, as I keep repeating, by employing high-energy fuels. I feel that rather than go into expensive engine development, probably the change of direction should be in the research and technical development, fuel development. No one is opposing bigger vehicles, because as you know on this committee we have been the biggest pushers for a bigger push—in fact, we are called the big push committee.

Mr. HOLMES. That makes you the big pushers for more push.

Mr. FULTON of Pennsylvania. But that isn't the point. We want the most efficient research and development without going into a quarter of a billion dollars' worth of engine development when there are competing systems that might be done cheaper. I think you must keep an open mind, don't you agree?

Mr. HOLMES. Yes, sir.

Mr. DADDARIO. This committee will adjourn until tomorrow morning at 10 o'clock in this same room.

(Whereupon, at 12:15 p.m., the committee adjourned until 10 a.m., Thursday, May 2, 1963.)

1964 NASA AUTHORIZATION

THURSDAY, MAY 2, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON MANNED SPACE FLIGHT,
Washington, D.C.

The subcommittee met, pursuant to recess, in room 356, Old House Office Building, at 10 a.m., Hon. Emilio Q. Daddario presiding.

Mr. DADDARIO. The meeting will come to order.

We will attempt to finish the construction-of-facilities portion of these hearings today and tomorrow. As a result, if there are areas within which we have been unable to come to a final determination, our staff and yours will work together and supply the additional information for the record. We can take that into consideration as we go along, and any place where you think it might be better and more efficient to supply the information in that way, will you please so indicate?

Mr. HOLMES. Yes, sir; we certainly will. Thank you.

(An additional 2 days of testimony was taken informally by the committee staff on June 6 and 7, 1963. The transcript of this testimony is contained in app. B.)

STATEMENT OF D. BRAINERD HOLMES, DEPUTY ASSOCIATE ADMINISTRATOR AND DIRECTOR, OFFICE OF MANNED SPACE FLIGHT, NASA; ACCOMPANIED BY WILLIAM E. LILLY, DIRECTOR, PROGRAM REVIEW AND RESOURCES MANAGEMENT; GEORGE M. LOW, DEPUTY DIRECTOR (PROGRAMS); RODOLFO A. DIAZ, ASSISTANT DIRECTOR FOR FACILITIES, OFFICE OF PROGRAM REVIEW AND RESOURCES MANAGEMENT; STANLEY M. SMOLENSKY, DEPUTY DIRECTOR OF LAUNCH VEHICLES AND PROPULSION

Mr. DADDARIO. If we could proceed then, with the launch systems, Marshall Space Flight Center, page CF–9, volume IV, part 2.

Mr. HOLMES. I have asked Mr. Stanley Smolensky to describe for the subcommittee our request for funds for the Marshall Space Flight Center 1964 construction-of-facilities program.

Mr. SMOLENSKY. Starting on page CF–9, our total request for Marshall Space Flight Center in the fiscal year 1964 budget is for 16 projects that generally have to do with the expansion and addition to the facilities there to match our increasing tempo of testing for the Saturn V and the Saturn program in general. The total amount is $38,469,000.

96-504—63—pt. 2b——9

The first project listed there is the acceleration test and calibration facility. We are requesting $1,700,000. This is on page CF–9–2. This facility is primarily an expansion of the present laboratory facilities to meet requirements in the Saturn V guidance and control testing program for a total of $1,700,000.

Colonel GOULD. The project description indicates that this facility will provide a capability for determining the influence of zero gravity high-level sound pressure vibration and extremes in temperature and vacuum conditions. What facilities are being used to meet this need at the present time?

Mr. SMOLENSKY. The temperature and vacuum chambers are existing facilities in other buildings in the Center and they will be moved into this facility.

As far as the linear acceleration tower is concerned, this is a unique and new facility and this is a pneumatic-operated tower that has in it a cage that permits us to develop zero gravity conditions over what is now considered a rather prolonged time, about 4 seconds, and it permits us to repeat these operations and accumulate zero gravity environment data.

Colonel GOULD. Has design been started on this project yet?

Mr. LILLY. Design has not been started.

Colonel GOULD. Do you plan to start before the fiscal year 1964 program is acted upon?

Mr. LILLY. We are, as you know, very short. We have already exceeded our available funds in advance design and planning. We are making every attempt to find ways we can either borrow or reprogram money to start design. However, we have not started design for this project yet.

Mr. SMOLENSKY. The next project——

Mr. DADDARIO. We would like to inquire just a bit further.

Colonel GOULD. What will be done with the space that is going to be vacated as a result of this project?

Mr. SMOLENSKY. I can't enumerate the uses of it, but it is in laboratories that have to be expanded. We could supply that for the record as to which laboratories will be vacated.

(The information requested is as follows:)

The space will not actually be vacated, but will be utilized as follows:

At present our environmental testing, hydraulic engine actuator activities, and flight simulation activities occupy adjacent areas. The Saturn V hydraulic actuator, associated hydraulic pump, control equipment, and flight simulation equipment will increase drastically in physical size over the present Saturn I equipment. This increase in hardware size will require physical expansion of the hydraulic activities simply in order to accommodate the larger hardware to the extent that all of the present environmental testing area is required for this purpose.

Colonel GOULD. You have indicated that you are going to move from one place to the other. Do you have all the equipment necessary for this facility?

Mr. SMOLENSKY. The equipment we are talking about is currently available. The rest of the environmental equipment that is listed in here and the temperature conditioning chambers and vacuum chambers are currently available on the Center.

Mr. GURNEY. Will this facility be used for other experiments beyond the ones presently being planned?

Mr. SMOLENSKY. Particularly in the zero gravity facility that we are providing here we have an opportunity to subject other compo-

nents. It will take, I have forgotten the volume, but it will take a weight of around 350 pounds and be able to subject it to zero gravity conditions. If there was a need for other components being subjected to these conditions, it certainly could be used for that. In addition, it can supply a vacuum bell jar over the cage and also permit the items to be checked out under vacuum and zero gravity conditions.

Mr. ROUDEBUSH. Where are your acceleration and calibration tests being conducted at the present time, and why aren't your current facilities and equipment satisfactory for future needs?

Mr. SMOLENSKY. The current equipment that we have is strictly for the Saturn I program or the Saturn IB program, and the requirements for the Saturn V are much more precise. I mean the navigation equipment and the control equipment requires a greater degree of precision than we can possibly check with the present equipment.

Mr. ROUDEBUSH. When will the type of equipment that you will use here be available to NASA?

Mr. LILLY. For this facility it is planned to be available in November and December 1964.

Mr. ROUDEBUSH. Will you need it at that time?

Mr. SMOLENSKY. Yes.

Mr. DADDARIO. Are there any other linear accelerators in existence throughout the country at the moment?

Mr. SMOLENSKY. I am sure there are. There are all types, but to our knowledge there isn't any that provides this zero gravity condition. We also have a vibration-free condition here that to our knowledge isn't provided on any of the sleds at any of the existing facilities.

Mr. DADDARIO. There is a linear accelerator at Wright-Patterson. Could you compare that accelerator with this one and give us the differences between the two, and why it is not sufficient to do this kind of work? The explanation in the book is not a very lengthy one, and it compels me to ask for that so we can show for the record how they do in fact differ.

Mr. SMOLENSKY. My understanding is that it provides vibrations to the system, but we will supply that for the record.

Mr. HOLMES. I think we should supply the details of a comparison for the record. I would like to say that a facility of this type located in Dayton wouldn't satisfy the requirement that Marshall has for development and testing of these new designs for the Saturn V on site. I think they just must have facilities for testing of this nature right at hand as a part of the laboratory. I think this has been precisely the Air Force's experience in locating facilities of their own at Wright-Patterson or other geographic locations.

(The information requested is as follows:)

The linear accelerator (Sulinac) is a cyclic, pneumatic device which allows the testing of inertia-sensitive equipment like guidance and control systems, subsystems, and components for launch vehicles and spacecraft, etc.

By means of this vertical linear accelerator it is possible to subject test specimens to a great variety of acceleration and deceleration conditions. There does not exist in this country a device which allows the application of the following acceleration profiles:

Subjecting the components in cyclic operation to smoothly built-up acceleration peaks up to 100 g.'s. The cyclic operation for certain test specimens, such as gyros, and accelerometers is of great importance for investigations where the detrimental effect of one acceleration application would not be detectable.

Therefore, the integration of these minute deviations is essential for the evaluation of the test.

A capability of great necessity of this vertical linear accelerator is the extremely close approximation of zero-gravity condition. Out of the multitude of possible tests the following two are given: Behavior of a gyro under zero-gravity conditions, and the study of liquids in containers at the absence of the influence of gravity. The zero-gravity environment is produced during 4 seconds per cycle by continuously controlled compensation of air drag, cable drag, and rail friction. This compensation is accomplished by means of a linear induction motor attached to the test specimen carrier. Control of this condition will be maintained by a closed loop servosystem employing an accuracy to verify zero-gravity condition to 0.002 to 0.004 g.

Typical data for the linear accelerator:

(*a*) Payload weight for test specimen: up to 350 pounds.

(*b*) Usable cylindrical space in carrier: 35-inch diameter, 44-inch height.

(*c*) Continuous monitoring of the test specimen during operation of the simulator.

(*d*) Observation of zero-gravity tests by TV.

(*e*) Repeatability of preset exact acceleration characteristics. Avoidance of disturbing vibrations in particular lateral vibrations so frequently prevailing during sled tests.

(*f*) Extremely low cost of testing even if the number of tests is considerable.

(*g*) Test in vacuum (bell jar) during subjecting the payload to acceleration or zero-gravity condition.

(*h*) Controlled environment for test specimen.

The proposed MSFC project will meet these requirements and the Wright-Patterson facility is not suitable for NASA use for two basic reasons: (1) it is insufficient to perform, for example, the most accurate testing required for inertial measuring units (gyro platforms) and (2) it does not provide for accurate simulation of zero gravity. Also, it is primarily biophysical and not applicable to launch vehicle instrumentation.

A comparison of this total facility with similar existing facilities is shown on the following chart:

Facility comparison

Location	Zero gravity capability	Linear accelerator	Acoustic facility	Centrifuge
Proposed MSFC	Available with this project.	(1)	Basic engineering tool and economic advantage.	Basic engineering tool.[4]
Wright-Patterson	Not available	(2)	Available at higher cost.	Available not applicable.[4]
Holloman	do	Sled test only.[3]	Not applicable	Available not applicable.
Wyle	do	Not available	Available and now being used.	Not available.
Other Government facilities and contractors.	do	Sled tests biophysical at Ames.[3]	Not applicable	Available not applicable.

[1] Available with this project. Insignificant lateral acceleration and vibration. Will develop pure linear acceleration which is closely controlled. Gyrosystems can be accurately alined and this alinement can be controlled and monitored during and at completion of tests.

[2] Biophysical—not applicable to launch vehicle instrumentation.

[3] Not pure linear acceleration—disturbing lateral accelerations and vibrations. Cannot compare alinements of gyrosystem before and after test. Does not permit integration of results.

[4] Used in one form or another by industry and most Government installations.

[5] Available—not applicable, indicates there is no constant azimuth drive and would require modifications that would restrict other work normally done on these facilities.

Mr. DADDARIO. Because the question of better use of facilities does come up so often, it would seem important in this particular case to make the most satisfactory explanation possible so that we may be advised as to the need of the accelerator at Marshall. We might have some concern, Mr. Holmes, as we go along, not only in this facility but in others, and in this we get back to the point we have touched on time and time again: As we build newer and better fa-

cilities of this type, what are the opportunities available to phase out other facilities which have been built in years past and which might be replaced by the newer ones? This would save money not only on the maintenance of those facilities but also on personnel costs. In addition, it would allow for the transfer of those personnel which have been trained in the use of accelerators of this kind to the newer facilities which are being constructed.

Mr. HOLMES. Yes, I think you make a very good point, and we certainly can cover these points in each case where there appears to be a question of that type in our request for facilities.

Mr. DADDARIO. It might be helpful.

Colonel GOULD. Your justification indicates that this facility will house an acoustic chamber for determining sound pressure wave effects on small vehicle components. During a recent visit, I noticed that the Wyle Laboratory has one of these facilities at Huntsville. Why couldn't this work be done by contract rather than by an in-house capability.

Mr. SMOLENSKY. I don't have the answer on the Wyle Laboratory acoustical test equipment. The test schedule and the requirements we have for correlating all of the instrumentation involved in testing the precise navigational instrument dictates that we have an integrated testing facility wherein we can calibrate both the test equipment and the actual measuring equipment which we are using to evaluate the navigational equipment.

Mr. HOLMES. I think we would have to look at the characteristics of the Wyle Laboratory and its present workload before we can answer that. I think we can do that for the record.

(The information requested is as follows:)

Marshall is using the Wyle facility now and plans, because of the workload, to continue using the facility at least as much, if not more, in the future. However, this does not alter the fact that it is essential to have this capability in-house. It is a matter of the need for the in-house capability rather than a difference in technical requirements that calls the need for an acoustic chamber at Marshall. This function is only one of an integrated facility in which guidance equipment must be tested. An instrumented package can be subjected to zero-gravity environment temperatures, high accelerations, and acoustic vibrations with recording equipment that will give comparative data. This is not true if one portion of the testing is done elsewhere on other instrumentation.

Mr. DADDARIO. The same comparison applies to this acoustic chamber. To my recollection there is an acoustic chamber at Wright-Patterson which has been recently constructed and which seems to be a well-planned facility. If we could get that into the record and draw a comparison, it would be very helpful.

Mr. HOLMES. Yes, sir; we will be glad to do that.

(The information requested is as follows:)

It is possible that some of the Marshall acoustic work could be scheduled to Wright-Patterson facility.

If the test were to be performed at Wright-Patterson's acoustic facility it would require the test equipment to be available for the preparation and duration of the test. This would mean that an extra set of duplicate operational test equipment would be required. At MSFC, the testing could be performed using an existing laboratory set of test equipment which could be switched in for this purpose. This would result in eliminating the need for a duplicate set of test equipment.

It is a matter of need for an in-house capability and operational economy, rather than a difference in technical requirements that dictates this facility should be at Marshall.

The equipment and the instrumentation here will also be subjected to other types of testing not available at Wright-Patterson such as the zero-gravity test, etc. This is a facility at MSFC that integrates several types of testing into one facility using the same instrumentation for more than one type test and makes data comparative.

Mr. DADDARIO. Any other questions, gentlemen?

(No response.)

Mr. SMOLENSKY. The next project is for the acoustical model test facility. We are requesting $2 million. This facility is to provide facilities for determining the acoustical environment generated by hot firings of scale model engines. That is on page CF 9–6. Primarily here the problem is to prepare ourselves to be in a position to test various configurations of both the launch vehicle under actual hot firing conditions so that we can investigate the lift-off problems and the acoustic problems that might cause any vibrations in the structure. This is a very critical facility to us in the event we run into any evaluations of proposed changes in our present and future designs of launch vehicle structures.

Colonel GOULD. The construction of the acoustic building is estimated at $33 per square foot. Could you give us the structural characteristics of this building causing the cost to be so high?

Mr. DIAZ. The construction is of reinforced concrete, blast resistant structure, with approximately 18-inch walls. The cost is based on similar facilities. One similar to this just went out for $35 a square foot.

Colonel GOULD. Have you committed any advance design funds to this project?

Mr. LILLY. No, we have not.

Colonel GOULD. Do you intend to prior to the fiscal year 1964 program——

Mr. LILLY. The same answer that I gave a moment ago applies in this case, too. I have not identified any money yet for the Marshall facilities, although I am attempting to get some.

Colonel GOULD. This project and the one preceding both have to do with acoustical testing. Has any thought been given to the combination of these two projects into one facility?

Mr. SMOLENSKY. There has been, but you are talking of entirely different items that are being tested. In the case of the guidance and control equipment you are talking about very delicate and precise instrumentation and systems that have to be subjected under very precise measurements. In the case of this hot firing of scale models, we are talking about acoustic instrumentation and effects as they are in the outside, in the surrounding area to the test stand. We do need the instrumentation in both places. I think you also have to consider the test facilities at both places.

Mr. LOW. Actually, the two facilities complement each other. The second facility measures the noise field that exists. The first facility described applies noise fields like this once they have been identified to see what the effect is on various components under laboratory conditions.

Mr. WAGGONNER. Primarily we are talking about the effect of these forces on the space vehicle itself?

Mr. LOW. That is right.

Mr. DADDARIO. Is there any such facility now in existence anywhere in the country?

Mr. DIAZ. No, sir.
Mr. SMOLENSKY. No, sir.
Mr. DADDARIO. This is an entirely new and unique facility?
Mr. DIAZ. Yes, sir.
Mr. DADDARIO. Is this one you would classify, Mr. Holmes, as a new national asset?
Mr. HOLMES. Yes, sir. I would indeed. One of our grave concerns is the structural integrity of our vehicles. I touched on this point in our discussion of the Gemini spacecraft and the Titan II for our first flight. As we move into the transonic area, we encounter enormous build-ups of noise and variations in pressure of plus or minus 2 to 6 pounds per square inch. These are the actual figures that the MSC people report that we might have. At the point in the Apollo spacecraft where the command module joins the service module, this type of vibration with the frequencies involved at the variations in acoustic level, can in a very short time cause fatigue in the parts and metal and tear them apart. Many vehicles are lost this way. I think anything we can do to gain knowledge on the ground before committing these expensive vehicles to flight test would be an increase in our Nation's capability to do this work.
Mr. DADDARIO. It is a facility which can be used by other agencies as well as one which can be used for a long period of time?
Mr. HOLMES. Yes, sir.
Mr. LOW. I believe in the Mercury program we had four flight failures, two in Little Joe and two in Atlas. Three of these four were caused by this kind of a noise and vibration problem. At that time we did not have the facilities to identify this on the ground.
Mr. WAGGONNER. How much of this instrumentation is comparable to that used during actual launches at the Cape so that it will give us an insight into the effects on the space vehicle and its components?
Mr. SMOLENSKY. The instrumentation under this project is the instrumentation that will be at this particular stand. It will be measuring the type of perimeters that we would encounter in any launch.
Mr. WAGGONNER. Haven't we conducted enough actual launches that we can provide the instrumentation at these stands?
Mr. HOLMES. No. For a new vehicle the only way we would have, unless we simulate on the ground with devices of this type would be to telemeter back or observe from films.
Mr. WAGGONNER. Then you think that to provide for the telemetry would be even more expensive than this?
Mr. HOLMES. We would lose the flight article. In Project Gemini, if the first one breaks up, the schedule is affected adversely and our costs increase. We have to be sure we have designed the flight article so that it can withstand this stress. The only way we have found to determine its integrity prior to flight is by means of ground simulation facilities of this type.
Mr. SMOLENSKY. This instrumentation is for the research and development instrumentation for this particular model test facility.
Mr. DADDARIO. Any further questions?
(No response.)
Mr. DADDARIO. We will proceed.
Mr. SMOLENSKY. The next project is additions to the components test facilities. We are requesting $3,875,000. The purpose of this

facility is to test vehicle and propulsion system components. Additions are required to conduct full scale R. & D. tests on components and subject assemblies to support the Saturn V program.

Colonel GOULD. I note that the fiscal year 1963 program included a project for the components test facility at an estimated cost of $4 million. It is also noted that $2 million was reprogramed from the fiscal year 1962 authorization. Does this constitute an addition to those facilities that were previously programed in fiscal years 1962 and 1963?

Mr. SMOLENSKY. Yes, sir.

Colonel GOULD. Does this project represent the final increment of this test facility?

Mr. SMOLENSKY. Yes, sir; for the Saturn V program.

Colonel GOULD. Have you initiated the design on this project?

Mr. LILLY. No, we have not started design work on this project yet.

Colonel GOULD. Do you intend to, prior to enactment of the 1964 legislation?

Mr. LILLY. If we can possibly find the money, we will.

Mr. HOLMES. Could I comment here? Since it appears to be of particular interest to the subcommittee whether or not we have initiated designs, which tends to imply that we do not need the design and engineering money that we have requested, I would like to repeat what I said the other day to clarify this point. We are under pressure from the Corps of Engineers, to provide advance design funds in much greater amounts than we have before in order to start construction earlier. The Corps of Engineers claims, and they have shown statistics to prove it, that we would run a much more efficient program if we did this. We don't have these funds. We are tightly pressed for funds, as you know, for fiscal year 1963 just to meet our program obligations. However, if advance design would lead, as it appears it would, to a more efficient program, we can reprogram at certain times in small amounts, on the basis of then using funds in fiscal year 1964 to pay back the borrowed funds. It would be unfortunate for us to lose funds requested for design engineering facilities in fiscal year 1964 because we reprogramed funds to do advance design in fiscal year 1963. If this were necessary, we would have to take a very long look before we did such reprograming and chanced hurting our programs in the future.

Colonel GOULD. Instead of building into your individual projects a reprograming concept, which is what you are telling us, why didn't you ask for additional advance design funds instead of only $10 million?

Mr. HOLMES. We did ask for $10 million. It was reduced to $5 million by this subcommittee.

Colonel GOULD. I am speaking of the fiscal year 1964 program.

Mr. HOLMES. I was referring to fiscal 1963.

Colonel GOULD. You said you wanted to leave these advance design funds in individual projects that you are talking about so you could reprogram them later on for further advance design work.

Mr. HOLMES. I didn't intend to say that. What I thought I said was that we were in some cases reprograming from our fiscal year 1963 funds in order to cover advance design on these fiscal year 1964 facilities. In doing that, I would not like to see us then decrease the

design and engineering money requested in the fiscal year 1964 budget by that amount. The only way we are able to identify advance design funds in fiscal year 1963 is to borrow from Peter to pay Paul.

Colonel GOULD. If you have already committed advance design funds for a specific project in which design funds are included in the fiscal year 1964 program, what will you do with that excess money?

Mr. HOLMES. It would be our intent to restore borrowed funds. In some cases, the agency may, as it did in 1963, use part of these funds to absorb appropriation reductions. It is quite obvious from your questions on each one of these items, Colonel Gould, that you believe that this should be extra money because we have already accommodated it in fiscal 1963. The only way we could accommodate it was by reducing funds in some other part of the program. As a result, these funds should be restored.

Mr. WAGGONNER. This money that you are able to reprogram on a temporary basis for advance design is actually money that is in all probability, or at least in most of the cases, available because of slippage in some program that allows you to use that money a little bit longer?

Mr. HOLMES. There might be various reasons—it could be because of slippage, because we did not have to obligate the funds quite as soon as we had planned to, or the possibility that we could delay some element of the program which was not a "bottleneck" item a month or two. If the absolute necessity arises, one has to balance these program elements for the most efficient use of funds.

Mr. GURNEY. How many dollars are you talking about in the money that you have borrowed from fiscal year 1963 for advance design funds in fiscal year 1964?

Mr. HOLMES. About $4 million. I fight every day to get $500,000 or a million dollars for one project or another. The situation is that tight, it spells the difference between keeping the job on schedule or not on schedule.

Mr. DADDARIO. You have some way or other always found the necessary funds, however, for advance design, have you not?

Mr. LOW. I think Mr. Lilly pointed out a moment ago that we have not yet found it for these Marshall facilities.

Mr. DADDARIO. I don't think he pointed out to my way of thinking that you haven't been able to find it. He indicated that you were looking for it and he implied that you would find it.

Mr. LILLY. I am certainly going to try.

Mr. DADDARIO. I think that is a little different. The committee understands your concern, Mr. Holmes, and I personally agree that this is a very important point that you have brought up. It is one that we should address ourselves to, and I am sure the committee will give considerable thought to your ability to plan ahead and to get advance design funds. I quite agree. We will keep this in mind as we go along, and see if we can clarify it.

Mr. HOLMES. Perhaps I could add one statement to make my position clearer. A few million dollars between now and the end of this fiscal year will make a great deal of difference as to what the Air Force can do in their problems with the Titan II. I certainly am going to see to it that the Air Force gets that money before Mr. Lilly puts any advance design money into these facilities, whether it delays them or not. As a program manager, I have to achieve this kind of balance.

These relatively small amounts at the end of the fiscal year can become quite critical.

Mr. DADDARIO. The committee recognizes that. Some of the questions being asked of you are those which we are asked by other Members of Congress. It is better to adjust our thinking on these points here and now rather than possibly being unable to answer their questions when the legislation goes to the House floor.

Mr. SMOLENSKY. The next project is on page CF 9–15, it is entitled "Additions to the test support shop." We are requesting $1,500,000. This facility will provide the additional support to the west test area. As we increase our whole testing program at Marshall, our capability to support in terms of maintenance of test stands and changes and machining to various components must be increased. This is a general increase in test support shop effort.

Colonel GOULD. What is the size of the existing test support shop?

Mr. SMOLENSKY. The existing test support shop consists of a total of 37,012 square feet. The facility consists of 35,672 square feet of shop space and 1,340 square feet of office space.

Colonel GOULD. What tests are required on the Saturn V that were not required on the previous launch vehicles?

Mr. HOLMES. The total concept of Saturn V, if I can answer the question, is almost entirely different from the test concept in the previous launch vehicles. We are going from a manual, analog type of test on the Saturn I in steps and stages toward a more digitized type of test in the Saturn IB, to a fully digitized test for the Saturn V, where we will be able to do a very rapid integrated test with computers. This means incorporating in that vehicle sensing devices for measuring temperature pressure and so forth which immediately change a coded message into digital form. The total test concept for the Saturn V is tremendously different. I think I should answer, to clarify the situation, that whether those differences really are the reasons for the additions of this test support building, I can't say. Someone else will have to say. The approach to testing is just vastly different.

Mr. SMOLENSKY. That is one aspect of it. Then of course the tremendous increase in components themselves. They are all new components. Each one has to be tested for reliability, for performance, performance as against specs, and it is a general increase of test body that we have at the Marshall Space Flight Center. I think you can appreciate the fact that every component that goes into the Saturn V, Marshall, having technical management of it, would like to assure itself through exhaustive tests that it is a well-qualified and reliable item. These are the sort of tests that we are conducting on all components furnished by the various vendors. As each test is conducted, if there is a change indicated or something goes wrong, or the test stands need modification, this is the type of general shop support needed in any test area. The basis for this is based on previous workloads, and it is an extension to support our oncoming test period.

Mr. FUQUA. You have an item of $100,000 for welding equipment. Isn't that an awful lot of welding equipment?

Mr. SMOLENSKY. Surprisingly, we have a great deal of welding to do there. These test stands for the Saturn V and Saturn I are rather long, and things happen to the deflectors. Really you are talking about armorplate welding in many instances. There is an awful lot of welding that has to be done. I would not consider this excessive.

Mr. HOLMES. Does this include welding for flight hardware?

Mr. DIAZ. No; to support the existing facilities, the facilities that are being built.

Mr. GURNEY. What do you use the lathes and mills for in testing?

Mr. SMOLENSKY. If any of the instrumentation or any of the fixtures should break down, we have to repair them, refurbish them, or if there is any hardware that is used that might be broken, we have to fix it and repair it on the spot, or if there is a modification that we need to introduce into one of these assemblies, we want to have some close support facilities that we can use.

Mr. DADDARIO. Don't you have that capability now?

Mr. SMOLENSKY. We have a capability that is currently overloaded, sir.

Mr. DADDARIO. Then this is an expansion of your present requirement to meet the future enlargement of your program?

Mr. SMOLENSKY. Yes, sir.

Mr. FUQUA. What is the basic design of this building? Is it just a hull type building?

Mr. DIAZ. There are three high-bay areas. One is 54 feet high, the second one is 35 and the third one is 25 feet high, sir.

Mr. GURNEY. What are you currently testing in the shop which you are about to enlarge?

Mr. SMOLENSKY. This supports our Saturn I program.

Mr. GURNEY. How long will that be going on?

Mr. SMOLENSKY. That will be going on for the next several years. It will be a continuous product improvement and development for the Saturn IV program.

Mr. GURNEY. When are you going to get the first hardware?

Mr. SMOLENSKY. According to our schedules, we feel this should be operating early in 1964.

Mr. GURNEY. That perhaps answers the question indirectly, but what I asked was: When are you going to receive your first hardware that is expected to be tested in this facility?

Mr. SMOLENSKY. I would say the latter part of 1963 some of the components should be received, and some of the actual larger components would be in 1964.

Mr. GURNEY. Won't there be any phasing out of the Saturn program which is presently occupying this existing building?

Mr. SMOLENSKY. Not in that time period, sir.

Mr. FUQUA. Will this be able to house the Saturn V?

Mr. SMOLENSKY. This reflects the buildup in Saturn V. We are particularly geared to the S–IC ground test program.

Mr. FUQUA. We won't have to build a new facility for the Saturn V?

Mr. SMOLENSKY. No, sir. This is in anticipation of our Saturn V program.

Mr. DADDARIO. Mr. Holmes, is this a facility which will be adaptable to future use?

Mr. HOLMES. It is really a shop facility; it will be adaptable for any use for doing support work for new tests stands and so forth. It will be extremely flexible, not specialized at all.

Mr. DADDARIO. No matter what kind of a program we go into in the future, because of the type of shop it is, this will be adaptable?

Mr. HOLMES. Yes, it will have a general application.

Mr. DADDARIO. We can expect that this will be of sufficient size to meet the demand for some years to come, is that right?

Mr. HOLMES. For the present planning at Marshall, yes, sir.

Mr. DADDARIO. Any further questions on this point, gentlemen?

(No response.)

Mr. DADDARIO. If not, Mr. Bell has a question on the acceleration tests and calibration facility. If we could go back to that, you may proceed, Mr. Bell.

Mr. BELL. Mr. Holmes, I had another committee meeting earlier so this question possibly may have been asked of you before. Concerning the acceleration test and calibration facility that you were talking about, I understand that the Air Force has at Holloman Air Force Base, N. Mex., an additional 35,000 test track capability closely simulating this acceleration, and that this represents an investment of $35 million and has an operating staff of over 100 people to take care of the workload. Isn't there some way that you could use this Air Force capability rather than duplicate this by setting up one of your own?

Mr. DADDARIO. Before we proceed with the answer, just to save time, we have asked for comparisons of this type that you are concerned about which will be included in the record. Would you like to have this facility also included for the record rather than having it answered now?

Mr. BELL. I would like to have that included for the record. I have some others.

(The information requested is as follows:)

The proposed MSFC facility does not duplicate the Holloman facility which has been determined to be unsuitable for this particular NASA application for the following reasons:

The Holloman track is the best in the country, but it does not provide simulation of flight conditions required for lunar missions. The shortcomings for this purpose are—

(*a*) No zero-g. capability.

(*b*) Disturbing lateral accelerations and vibrations.

(*c*) The difference between horizontal and vertical accelerations is that the horizontal acceleration is always influenced by gravity.

(*d*) The linear acceleration levels are not sufficiently controlled.

(*e*) The comparison of alinements of gyro systems before and after sled tests are not sufficient for our accuracy requirements.

(*f*) The sled test does not permit integration of results as on our requested cyclic device.

Mr. HOLMES. I would like to comment on that one, if I may.

Mr. DADDARIO. Certainly.

Mr. HOLMES. We are familiar with the facility at Holloman. In fact, we are using a Navy system for sled testing of Gemini. It is not a similar facility to this one. This is a zero-gravity drop tower where you drop something down with linear acceleration in a tower. They are not comparable facilities.

Mr. LOW. At Holloman one gets high gravities, here one gets zero gravity.

Mr. BELL. What was that?

Mr. HOLMES. High versus zero gravity.

Mr. BELL. Do you have occasion to use that?

Mr. LOW. Yes, sir; in fact, the guidance systems for the Saturn are being tested at Holloman.

Mr. BELL. I thought the Air Force might have the same need that you have for the high gravity as well as the zero gravity, and conceivably you could join forces in this area and combine them.

Might it not be cheaper to do that in the long run?

Mr. HOLMES. I think that they are completely different facilities. One is a sled that slides along the track; the other is a tower from which test articles are dropped. I am sure we would welcome the Air Force to make tests at Marshall, just as they welcome us.

Mr. BELL. You might have the occasion to do both.

Mr. HOLMES. Yes, sir; I understand.

Mr. DADDARIO. This follows the same thing that we were discussing before.

Mr. HOLMES. It does, Mr. Chairman.

Mr. BELL. I have a couple more.

According to some of my preliminary inquiries from the various Government agencies, I understand there are other departments that have antenna research facilities. Have you looked into this?

Mr. HOLMES. Yes, sir. I am familiar with many antenna research facilities, both within industry and within the other Government agencies. In the planning for our particular facilities, which are not very extensive by national standards, we have found no duplication in any of the ones we have requested.

Mr. BELL. There are none that you can use in any way?

Mr. HOLMES. We do use many facilities, if they meet our special needs.

Mr. BELL. But you still need to build——

Mr. HOLMES. Facilities of our own, for our own special devices to be used in space; yes, sir.

Mr. BELL. Is that because these don't particularly fit your requirements.

Mr. HOLMES. I am talking in generalities now, but almost always it is because of either one of three criteria: because the other facility doesn't fit our particular technical devices, or second, because the other facility is so overloaded that it can't accommodate it, or three, because it is just not practical from a geographical separation to use that facility.

I think we will find within the other departments this very same thing. You can find many duplicate facilities in the Army or the Air Force. They are completely justifiable because of their geographical separation or because of their workload.

Mr. BELL. I notice a provision for an 80,000-cubic-foot test-chamber. Don't you have something like that at the Manned Spacecraft Center?

Mr. HOLMES. We have an acoustic test facility; yes. However, it is a different type of test chamber. The one that we are requesting at Marshall is to deal with the type of vibration and the type of noise that one gets during the launch. It gets so high that it could break a spacecraft or launch vehicle apart. The Houston facility is concerned primarily with the noises in the spacecraft systems and subsystems.

Mr. BELL. There is a philosophy in this, as I am sure you are aware. The taxpayers are getting pretty well fed up with some of the expenditures in this country, and they want to economize. Whereas it might be desirable for NASA to have additional facilities of its own, there might be a considerable amount of money saved, perhaps, if NASA

were to use some of the facilities that are available in other Government agencies.

I think this should be watched a little closer.

Mr. HOLMES. I couldn't agree more, Mr. Bell. I can say with honesty and sincerity that we have tried not to take a parochial view, that we have tried not to spend unnecessary money on facilities. After the NASA reorganization we invited the Air Force to participate closely with us. As a matter of fact, we gave General Ritland's group, representing the Air Force Space Systems Command, office space in our building so they could be intimately familiar with what we are doing. We provided the Air Force with our budget books as soon as we had the preliminary data.

I think our relationship with the Air Force is excellent, and the only reason I am stressing Air Force is because if there is any overlapping, I think that is where it is. I think all the steps have tended to minimize this attitude of "We must have ours; we can't use anybody else's."

I am sure there is some of it in an organization as large as we have. I hope it is minimum.

Mr. BELL. I am going to take this up later. I will not take your time now because I understand we will be discussing this Monday or Tuesday. However, I think bioastronautics is an area in which there might be some considerable saving. Would you like to comment on that briefly?

Mr. HOLMES. We have had a great deal of coordination with the Air Force in this area. As an example, approximately a year ago at this time Dr. Hugh Dryden, the Deputy Administrator of NASA, took a trip to the various Air Force facilities. I believe that Mr. John Rubel of the Department of Defense accompanied Dr. Dryden.

We had a joint working group between Dr. Nancy Roman's office, my office, and Col. John Talbot's group.

This working group prepared a report of any duplication in the bioastronautics or aerospace medicine area. We determined that we were already fully utilizing the Air Force facilities. In fact, the conclusions indicated that if we asked the Air Force to do any more for us, it would have to add to its staff. In some cases our needs have already caused the Air Force to add to its staff. It appeared to me from this analysis that there was almost complete coordination between NASA and the Air Force. As I mentioned, the Air Force was doing as much for us as it would be able to without increasing its staff.

Mr. DADDARIO. Mr. Holmes, you won't be here next week when we go into this. However, just so the record on that point may be kept clear, I have had an interest in bioastronautics for some time. I believe that in this area the Air Force perhaps ought to enlarge its staff, and that its facilities ought to be developed to take care of the NASA requirements, rather than to build up a separate bioastronautic capability within NASA.

Mr. BELL. Will the chairman yield on that point?

Mr. DADDARIO. Yes.

Mr. BELL. It is my understanding from the testimony of General Schriever that the Air Force has offered NASA an opportunity to join with them in bioastronautics.

Mr. DADDARIO. We can't debate that now, but I think we should look into it later, Mr. Bell.

Just one further point: Dr. Dryden's position has always been, as I understand it, that the NASA ought to be involved in this area to the maximum degree, whereas the Department of Defense has felt that it could take care of some of NASA's requirements so that NASA could be involved to a minimum degree.

The question is: "Where between these two points is the best solution?" The fact that this committee understood that there would be an agreement, and that Dr. Dryden and Mr. Rubel said it would be available to the committee shortly after the close of the hearings last year, there remains a great deal of dissatisfaction in this committee. Even though there appears to be a better relationship in this area between NASA and the DOD, this has not been spelled out and the agreement has not been supplied to the committee.

This really is not your problem, Mr. Holmes, but we will take it up at a later date. Mr. Bell, we agreed that we would look into the specific details through our staffs, and that this would then be supplied for the record at a later date. We could get a complete breakdown of all of those questions that concern us.

Mr. SMOLENSKY. On page CF 9–19, the next project is "Barge, dock and loading facilities," and this would provide modifications and improvements to the water landing and loading facilities for the Saturn booster barges on the Tennessee River at Huntsville.

We are requesting $800,000.

Mr. DADDARIO. Questions.

Colonel GOULD. In the fiscal year 1963 program, under the "Utilities installations project," there was an item of $240,000 for improvements to docks and channels. What was accomplished with this $240,000?

Mr. DIAZ. These funds were turned over, Colonel Gould, to the Corps of Engineers in November 1962 for the enlargement of the approaches to the dock. The project in 1964 will complement and finish the work that was started by the Corps of Engineers.

Colonel GOULD. Was any work done on the existing docks?

Mr. DIAZ. Not on the dock itself. other than the approaches to it.

Colonel GOULD. What is the volume of the present barge traffic for the Saturn booster program? Do you have any figures on volume?

Mr. DIAZ. We would provide that for the record.

(The information requested is as follows:)

Plans provide for handling Saturn boosters are as follows from 1963 to 1967: Calendar year 1963, 5 stages; calendar year 1964, 8 stages; calendar year 1965 15 stages; calendar year 1966, 13 stages; and calendar year 1967, 10 stages.

Additionally 15 to 20 trips annually will be required in transportation of various items of equipment.

Mr. FUQUA. Is there any commercial transportation, other than in connection with the space program, going on at this facility?

Mr. DIAZ. No; there is not, sir.

Mr. FUQUA. It is strictly limited to Marshall's requirements?

Mr. DIAZ. Yes, sir.

Mr. FUQUA. Is it possible that this could be used for commercial transportation? Would it interfere with the security or anything else?

Mr. SMOLENSKY. I would say it is a possibility. Knowing the base down there, it would depend on a number of factors, such as local agreements.

Mr. GURNEY. How long has the existing wharf been there?

Mr. SMOLENSKY. The existing wharf was constructed by the Army and completed during October 1960.

Mr. GURNEY. In other words, the existing wharf was not built for the space program?

Mr. SMOLENSKY. Modifications were needed.

Mr. HOLMES. The existing wharf required modifications to handle traffic for the enormous Saturn boosters. Certainly it had to be modified significantly to handle shipping of a booster of the Saturn's proportions. Our investment in the dock was to handle boosters for the space program.

Mr. GURNEY. You are talking about this program?

Mr. HOLMES. I am referring to the one that we are using for the S–I stage of the Saturn I. We ship it by barge down to the cape and have a similar facility at the cape to take the booster off the barge. This dock is to handle a larger booster, the first stage for the Saturn V.

Mr. GURNEY. Have you made any large expenditures for that wharf recently?

Mr. HOLMES. Last year we had some in the budget.

Mr. DIAZ. That is the first time that we have put any money in it.

Mr. GURNEY. That is for this type program?

Mr. DIAZ. Yes.

Mr. GURNEY. The existing wharf has been in there for some time and was not constructed recently for some other part of your program?

Mr. DIAZ. Other than maintenance work, no major amount of funds was put into it.

Mr. SMOLENSKY. The next project is on CF 9–21, "Expansion and modernization of high-pressure gas and propellant systems." We are requesting $4 million. This is to provide new high-pressure lines to all test and fabrication facilities serving the Saturn V program—new compressor facilities, storage facilities, and new liquid oxygen transfer equipment; also leak detection systems. In our view, it is absolutely essential to support the facilities becoming operational by early 1965, and for the peak of the S–IC operational development.

Mr. DADDARIO. Questions?

(No response.)

Mr. SMOLENSKY. The next program is on page CF–9–24, entitled "Expansion of computation facilities."

In fiscal year 1964 we are requesting $2,315,000 for the construction of a 43,000-square-foot addition to the computation building to allow expansion of computation facilities at Marshall Center.

Colonel GOULD. What is the size of the present computation facility?

Mr. SMOLENSKY. May we provide that for the record?

(The information requested is as follows:)

The existing building which was constructed by the Army is 55,053 square feet. We have augmented this facility through the fiscal year 1963 program by providing for an additional 41,700 square feet. Construction is scheduled to start during June of this year for this increment.

Colonel GOULD. It is noted that this building will provide space for about 90 people. Where are these personnel presently housed?

Mr. SMOLENSKY. At present personnel are housed in three different locations—the Huntsville Industrial Center, which is located about 12 miles from MSFC, a former warehouse and office building, and a

former warehouse located at the Arsenal, both of which were built in 1942.

Colonel GOULD. I note that as part of your cost estimate you are purchasing equipment in the amount of $675,000 for data processing and $225,000 for data reduction. Can this particular type of equipment also be rented or leased rather than purchased?

Mr. SMOLENSKY. I would say that this type of data processing equipment certainly can be rented, but this data processing equipment is designed to fit into our whole test program and test facilities to be used for the consolidation of our computer facilities for more efficient operation of those computer facilities.

Colonel GOULD. Are not rapid advances being made each year in the computer field on new and better equipment? If you are under a leasing arrangement with computer manufacturers, you can take advantage of newer equipment as it comes into being and replace existing equipment without having to go into modernization costs for owned equipment.

Mr. HOLMES. We in NASA continuously study this question of whether it is more economical to buy or to rent, Colonel Gould. I don't have the answer to your specific question. We can get it for the record. I am quite certain in my own mind that it has been looked at and found to be most economical to buy.

I can give you an example of the type of thing that we are currently looking at. We have computers for the Mission Control Center at Houston. The break-even point on "buy versus rent" is the first quarter of 1966. We have to weigh various factors. We must study whether it is cheaper for the Government to buy this equipment. For example, we have to decide whether or not, if manufacturers came out with better equipment to rent, we could afford to change the equipment at that later time because of the great programing expenses. Certainly if the date were 1964 instead of 1966, you could say let's rent it. My point is that we continually study the most efficient way. You raised a very good point. I am quite certain that the reason that we are requesting funds for purchase of this item stems from the fact that it is the most economical way. I would like to confirm it for the record.

(The information requested is as follows:)

The equipment can be leased but there are several serious disadvantages and among them are high rental fees and restrictions to configuration change. The primary advantage to purchase of equipment over leasing is in the ability to modify the machines to meet constantly changing requirements. The equipment to be purchased for this addition is of two basic types; analog equipment for simulation work and data reduction equipment for reduction of all types of test and flight data. The Computation Division can make immediate modification to both of the above types of equipment as the need for modification arises. If the equipment was being leased, it would be extremely difficult to work through the manufacturers to accomplish necessary changes. It should be pointed out that the above equipment is set up to simulate specific conditions and to reduce data from specific tests, flights, etc. This emphasizes the need for great flexibility in adjusting to changing requirements.

Mr. DADDARIO. I think Colonel Gould's question is a good one, too, Mr. Holmes. This committee has inspected some computer plants, and we have been shown the advances that have taken place in just a few years. One small machine now does the work of machines that at one time would fill a room of this size. If we could have an analysis in regard to the question asked, it would be helpful.

Colonel GOULD. Is the existing computer facility mentioned in the justification completed and now in operation or is it under construction?

Mr. LILLY. The existing computer facility is in operation.

Colonel GOULD. What percent of the personnel engaged in your activities are now housed in the existing facility?

Mr. SMOLENSKY. May we furnish that for the record?

Mr. DADDARIO. Yes; that may be supplied for the record.

(The information requested is as follows:)

There are 417 people engaged in computer operations to date and approximately 55 percent of these people are located in the existing facility.

Mr. FUQUA. What type of building is this going to be? Is this going to be just an administrative-type building or is there any special construction requirement that necessitates the cost of $25 per square foot?

Mr. DIAZ. This is based on similar facilities that have been built down at the Marshall Space Flight Center, sir.

Mr. FUQUA. Do you have gold in the walls?

Mr. DIAZ. No, sir. The cost just seems to be running that way down there for this type of structure.

Mr. FUQUA. Then I am going to get into the building business in Alabama, if there won't be a conflict of interest.

Mr. HOLMES. Of course, this building has to have a controlled environment.

Mr. FUQUA. Air-conditioning?

Mr. HOLMES. Yes, it requires air-conditioning and control for the computer, and it also has to have a ducted floor so that cables can go under the floor.

Mr. FUQUA. But there is no other real special requirement such as 18-inch walls, and so forth?

Mr. HOLMES. No. We did agree to provide a comparison of these costs of one building to the other and justify if for the record, and we will certainly do it in this case, too.

(The information requested is as follows:)

The building will be a concrete frame structure with masonry block curtain walls. It will be air-conditioned to insure humidity and temperature control throughout the facility and special air circulation will be required for equipment cooling. Raised floors are being provided to permit handling of required cabling. The estimate cost of $25 per square foot is based on completed design and unit costs developed for the addition authorized in fiscal year 1963 program.

Mr. DADDARIO. Can we move along to CF 9–27, "Extension to the Load-Test Annex"?

Mr. SMOLENSKY. We are asking there for a total of $3,360,000. This request is to construct an annex to the extension of the east end of the present load-test facility. We have to provide expanded facilities for structural testing for the Saturn V program. This is a very vital and important addition, which will permit us to subject the large structures to various static loads and vibrations testing. This capacity is vital to our testing program.

Colonel GOULD. In fiscal year 1962, $1,703,000 was authorized for this project, plus reprograming from C of F program and the RD–O program, bringing the total available for this facility to $4.4 million. What is the status of these prior authorizations and appropriations?

Mr. SMOLENSKY. First of all that provided for the present load-test annex and also the increase occurred as a result of our going from the C–3 program to the C–5 program. We had to add additional facilities in there. In addition, there were some increases in costs on the bid opening which accounted for something like a million dollars.

Colonel GOULD. Has the previously authorized project been completed?

Mr. DIAZ. No, sir. That is under contract. That has been designed and under contract.

Colonel GOULD. Construction has started?

Mr. DIAZ. Yes, sir.

Colonel GOULD. When do you anticipate it will be finished?

Mr. DIAZ. The fiscal year 1962 project will be completed in March 1964.

Colonel GOULD. Would you define for us, please, what were the increases in scope beyond that which was authorized in the fiscal year 1962 program?

Mr. DIAZ. May I supply that for the record, please, sir?

(The information requested is as follows:)

The increases in scope of the facility since authorized in the fiscal year 1962 budget consist largely of those changes caused by the growth from a C–3 vehicle to the Saturn V configuration. This includes an increase in the vertical load test capability from 20 to 30 million pounds. In addition a capability has been designed into the facility for exerting lateral loads of 1.2 million pounds. This necessitated stiffening of the structural members of the stand and reinforcement of foundations.

Colonel GOULD. On page 30 you indicate that consideration has been given to the use of fiscal year 1963 advance design funds to expedite development of this project. Since the budget books were put together, has this determination been made?

Mr. LILLY. No, we have not put money out.

Mr. DADDARIO. Any other questions on this point, gentlemen?

Mr. GURNEY. Yes. This capability of a 2 million pound testing machine, I take it, is the result of the F–1 engine. Are you or any others engaged in the space program developing a larger engine than this?

Mr. LOW. No, sir.

Mr. GURNEY. How about soild fuels?

Mr. HOLMES. Solid fuels would give a greater thrust. I don't know enough about the details of the machine to give you an exact answer. In general, a solid fuel booster and engine are inseparable, as you know. There is a tank with a solid propellant in it. You don't have the problem of having to load a steel beam structure which is carrying engines with these thrust factors. I think that the answer is that a machine of this type would not be necessary for testing solids. In the liquid propulsion area, Mr. Low's statement is correct, we don't have any higher thrust than this.

Mr. GURNEY. What I am thinking about is the cost of the testing device. It would soon become obsolete with the next engine, wouldn't it?

Mr. HOLMES. You would have to extrapolate to make it work.

Mr. GURNEY. Do you think this is sufficient to take care of your future requirements in this testing area?

Mr. HOLMES. Yes. I think that this facility would accommodate the engines that we presently have under development or are planning, including the M–1 engine.

Mr. DADDARIO. Mr. Waggonner.

Mr. WAGGONNER. Mr. Holmes, when we were talking earlier about the additions to the test support shop beginning with CF 9–15 over to CF 9–17, you project the purchase of three cranes, one 25-ton bridge crane, one 20-ton bridge crane and one 5-ton bridge crane at an estimated cost of $60,000. We are talking here about the extension to the Load Test Annex, and on page CF 9–31 you project the cost of two 20-ton bridge cranes as $180,000. What is the difference?

Mr. DIAZ. The difference, sir, is the span of the cranes. The three smaller cranes also——

Mr. WAGGONNER. Except back in your other facilities your support for your crane was included in the cost of your building.

Mr. DIAZ. Right.

Mr. WAGGONNER. Isn't the support for your crane included in your building cost here because your construction cost is $31.90 per square foot?

Mr. DIAZ. The supports would be included, yes, sir.

Mr. WAGGONNER. Why does the span make any difference?

Mr. DIAZ. The span in here—the structure that holds the crane—in here, as I recall, this would be about 100 feet. The others are smaller. Also the controls for the smaller cranes are not as critical as these larger cranes we have here.

Mr. WAGGONNER. How much greater is the span on these two 20-ton cranes, and the 20-ton crane and the 25-ton crane in the other facilities?

Mr. HOLMES. I think that is a very good question. We ought to supply just what these higher cranes are and why we say it is going to cost nearly three times as much. I don't know. I will be glad to get it for you.

Mr. WAGGONNER. There is a discrepancy.

Mr. HOLMES. I think it is a reasonable question. I would like to know myself now that you have raised it.

Mr. DADDARIO. That will be supplied for the record?

Mr. HOLMES. Yes, sir.

(The information referred to is as follows:)

The cost of cranes for the Load Test Annex were based on actual quotations received from manufacturers. The difference in crane costs between the test support shop and the Load Test Annex is due to many significant factors. For instance the span of the test support shop is only 60 feet whereas the Load Test Annex has a span of 110 feet. The control systems are also very different. The test support shop requires only the simplest kind of pendent controls, whereas the Load Test Annex requires a complex rheostat control system which is suitable for the handling of large expensive components.

Mr. FULTON of Pennsylvania. I have a general question. How do you procure these items? Do you advertise for them and obtain them from the lowest bidder on NASA specifications or do you buy these just on the open market?

Mr. DIAZ. This will be advertised for, sir, and obtained from the lowest bidder.

Mr. FULTON of Pennsylvania. How much of an advertisement do you do so that we get a broad base of possible suppliers? Can you supply that for the record?

(The information referred to is as follows:)

Bids are usually requested on equipment and requests for proposals obtained from as many manufacturers as are available on large items, with a minimum of three bidders.

One other thing. On facilities such as the Ultra High Vacuum Space Chamber Facility of $2,685,000, previously NASA has been contracting with special contractors on private negotiation. On my objection to several points such as these, NASA sent me a telegram saying that facilities such as the Ultra High Vacuum Space Chamber Facility will be procured on open bid. Is NASA following this practice in all instances?

Mr. HOLMES. Are you on page CF–8, "Manned Spacecraft Center?"

Mr. FULTON of Pennsylvania. That is on the sheet that has been given to us, an Ultra High Vacuum Space Chamber Facility on the same page as the Manned Spacecraft Center.

Mr. ROUDEBUSH. At Houston.

Mr. FULTON of Pennsylvania. I am just asking your general practice in the procurement of items of this type.

Mr. HOLMES. We will be glad to supply that for the record.

(The information referred to is as follows:)

Competitive bid procedures are followed for the construction of our facilities. On highly specialized and complex projects, the capabilities of contractors are evaluated to determine their qualifications to perform the work. The qualified contractors are then invited to bid.

Mr. FULTON of Pennsylvania. For example, on your Acoustic Model Test Facility of $2 million, I would like to know whether that is being let on public bid, also, that there are public bids on the barge dock and loading facilities, and that the expansion and modernization of the high pressure gas and propellant system is likewise put out to public bid. Would you supply that for the record?

Mr. HOLMES. Yes, sir, we will supply that for the record.

(The information referred to is as follows:)

It is the practice of NASA to construct facilities by open, competitive bidding. Therefore, each of the projects which were mentioned will be advertised and the contract will be awarded to the lowest responsible and responsive bidder.

Mr. DADDARIO. We will proceed to extension to the Propulsion and Vehicle Engineering Laboratory, CF 9–32.

Mr. FULTON of Pennsylvania. Can you justify your $31.90? Are you going to do that in every instance?

Mr. DADDARIO. They are going to do that in every instance.

Mr. SMOLENSKY. We are requesting here $1,900,000 for an extension to the east end of the present laboratory with cafeteria facilities attached, as a one-story structure, on the south side of the extension for 400 people engaged in R. & D. in the vehicle engineering and the propulsion division now located at Huntsville.

Colonel GOULD. When was the existing Propulsion and Engineering Laboratory constructed, or has it been constructed?

Mr. LILLY. It has been constructed.

Colonel GOULD. What was its size?

Mr. DIAZ. The overall size of the existing facility is 105,700 square feet.

Colonel GOULD. The justification indicates that 600 of the personnel assigned are now occupying leased space in Huntsville. What is the total strength of this division?

Mr. LILLY. About 897 at the end of this fiscal year, sir.

Colonel GOULD. How many personnel will the existing building accommodate?

Mr. LILLY. It will accommodate 400.

Colonel GOULD. You are providing space for 400 more in this addition. Despite the dispersed locations, would the deferral of this project really have a serious impact on your overall program, or could you continue to operate?

Mr. SMOLENSKY. In my opinion, with the increased testing that would be going on and with the increased need for coordination, I would say it would be most inefficient to have our people spread as they are right now in this particular area.

Colonel GOULD. Would it cause any delays in your program actually?

Mr. SMOLENSKY. It certainly would cause some delays, because it takes more time in terms of getting people together, coordinating technical reports and computations.

Mr. DADDARIO. Any further questions, gentlemen?

Mr. FULTON of Pennsylvania. How much delay would there be?

Mr. SMOLENSKY. I'm not sure that we have data available to supply an estimate of that type of delay.

Mr. FULTON of Pennsylvania. What is your estimate of the delay if you don't get this cafeteria?

Mr. SMOLENSKY. We have not made an estimate of this delay either.

Mr. HOLMES. It would be very hard to say without studying it. I think if you wanted us to, we could study what it would be. When you talk about a facility delay, unless it is a facility that has to meet a certain flight test, but rather a general support facility such as this is, it is difficult to pinpoint whether it is 2 months or 3 months or a year.

Mr. FULTON of Pennsylvania. We are trying to find out how necessary such an installation is. I would like to have some means of deciding it, rather than saying it would be nice to have a cafeteria.

Mr. HOLMES. Yes, sir. You are referring to the cafeteria?

Mr. FULTON of Pennsylvania. I use that as an example.

Mr. HOLMES. Why don't we get something for the record on that.

(The information referred to is as follows:)

It is not possible to evaluate a set time which the overall program would be delayed by a deferral of the project referred to above. However, it is a certainty that continued separation of the various branches of P. & V.E. will hamper the timely execution of the program. The efficiency of the P. & V.E. Division at Marshall is reduced by the separation of its closely integrated groups. This Division has primarily responsibility for the vehicle design and propulsion systems of Saturn V.

Colonel GOULD. The design and layout of this building is very similar to the one at Houston that we talked about last week. I notice that the unit cost per square foot here is $21. The one at Houston is estimated at $24.25. Also, I noticed one out at Ames Research Center for $19.50. All three of these structures are very, very similar. The cost index at Houston is 0.95, the cost index at Marshall is 0.9, and the cost index at Ames in California is 1.05.

Could you give us any reason why there is such a variance in similar type facilities throughout the NASA program?

Mr. DADDARIO. Would you supply that for the record, please?

Mr. HOLMES. Yes, sir.

(The information requested is as follows:)

The following comparison of structures is furnished for the record:

Extension to the Propulsion and Vehicle Engineering Laboratory, Marshall Space Flight Center (70,000 square feet at $21 per square foot).—Project provides for a five-story structural steel frame building with porcelain steel panel curtain walls in aluminum framing. A basement of approximately 3,500 square feet is provided for housing air handling equipment and chiller units and a penthouse for elevator equipment is included. Additionally a separate single-story cafeteria with a seating capacity of about 300 people is provided containing about 7,000 square feet of area. The unit cost of this project is based on costs experienced in construction of the five-story addition to the P. & V.E. building authorized in the fiscal year 1961 program, adjusted to reflect the current cost index.

Project engineering facility, Manned Spacecraft Center (84,500 square feet at $24.25 per square foot).—This project provides for a five-story structural steel frame building with precast exposed aggregate panel curtain walls. A mechanical equipment room of approximately 3,400 square feet is located on the roof for housing air handling equipment. The unit cost of $24.25 is based on the actual cost of construction on the project management building which is currently under construction at MSC. The latter facility and proposed project are essentially of the same design.

Administration management building, Ames Research Center (office area, 47,100 square feet at $19.50 per square foot; basement area, 17,600 square feet at $15 per square foot).—Project provides for a single two-story structure with two adjoining single-story wings constructed with reinforced concrete frame and integrated poured concrete walls containing approximately 47,100 square feet of floor area. A partial basement of 17,600 square feet is also provided for mechanical equipment and record storage. The unit costs established for the proposed facility are based on costs experienced on the data reduction building, a structural duplicate of the facility.

As set forth above all of the unit costs used at the respective sites are based on actual construction experience. The cost variations are attributed to the different types of construction employed at the respective locations and variations in costs of material and labor at these locations.

Mr. DADDARIO. We will move along to the Hangar for Vehicle Components.

Mr. SMOLENSKY. It is on page CF 9–35. We are requesting $2,800,000 for the design and construction of an industrial type building, 250 feet long, 200 feet wide, to prepare an area for receiving, checking, and preparing large components for the Saturn V S–IC stage program.

The next item is on page CF 9–39, "Hazardous operations"——

Mr. DADDARIO. Wait a minute. We thought you had more of an explanation.

Mr. HOLMES. Didn't you want to give a few more words of explanation?

Mr. SMOLENSKY. The current facilities just don't permit the handling of large bulkheads and fuel and oxydizer tanks, and this is all in expectation of the components coming in for the S–IC stage. It is vital to receive these items, store them, have them ready for the assembly and ground test program.

Colonel GOULD. In the fiscal year 1963 program, a Components and Subassembly Acceptance Building was authorized for $950,000. This project was justified on the basis of providing a facility that was required for the receipt, inspection, and testing of large cumbersome components. It appears that the justification for the fiscal year 1963 building and the one supplied here for fiscal year 1964 have similar justifications. Would you comment, please, on the relation between these two facilities?

Mr. SMOLENSKY. May I supply that for the record?

Mr. DADDARIO. Yes, you may.

(The information referred to is as follows:)

The components and subassembly acceptance building is required to provide the inspection area for receiving components and all required inspection equipment. The hangar for vehicle components will be used primarily as a holding area for components received from Michoud and the fabrication building until they are required for final assembly. It is essential that these components be given protective storage up to their inclusion in final assembly. A large portion of the components and subassembly acceptance building is used for electrical and mechanical inspection of small components and for X-raying inspection of welds and will require suitable power and other pertinent inspection equipment utilities.

Colonel GOULD. Could you tell me whether the Components and Subassembly Building has been completed?

Mr. LILLY. It is not completed. It is under construction.

Colonel GOULD. Do you have an estimated completion date?

Mr. LILLY. The estimated completion date for this facility is April 1964.

Colonel GOULD. I have one further question. You state that the existing Army warehousing in the area, I assume at Redstone Arsenal, is inadequate because of the lack of cranes, overhead clearance, et cetera. Would the Army make these buildings available to NASA? Have you contacted the Army as yet with respect to this matter?

Mr. DIAZ. We will have to supply that for the record.

Colonel GOULD. It is my understanding that there is some warehousing at Redstone which is in excess to the Army's need. Is it possible that these buildings could be made available to NASA and serve your purposes in lieu of constructing the new facility?

Mr. DADDARIO. If that is the case, we ought to have that information very quickly. It ought to come directly to the chairman of this committee, Mr. Holmes, and not just be included in the record.

Mr. HOLMES. I have so much respect for the thoroughness with which Marshall approaches this problem, I am almost certain in my mind that the reason that they are adding this building is due to the fact that they don't have capacity in the 1963 budgeted building and it is impossible to use the Army facilities. I would like to get this for you. We will have to go to Marshall to get it, and we will present it to you in 2 days.

(The information requested is as follows:)

The feasibility of using existing NASA or Army owned facilities for larger components was studied extensively prior to development of this project. However, the height and access opening and lack of overhead cranes are limiting factors which preclude general use or economic modification. For instance, bulkheads, fuel and oxidizer tanks, skins and cylinders require high bay clear-span area as holding space. Therefore, these buildings, while available, cannot be used for the large components common to the S–IC vehicle. However, NASA has obtained and is using similar structures for the storage of smaller components.

Mr. DADDARIO. The nature of it should come directly to the chairman. We will move to "Hazardous Operations Laboratory."

Mr. SMOLENSKY. On page CF 9–39, we are requesting a total of $500,000 for the construction of a building in which environmental and functional tests and calibration can be accomplished which, because of their hazardous nature, cannot be done in existing facilities. This was the result of a safety survey conducted at the Center.

Mr. DADDARIO. If there are no questions on this point, we will move to "Modernization of Instrumentation and Control Systems in the East Area."

Mr. SMOLENSKY. This is on page CF 9–43, and we are requesting a total of $3,500,000. The project covers the procurement and installation of urgently needed replacement and modernized equipment in the blockhouse serving the east test area. This project goes along with the problem of trying to speed up our whole data acquisition and data reduction program and trying to automate the acquisition of the results of tests and data.

Mr. Holmes touched on that before, and this is the project that provides the instrumentation to the blockhouse.

Mr. DADDARIO. Is this an extension of existing programs? Do you have something going on at this time as far as automation is concerned?

Mr. SMOLENSKY. Yes, sir. It is an across-the-board program on the whole Saturn V, and you will hear that in the presentation of our whole program facilities.

Mr. DADDARIO. We will move to CF 9-46, "Modification to the Vehicle Assembly Building."

Mr. SMOLENSKY. Here we are requesting a total of $1,800,000 to raise the roof of the vehicle assembly building to provide a high bay area, approximately 141 feet long by 140 feet wide with approximately 1,000 square feet, to support the Saturn I–C program.

Mr. WAGGONNER. What about further modifications? We have talked a long time about the fact that NASA is working on the M–1 engine. Is this building being modified to take care of further expansion, or are you just increasing the inside clearance of this building for the S–IC stage?

Mr. SMOLENSKY. This is primarily for increasing the building to handle the Saturn V's S–IC stage.

Mr. WAGGONNER. Just the S–IC stage?

Mr. SMOLENSKY. Just the S–IC stage.

Mr. LOW. There may be a misunderstanding here. The Saturn S–IC is the booster stage for the Saturn V vehicle. It is the biggest stage contemplated under development.

Mr. FULTON of Pennsylvania. Why can't that be done at Michoud?

Mr. SMOLENSKY. Marshall has the responsibility for conducting the program and the development of certain ground stages on the S–IC program. They must assure themselves of the techniques of both assembling the single tank structures and also of the assembly of the stage, itself.

Mr. DADDARIO. Colonel Gould, you have some questions?

Colonel GOULD. The justification indicates that the ground-test vehicle which will be moved in and out, repeatedly, of the assembly building up until 1966. What is projected beyond 1966?

Mr. SMOLENSKY. I would assume that after 1965 we do have a product improvement program that would require continuous testing. I can give you more details on that.

Colonel GOULD. Is this project being justified on the basis of operations between now and 1966 only, or do you have something beyond that?

Mr. SMOLENSKY. There is a continuous need, and I would visualize throughout the use of the S–IC stage and the Saturn V program we would have a continuous need for ground testing and proving out certain new modifications to the ground stages.

Mr. HOLMES. I am sure that Marshall will have S–IC stages at Huntsville through this decade; therefore, they will need buildings

to be able to accommodate them. To put it in the perspective that I like to look at it, the assurance that we are going to have a good, reliable vehicle on the pad, I think, is greatly increased by Marshall having the capability and thrust facilities already authorized to develop the early engineering model, in the case of the S–IC, four models.

Colonel GOULD. One further question. I notice the cost of modifying this building is estimated at $72.35 a square foot. From the plan you show in the book, it seems to be simply a matter of raising the roof some 20 feet, as I interpret this, although it is not quite clear from the sketch. You could build a new structure for that cost. Could you give us some justification for the high cost?

Mr. DIAZ. Colonel Gould, the contractor will be required to seal off those areas because the rest of the building will be in operation. Also, the foundations will have to be built up to take care of this new design work. Consideration is now being given, instead of modifying the structure the way it is shown here, to just having an addition to it.

Colonel GOULD. How much will that cost? Will it be more economical to do this?

Mr. DIAZ. We haven't reached that point yet, to determine whether the unit cost will be more for the new building.

Mr. FULTON of Pennsylvania. Are you sure you need the money in this next fiscal year?

Mr. DIAZ. Yes, sir.

Mr. FULTON of Pennsylvania. Why?

Mr. WAGGONNER. They can't get the S–IC stage vehicle in here for assembly; the roof is too low.

Mr. SMOLENSKY. Our operational date for that is October 1964.

Colonel GOULD. When will the decision be made on whether to build an addition on or to modify the existing building?

Mr. DIAZ. That has to be made very soon, sir. It is now under study. I can't say how soon.

Mr. DADDARIO. This is some information that we should have quickly, too, and if there is any variance in cost.

Mr. HOLMES. I would like to point out that you are getting it before I am. I agree with you, I would like to have it, also.

(The information requested is as follows:)

A final assembly facility is urgently needed in support of the Saturn V program. To satisfy this requirement a determination was made to modify the existing vehicle assembly building. This determination was based upon manufacturing plans current during the period of project preparation.

These manufacturing plans have undergone significant changes which now indicate that the vehicle assembly facility will be totally committed to fabrication of the Saturn V vehicle. As a consequence, a modification project could burden the S–IC manufacturing program with severe problems of interference. Our examination of the effect of such possible interference and studies of alternative solutions for siting the final assembly facility prompted our indication to the committee that alternative plans were under study.

The most promising alternative under consideration calls for combining this final assembly requirement with the hangar for vehicle components which is also included in our fiscal year 1964 construction of facilities program. This plan would require approximately 7,400 square feet of space in addition to the 14,700 square feet provided in the modification project. This space is necessary to house general support functions such as officers, handling and visual inspection of components, equipment, tools, and fixtures. Current studies do not indicate that adoption of this plan would necessitate a funding increase since there would be a reduced cost in providing the high bay area.

Another alternative under study is the construction of an addition, rather than a modification of the existing assembly building. However, this plan possesses a significant disadvantage since the surrounding area is congested. Therefore, extensive relocation of roads and utilities would be required in order to provide a reasonable layout.

In summary, the most promising alternative under consideration, a final assembly facility constructed in conjunction with the hangar for vehicle components, will not result in an extensive revision to the project. The only significant revision will be a change in location.

Mr. ROUDEBUSH. As I follow your plans for construction and modifications, I gather that your requests are all geared to the largest vehicle, the Advance Saturn; isn't that correct?

Mr. HOLMES. Yes, sir.

Mr. ROUDEBUSH. Some of the clearances are rather close. If you were to build a slightly larger vehicle than the Advance Saturn, none of these buildings would be usable; isn't that correct?

Mr. HOLMES. Yes; that is correct.

Mr. ROUDEBUSH. If we did go into a Nova program sometime in the future, every hangar facility, every crane, every single installation you have would be unusable; isn't that true?

Mr. HOLMES. Of the type installation to which you are referring; that is correct.

Mr. ROUDEBUSH. I just want to put that observation in the record at this point.

Mr. WAGGONNER. The assembly building?

Mr. HOLMES. Where you have the whole vehicle assembled.

Mr. ROUDEBUSH. Where you have the vehicle as an entity; yes.

Mr. HOLMES. The problem arises that we might allow another 10 or 15 feet and find at a later date that it is a foot too low. Since the vehicle isn't defined, it is a difficult judgment to make. With these vehicles as large as they are, I doubt very much that it would be wise for us to make the buildings any larger than necessary just on the chance that we might have an assembly that was larger. If a future vehicle were solid, it might be a cluster of solids that you wouldn't assemble in Huntsville at all.

Mr. ROUDEBUSH. I am not criticizing your management decision. I am just observing for the committee that these buildings have a capacity which ends with the Advance Saturn. If we go into any other programs, your cranes and everything else will have to be replaced.

Mr. FULTON of Pennsylvania. With the M–1 engine being scheduled for 1972 production, it doesn't seem to be too immediate a problem when you talk about the Nova-type construction, is that correct?

Mr. HOLMES. I think that the time schedule you are talking about is about right, yes, sir.

Mr. FULTON of Pennsylvania. I read an article not too long ago that said the M–1 engine was lagging behind by 3 years. Would you comment on that for the record?

Mr. WAGGONNER. He did that yesterday.

Mr. HOLMES. I will be glad to comment. That article was written by someone who didn't know what he was talking about, I suspect.

Mr. FULTON of Pennsylvania. I will supply you the article.

Mr. HOLMES. The philosophy of the M–1 engine has changed. It is not a slip of 3 years when you decide to make a more advanced engine.

Mr. FULTON of Pennsylvania. At the end of the last session there was a question that I had asked you which you hadn't answered, and which I would like for you to answer for the record.

(The information requested is as follows:)

M–1 PROGRAM STATUS

Since the inception of the M–1 program, the following has been accomplished from May 1962 to April 30, 1963.

In the R. & D. program Aerojet, under the guidance of the Lewis Research Center, has selected configurations and design concepts and initiated the design of all components of the engine. For major components initial designs and procurement of materials have been completed and fabrication started. The first test of full-scale gas generator was recently completed. With hardware now in process, the first thrust chamber and liquid oxygen pump tests are scheduled late in calendar year 1963 with H_2 pump tests scheduled in early calendar year 1964.

The major portion of facilities funding has been used to modify existing Titan facilities in E area in Sacramento, Calif., to provide the test capabiilities for large components such as gas generators, controls, and injectors.

H–8 and C–9 large thrust chamber and gas generator test stands have been designed and construction essentially completed. Design of the four large test stands of the new K area at Sacramento have been initiated. For all of these facilities Aerojet provides land, site preparation, and brick and mortar with NASA providing the specialized severable equipment.

When the lunar orbit rendezvous mode was selected for the lunar mission program, an urgent development effort for a large vehicle with a direct flight capability was no longer necessary. This decision allowed the establishing of a more orderly 5-year program to preflight rating test for the M–1 engine instead of the 4 years originally contemplated. This action had two major effects on the program: (1) funds in initial years of the program were reduced, and (2) the nominal thrust level of the engine was raised from 1.2 to 1.5 million pounds and more advanced state of the art, consistent with a post-Saturn-vehicle flight date was incorporated.

As one example of the latter effect, a multistage axial flow hydrogen pump and two-stage turbine were substituted for the single stage centrifugal pump and turbine of the original design.

Since changes in the design concept occurred during the early design phase the impact on total program cost is relatively minor. As mentioned above, the cause of the stretched out program, initial costs were considerably lower than programed. Costs of facilities, which were designed to serve a 1-million-pound-plus-thrust-class engine were affected to an even lesser extend than the R. & D. program.

Mr. DADDARIO. Mr. Waggonner.

Mr. WAGGONNER. When we were talking about parking facilities in the computation facilities expansion a minute ago, you estimated that for your parking facilities expansion cost would be $4 a square yard. Here we see that the cost will be $5 a square yard. You have twice as much parking facility expansion here, as we have over the other facility, which would indicate that percentagewise the cost would go down; however, the cost goes up 20 percent. Would you comment on that?

Mr. DIAZ. The actual cost of construction is running between $3.75 and $4.50. This is a contract price. The reason the facility you were talking about is $4 is because some of the grading is being done on the site clearing and development. So part of it is being taken care of already. Therefore the cost——

Mr. WAGGONNER. You have $180,000 for site development.

Mr. HOLMES. Why don't you answer Mr. Waggonner's question for the record unless we have it available?

Mr. WAGGONNER. That is fine.

(The information referred to is as follows:)

The actual cost of construction is running between $3.57 and $4.50. This is a contract price. The parking area for the computation facility is estimated at $4 per square yard since grading of the parking site is included in the lump-sum cost of the site clearing and erosion control item. The unit cost of parking facilities of the Project Engineer Office on the other hand includes the cost of the parking area site grading.

The $180,000 referred to is for the total category of "Site development and utilities" and compares with the $145,000 for the "Computation facility."

Mr. PATTEN. May I ask one question?

Mr. DADDARIO. Yes.

Mr. PATTEN. Mr. Holmes, it seems that roads and bridges have to be widened every few years. Do you feel that your men have given this question of the size of these assembly buildings careful consideration, and you have come up with your best judgment to do it in this way?

Mr. HOLMES. Yes, Mr. Patten, I do. Primarily because the size is already so large.

Mr. PATTEN. These large boosters have been criticized frequently and an article I read the other day said we are going too far. But it is your considered judgment that these facilities are sufficient for our needs even though you can't sit here and say you are going to have 50-foot diameter vehicles in 1972. Is that correct?

Mr. HOLMES. I don't think we have sufficient data to justify to you building a larger building with the additional costs required.

Mr. WAGGONNER. I think we ought to keep it clear that we are not talking about all the facilities which are being built. This happens to be the assembly building at this Marshall Test Facility. That is the only facility that can be classified that way.

Mr. HOLMES. Only those facilities that concern the full assembly.

Mr. PATTEN. You need new pads, new instrumentation, a different barge, and almost everything we have mentioned for Saturn V. It goes a little further than just the width of the building.

Mr. HOLMES. Correct. All these items are concerned with the assembled vehicle.

Mr. DADDARIO. This opens up the question again, Mr. Roudebush.

Mr. ROUDEBUSH. Yes, it does, and I might state for my dear friend from New Jersey's standpoint, I am looking for future economies and also past mistakes. We have an assembly and checkout building at Marshall which obviously is quite capable of handling the Saturn I–C, the first configuration of the Saturn. We have had the concept of the Advanced Saturn for several years now, isn't that true? When we built the Saturn I–C, was that the biggest rocket that this country had ever built?

Mr. HOLMES. I think that it was bigger than some people had intended to build.

Mr. ROUDEBUSH. That is probably true. Of course, this goes back before the time when you were the Director of the Office of Manned Space Flight, but why wasn't some thought given to making these facilities larger? Are we repeating a past mistake now to build their capacity just large enough to house the Saturn I–C?

Mr. HOLMES. As to the Saturn V, I don't think we are making a mistake. It is true that 18 or 20 months ago we didn't envision the first stage of the Saturn V as a five-engine stage. Today we could allow a hundred-foot headroom and it probably would accommodate anything we would want to do in the future, but I doubt if we could

justify construction of such a building to either ourselves or to you. To make it higher and find out later that it was not needed at all would be a mistake.

Mr. ROUDEBUSH. I am not implying that you are wrong. I just hope that 10 years from now I won't be sitting on this committee when we get ready to go to Mars or Venus and have to raise the roof again.

Mr. FUQUA. "Raising the roof" can be taken two ways.

Mr. ROUDEBUSH. I am talking about it in a physical sense.

Mr. FULTON of Pennsylvania. May I add Mr. Roudebush to the group of volunteers who want to go to Venus or Mars?

Mr. ROUDEBUSH. I delete my name.

Mr. DADDARIO. I don't think we should involve Mr. Roudebush in this volunteer business. The committee has reserved that for Mr. Fulton.

Mr. FULTON of Pennsylvania. I am ready at any time. I am serious about it.

Mr. DADDARIO. We will move along to the project "Engineer Office," CF–9–50.

Mr. SMOLENSKY. Here we are requesting $2,650,000. This project will provide working space for 700 personnel in the technical project and supporting offices. At the present time these people are located in several leased areas in Huntsville. This is the same problem we had on a previous project. As our test load increases in the next year, the need for coordinated engineering planning and evaluation of test results becomes more and more paramount, and this is a question we feel is justified.

Mr. DADDARIO. Colonel Gould.

Colonel GOULD. We authorized, in the fiscal year 1963, a $2.5 million facility for engineering and administration purposes. I understand that this building is now under construction; is that correct?

Mr. DIAZ. That is right.

Colonel GOULD. What is the estimated completion date of that facility?

Mr. LILLY. The Engineering and Administration Building in the fiscal year 1963 program will be completed in May 1964.

Colonel GOULD. How many personnel will the building accommodate when it is finished?

Mr. DIAZ. It is presently planned to house approximately 700 people.

Colonel GOULD. The project includes parking space for 400 vehicles. The 1963 project also included parking space. How many vehicles will the parking areas accommodate when this facility is completed?

Mr. DIAZ. The total parking space will accommodate approximately 800 cars for the two facilities.

Mr. DADDARIO. We will proceed to "Support Operation Building."

Mr. SMOLENSKY. On page CF 9–53, we are requesting $500,000 for the construction of a shop-type building with engineering space to house contractors' support people.

The existing facilities do not provide for sufficient engineering space, administrative office space and a small repair and maintenance shop to house and support contractor personnel.

This, again, is related to our buildup in testing that will be coming up in this next year.

Basically, the need of having contractors' support close to the test sites is important from a standpoint of their both being able to service the test sites, assess the data, and then to quickly, in engineering offices, evaluate the data and recommend in some cases, changes that perhaps can be made on the spot.

Mr. DADDARIO. Questions, gentlemen?

(No response.)

Mr. DADDARIO. If not, we will proceed to "Utility Installations," CF 9–56.

Mr. SMOLENSKY. Here we're requesting $5 million for the general extension and modification of existing utility systems and new utility systems in support of the Marshall Space Flight Center.

Mr. DADDARIO. There are numerous technical questions, which we will leave to the staff, Mr. Holmes.

Mr. HOLMES. Yes, sir.

Mr. DADDARIO. Are there any other questions?

Mr. FULTON of Pennsylvania. Are all these utility installations needed now?

Mr. LOW. They are in support of the building program that we have just described.

Mr. DADDARIO. We only have a short time, gentlemen, but I would like to get into the Michoud plan, if we could. Would you proceed with the "Additions to the Production Facilities"?

Mr. SMOLENSKY. In 1964 we are requesting here a total of $6 million to provide for support servicing building, mezzanine cafeteria, central maintenance shops, increased master substation capacity, and several test facilities, including a hazardous test facility for the Saturn I stage, hydraulic test facilities, and structural facilities, plus additional test positions for the distress coding facility for the Saturn I program, plus functional checkout control room conditions.

It is a general buildup that is required to meet our requirements for the production of the S–I stage at Michoud.

Colonel GOULD. There is a new engineering building, I understand, to be built at Michoud which will be about 500,000 square feet. That is as a result of a reprograming action in the amount of $10,150,000 from fiscal year 1963 funds.

My question is: When the new engineering building is completed, why can't the existing engineering building be used to accommodate much of the support activities that you plan for the support service building?

Mr. DIAZ. The people who are moving into the engineering building that is now in process are those who are in leased space in town or who will be coming in.

Colonel GOULD. You have people in leased space?

Mr. DIAZ. These are the contractors' people.

Mr. LOW. The Boeing and Chrysler people.

Mr. HOLMES. Not only are they in leased space, they are in leased space that is a half an hour away. We are trying to rectify that situation.

Colonel GOULD. You indicate that the support service building is going to house reproduction, photographic and communications functions, and 36,000 square feet will be required. Couldn't part of the administration building be used to accommodate part of the support service?

Mr. SMOLENSKY. I think our buildup for the use of that building is well committed, and it is needed in addition to the other building.

Mr. DIAZ. Yes, that is correct. This is in line with the buildup.

Mr. SMOLENSKY. This planning on the Michoud plant has been very thoroughly laid out.

Colonel GOULD. When I was down at Michoud not too long ago, it was indicated that the plans for the utilization of the existing administration building had not really been firmed up, and that is the reason I am exploring this point.

If you do not have a utilization plan to fully use the existing administration building when vacated, I think this should be done before a new support service building is programed. Would you comment on that, please?

Mr. HOLMES. Yes, I would be glad to. I am surprised to hear that comment, because, as I think you know, we are presently going ahead with plans to build an office building to house personnel on our Government-owned land there. We haven't anywhere near enough space to accommodate the men necessary to do this job. In justifying that office space to me, they presented detailed charts of floor areas that might be available or might be modified to accommodate personnel, both Chrysler and Boeing as well as our Government employees. The plan appears to be very well thought out. Further, it drew a very sharp conclusion that we just did not have very much space.

Colonel GOULD. With the chairman's permission, all we would need is a utilization plan or a detailed narrative indicating the contemplated use of the existing administration building after the new one is completed.

(The information requested is as follows:)

The projected buildup of office-type personnel at Michoud is such that both the existing administrative building and the new engineering and office building are needed to meet office space requirements (see office space requirement chart attached). At present, there is a definite deficiency of office space for administrative-type personnel at Michoud. The new building is needed to accommodate the additional personnel that will be added by the contractors to meet production schedules.

Michoud operations—Office space requirements

Facility	Office space (net square feet) [1]	
	1964 (December)	1965 (December)
Administrative building	[illegible]500	60,500
Engineering building	[illegible]30	77,250
Computer building	[illegible]0	9,000
Clairborne Towers (leased)	[illegible]50	
Allen Towers (leased)	208,000	
New engineering and office building		400,000
Total space available	394,400	546,750
Office space requirements	558,000	546,750

[1] Net area excludes walls, toilets, stair wells, vaults, equipment, and special purpose areas.

With regard to the central maintenance shops which are included in this project, which contractor is going to use these maintenance shops?

Mr. DIAZ. Mason Rust.

Colonel GOULD. What does his contract consist of, please? What are his functions?

Mr. SMOLENSKY. Mason Rust has the function there of actually maintaining the complete plant and providing all the support service in terms of maintainance of utilities and security and operating the plant as such.

Colonel GOULD. Is Mason Rust also a manager of construction at this site?

Mr. HOLMES. They have managed some incidental modification-type construction. I don't believe they have been given the responsibility to manage any new additional structures. If they have, I am not aware of it.

Mr. DADDARIO. How did Mason Rust receive this maintenance contract, Mr. Holmes?

Mr. SMOLENSKY. The original contract was based on a competitive proposal.

Mr. DADDARIO. Would you get the details for us?

Mr. SMOLENSKY. Yes, sir.

Mr. HOLMES. Our philosophy was that it would be in the best interest of the Government to have a contractor do the housekeeping, the maintenance and to provide this service to the production contractors, Chrysler and Boeing in this case. We went out on a competitive basis to get such a contractor. The part I am doubtful about is whether there have been extensions to this contract and whether they were competitive and so forth. We will get that for you.

(The information referred to is as follows:)

The Mason-Rust Co. was selected on open competition for negotiation based on 36 proposals received from industry. Their selection was based on best qualification for required services and the maximum advantage to the Government from the standpoint of cost. Their function is to provide general support service, plant engineering, maintenance, repair and alterations, and coordination of stage contractors' equipment installation and necessary plant modification.

Mr. WAGGONNER. Mr. Holmes, we can compare this hazardous test laboratory here with the hazardous operational laboratory that we are going to build at Huntsville?

Mr. HOLMES. No, we can't. The two facilities are different types.

Mr. SMOLENSKY. Actually, in any of the fuels that we use and the components that are used, they will have to be undergoing tests, and they are hazardous. There is certainly some comparison in the type of hazard, and we are using the same types of hazardous equipment. This is for the Saturn S–I stage, and the contractor must have a hazardous teststand where he can test any new product on improvements and where he can also conduct quality assurance tests and qualification tests.

Mr. HOLMES. If I can interrupt a moment. The reason I said they were not comparable is that the one at Huntsville was hazardous because of firings, explosives—pneumatics, and so forth. It is hazardous to the things that go into the building of the vehicle and the testing.

Mr. FULTON of Pennsylvania. When we hear that there are 27,000 vehicles at the Marshall Space Flight Center going in and out each

day and when we see the need for new Government construction at these various installations, it does bring up a policy question. In industrial management when there is too great a concentration, we get various levels of extra things that are needed simply because of the concentration.

In the U.S. space program, one of the criticisms is that it is becoming too concentrated in certain areas, and that activities that could be spread around the country are nevertheless being concentrated. This criticism is that not only scientists but engineering talent is being drawn from the rest of the country at high rates of pay from other activities of industry which are essential to the economy of the United States.

My question is this: After having been at Marshall Space Flight Center and a number of these installations, why isn't some of this research and testing contracted out to private industry so that there is a larger apread of this work around the country? I have seen at some of these installations what I would call research of a basic nature on tensile strengths, items of that kind, which to me have no reason for being closely allied to an industrial manufacturing and assembly process.

Have you made a review to see how you could spread some of this terrific concentration on research and development around the country without adding to the cost of the program? Secondly, have you made a survey to see whether private industry could better handle many of these functions instead of this tremendous Government building program?

I wish you would put that in the record for us rather than answer it now.

Mr. HOLMES. Yes, sir.

(The information requested is as follows:)

NASA has surveyed the capabilities of industry for each of our major programs and has made maximum use of existing contractor facilities. The Government is providing facilities for contractor use only where suitable facilities do not exist. The facilities requested at the NASA centers are considered minimal to provide the technical competence necessary to administer and technically direct the research and development projects assigned to them.

It is NASA's policy to perform research and development projects through contracts with private industry whenever possible. At the present time more than 90 percent of our current program funding will go to the various contractors throughout the country. NASA has studied and will continue to study ways to distribute the research and development projects throughout the Nation, consistent with the program needs and available funds.

Mr. DADDARIO. Any further questions?

Mr. WAGGONNER. Off the record.

(Discussion off the record.)

Mr. FULTON of Pennsylvania. I would like this on the record. I think we must look at the overall impact of this concentration on the U.S. economy. We must consider the training of the industrial management talent, the scientific and the research talent as well as the engineering talent for many other worthwhile activities in our U.S. economy. After all, it isn't all just space. We must see that, as my position is, since the space program is becoming so big that it is

almost a way of life, every U.S. citizen should get a chance to share in it as well as every locality. I am against the basic tenet of Mr. Waggonner, that we should concentrate the steel industry, the aluminum industry, the copper industry, or space industry.

Mr. DADDARIO. Any further comment, Mr. Waggonner?

Mr. WAGGONNER. We have got room to grow.

Mr. DADDARIO. This committee will adjourn until tomorrow morning at 10 o'clock in the same room, when we will proceed with parking and security improvements.

(Whereupon, at 12:30 p.m., the subcommittee adjourned to reconvene at 10 a.m., Friday, May 3, 1963.)

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1964 NASA AUTHORIZATION

FRIDAY, MAY 3, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON MANNED SPACE FLIGHT,
Washington, D.C.

The subcommittee met, pursuant to recess, in room 356, Cannon Building, at 10 a.m., Hon. Emilio Q. Daddario presiding.

Mr. DADDARIO. The meeting will come to order.

Yesterday we had just finished the additions to the production facilities at Michoud. We will begin today with the parking and security improvements.

STATEMENT OF GEORGE M. LOW, DEPUTY DIRECTOR (PROGRAMS), OFFICE OF MANNED SPACE FLIGHT, NASA; ACCOMPANIED BY WILLIAM E. LILLY, DIRECTOR, PROGRAM REVIEW AND RESOURCES MANAGEMENT; RODOLFO A. DIAZ, ASSISTANT DIRECTOR FOR FACILITIES, PROGRAM REVIEW AND RESOURCES MANAGEMENT; STANLEY M. SMOLENSKY, DEPUTY DIRECTOR OF LAUNCH VEHICLES AND PROPULSION; ADELBERT TISCHLER, ASSISTANT DIRECTOR FOR PROPULSION; CAPT. ROBERT F. FREITAG, DIRECTOR, LAUNCH VEHICLES AND PROPULSION; AND CAPT. JOHN K. HOLCOMB, ASSISTANT DIRECTOR FOR LAUNCH OPERATIONS, LAUNCH VEHICLES AND PROPULSION

Mr. LOW. Yes; Mr. Chairman. Mr. Smolensky, who is Deputy Director of the Office of Launch Vehicles and Propulsion, will again handle this this morning.

Before we get started, I would like to introduce Capt. Robert F. Freitag, who is the Director of the Launch Program, who has joined NASA within the last month or so.

Mr. SMOLENSKY. We are on page CF 10–15 and under the title "Parking and Security Improvements" we are requesting $610,000 to provide security roads, security lighting to serve the Michoud plant.

Mr. DADDARIOS We will move on to the project—"Road and Airstrip Rehabilitation," CF 10–1B.

Mr. SMOLENSKY. Here we are requesting $760,000 which provides for the rehabilitation of the main plant roads, a portion of the runway and construction of an airstrip to support the deliveries of the S–I and the S–1C stage deliveries.

Colonel GOULD. You indicated that you are only going to rehabilitate a portion of the airstrip?

Mr. SMOLENSKY. Yes.

Mr. DIAZ. We are going to rehabilitate the entire airstrip.

Colonel GOULD. The justification indicates rehabilitation of the entire strip. What types of aircraft do you propose to fly in and out of Michoud?

Mr. SMOLENSKY. We are considering small aircraft to support the emergency supply of critical materials and small parts in support of the manufacturing contract.

Colonel GOULD. Do you have any estimate of the volume of fixed-wing aircraft that will use this runway?

Mr. SMOLENSKY. No. I might say that primarily this airstrip will be used to move the stages to the docks.

Colonel GOULD. This is from the plant down to the barge loading dock?

Mr. SMOLENSKY. Correct.

The rehabilitation of the strip, must provide for the weights of the stages to be moved over the strip. We are talking about a 300,000-pound dry weight S–IC stage, and 25,000-pound S–I.

Colonel GOULD. Most of the air shuttle service in the general area such as from New Orleans airport, from Slidell and the Mississippi Test Facility, will be primarily by helicopter, will it not?

Mr. SMOLENSKY. We are considering both helicopter and small-type aircraft.

Mr. FUQUA. How many flights per day, average traffic, do you expect that this runway will use? It is not going to be used to any great extent, is it?

Mr. DIAZ. It is anticipated that the number of flights will be rather limited. We expect only cargo and administrative aircraft to use the strip.

Mr. FUQUA. Couldn't you use the airport at New Orleans, that is only 10 miles away, since there will not be a lot of traffic coming in and out?

Mr. DIAZ. The New Orleans Airport is about 10 miles distant with a 45-minute travel time each way.

Mr. FUQUA. If you are not going to have much traffic coming in, and the cargo is limited, time is not going to be of the essence.

Mr. LOW. Mr. Congressman, one of the main features of an airstrip like this one adjacent to a plant is in connection with the last minute changes, repairs and so on on the launch pad at Cape Canaveral. We have found in our tests (I know in the past for example at 2 o'clock in the morning during checkout of the stage before a launch) that one critical piece has malfunctioned and a check indicates that back at the factory a piece is available.

It is in those cases that the time element from getting to the plant down to the airport down to the skid strip at Cape Canaveral down to the missile is important.

I know it has happened in the Saturn program and in the Mercury program.

Mr. FUQUA. You are probably going to need one up around complex 39 at Merritt Island. It is a long stretch from the skid strip at Cape Canaveral to Merritt Island, and will probably take you 40 minutes to get there.

Mr. LOW. It probably will.

Mr. DADDARIO. You certainly could use helicopters.

Mr. LOW. To the main airport?

Mr. DADDARIO. We are talking about the rehabilitation of an entire airfield for what seems to be limited use. Have you looked at a cheaper way to do this? If you are going to use it just in this limited way, is there some way to rehabilitate the field for this kind of use? It seems quite doubtful to me that we should spend this kind of money just to take care of a remote possibility. I doubt if we ought to gear up our whole program for something that might happen at 2 o'clock in the morning.

Mr. SMOLENSKY. Sir, as I mentioned, there are two reasons for this rehabilitation, and I think we are overlooking the primary one. We have an available airstrip that needs rehabilitation and will form part of the roadway for moving these very heavy stages down to the dock.

Mr. DIAZ. Under any circumstances at least half of the airstrip will require rehabilitation.

Mr. DADDARIO. How wide is the airstrip as it now stands?

Mr. DIAZ. As I recall the airstrip is about 150 feet in width.

Mr. DADDARIO. How much would you need for a roadway? 20 feet?

Mr. SMOLENSKY. Sir, the diameter of the stage is 33 feet in itself and then the overhang on the transporter.

Mr. FUQUA. How many tons does the stages weigh that you will be moving?

Mr. SMOLENSKY. 300,000 pounds, which is 150 tons itself, plus the transporter, so you do have quite a need for a hard-paved road.

Mr. LOW. As Mr. Smolensky pointed out it is not any one of the reasons that we have described that leads to the conclusion to request funds for the rehabilitation of the airfield, but the combination of the convenience for passenger transport in and out to the plant, the emergency providing of supplies, and the dual use of the runway as a roadway, has led us to the conclusion that rehabilitation of the field would be proper to request at this point in time.

Colonel GOULD. That portion of the runway which you are going to use as a road to move the launch-vehicles to the loading dock—could you not mud-jack the sunken slabs into proper elevation and patch the expansion joints and the cracks as a temporary measure? Will it accommodate the loading?

Mr. SMOLENSKY. Sir, I am not familiar with those details.

Mr. LOW. I am sure if the only purpose were to build this into a road, it could be done cheaper than the $760,000 that we are requesting.

Mr. DADDARIO. I think we ought to look into the possibility of an alternate and cheaper way to do this. You and the staff should get together on this. Any further questions, gentlemen? (No response.)

We will move along to the vehicle components supply building, CF 10–21.

Mr. SMOLENSKY. Here we are requesting $2,633,000 to provide storage of parts, subassemblies, production materials for the stage contractors, and the support contractor to support the S–I and the S–IC deliveries. The present plant layouts consistent with our production schedules indicate that the entire existing building will be required for manufacturing operations.

Mr. DADDARIO. Colonel Gould.

Colonel GOULD. There is an existing large building located on the southwest corner of the plant proper which was formerly used as a foundry. Why couldn't this building be converted temporarily for use as a vehicle component storage facility?

Mr. LILLY. We have included this building in our plans Colonel Gould, and I shall be pleased to provide you with the proposed use of this facility. Are you referring to the structure located on the east side of the plant?

Colonel GOULD. It is located on the southwest corner of the plant.

Mr. LILLY. I do not have the details before me; however, it is my recollection that rehabilitation of this facility approaches the cost of a new facility. As I also stated, there is a proposed use for this building.

Colonel GOULD. What is the basis for the requirement of 25,000 square feet, 100,000 square feet, and 75,000 square feet, respectively, to meet the contractors' needs?

Mr. SMOLENSKY. The S–I contractor is requesting 25,000 feet to store various components and subsystems to support his delivery schedule. These include the stub fins and engine skirts and turbine exhaust fairings and other components that he has coming in from vendors.

Fifty percent of the area he is asking for must be controlled for humidity environment during the storage of these items prior to his actual use of them.

Colonel GOULD. You say that the contractors have requested this much space. Have you checked into this as to the validity of the requirement?

Mr. DIAZ. The original request from the contractor was much higher. NASA reviewed and reduced the requirements to what is now before you.

Colonel GOULD. You can support these requirements based upon volume of storage?

Mr. LOW. That is correct.

Mr. LILLY. The actual amount that was requested for the S–IC was 200,000 square feet, which was reduced as a result of our detail studies.

Mr. SMOLENSKY. That is to 100,000.

Colonel GOULD. The main problem that comes to mind is that we have a main plant which encompasses some 43 acres under one roof, and then suddenly we need an additional 200,000-square-foot building to provide more storage. Is the main plant fully committed for manufacturing purposes?

Mr. SMOLENSKY. Yes. Actually, we have had an intensive study of the utilization of the whole plant, including all of the production and material flow schedules, and the results of this master planning for the plant indicates the need for this particular building.

Mr. FUQUA. I might say, Mr. Chairman, that the construction cost of this building is a little bit more in line than some of the other outrageous costs that have come before us. It still seems high, though.

Mr. LOW. We will provide justification of all construction costs this week.

Mr. DADDARIO. Will you look into this massive plant and determine if it is being adequately utilized?

Colonel GOULD. Yes, sir.

Mr. DADDARIO. We will move along now to Mississippi Test Facility, which begins on page CF–11.

Mr. SMOLENSKY. The Mississippi Test Facility is a complex that will be used for the acceptance testing of the S–IC stages and for the acceptance and developmental testing of the S–II stages. In fiscal year 1963 our budget amounted to about $71 million, and in fiscal year 1964, to continue the development of that facility, we are requesting a number of projects totaling $111,690,000.

Colonel GOULD. The legislative history for the Mississippi Test Facility indicates that in fiscal year 1962, $30.8 million was authorized. For fiscal year 1963 there were authorized or reprogramed into this facility $122.7 million. This brings the total authorized and reprogramed to date, $153.6 million.

How much of this prior authorization has been committed? How much has been obligated? When will the balance be obligated?

Mr. LILLY. The amounts, Colonel Gould, we would have to correct in detail to adjust to your numbers. In 1963, for instance, our authorization for this program by this committee was $92,500,000. This amount included $43 million, as I recall it, for the Nova stage facilities. As you know, in terms of our total availability, all of the funds that were authorized by this committee were not available to the Office of Manned Space Flight.

Our authorization within NASA as is stated in the budget book, for the Mississippi Test Facility has been $71,082,000.

The status of that money in terms of commitments and obligations as of March 31 was as follows: committed, $27,691,000; obligated $21,225,000. We expect to obligate the balance in the following manner. We expect to obligate $2,065,000 in April; $9,497,000 in May; $3,402,000 in June; $13,045,000 in July; $11,632,000 in August; $6,529,000 in September; and $3,687,000 in October.

Colonel GOULD. The $21 million that you show obligated—is this amount actually under contract or is it a case of the funds being committed to the Corps of Engineers only?

Mr. LILLY. These are funds which have been obligated to the Corps of Engineers. As you know the corps normally requires us to have the funds in their hands before they advertise for bids.

Colonel GOULD. In your construction status report for fiscal year 1963, you indicate $7 million in construction of facilities and $19.8 million in R. & D. reprograming from 1963 as part of the authorization of $92.5 million that you mentioned. What was the nature of that action?

Mr. LILLY. Those actions, Colonel Gould, concern themselves with the S–II facilities, which had not been previously authorized. Specifically the $20 million was for the S–II test stands. The $7.5 million was for the utilities required by putting in the S–II stands. The remaining $2.4 million provided for starting an electronics instrumentation and materials laboratory.

Colonel GOULD. The NASA strength for this site is included in the personnel summaries at Marshall, however they have not been broken out for MTF. Would you give us the personnel strength plan for this facility?

Mr. LILLY. I do not have the actual number of people programed, for MTF proper. The numbers I do have reflect total personnel requirements through fiscal year 1968, broken down into numbers requiring administrative space, and so forth.

The actual numbers identified for MTF out of the total for the Marshall Space Flight Center, I would have to supply.

Colonel GOULD. The budget book does not break it out. I think it should be provided.

Mr. LILLY. There is a continued shifting of people from Marshall Space Flight Center such as Dr. Heimburg's test division personnel relative to criteria and design for test facilities. Captain Fortune's actual staff there I would have to get for you.

(The information requested is as follows:)

Within the MSFC, test division, personnel breakdown in the fiscal year 1964 budget submittal, the following personnel staffing is programed for the Mississippi Test Facility:

Fiscal year 1962	0
Fiscal year 1963	20
Fiscal year 1964	100

Below is the total personnel staffing requirement for MTF through fiscal year 1968:

	Fiscal year 1963	Fiscal year 1964	Fiscal year 1965	Fiscal year 1966	Fiscal year 1967	Fiscal year 1968
NASA	20	100	130	145	160	160
Contractor and other	13	267	1,575	2,540	3,300	3,300
Total	33	367	1,705	2,685	3,460	3,460

Colonel GOULD. When you are programing for facilities at a given site, it must be based on a certain number of people.

Mr. LILLY. Colonel Gould, our total personnel estimates, which form the basis for our facilities requirements, up through fiscal year 1968, are 3,460 people. The total number requiring housing is 2,831. The total requiring office space is 930. The total amount of planned office space is 89,317 square feet.

Mr. DADDARIO. If we could proceed, then, to the Advanced Saturn, (First Stage) the Static Test Facilities on CF 11–2.

Mr. SMOLENSKY. Our plans for this S–IC complex and our requirements include the need of two actual test stands, which are dual-position test stands.

In fiscal year 1964 we are requesting $35,983,000 to complete the first test position of one of these dual-position test stands; plus the attendant test control center, the stage storage buildings, the observation bunker and guardhouse, and canal, roads, and utilities.

Colonel GOULD. What is the relationship of the S–IC test stand being built at Marshall and the one being built at MTF?

Mr. SMOLENSKY. The one at Marshall is a developmental test stand that will be used continuously for the all-systems developmental program at Marshall.

The S–IC test stand being used, or built, at MTF will be for the actual acceptance testing of the stages manufactured by Boeing.

Mr. LOW. Another way to put it is an early version of the launch vehicle will be tested at Marshall on the test stand. This is a developmental test, you work out the bugs on a stand of this type. Each one of the stages to be made at Michoud will be acceptance tested or test fired before launch at the Mississippi Test Facility.

Mr. DADDARIO. They are the same type of facilities; are they not?

Mr. Low. At the Marshall stand there would be considerably more instrumentation and flexibility than at the MTF stand.

Mr. SMOLENSKY. One is a R. & D. stand, and the other is an acceptance testing stand.

Mr. DADDARIO. It is a label that you put on them, but they both can perform the same function. One may be able to do it to a greater degree, but they fundamentally involve the same kind of construction and testing equipment; do they not?

Mr. SMOLENSKY. The amount of testing equipment that is used in the development stand would be of a higher order and more than you would necessarily need for acceptance testing?

Mr. Low. I think, to answer your question, Mr. Chairman, the work to be done at MTF could also be done at the Marshall stand. The opposite is not true, because the Marshall stand would be better equipped, with more instrumentation.

Mr. DADDARIO. Why isn't it all done at Marshall? What is the reason behind the construction of the extra facilities, how does it fit into the program, and why is it necessary?

Mr. SMOLENSKY. The all-systems vehicle that we are using on the S–IC stands at Marshall will be subjected to continuous checking throughout the life of the S–IC stage. This is a vehicle that is patterned after the flight vehicle, and is a vehicle on which we test any modifications or any improvements. Also, if we do run into problems on the actual operational vehicle, this is the one ground test stage that we keep at Marshall for furthering our R. & D. program, and the improvement of the stage, itself.

It will be continuously tested from the standpoint of improving the reliability of the components, and gaining history on the operation of the components. Also, you will find in all of our development-stage programs, that we have an all-systems test stage that is used throughout the development program, and also the production program.

Mr. DADDARIO. Maybe I just don't understand this, but you have given a good explanation as to why you need the test stand at Marshall.

Why do you need this at MTF and why can't it all be done at Marshall? Why, for example, if you do need both of them, don't you take into consideration the training of personnel in this kind of business; why isn't it all at one place?

Mr. Low. We could have built additional test stands at Marshall for the acceptance testing, but this would mean that the stages manufactured at Michoud would have to be barged up the river to Marshall, and then tested at Marshall, and then they would have to be sent from Marshall to the cape. The added time involved in this operation would actually be a day-by-day delay factor in the manned lunar program itself. A secondary factor is the amount of testing that can be done in the Marshall area, because of its proximity to Huntsville, as opposed to the amount of testing that can be done at the MTF where we have a tremendously large area which will be uninhabited during the tests.

Mr. DADDARIO. Turning that around and again considering the training of the personnel, why isn't it all done at the Mississippi Test Facility?

Mr. Low. Two reasons for that, Mr. Chairman.

The first one is that the test stand at Marshall is on an earlier schedule, I believe, than the one at MTF. The developmental testing has to start earlier than the acceptance testing. We could not have built a test stand at MTF as early as the one at Marshall, because the land was not available, and the area was undeveloped.

The second reason there is that the type of testing done at Marshall is done by research and development people. They are the engineers that, on a day-by-day basis, check out modifications in the vehicle and so on. The testing at Mississippi is done by production people. They are the people who have produced the stages, the Boeing people; they now test fire once or twice before shipping to Cape Canaveral for a launch.

They are different kinds of testing.

Mr. Daddario. One of the reasons you have them at two separate places, then, is simply because of the progress that the program has made over the past year. It just happens that you have built one at Marshall and have it there.

Mr. Lilly. There was a very conscious decision and study of this question at the time we decided to build this stand at Marshall, Mr. Daddario.

Permit me to go back in history. The Marshall stand was originally designed to test what we called the C–3 vehicle, which had an entirely different configuration from our Saturn V vehicle. Therefore, at the time the decision was made to proceed with the Saturn V vehicle the alternative actions of proceeding with a Marshall stand as opposed to suspending construction at Huntsville and proceeding with a new facility at MTF were analyzed in detail. Our studies led to the conclusion that time was an overriding factor. Therefore, the decision was made to proceed with construction of the Huntsville facility since it would be ready to accept the first ground-test article during the early part of calendar year 1964. On the other hand, a test stand could not be made available at MTF within the same time frame.

Mr. Smolensky. May I add to that, Mr. Daddario. As I mentioned before, our plan here for this complex visualizes two dual-position stands, and at this point in time we are attempting to complete this first test stand. The overall program schedules were examined very thoroughly in terms of determining our requirements for these test stands, and they are all required, if we are to meet our schedules.

Mr. Daddario. I understand it is the position of NASA that they are all required. That is quite obvious, because you are asking for them.

I am trying to find out why they have to be in different places. It seems to me, that the kind of personnel involved in this would perhaps be better concentrated and more efficient if located in one place. That seems to be the situation from the nature of the answers to the questions.

It boils down to a situation in which we find ourselves having one facility more readily available simply because of circumstances. Isn't that about the size of it, Mr. Low?

Mr. Low. Yes, sir. There is, as you point out, the convenience of time—I shouldn't say the convenience of time, but the fact of time, we needed one stand early; only Marshall was available.

In the area of location, it would not make sense to put the production stands at Marshall because of the distance of transportation and because of the noise generated by these tests, and the continued amount of testing that must be done in the acceptance tests. These reasons together lead us to the requests that we have made.

Mr. DADDARIO. As you look ahead through the years, and taking Mr. Lilly's point of view on the adjustments in thinking you had to make in the development of the Marshall Test Facility, is it possible that we will be able to eventually concentrate this kind of activity at one plant—at MTF, for example—and have a saving, notwithstanding the fact that we do have the test facility at Marshall. Aren't we eventually going to give up some of these and concentrate the manpower in one place, thereby reducing the maintenance and other costs?

Mr. LOW. Our attempt is to go in that direction where it is at all possible or feasible.

Mr. DADDARIO. Is that a possibility in this instance?

Mr. SMOLENSKY. I would like to comment about the fact that Marshall Spaceflight Center is essentially a research and development organization, therefore the test stand we have there will be continued in support of the development program.

Here you are talking about test stands to support the production program of articles coming out of Michoud.

Mr. LOW. I think to answer your question more specifically, Mr. Chairman: That if the Mississippi Test Facility had been in existence, we probably would not have started the stand at Marshall.

Your points would have been the overriding factors, and we probably would have put all the development and production stands at Mississippi.

Mr. DADDARIO. The fact that you have labels on these things as research test stands and development test stands is not so important when you consider the statement you have just made. It is a bind in which you get caught occasionally.

Mr. LOW. It is a consideration, but it is not the most important consideration.

Mr. DADDARIO. Following that through logically, the time can come when, despite these labels that are put on them, we can concentrate the activities where the facilities can take care of both research and development?

Mr. LOW. Yes, sir.

Colonel GOULD. There is an item in the cost estimate for this project on page CF 11–12 indicating "Test Stand Deflectors" for $1,875,000.

There was an item in the 1963 program for $1,500,000.

How many test stand deflectors are we buying for $1,875,000?

Mr. SMOLENSKY. Two.

May I explain something? We feel that this item on page 11–11 should have been more appropriately carried in the 1963 program under the equipment instrumentation and support systems.

Colonel GOULD. Could have been more appropriately carried?

Mr. SMOLENSKY. Yes——

Colonel GOULD. Do you mean it should have been under the 1963 column?

Mr. LOW. Yes; under the 1963 column.

He is talking of the $1.5 million item in 1963, test stand deflectors. These are the same type of items that for fiscal 1964 are budgeted not

under "Facility construction and modification," but under "Equipment instrumentation and support items."

Colonel GOULD. How many did you buy in fiscal year 1963 for $1.5 million, and how many are you buying in fiscal year 1964?

Mr. DIAZ. Colonel Gould, we are programing for a total of two deflectors, one for each fiscal year.

Colonel GOULD. Has there been a $375,000 increase since fiscal year 1963?

Mr. SMOLENSKY. We are also including in the 1964 the installation of both of them.

Colonel GOULD. That answers my question.

I note you are asking for a stage storage building for $1,415,000. What is this for?

Mr. SMOLENSKY. This is in the operation of the test stands, the actual stages will be delivered to these buildings. They will be stored here, prior to the test. They will be taken here after the test for any reexamination.

Colonel GOULD. Please define the purpose of the item "Adaptation Hardware" for $520,000?

Mr. SMOLENSKY. This is the equipment to attach the stage to the load frame, the actual adaptation hardware on the stand.

Mr. PATTEN. This fascinates me.

If these things cost millions of dollars and you have one at Marshall; how long do you let the boosters stay on the stand?

Say the one in Mississippi, if you bring your first stage in, you have it out there testing it, how long will it take? A week? Three weeks? Six weeks?

Mr. LOW. I think we could probably explain that in terms of the stage—the first stage for the next Saturn to be launched this fall. This is the S–1 stage for the fifth Saturn flight.

On the acceptance testing of that stage, that was on the stand for about 6 or 8 weeks.

Do you know the exact time of that?

Mr. SMOLENSKY. Eight weeks.

Mr. LOW. So this is a time period that is taken in the acceptance testing of a stage.

Mr. SMOLENSKY. May I add something to that?

We are planning right now about four acceptance tests a year which take about 3 months. First the stage is mounted on the stand. Then all the necessary connections are made, including instrumentation connections, and checkout.

There are very elaborate checkouts for each and every step we go through, and then finally, prepare it for the actual run.

In our acceptance tests, we are currently planning to run two tests, short duration firing, and then followed by a longer duration firing.

Now, between the two tests, the stage would then have to be taken off and refurbished and put back on. It is quite an elaborate process.

Colonel GOULD. The next project is the Advanced Saturn Second Stage, S–II, Static Test Facilities, CF 11–14.

Mr. SMOLENSKY. Here we are requesting $19,148,000 to provide operable two single stage test complexes to test the second stage, the S–II stage of the Saturn V.

In fiscal year 1964 we will be providing for the second test stand static servicing, storage buildings, observation bunkers, guard houses, canals, roads, and utilities for the second stage.

Colonel GOULD. There have been a total earmarked in the fiscal year, 1962 and 1963 programs of $8.4 million for design and engineering.

According to the project description, the fiscal year 1964 increment will complete the S–II test complex at an estimated cost of $39.2 million.

The design and engineering services costs represent 27.2 percent. This is a very high cost for engineering.

Do you have any comment on that, please, Mr. Lilly?

Mr. LILLY. I don't quite follow your figures of $8.4 million for engineering and design.

Colonel GOULD. $3.4 million and $336,000 advanced design funds have been made available for this test facility.

In addition to that, the 1963 program authorized $3.4 million for design and engineering services, and the 1964 program seeks an additional $938,000.

This brings the total to $8.4 million for a $39 million project.

Mr. LILLY. The actual amounts which have been applied and are currently provided for design and engineering services are reflected in this book for fiscal 1963 which is $3,353,000 and $983,000.

The amounts shown for fiscal year 1963 took into account the advanced design funds which were allocated to this project.

Mr. LOW. This means that the total percentage is somewhat in excess of 10 and not 27.

Colonel GOULD. How much has been programed for design and engineering, including advanced design?

Mr. LOW. The amounts are $3,353,000 and $938,000.

I think that this averages out to about 11 percent, Colonel Gould.

Colonel GOULD. I notice that the deflectors for this stand cost only $575,000, whereas the ones for the other stand were $3 million for two stands.

Why is there a difference in these costs?

Mr. SMOLENSKY. You are talking different stages here. In the case of the S–I stage, you are talking liquid oxygen, RP fuels, and this is a liquid hydrogen stage, there are different levels of thrusts here, and there are entirely different requirements.

Mr. LOW. The thrust level of the S–IC stage, which had the more expensive deflectors, is 7½ times the thrust level of the S–II stage.

Therefore, we need a much firmer, bigger, more solid deflector for the S–IC stage.

Colonel GOULD. Are these test stand deflectors fabricated on the site, or are they bought from a manufacturer and shipped in as entities?

Mr. DIAZ. They are delivered to the site as an entity ready for installation.

Colonel GOULD. What is the average leadtime for a test stand deflector of this nature?

Mr. SMOLENSKY. We can supply that for the record.

(The information requested is as follows:)

Leadtime for procuring and installing the S–II deflector is as follows:

	Weeks
Leadtime for procurement (includes design, fabrication and delivery to site)	32
Leadtime for installation	21
Total time required	53

Mr. FUQUA. What is the difference in the test stands that you have in California, versus the ones that you have in Mississippi?

Mr. LOW. For the S–II stage?

Mr. FUQUA. Yes.

Mr. SMOLENSKY. At Santa Susana we have two S–II test stands. One is a developmental test stand for what we call battleship testing. That has a very high walled tankage to permit full duration firing of our engines to test and prove our propulsion system, and you will find in the case of the liquid hydrogen stages that we are making, we have a battleship stage for each one of these, because of the hazardous conditions of testing liquid hydrogen.

In addition, we have a developmental test stand there for the all-systems type of testing we described under the S–IC stage, which is essentially a flight-type stage wherein we check in great detail the functioning of the overall system.

At Santa Susana we do have the problem of being restricted to a limited amount of firing, due to the hazardous condition of this testing.

We call it short duration firing. We cannot fire this stand for its full duration.

For that purpose, we are projecting this second stand at MTF to be used for the all-systems testing, which will be a continuous support of our research and development program.

Mr. FUQUA. Why is it not possible to do all this in Mississippi, going back to the argument that Mr. Daddario had about the Marshall Space Flight Center?

Mr. LOW. Mr. Congressman, it is exactly the same problem that we had on the S–IC stage.

We must start testing on the S–II stage before the Mississippi Test Facility test stands will be available. This is being done at the test stands at Santa Susana.

As Mr. Smolensky pointed out, there is one other important difference, at Santa Susana we are limited to about 1-minute duration running time. We cannot fill the stage beyond this point because we cannot have more than that amount of hydrogen and oxygen in the stage at any given time at Santa Susana.

At Mississippi we will test the stages for the full duration, which is about 7 minutes running time.

Mr. GURNEY. Were the test stands at Santa Susana built especially for testing this stage?

Mr. SMOLENSKY. They were, yes.

Mr. GURNEY. Why couldn't they have been built at Mississippi?

Mr. LOW. It was again a matter of time.

The Mississippi test stands will come in too late in the program to allow us to do the initial testing which must be done if we are to maintain our schedules for this program.

Mr. GURNEY. The question I was asking was: Why didn't you build the test stands at Mississippi first, so you could have done the test firing that you are doing in California?

Mr. LOW. It is my understanding that the Mississippi facility is being developed as quickly as it possibly can—once we got the go-ahead to start work at Mississippi.

It was just physically impossible to build the stands there any sooner.

Mr. GURNEY. Is that because you hadn't gone ahead with the facility soon enough?

Mr. LOW. Because we didn't develop our master plan for the entire Apollo program soon enough. Which master plan includes the Mississippi test facilities.

Mr. GURNEY. Had you been able to do that, then you probably could have conducted these tests at Mississippi and eliminated those at California?

Mr. LOW. Yes, sir.

Mr. SMOLENSKY. There is also, Mr. Gurney, the problem that we, as a matter of principle, in trying to develop these items, attempt to have the engineering function and the test functions related or as close as possible.

In this case it is North American, the engineering is done at Downey, Calif., in Seal Beach, and it is highly desirable to have the test facilities at close proximity to the engineering facilities.

It is much like the R. & D. discussion we had on the Marshall Space Flight Center. Our plans call for a third test stand at MTF to augment our acceptance testing.

Mr. DADDARIO. Is it so highly desirable that it is the compelling factor when it is also so highly expensive?

Mr. SMOLENSKY. I am not saying it is the compelling factor. You can, of course, move people around.

In the case of the Boeing engineering effort on the S–IC stage, since there were no test sites near, we have a joint developmental program between Boeing and Marshall Space Flight Center.

Mr. LOW. The compelling factor, again, Mr. Chairman, was time.

Mr. DADDARIO. I think this ought to be taken into consideration, because when we are talking of facilities of this kind, Mr. Low, both Mr. Holmes and General Schriever have constantly referred to them as national assets, and that is because they are so expensive. They ought to be in one place, and they ought to be used by everybody for every possible purpose.

It seems to me that the sooner we can get over this problem of time and this question of desirability in items involving so much expense, we ought to consider them as national assets, and we ought to place them strategically in such places that they can be efficiently used by all agencies and industries under contract to Government.

Mr. LOW. We are in complete agreement with that.

Mr. GURNEY. I think you can probably make a fair statement that this particular one we are talking about, it may be true of others, has been made more expensive because you have a crash program on, isn't that correct?

Mr. LOW. We are in a program with a definite goal to reach the Moon before the end of this decade, and on these time scales we had to do the things we are now discussing.

Mr. DADDARIO. What is the inhibiting factor which limits the amount of test time at the Santa Susana plant? Is that a security precaution, or what?

Mr. LOW. It is a hazard precaution, Mr. Chairman.

If we completely filled the S–II stage at Santa Susana with hydrogen, liquid hydrogen, liquid oxygen, the explosive equivalent of that in case of a malfunction or in case of an accident could be so high as to endanger adjacent property, inhabited property. By only filling the stages partially, so that there is not a complete load of fuel in it, and therefore the burning time is only a fraction of the total burning time, we can minimize this explosive hazard and confine the hazard to within the test area of the Santa Susana facility.

Mr. DADDARIO. Will this still allow you to use this expensive facility to its complete extent?

Mr. LOW. As Mr. Smolensky pointed out, we can use the facility at Santa Susana for complete battleship testing. By that I mean we use heavy tanks.

There the explosive hazard is minimized. So far as doing developmental testing, the facility at Santa Susana is definitely limited and this will have to be done also at Mississippi.

Mr. DADDARIO. Does this mean as the program develops you will probably eliminate Santa Susana because you will be able to get better test use out of other facilities?

Mr. LOW. As you have urged us before, we will eliminate the use there for the S–II testing as soon as we have satisfied ourselves that the initial development testing that is being done there, and is being carried out by people who are now there, is finished.

Mr. SMOLENSKY. Our current plans for the use of the two test stands at Santa Susana do envision continuing battleship testing on the S–II stage and it also envisions component testing on the short-duration stand that we have, where we would have been using the all-systems testing.

The important thing here to remember is that this is the liquid hydrogen stage, and we do want to gain, as much as possible, reliability factors and confidence factors on this particular stage.

It is a very important stage to us. The more testing we can get on in these various stands is to our benefit.

Mr. DADDARIO. I understand that, and I think Mr. Low has given us the answer to it, because it does fill in a gap, and it does seem to me that we will get away as quickly as possible from an area which involves so much hazard.

You have a limit beyond which you can't go, and that must be a factor to be considered for the future.

Mr. FUQUA. Mr. Chairman?

Mr. DADDARIO. Yes.

Mr. FUQUA. Was this facility at Santa Susana constructed with the prior knowledge that you would only be able to do limited testing there, only battleship firings?

Mr. LOW. On the battleship firings, we can do full duration test runs.

Mr. FUQUA. Was the facility constructed with this large amount of funds expended for this facility with the prior knowledge that you couldn't use it to the fullest?

Mr. LILLY. No sir, it was not.

Actually, in our 1962 and 1963 budgets, we had full intent of using that for our tests, and that is why we had not programed in our 1963 facility for the S–II facility in Mississippi.

In the meantime, from the information that was developed in the decisions on the safety distance criteria, it was determined that we could not do it. That is why we had to use the reprograming authority in 1963 to get it started in Mississippi.

Our fee area at Mississippi is 13,500 acres, and we have approximately 128,000 acres of buffer zone around it.

Mr. DADDARIO. Any other questions, gentlemen?

(No response.)

Mr. DADDARIO (continuing). We will move to the project for the Bridge for the U.S. Interstate Highway No. 10, at a cost of $4,500,000.

Mr. SMOLENSKY. This project, which will provide for a four-lane highway and bridge, will also provide clearance via the river.

Mr. DADDARIO. We will move along to the project for the Control Center and Data Acquisition and Handling Facilities.

Mr. SMOLENSKY. In this project we are requesting $4,613,000, which will provide for the operable control and data processing facilities in support of the Advanced Saturn stages test program at MTF.

In fiscal year 1963, the structures were provided for three facilities, and in fiscal year 1964 we will be providing for the remainder of the equipment requirements developed to date.

Mr. DADDARIO. Any questions on this item, gentlemen?

(No response.)

Mr. DADDARIO (continuing). We will move along to Electronics, Instrumentation, and Materials Laboratory.

Mr. SMOLENSKY. In this project we are requesting $2,716,000 to provide facilities for the Measurement and Standards Laboratory, Photo and Video Laboratory, Electronic and Instrumentation Laboratory.

Colonel GOULD. The $2,437,000 that is shown in this project for fiscal year 1963 was not a specifically authorized item in the fiscal year 1963 program; was it?

Mr. DIAZ. No, sir. It was a reprogramed item.

Colonel GOULD. Did the funds come from construction of facilities or from Research, Development, and Operation funds?

Mr. LILLY. In this instance the required amounts were transferred from research, development, and operation.

Colonel GOULD. Would you amplify your remarks, Mr. Smolensky, as to the requirement for a laboratory at MTF when we have like facilities at Marshall?

Mr. SMOLENSKY. The laboratories here, we have three of them actually, are related first to the Electronic and Instrumentation Equipment Laboratory.

This is to service all of the transducer equipment and test equipment that we have on the various stands. There is a tremendous amount of electronic equipment that will be used throughout the Mississippi test facility area, and in order to service and repair and maintain it properly these are the laboratories that will be used.

Mr. LOW. These are meters, oscilloscopes, and test equipment that must be adjusted, updated, calibrated on each test to assure ourselves of the test results.

Colonel GOULD. So it is a repair and maintenance shop, rather than a laboratory; is that right?

Mr. SMOLENSKY. Yes.

Colonel GOULD. When is this facility actually needed?

Mr. LILLY. This facility is required to be complete by December of 1964.

Mr. DIAZ. It must be operational by the early part of calendar year 1965.

Colonel GOULD. Has the construction been started yet?

Mr. LILLY. No; it has not, Colonel Gould.

Colonel GOULD. What is the schedule?

Mr. LILLY. The schedule date for contract award of this facility is July of this year.

Mr. DIAZ. July of 1963.

Colonel GOULD. For this item?

Mr. DIAZ. No, sir; for the item reprogramed during fiscal year 1963.

Colonel GOULD. The fiscal year 1963 increment?

Mr. LILLY. The 1963 increment.

Mr. DADDARIO. Any further questions, gentlemen?

(No response.)

Mr. DADDARIO (continuing). If not, we will move along to F–1, the project for the F–1 Engine Systems Test Stand.

Mr. SMOLENSKY. Here we are requesting a total of $9 million to provide an operable test stand to support the tests of the F–1 engines in conjunction with the S–IC stage testing.

Colonel GOULD. Approximately $35 million have been authorized for the construction of five F–1 engine stands, plus supporting facilities at Edwards Air Force Base.

Also, at Marshall, $6 million have been authorized for the construction of an F–1 engine test stand.

These test stands were justified as research and production test facilities.

Why can't the facilities at Edwards and Marshall be used to meet this need?

Mr. SMOLENSKY. The test stands at both Edwards and at Marshall are committed to both the development of the F–1 and the acceptance testing of the F–1 engine, and this stand is a requirement to support the acceptance testing of a stage.

What we visualize here is five engines per stage. Our plans call for the need of a nearby test stand wherein if anything happens to any of the engines on the S–IC stand as it is being acceptance tested, it can be removed, and the S–IC stand provides for that, taken to the F–1 test stand, recalibrated, rechecked, and reaccepted, or if we do have to put on a totally different engine, we will be able to acceptance test it right on the spot and then put it into the stage itself.

It is in support of this S–IC acceptance testing exclusively, Colonel Gould.

Colonel GOULD. If you have spare engines on hand, why couldn't one that has been taken off be shipped to Marshall to be checked out and recalibrated?

Mr. SMOLENSKY. We do also have the F–1 engine stand at Marshall.

We believe it will be fully committed in support of the S–IC stage development testing that will be continuing, the all-systems testing at Marshall.

The tests we visualize fully utilize the stand at Marshall and our requirement for the stand at MTF is based on our schedules for the S–IC stage acceptance tests.

Colonel GOULD. You say that the testing volume is so great that the capacity of the ones at Edwards and at Marshall would not be able to absorb any additional testing.

What is this volume? What is the schedule?

Mr. SMOLENSKY. I do have that here.

We have planned it, we have planned the number of tests for each stand, both developmental tests and acceptance tests.

Mr. GURNEY. How many test stands do you have at Edwards?

Mr. SMOLENSKY. We have three test stands that we are building. We are using a total of five engine test stands and one thrust chamber test stand.

Mr. GURNEY. You mean presently you are?

Mr. SMOLENSKY. We are presently using two engine test stands and one thrust chamber test stand. And we are building three engine test stands.

Mr. LOW. We would be happy to go over the detailed schedule for this with Colonel Gould.

Mr. DADDARIO. I was going to ask, Mr. Low, if you would be kind enough to have it gone over with Colonel Gould and to also have it placed in the record.

(The information requested is as follows:)

Utilization of F–1 engine test stands

Location and stand	Number and type of engine tests				
	Calendar year 1963	Calendar year 1964	Calendar year 1965	Calendar year 1966	Calendar year 1967
Edwards AFB:					
Thrust chamber stand 2A	197 R. & D.	180 R. & D.	180 R. & D.	Continued testing; actual number of tests to be finalized.	
Engine stand 1A	150 R. & D.	97 R. & D.	72 R. & D. +QUAL.		
Engine stand 1B (2 position)	192 R. & D. +2 ACC.	153 R. & D.	168 R. & D.		
Engine stand 1C	----------	39 R. & D.	68 R. & D. +QUAL.	5 ACC.	12 ACC.
Engine stand 1D	----------	11 ACC.	13 ACC.	14 ACC.	12 ACC.
Engine stand 1E	----------	9 ACC.	13 ACC.	14 ACC.	12 ACC.
Marshall Space Flight Center: F–1 engine, stage development stand.	----------	S–1C stage development support effort [1]			
Mississippi test facility: F–1 engine, stage acceptance stand.	----------	S–1C stage production support [2]			

[1] S–1C stage development support to commence in early 1964 and continue during the life of the program on a nonscheduled basis as required.

[2] S–1C stage production support to commence in latter part of 1965 and continue during the life of the program on a nonscheduled basis as required.

Legend: R. & D.—Research and development testing. QUAL—Engine qualification from Nov. 19, 1965, through Feb. 19, 1966. ACC—Acceptance testing: The present contract covers delivery of the 1st 76 engines listed. The remaining 41 engines reflect current estimates for vehicle requirements.

Mr. GURNEY. Let's pursue that just a little further.

Since you have five test stands at Edwards, how long does it take you to ship these engines from California to, say Mississippi?

Mr. SMOLENSKY. I don't have the exact delivery time. I am sure that has been included.

Mr. GURNEY. It would seem as though if an engine needed to be recalibrated, somehow it could be——

Mr. LOW. The shipping time is about 1 week.

Mr. DADDARIO. These are things that Colonel Gould will look into.

Mr. LILLY. The engine trucking time from the west coast is approximately 1 week.

Mr. DADDARIO. We will move along to the project—"Maintenance Facilities."

Mr. SMOLENSKY. In this project we are requesting $5,987,000 to provide a test maintenance shop to maintain specialized facilities to support the test schedules.

Colonel GOULD. There was a supply and maintenance complex authorized in fiscal year 1963. Why cannot this be used to meet this requirement initially in lieu of building a new building for supply and maintenance?

Mr. LILLY. Both items are fully needed, Colonel. The status of the fiscal year 1965 item you are referring to is as follows: Design was completed in April, the advertising period will begin on May 10, and a contract award is scheduled to be made in June. However, the requirement for the fiscal year 1964 facility took into consideration the availability of the fiscal year 1963 project.

Colonel GOULD. How many vehicles are going to be located at this site requiring maintenance?

Mr. SMOLENSKY. May we furnish that to you, Colonel Gould?

(The information requested is as follows:)

There will be a total of 600 vehicles at MTF that will require maintenance. Below is a breakdown of such vehicles:

Standard sedan	60
Buses	45
Small trucks (½ to 1 ton)	215
Large trucks (1½ to 5 tons)	63
Special vehicles (such as ambulances, firetrucks, refuse trucks, wreckers, etc.)	12
Semiflat bed trailers	10
Tractor crawlers	5
Loaders	3
Cranes	3
Street sweepers	2
Road roller	1
Road grader	1
Forklift	24
Tractors	10
5-ton cranes	5
Miscellaneous type vehicles and equipment (motor scooters, concrete mixers, air compressors, battery chargers, etc.)	141

Colonel GOULD. Please supply that for the record and send me an advance copy for early review.

I notice that a marine maintenance facility is being provided. Is it NASA's plan to procure its own towboats and barges or will this be a contractual effort?

Mr. SMOLENSKY. We have a transportation plan, and it includes barges for stage delivery.

Mr. LOW. Captain Holcomb is the man who developed our transportation plan.

Captain HOLCOMB. We will have our own barges for our stage delivery.

Colonel GOULD. How many barges are you buying?

Captain HOLCOMB. I believe we are talking about six at this time.

Colonel GOULD. How about your towboat fleet; is this going to be contracted for, or are you going to develop your own towboat fleet?

Captain HOLCOMB. This will be a contractual operation.

Mr. FUQUA. You will just have a bed——

Captain HOLCOMB. Yes, sir; the barges will have to be specially configured. So far as the tug services are concerned, we will contract for those.

Mr. GURNEY. Have we tried to secure private barges to see if private companies can adapt their barges to handle this?

Captain HOLCOMB. We have obtained our barges out of the maritime service reserve fleet, and these we will configure especially for this purpose; they have to have special shelter, special protection.

Mr. GURNEY. What I asked was, have you contacted private concerns to see whether they could meet this need?

Captain HOLCOMB. I do not believe that they had contemplated going out to a contractor for these special configured barges to be contractor owned.

Mr. GURNEY. That ought to be investigated.

Captain HOLCOMB. However, it will be contractor operated.

Mr. DADDARIO. I agree, Mr. Gurney, that it ought to be looked into to see what the alternative prospects are. I think you should take that point up, Colonel Gould.

Captain HOLCOMB. I am sure, Mr. Gurney, that this was looked at initially. I am not at all sure why it was discarded. We will get that answer.

Colonel GOULD. How many barges do you now have in the fleet?

Captain HOLCOMB. I believe we have two at this point.

Colonel GOULD. Have they already been converted?

Captain HOLCOMB. Yes.

Colonel GOULD. What is the timetable on the procurement of the other five?

Captain HOLCOMB. I would like to furnish that for the record, Colonel Gould.

(The information requested is as follows:)

The barges were obtained from Army surplus in Charleston, S.C. They will be shipped to New Orleans this month where they will be refurbished and converted to be able to transport the cryogenics. The five barges will be operational January 1, 1965.

Colonel GOULD. Do you know what the cost of the conversion of these barges is?

Captain HOLCOMB. I do not have that information.

Colonel GOULD. Would you supply that for the record?

Captain HOLCOMB. I will, sir.

(The information requested is as folows:)

The cost of conversion of the five barges is as follows:

Propellant storage barges (2 at 93,000 gallons each)	**$1,100,000**
Propellant storage barges (3 at 20,000 gallons of liquid hydrogen each)	**1,500,000**
Total cost for conversion of the five barges	**2,600,000**

Colonel GOULD. You have a marine maintenance facility also planned for Marshall. Why do you need one at Marshall and one at MTF?

Mr. SMOLENSKY. If emergencies happen, we would need maintenance service at both places.

Colonel GOULD. We have all kinds of contractual effort available on practically every major river in the country that can do barge maintenance and repair work. The point is, why do we have to build into this system a maintenance capability when it can be done through contractual effort, and in view of the limited number involved?

Mr. LOW. We will have to reexamine the results of our studies here and discuss them with you later, Colonel Gould.

Mr. DADDARIO. I think that is a very good suggestion, Mr. Low, and it ought not be based upon an emergency. We cannot be running this whole program by building the facilities on the basis not of private industry in certain areas being able to do a job which it is already doing only because of the fact that they would not be available on an emergency basis. I do not think we ought to operate on that basis.

Mr. LOW. Yes, sir. If we may move along.

Mr. SMOLENSKY. The next project is on page CF 11-44 for a navigation lock. This lock is required in support of the river and canal system to allow transportation of vehicle stages to and from MTF.

Colonel GOULD. The lock proposed for the launch operation center at Canaveral is 90 feet wide by 400 feet. The one proposed here is 100 feet wide by 800 feet long. Would you comment on the difference?

Mr. DIAZ. The lock design at Cape Canaveral has been revised by the Corps of Engineers to provide for a 90-by-600-foot structure. The MTF lock design has been based upon standard lock configurations for the Mississippi, therefore this facility will be 110 feet wide by 600 feet in length.

Colonel GOULD. Would you secure from the Corps of Engineers, please, the reason for the difference in design at LOC and at Mississippi and provide it for the record?

Mr. DIAZ. Yes.

(The information requested is as follows:)

The lock proposed for the Mississippi test facility is 110 feet wide by 600 feet long. The lock now proposed for the Launch Operation Center at Cape Canaveral is 90 feet wide by 600 feet long.

The size of the MTF lock is a standard size in the Mississippi River Valley area. The size of the Cape Canaveral lock was originally based on the Intracoastal Waterway standard of 56 by 400 feet. Subsequently, because of NASA requirements, the width of the proposed lock was increased to 90 feet. After the width was changed the Corps of Engineers determined that the length should be increased to 600 feet to provide a lock comparable to the standard 86 by 600 feet lock as proposed in the cross-Florida Canal system. Consequently, the size of the lock being designed for Cape Canaveral is now 90 by 600 feet.

Mr. DADDARIO. Security control facilities.

Mr. SMOLENSKY. $657,000 to provide security control facilities for MTF including buildings at the north and south gates for control of entrance and egress from the area.

Colonel GOULD. What means of perimeter security will be provided around this site?

Mr. DIAZ. The perimeter will be patrolled.

Colonel GOULD. What are the construction and design leadtimes for this project?

Mr. LILLY. The design time for this project is approximately 6 months. With a construction leadtime of about 6 months. Our present schedule calls for completion of these facilities by November of 1964.

Mr. DADDARIO. If there are no further questions, we will move along to the sonic measuring facilities.

Mr. SMOLENSKY. We are requesting, here, $1,760,000 to provide facilities to analyze and determine whether the conditions will allow for safe testing of rocket engines or boosters. This is CF 11-52.

Colonel GOULD. A sonic measuring facility and an acoustical laboratory, I think it is called, has already been provided at this site in temporary facilities. Why cannot these facilities be continued in use for another year?

Mr. SMOLENSKY. May I supply that for the record?

Colonel GOULD. Yes.

(The information requested is as follows:)

The existing temporary sonic facility cannot be continued for another year for the following reasons:

(1) The existing temporary facility which was set up in a modified five-room residence was designed for the limited use of gathering a history of atmospheric sound propagation in the area for 1 year. The planned permanent facility is designed for much wider uses including—

(a) determining and predicting noise propagation;

(b) gathering weather and sound data to be used for scheduling rocket test firings under favorable weather conditions; and

(c) checking performance of equipment at various sound levels.

(2) The existing facility is currently housing equipment with capability of only one-tenth that required to simulate actual test firing conditions. The permanent proposed facility, therefore, has different and larger equipment needed for sonic measurement of actual firing conditions which will commence in October 1964. This equipment, therefore, could not be housed in the existing facility which is already overcrowded.

Mr. LOW. Perhaps Mr. Lilly could answer that.

Mr. LILLY. I think we would have to supply the details on this item. I believe that these temporary facilities were relocated from the Marshall Space Flight Center in order to initiate acoustic atmospheric studies which were required as a prelude to development of a master plan for the Mississippi Test Facility.

I believe that the facility is very preliminary. It is not the type of a facility which can satisfy a long-range continuing need. If you have been there, Colonel Gould, you will recall the small rig and associated small buildings which make up this facility.

Colonel GOULD. It is my understanding that these sonic measuring facilities are required at the site where testing is being carried on in order to determine the appropriate time from a standpoint of atmospheric conditions to fire.

Mr. LOW. That is correct.

Colonel GOULD. You couldn't use the facilities at Marshall to satisfy this need?

Mr. LOW. That is right.

Mr. DADDARIO. Transportation and parking facilities.

Mr. SMOLENSKY. This is page CF11-57, we are requesting $7,585,000 to provide roads, internal railroad system, and parking areas at MTF. It also includes provision for relocating State Highway No. 43.

Mr. DADDARIO. There are a series of technical questions which Colonel Gould will take up with your staff. We will move along with Utility Additions and Extensions.

Mr. SMOLENSKY. In this project we are requesting $6,559,000 to provide for utility and support requirements for the Saturn V stage test program at MTF.

Colonel GOULD. The fiscal year 1963 program authorized $13.5 million for utilities and support facilities. This project shows in your cost estimate only $8.7 million for utilities for fiscal year 1963. What happened to the other $4.8 million?

Mr. LILLY. The $13.5 million authorized in fiscal year 1963 provided not only for utilities but for support facilities as well. The $8.7 million represents the utilities phase of the fiscal year 1963 project only. It is presented in this manner in order to provide a complete picture of funds programed for utilities.

Mr. DADDARIO. Any further questions, gentlemen?

Mr. GURNEY. I wonder if they could furnish an answer for the record on that highway? I understand this facility is in a remote area with a lot of land. Why couldn't the site be pushed farther to the east, I think it is, or the west, whatever it is, and gotten out of that State highway that you are building of $2 million? Could you get that for the record?

(The information requested is as follows:)

The MTF test facility area (fee zone) could not be moved to the west or to the east without costing considerably more money than the $1,950,000 required to relocate State Highway No. 43. If the main test facility site were moved sufficiently to the west to avoid Highway No. 43, the whole town of Nicholson, would have to be acquired and its population removed. Besides the hardship inflicted on the people involved, the cost of such an operation would be considerably more than $2 million. In addition, U.S. Highway No. 11 would have to be relocated at a considerable cost.

Similarly, if the main facility site area were moved sufficiently to the east to avoid Highway No. 43, the following will be affected:

(1) The canal system used for transporting the vehicle stages and the cryogenics will have to be extended.

(2) The buffer zone must be extended to include the town of Kiln, Miss. The population of Kiln will have to be moved involving great hardship to the inhabitants as well as additional cost to the Government.

(3) The county road from Santa Rosa, Miss., to Kiln, Miss., will have to be relocated at a cost of approximately $300,000.

Mr. DADDARIO. This is one of the precise questions which Colonel Gould has on his list.

Proceed to "Warehouse additions and storage facilities."

Mr. SMOLENSKY. For this project we are requesting $2,318,000 to provide for warehouse storage facilities to store flammable materials and all supplies except booster related material.

Mr. DADDARIO. We will move along to "Waterways and docking facilities."

Mr. SMOLENSKY. In this project we are requesting $4,442,000 to provide for the means of transportation for materials, propellants, and stages to and from MTF.

Mr. DADDARIO. Any questions, gentlemen?

Colonel GOULD. Have advanced design funds from fiscal year 1963 been committed to this project?

Mr. LILLY. As a part of the statutory reprograming action that was forwarded to the committee we had intended and hoped to identify

approximately $283,000 for this item. I explained to you yesterday, Mr. Holmes is withholding actual authorizations to the center until we can study other shortages we are exercising, and thus balance our total requirements. We fully intend and hope that these funds can be made available for the early intitiation of design.

Mr. GURNEY. What draft do these barges require?

Captain HOLCOMB. I believe these are about an 8-foot draft. It requires about a 10- to 12-foot channel.

Mr. GURNEY. Deep?

Captain HOLCOMB. Deep, yes.

Mr. DADDARIO. Gentlemen, we skip over a little section here which is assigned to one of the other subcommittees, and move to "Various locations."

Mr. SMOLENSKY. The first project that pertains to our program is on page CF13–3.

Mr. DADDARIO. In the interest of saving some time in this whole area, we have a series of questions, and if it becomes necessary we will go over it item by item.

Colonel Gould, why don't you ask some questions on all of these various locations?

Colonel GOULD. On the F–1 program at Edwards, Canoga Park, and Santa Susana—prior authorization as shown in this book and as previously authorized differs by some $11 million. The total authorization is $48.9 million, and as shown in the 1964 books is $37.5 million, a difference of $11.4 million. This appears to be a great difference.

Were there any delays in the F–1 program that caused reprograming of these funds?

Mr. LILLY. Is your question, Were any delays incurred in the F–1 because of these?

Colonel GOULD. No, did any delays occur which caused this reprograming?

Mr. LILLY. No, in balancing our funds we obviously tied them to the scheduled requirements. Specifically, I am not familiar with any delay which brought about this situation, Colonel Gould. It is true that we had to balance our fiscal year 1962 supplemental request against the availability of 1963 funds, which as you know did not occur until October. However, I cannot recall specifically any delays in the F–1 program that caused this reduction.

Colonel GOULD. This $11.4 million was reprogramed to other needs?

Mr. LILLY. That is correct.

Colonel GOULD. All these facilities under "Various locations" are primarily for contractor plant, is this correct?

Mr. DIAZ. That is correct.

Colonel GOULD. De we retain title to all these facilities that we build at contractor plants?

Mr. LILLY. Yes, sir; we do. Wherever construct facilities on other than Government-owned land, there is a requirement that we have a long-term lease with an option to buy.

Colonel GOULD. What is your definition of a severable facility?

Mr. DIAZ. All those components above the substructure and foundations are considered to be severable.

Mr. DADDARIO. You mean by that anything that can be torn down and carted away?

Mr. DIAZ. Yes, sir; these items are considered severable.

Colonel GOULD. In reference to the H–1 engine production facilities shown on page CF13–12, does an agreement exist between DOD and NASA for the use of the Air Force facility at Neosho?

Mr. DIAZ. Yes, sir; it does.

Colonel GOULD. When this furnace that you propose to build here is put in operation who is going to operate it?

Mr. TISCHLER. It will be operated by the contractor.

Colonel GOULD. Is this a research and development facility or a manufacturing facility?

Mr. TISCHLER. It is a manufacturing facility.

Colonel GOULD. Who is going to design and build these facilities?

Mr. TISCHLER. I cannot be sure of that entirely. I believe the design would be by Rocketdyne on the basis of their past experience with similar facilities. The construction would be by some outside contractor.

Colonel GOULD. This is part of a negotiated contract rather than a competitive bid contract?

Mr. TISCHLER. I am not sure. I can supply this for the record.

(The information requested is as follows:)

It is anticipated that North American will do the engineering design work and subcontract out, on a competitive bid basis, the construction phase.

Colonel GOULD. Previously when we were talking about the F–1 stands at Santa Susana there were some indications that there were hazards involved in this area. I note at Santa Susana this year we are going to spend an additional $2.2 million in support of the F–1 engine program. Are we furthering a hazardous condition here by continuing to build facilities in a place where we know we cannot conduct full tests?

Mr. TISCHLER. I don't believe so in this case. These facilities at Santa Susana are primarily for component testing. These components do not require the use of large quantities of propellants as do the engine testing facilities.

Colonel GOULD. Are there like hazards existing at Canoga Park?

Mr. TISCHLER. None there to my knowledge, since this is a manufacturing and engineering facility primarily. There is no testing work at Canoga Park.

Colonel GOULD. The chairman brings up the point that you are expanding the liquid oxygen system at Santa Susana, and that was quoted as being one of the major hazards, and we are going to spend another $1.3 million to expand this system.

Mr. TISCHLER. The purpose for this is to add to the storage supply in the general west coast area. There is an oxygen manufacturing plant owned by the Air Force on the Santa Susana property, and the intent of this facility to expand the storage capacity at that plant.

Mr. DADDARIO. Are you limited——

Mr. TISCHLER. The storage facility does not involve a hazard.

Mr. DADDARIO. You are not limited in the amount of liquid oxygen you can store because of any hazard?

Mr. TISCHLER. No, sir.

Mr. LOW. The hazards I was referring to earlier was the testing in flight hardware stages.

Colonel GOULD. I have no questions on the H–1 engine. No questions on the J–2 engine program. I have a few on the M–1 engine, Mr. Chairman.

The history of the authorizing legislation for the M–1 engine program indicates that in fiscal year 1962 $13.8 million in R. & D. funds were earmarked for construction of contractor facilities, and in fiscal year 1963, $16 million more were authorized. This brings us to a total of $29.8 million available already for the construction of these facilities.

Now, it is my understanding that Aerojet has been operating under letter contract, and is still operating under letter contract pending signature on the final contract. How much of these prior funds authorized have been obligated?

Mr. LILLY. During fiscal year 1962, we notified the committees that R. & D. funds in the amount of $16,194,000 would be used for the construction of M–1 facilities. However, we did not use all of this authority. About $12.7 million was obligated, but, about $7.1 million of this amount was budgeted for test equipment which would not normally be included in a construction project except that in this instance we presented a total facilities package for R. & D. funding. Of the $13 million in this fiscal year, I believe there was the February or March final figures, where around $3 million had been obligated on it. I would have to get you the exact figures on that. As you know, we are holding up on definitizing that contract.

Colonel GOULD. The figures that I have, Mr. Lilly, indicate that the letter contract encompassed $13.2 million for the facilities, of which only $10.7 million have actually been expended. This means that the authorized $16 million for 1963, or as you have put it $13 million, have not yet been obligated.

Mr. LILLY. That is correct.

Colonel GOULD. So it appears as though you have a backlog in authorization of somewhere between $13 to $16 million. What effect on the overall program would there be if this $16 million requested for fiscal year 1964 were deferred?

Mr. TISCHLER. It would immediately have an effect on the scheduling of the development of the M–1 engine. The money appropriated for construction of facilities items in the 1962 and 1963 budgets covered the modification of facilities which are at the Aerojet Sacramento site. The 1964 money covers the investment or the construction of engine test stands, and these engine test stands are a limiting item.

Colonel GOULD. Are there no engine test stands available?

Mr. TISCHLER. No engine test stands available, per se, at the present time.

Colonel GOULD. Why do you say "per se"?

Mr. TISCHLER. I mean the engine testing will be done on the new facilities which will be constructed specifically for that purpose.

Colonel GOULD. Can an F–1 test stand be used to test an M–1 engine?

Mr. TISCHLER. With considerable modification it could. I can assure you that the F–1 test stands that we are constructing are very much needed for the F–1 program.

Colonel GOULD. In the contract that has been negotiated with Aerojet, how much is included for the construction of the facilities?

Mr. TISCHLER. There are in fact two contracts that have been renegotiated, one for the R. & D. portion of the work and the other for the facility portion of the work. I believe the contractor's figure for the facilities portion is $48 million total.

Mr. LOW. Mr. Chairman, since NASA has not yet signed this project, I don't think we can get, in open session here, into any further details of these facilities numbers.

Mr. DADDARIO. I think that is proper.

Mr. LOW. Insofar as the M–1 engine facilities are concerned, these match the investment program that we discussed here several days ago. It is our best judgment that this is a proper program for the future engine investment. But I think we discussed with you here several days ago that this is a matter of judgment.

Colonel GOULD. This is a 60-month program, according to the justification. When will testing reach its peak in the program, and how long will that peak last?

Mr. TISCHLER. The testing will reach its peak in 1965–66 era of time. That testing rate will continue to the point where the engine is used, of course.

Colonel GOULD. The project for the facilities for the S–IVB stage program, Douglas Aircraft in Santa Monica, page CF 13–27—I can find no specific authorization for the $1.9 million shown in this project for fiscal year 1963. I assume that these funds are allocated from R.D. & O.?

Mr. LILLY. That is correct. R.D. & O. funds were used under authority granted by section 1c of the authorization act.

Colonel GOULD. Just as a matter of clarification, Mr. Lilly, sometimes the construction of the contractor facilities will show up in the construction of facilities portion of the program, and sometimes they don't. Could you tell us what your policy is?

Mr. LILLY. Our present policy is that whenever we can identify a facilities requirement, sufficiently early in the programing cycle, it is included in a construction of facilities budget. However, if we do not foresee the need for facilities at a contractors' plant until late in the cycle, we use section 1c of the authorization act. If the cost exceeds $250,000 we must, of course, notify both the congressional committees.

As you know, facilities items costing over $50,000 are required to be included in a facilities contract which does not normally carry a fee; therefore, it is to our advantage to classify such items as facilities, whenever possible.

Colonel GOULD. In this project you show $500,000 for design engineering service, although the construction part of the project is only $1.3 million. This represents about 40 percent of the construction estimate which is excessive. What is the basis for the $500,000?

Mr. LILLY. The design and engineering category covers not only the brick and mortar but the equipment and instrumentation as well, which must be designed into a complete functional system.

Colonel GOULD. The next project I would like to ask a question on is the "Improvements to the RL–10–A3 test facilities," page CF–13–30. From the project description the existing facilities are apparently contractor owned but are recapture-type industrial facilities financed previously by the Air Force.

If this is the case, why is this project included in the construction of facilities program and not part of the R. & D. program?

Mr. LILLY. This, Colonel Gould goes back to the NASA policy I previously described; wherever we can identify an item in time to include it in the budget we do so.

Colonel GOULD. Would you define for the committee, please, what these test stand modifications, fuser modifications, gas storage modifications, and nitrogen system modifications consist of in general terms?

Mr. TISCHLER. This is a very difficult question to define without a considerable lecture on the facility itself. This engine needs to be tested in a simulated altitude condition because it is designed to be used at that altitude, and to produce such an altitude position while the engine is being tested requires the use of a defuser and a steam system. This is a part of the total facility requirement where we intend to improve the capability of this altitude simulated condition. We also have been running into a considerable problem of lack of adequate gas storage facilities in the operation of the gas at Pratt & Whitney presently, and we intend to expand that. The total amount of money involved in this is relatively modest, I should say.

Colonel GOULD. Is this part of the contract with Pratt & Whitney?

Mr. TISCHLER. This is not part of the CPFF work at Pratt & Whitney.

Colonel GOULD. Is this going to be let on a competitive bid basis?

Mr. TISCHLER. It probably will. I cannot be sure of this at the moment.

Mr. DADDARIO. Do any members of the committee have any questions on any of these facilities?

(No response.)

Mr. DADDARIO (continuing). We will move along to launch vehicle operations. I understand you have some sort of a film on this.

Mr. LOW. Captain Holcomb, who is the assistant director for launch operations in Captain Freitag's office, will handle the presentation on this, and I believe he has a short film on this, also.

Captain HOLCOMB. This is for the construction of facilities at the launch operations center at a total of $312,855,000. Of this, two of these items, the deep space network launch station and the satellite operations facility, have been defended before the subcommittees, one before Representative Karth and the other before Representative Hechler, for a total of 5.8.

The first item is the Advanced Saturn launch complex No. 39 at $217,219,000. The fiscal year funding for launch complex 39 provided one launch pad, vertical assembly building, transporter, and other ground support equipment and utility service.

The 1964 increment includes funds for site development, utility installing, the activation of the vertical assembly building, the second of three launch pads, the extension of the crawler transporter road way, ordnance storage facilities, arming tower, propellant service and distribution system, launch umbilical towers, and cabling. At this point I would like to show a 10-minute film which illustrates how all these components of the complex work together.

The NARRATOR. The magnitude of the manned lunar landing program has led to the evolution and adoption of a new launch operations concept. Because of the immense size of the vehicle to be used and the expected increase in required launch rate, a mobile concept

which separates vehicle assembly from launch has been developed. Separate stages of the launch vehicle and the spacecraft which will be received from barges and assembled in a central area. After checkout the assembled launch vehicle, spacecraft launcher, and umbilical tower which will be transported in a launch-ready position to the pad. C–5 stages which will be shipped to the Merritt Island launch area by oceangoing vehicles, arriving at the channel terminal, stages which will be rolled onto transporter and towed to the vertical assembly building.

This is the vertical assembly building in which the launch vehicle and the spacecraft will be assembled and checked out.

The three operational elements are a high bay area, a launch control center, and a low bay area. The high bay area is 52 feet high by 513 feet wide and 432 feet long. It contains four checkout bays. Each pair of bays is served by a 250-ton crane with a hook height of 456 feet. Each bay has four elevators to provide personnel access to the various levels of the bay.

Prior to the arrival of the first stage of the C–5 vehicle, the S–IC stage, the launcher umbilical tower is positioned in the high bay area of the building. The launcher umbilical tower on which the spacecraft will be assembled provides the base for actual launch and is designed for the temperature, stresses and vibrations of holddown in launch.

The platform is a steel structure, 25 feet high, 160 feet long, and 135 feet wide. It rests on six steel pedestals 21 feet high. An umbilical tower extends 380 feet above the deck. The S–IC stage will then be moved into the high bay area transfer aisle on its transporter, up to the 250- and 175-ton cranes and hoisted to a vertical position. The 250-ton crane will move the stage to the launcher umbilical tower. It will be lowered onto four launcher arms which are mounted on the top deck of the launch platform and will undergo testout.

The S–IC stage which in turn is integrated with the instrumentation in the launch control center. A high C data link is provided between the launch umbilical tower and the launch control center. This link will connect at either the vertical assembly building or at the pad above general office space on its first floor.

The launch control center provides telemetery check-out stations on the second floor. On the third floor are four firing rooms, one for each bay of the vertical assembly building. Each firing room contains an identical set of controls and monitoring system so that launch of the vehicle and checkout of the other vehicles may take place simultaneously.

Upon arrival at the Merritt Island launch area, the S–II and S–IVB stages will be transferred to the low bay area for checkout. This has eight checkout cells equipped with systems and operations in other States. A 175-ton overhead crane serves the transfer aisle between the high bay and the low bay areas.

The S–II and S–IVB stages will arrive at the vertical assembly building in a horizontal position on a specially constructed transporter. They will be pulled into a vertical position by the overhead crane and swung into the waiting base. The S–II and S–IVB stages will be stage tested separately in the low bay area. The electrical ground support equipment for stage checkout will be located in the control room adjacent to the checkout cells.

After approximately 4 weeks of extensive checkout the S–II and S–IVB stages will be ready for mating with the S–IC stage; also checked out and waiting in the high bay area of the building.

The S–II stage will be positioned in the center aisle for installation of the S–IC interstage adaptor. Following this the S–II will be moved to the high bay area and mated to the S–IC stage. After mating the various stages of the launch vehicle, the unit is ready for transportation to the pad.

The key to the mobile concept of complex 39 is the crawler transporter. This unit is 131 feet long and 114 feet wide. The electric main drive systems have four double jack crawlers.

These may be centrally steered or the front or rear trucks may be steered as pairs. The crawler can transport a maximum load of 12 million pounds and use hydraulic jacks to lift and lower its cargo. The crawler transporter moves under the launch umbilical tower, lifts it into position and moves out of the building onto the transport crawler way. The crawler transporter can move the launcher umbilical tower and the C–5 vehicle against constant winds of 40 knots and can negotiate turns of a 500-foot radius.

The crawler way is an especially prepared roadbed which will take a total load of 17½ million pounds. Average ground pressure under crawler tracks is 65 pounds per square inch. The crawler way is 100 feet wide and has a grade of 5 percent approaching the pad.

The launch pad area is designed for final preparation of the space vehicle for launching, including propellant and ordnance loading, final checkout and countdown. The pad area is roughly circular and is located approximately one-half mile from the ocean. The distance between the pads will allow each pad to function independently.

However, it will be necessary to clear personnel from the adjacent pad during an actual launch. The mean level of the pads is 6 feet above sea level. The center portion of each pad is elevated 42 feet above the grade. A pad terminal connection room is located underground adjacent to the pad. It will house electronic equipment which will provide a connecting link for communication and visual data by transmission lines from the launch communications center to the launcher umbilical tower. It will also serve as a distribution point for high-pressure gas and electrical systems.

Arriving at the launch pad, the crawler system will move the umbilical tower into position and lower it onto the steel pedestals. The position will be plus or minus 2 inches.

After the launch umbilical tower is positioned on the pad, the crawler transporter will move off the pad and try to position the arming tower. After preparations have been made the crawler transporter will move the arming tower into position beside the space vehicle. The structure is 415 feet high and measures 150 feet by 125 feet at its base. The top is approximately 80 feet square.

The tower provides 360° access to the vehicle, including platforms for ordnance installation and service access. A mobile 2-way steel frame deflector will be positioned under the center line of the vehicle 35 feet from the exhaust flame of the F–1. After ordnance installation, checkout and simulated test flight, the space vehicle is ready to enter the countdown stage of the launch operations. The tower will be withdrawn from the pad to a safe distance. Launch control

operations are conducted from the launch control center located more than 3 miles from the launch site.

Propellant loading of the Apollo spacecraft will be performed prior to T-minus-7-hours on launch day. At approximately T-minus-4-hours after the propellants are loaded, the astronauts will enter the spacecraft over the umbilical tower. The S–IC stage will be ignited.

During thrust buildup of the F–1 engine, the operation of each of these engines will be automatically checked. On confirmation, the mix and lift-off will occur. When fully operational the concept of separate checkout, assembly, and launch will give a la unch range of 3 to 1 over present operation procedures.

Captain HOLCOMB. The models that you see here along the side were the models that were used in taking the movie. They come apart at the top so you can see how they operate. The breakdown on launch complex 39 is at construction of facilities 6–28 at $217,219,000.

Mr. DADDARIO. Colonel Gould has some questions.

Colonel GOULD. Including supporting facilities previously programed, there has been a total of $444 million made available for this complex. I believe that about $48 million of this was for Advanced Saturn supporting facilities. The justification indicates that 40 percent of this complex was programed in fiscal year 1963 and 50 percent of it is being programed in fiscal year 1964. What is the total cost of this complex going to be?

Mr. LILLY. The total cost is still being refined, as we get our more definitive designs, Colonel Gould. Our current estimate indicates that it is going to run very close to a half billion dollars, $500 million. The exact figure we have on it right now is I believe $481,576,000.

Colonel GOULD. How much of this is already under contract?

Mr. LILLY. In terms of the amount on complex 39 that is obligated as of the 31st of March it was $18,881,000. Committed was $38 million. As you mentioned previously, sometimes when we turn the money over to the corps, it is not necessarily obligated in a contract at that point.

Colonel GOULD. When you say "committed," do you mean $38 million has been made available to the Corps of Engineers?

Mr. LILLY. Yes.

Colonel GOULD. And $18.8 million has been actually obligated?

Mr. LILLY. Actually obligated.

Colonel GOULD. Under contract?

Mr. LILLY. No, I cannot say that.

Colonel GOULD. It has been given to the corps?

Mr. LILLY. That is right.

Mr. DADDARIO. When this subcommittee first looked into this, the estimated cost in 1962 for this whole complex No. 39 was $400 million. When this same subcommittee visited Canaveral in January we were told that the estimate had gone up to $432 million, as I recall it. Now you give us an estimate of over $500 million.

What has happened since this project was initiated to bring its cost up to $500 million, over $100 million beyond that originally estimated, and how much more can we expect it to rise?

Mr. LILLY. Mr. Daddario, I don't recall the $400 million estimate. I do recall last year our estimate of $432 million.

Mr. DADDARIO. This was the second figure. The original figure was $400 million. I think the record will indicate that.

Mr. LILLY. In terms of the validity at the time, we made our estimate last year we, of course, did not have design criteria. There was planning on it, but the complex had not been completely priced out.

As you recall, at the time our concept was based upon a rail transfer system and other such items.

Mr. DADDARIO. That was a very small part of the cost. That never was over $10 million, and that has gone down.

Mr. LILLY. That is right. I was using that as an example of the things that hadn't yet been decided at that point in time. As I recall we had about $8 or $10 million in the budget for the rail system itself. However, going to other concepts, such as the crawler system, it has had other effects on things such as the launch pads. The height of the pads, I believe, was raised about 12 feet. I can't really give you a definitive answer of why the difference between $400 million, $432 million, or, as we estimate now, approximately $500 million. There probably have been many more technical concept changes.

Perhaps Captain Holcomb can discuss any changes that have been made in the original concept which resulted in increased costs. Our estimate, of course, is always based on the best information that is available. I could not say that the $500 million will be the final figure because any active launch complex will require continuous expenditures. As an example, there have been been relatively small amounts of funds needed to modify the facilities at complexes 34 and 37 to provide for the development changes in the vehicle.

Do you have anything to add, Captain Holcomb, on any changes that have taken place or the degree of firmness of the designs now that give us more confidence in these costs?

Captain HOLCOMB. The primary difference is that now we know pretty much what we are planning to do. Now as a result of having actual designs and having firm design criteria, we feel we are in a position where we are quite confident that the numbers we have are good numbers.

Mr. DADDARIO. Can we assume then, Captain, that every time we start off with a concept of this kind that the estimate is going to be 25 percent out of line?

Captain HOLCOMB. I think that when you move into an area which is so new and unknown as this that you are bound to find that your estimates are not always going to be entirely accurate. Not all of these things have gone up. There have been one or two that have gone down, but they have been considerably outnumbered.

Mr. DADDARIO. If you consider what you have said, you place this committee in an extremely embarrassing position. When we take the information that you give us, we expect, of course, there will be changes. But if we establish a criterion here that we must get a program underway so there will be no slippage in achieving a national goal, but that as the program develops the cost will increase some 20 or 25 or 30 percent, this committee finds itself then in the embarrassing position of explaining this increase to the other Members of Congress. I doubt that they will take the explanation that you have given us as being a proper one.

Captain HOLCOMB. The people that made up the budget in the first instance were using the best engineering judgment that they were able to assemble at the time. As we have moved into the stage which is preliminary to the hardware, we have found that we know more about

it and we have found that these things have actually run more money than we estimated.

Mr. DADDARIO. What has happened since it was first conceived? You have already had opportunity to look into it and have increased the estimate from $400 to million to $432 million in January. Then in the month of May we find that you come up with a figure of over $500 million?

Captain HOLCOMB. We have found in some of our engineering designs, for instance in the vertical assembly building, that the design of this is very complicated. It is one where the strength of the members, the size of the members, the operation of the building has caused it to go a little higher than it originally did.

On the pad, for example, we determined that when we shifted from the rail to the crawler concept, it was necessary to raise the height of the pad, this is so we could get the deflector up above the water table, which would have made us a very difficult problem otherwise. We have expanded the size of the pad from 2,000 to 3,000 feet in diameter. These are engineering necessities that they have found as we have gone along.

We are very conscious of the taxpayers' dollar. We are trying to restrict these to the minimum and hold our construction as low as we can. But in order to carry out the job, we have found that these increases are necessary.

Mr. DADDARIO. When we were in Canaveral in January and when the price of this was put at $432 million, the decision had already been made to go to the crawler from the rail. So I would assume that the initial costs involved in the determination to go to the crawler had already been included in the increased cost of $432 million.

That decision having been made, what other decisions have occurred since January, or actually since February, to increase the costs almost another $100 million?

Captain HOLCOMB. I don't think you can point to any specific decision, Mr. Daddario.

Mr. DADDARIO. Can you shed some light on this, Mr. Lilly?

Mr. LILLY. I beg your pardon?

Mr. DADDARIO. Can you add to this at all?

Mr. LILLY. I obviously wasn't at Canaveral during your hearing down there in January. I thought our $432 million estimate had been known a considerable time prior to January. Possibly some confusion has entered into this because of the number of pads. We have always had a plan of three pads for the complex, but the third pad was not to start until later. We weren't budgeting for the third pad until 1965.

I do not know whether the figure they gave you in January the $432 million included or excluded the third pad.

Mr. DADDARIO. I can't recall that item. It might be helpful if we could get this into proper perspective.

Mr. LILLY. As Mr. Holmes stated the other day, NASA's policy is to budget on what is called a "turnkey" concept. However, when we have an extremely complicated development with a large outlay of funds required, such as launch complex 39, we budget for it incrementally. We tell you we are doing it this way because we have no basis for coming up with a real firm cost estimate.

The fact that we came in to start with on an incremental funding basis was partly a recognition that we really didn't have a firm cost estimate. Our best estimate at that time was $400 or $432 million. The reason why we have put so much stress on the need for advance design funds is to allow us to develop and present to you a firm estimate as soon as possible.

Mr. DADDARIO. The explanation does fall a little bit apart when we break it down. We start off with the $400 million figure and then sometime after that, some considerable time, have it go to $432 million, and then within a very short time, within just a matter of a few months, the cost increases to over $500 million. The logic of the argument becomes pretty cloudy.

Mr. LOW. The only point that I might add, Mr. Chairman, is that this also happens to be the time that our A. & E. team, our design team is now working very hard in this facility. This committee was selected, I think since we appeared before you a year ago, and started sometime in the fall; I don't know how far they have gotten, but they are now getting to the hard facts on this design.

Mr. LILLY. I would add one more point on our scheduling system regarding official time and cost estimates. Our procedure provides a restriction on piecemeal revisions of estimates. On a project or facility of this magnitude proposed changes to an official schedule would require Mr. Holmes' personal review and agreement.

If $432 million was the officially approved estimate, this estimate would not be changed, even though there may have been preliminary indications of increases, until Mr. Holmes had reviewed and approved a schedule change.

Mr. DADDARIO. I think you have hit on a very good point, and if that is the case, at the time you spread this out for us, I think we should have an explanation of that, and some indication of what the prospects were at the time. If there was a higher figure, why that was not given to us at that time.

Mr. LILLY. I don't know at this point whether or not $432 million was the approved estimate in January.

Mr. DADDARIO. Yes, since we are looking for the key to this, if that was the situation, it ought to be made clear.

Mr. GURNEY. I understand the amount expended or earmarked for this launch complex is $38 million, of which $18 million has been turned over to the Corps of Engineers?

Mr. LILLY. $18,881,000 has been obligated.

Mr. GURNEY. This is out of a figure in last year's budget of $168 million?

Mr. LILLY. $167,850,000, yes.

Mr. GURNEY. We have for this coming year $217 million. What I can't understand is why do we need $217 million for engineering difficulties or whatever it is when the thing has been slowed down so that you haven't even been able to scratch the surface on the money earmarked for last year yet? Why is it?

Mr. LILLY. The basic delay in obligations is the time required for design. When the design is completed, the big money goes out for construction. It is after the design and the specifications are completed that construction contracts are awarded and the large obligation of funds occurs.

Mr. GURNEY. This I understand, but actually what, 10 percent, or 15 percent of the money earmarked for 1963, that hasn't gone out yet,

although you have a place for it, and the year is nearly up. So I return to the question why do you need $217 million for the coming year?

Mr. LILLY. Mr. Gurney, I think you will find that the money will move much faster from this point on. The figures I gave you of $18.8 million was a March 31 figure. Our projected schedule on the balance of the $167 million, incidentally, is for $5.3 million to be obligated in April, $19.8 million in May, $66.7 million in June, $4.6 million in July, $24.9 million in August. There is $25.6 million for the third package on the vertical assembly building which will be combined with an additional amount in 1964 to go out in October.

We have our plans laid out month by month as to when it will be obligated. Our current estimate is that the amount unobligated at the end of fiscal year 1964 will be less than $10 million from the combined funding in fiscal years 1963 and 1964.

Mr. GURNEY. When do you need this facility?

Mr. LILLY. This facility is scheduled to be completed in November of 1965 and ready for operational use, I believe, in January or February of 1966.

Mr. LOW. It is to accept the first S–IC stage for checkout and operation. The schedule is compatible with the stage schedule.

Mr. GURNEY. When you say the S–IC stage, is that the full vehicle?

Captain HOLCOMB. That is the first stage of the Saturn V launch vehicle.

Mr. GURNEY. Is this the only facility that can handle that stage?

Mr. LOW. Yes, sir.

Mr. GURNEY. How about your complex 37?

Mr. LOW. Complex 37 will handle the S–I stage, which develops a million and a half pounds of thrust.

Mr. PATTEN. The figure that we heard was $432 million. If we are up $50 million, the increase would only be 12 percent. If we take $400 million into $500 million, then it is embarrassing. The only figures I heard were $432 and $481 million.

Mr. LILLY. Mr. Daddario has the record on that and I am sure he is correct.

Mr. PATTEN. I came in after the exchange, apparently.

Mr. DADDARIO. The testimony this morning was that the total cost would be over $500 million.

Mr. LOW. But Mr. Lilly also pointed out that his firm estimate was $481 million of that.

Mr. LILLY. I think what I said was that in round numbers we estimated it at $500 million and as I recalled our more precise estimate was approximately $481 million.

Mr. PATTEN. If it is $481 million, you are not up above 12 percent. It would make a big difference to us when we have to explain it rather than be 20 or 25 percent.

Mr. GURNEY. The money is requested for 1964, I take it, you have done practically all the engineering on it; this is a followup on the stuff you started in 1963 or about to start?

Captain HOLCOMB. Many of them are incremental. There are a few new items, such as the arming tower, but we have been underway on the criteria for this for some time.

Mr. DIAZ. That is correct. Most of this is in process.

Colonel GOULD. What degree of flexibility is being built into complex 39 that will enable it to meet follow-on programs?

Captain HOLCOMB. There is a great deal of flexibility in the vertical assembly building permitting it to take the Saturn V and many modifications of the Saturn V, including the nuclear stage.

It will also be to handle the Saturn IB program.

As far as talking about the follow on, I assume you are talking about Nova or something of that nature. This gets into the same type of conversation, I think we had yesterday, with regard to the facilities at Marshall. I think you have to look back at something like Thor, which has been a very reliable workhorse as a space booster.

Over a period of years, that vehicle has received one modification after another. It has had more and more useful satellite applications.

However, the payload weight has been severely limited. We have had to go to the ultimate in miniaturization.

In Saturn V we have a space truck that is going to be able to get a load of hardware and men out into space stations, and to launch planetary probes, and I anticipate that we will have a history of modifications and useful applications of this vehicle which will continue for many years.

When the Nova comes along with its greater capability of a half million or a million pounds in orbit, you will find that the vertical assembly building and our launch complex 39 is going to be saturated with our operational programs and our problem will be how will we accommodate the workload we have, and whether we must add to the complex.

Colonel GOULD. A recent release on the Nova program indicates it will be 450 feet high and 100 feet in diameter.

Is this vertical assembly building capable of accommodating a vehicle of that size?

Mr. LOW. Colonel Gould, I don't think even those numbers on the Nova are firm in any sense of the word. Specifically, the answer to your question is that the vertical assembly building will not be able to take any stages larger than the Saturn S–IC stage. It will be able to accommodate modifications thereof, yes, but not considerably larger stages.

Colonel GOULD. How about the launch pads? Are they going to be big enough to take anything larger than Saturn?

Mr. LOW. Not substantially larger.

Colonel GOULD. And the umbilical towers and arming devices that you are planning will not need anything larger?

Mr. LOW. That is correct.

Colonel GOULD. What is the construction leadtime for these fiscal year 1964 items, Mr. Lilly, please?

Mr. LILLY. Yes. On the fiscal year 1964 items we expect to have a construction leadtime of 25 months, completing, as I said, by November of 1965.

Colonel GOULD. November of 1965?

Does this coincide with the advanced Saturn launch schedule?

Captain HOLCOMB. It ties right into it.

Colonel GOULD. Why are three pads with supporting facilities needed to meet initial phases of this schedule?

Why can't one or two pads be provided and still meet the initial phases?

Captain HOLCOMB. We do not have three pads. In fact, you notice in the budget we call for one additional pad, giving us a total of two. This means that we will have a capability of taking care of our first launch on the first pad, and on the second pad, we will have a backup so that if we do have a catastrophe at some point, the program will not come to a halt.

Colonel GOULD. You say you do not have three pads. The justification states that you are providing supporting facilities and site development for the third pad.

Mr. LILLY. The supporting facilities are included as a matter of economics, based on our full intent of building three pads. For example, by having the same contractor to continue, right on, with the crawler ways until they are completed to all three pads will result in savings.

Colonel GOULD. Will two launch pads meet the initial launch schedules of the advanced Saturn?

Captain HOLCOMB. Yes.

Colonel GOULD. The launch pads were orginally estimated in the fiscal year 1963, I believe, as costing about $5 million each.

I notice that the estimate has now been increased to $15.9 million each.

Could you give us any explanation for that, please?

Captain HOLCOMB. This ties into the earlier discussion with Mr. Daddario. The earlier estimation which we had in our fiscal 1963 congressional concept, which was keyed to the rail concept, was based primarily on extrapolation of the cost figures which we were familiar with on launch complex 34 and 37.

We did not have a firm siting of the pads at that time. We had not done our core samplings. In the meantime, the pads have been sited. We do have a detailed knowledge of both the surface and the subsurface conditions.

We have shifted from the rail transporter to the crawler. We have raised the pad 12 feet. We have expanded the pad itself to have a 3,000-foot radius, rather than the 2,000-foot radius.

These factors have all combined to raise the cost from that which we originally estimated.

Colonel GOULD. Some of the elements you have mentioned are not included in the cost of the pad itself, and I fail to see why the original estimate has been increased 300 percent.

What is the difference between the deflectors that you plan on these pads at Canaveral and the one at the Mississippi Test Facility, for example?

Captain HOLCOMB. There is quite a bit of difference, and you will find that the deflectors that we have at the cape are a little cheaper than the ones we have at the Mississippi Test Facility for a comparable size of booster.

The reason for this is at the Mississippi Test Facility you are having repetitive tests which run full duration, where the vehicle is tied down and is subjected to intense heat and pressure for a long period of time.

At the cape it is subjected to these conditions only momentarily prior to lift off. We are able to use a dry pad, rather than a wet pad.

Colonel GOULD. At Canaveral, the deflectors included are estimated to cost $3.8 million, whereas the ones I am told at the Mississippi Test Facility are $2.8 million.

Captain HOLCOMB. There are four of them included.

Colonel GOULD. I notice that you are providing in this $217 million package some ordnance facilities and operation support buildings.

Why can't this requirement be provided by the Advanced Saturn support complex?

Captain HOLCOMB. You must remember that these pads are located about 3 miles away from the vertical assembly building.

This type of facility provides the close-at-hand workspace where mechanics and technicians can move right from the priming tower and from the pad itself to a shop area to do rapid response work and get back on the job without having to travel 3 miles back on the job without having to travel 3 miles back to the vertical assembly building. This would involve a lot of lost time, which is a particularly important consideration. When you arrive at the pad you have a very short period of possibly a week out in the pad area, and time is critical at that point.

Colonel GOULD. Does 3 miles make that much difference?

Captain HOLCOMB. Yes, sir; it certainly does.

Colonel GOULD. I notice that three operations support buildings have been requested, one for each launch pad.

Why can't these be combined into one central facility?

Captain HOLCOMB. The pads themselves are separated by 9,000 feet because of blast hazard, and this would mean traveling 3 miles from pad No. 1 to pad No. 3, for example.

Colonel GOULD. The ordnance facility is estimated at $70 per square foot. What makes this cost so high?

Mr. DIAZ. This cost is in line with similar facilities built by the Air Force at the Canaveral area.

Mr. FUQUA. What type building is it?

Mr. DIAZ. The facility is an igloo-type building, that will be of heavy-type construction, sir.

Mr. PATTEN. Your Merritt Island complexes are all at sea level, aren't they?

Captain HOLCOMB. Just about.

Mr. PATTEN. How do you provide your 5 percent incline?

Captain HOLCOMB. How do we provide in the crawlerway? It says maximum 5 percent, and this is the incline that, as you go from the area which is very near the sea level, up to the pad elevation, you reach about 42 feet.

I think we are 6 feet above sea level at the pad itself. We use a maximum 5-percent grade going up to that area.

Mr. PATTEN. That 5° wouldn't be enough so that you would need brakes or something?

Captain HOLCOMB. Oh, no.

Mr. PATTEN. Is it a factor in helping you navigate? You wouldn't want to go up against 5°. Is the 5° incline negligible?

Captain HOLCOMB. It is negligible. With this crawler, we should have no problem whatsoever.

Colonel GOULD. How did you arrive at the economics of this matter? Is it expressible?

Captain HOLCOMB. I didn't express it in terms of economy. I expressed it in terms of the time of the differential in moving from a pad area back 3 miles to the vertical assembly building, to get work done.

Colonel GOULD. Isn't this an economical term?

Captain HOLCOMB. Well, if you are talking economy of time.

You are talking operational problem at a time when your countdown is being counted in minutes and hours.

Colonel GOULD. How much did the umbilical towers at pads Nos. 34 and 37 cost?

Captain HOLCOMB. The structures themselves cost about $1 million.

Colonel GOULD. I notice that the three towers in fiscal year 1964 are going to cost around $12 million each.

Captain HOLCOMB. This is an entirely different animal.

They are not too comparable unless you are going to compare the tower that sits on top of what is called the launch umbilical tower with what we have over at 34 and 37.

You have to remember that this launch umbilical tower is partly launch pad and partly umbilical tower.

It has in it a computer which runs part of your checkout equipment, which must have air conditioning, it has deluge systems in it, your propellant servicing comes through this area, you have your high pressure gas lines, your fuel lines, it has 100 extra feet of height on it, compared to the launch complex 34 and 37. It has eight swing arms, as compared to a maximum of four which we will have over at launch complex 37.

To really make a comparison you would have to look at the total launch pad, plus the launch umbilical tower, as compared to the launch pad and umbilical tower in 34 and 37.

Mr. LILLY. I did not understand the figures you used for these towers Colonel Gould. The budget figure is for 5 towers—$22.4 million in fiscal year 1963 and $34.1 million in fiscal year 1964.

Captain HOLCOMB. In fiscal year 1963 we are procuring two launch umbilical towers and the steel for the third. In fiscal year 1964 we are completing that tower and obtaining two more.

Colonel GOULD. Why do we need five towers?

Captain HOLCOMB. In order to service four bays in the vertical assembly building and to provide time for refurbishing, which will have to be done after every launch, we will need five towers.

Colonel GOULD. The cabling in this program totals $2.9 million in fiscal year 1963, and $1.4 million in fiscal year 1964. The majority of this is for crawlerway cabling.

What does this consist of that makes it so expensive?

Captain HOLCOMB. Cabling is what you might call a generic term. It includes all sorts of cabling and wire types. Budget figures include cabling not only for transmitting data and information between locations such as the vertical assembly building and the launch umbilical towers and the launch control centers, it also includes the wiring within these facilities.

Much of the material must be of high quality, shielded and compatible with liquid oxygen. This is a particularly serious design requirement.

There are about four basic types of cable. One that you might call "cable," is 60 conductor No. 12 wire, individually shielded, which we use for data transmission.

We have coaxial cable which is used for high-frequency transmission. This runs $12 to $14 a foot. We have communication cables which are made up of twisted pairs. The estimated cost for a 90 pair twisted layup runs $14 to $16 a foot. And your TV cable, where you have two, runs you $2 to $3 a foot.

As an example of the kind or the amount of cabling that we need between the vertical assembly building and pad-B, we will need approximately 460,000 feet of what I described as just cable, 23,000 of coaxial, 23,000 communication cable, and 46,000 of TV cable.

We took our total cable requirements and we estimated it against these costs to come up with this figure.

Mr. DADDARIO. Any further questions, gentlemen?

(No response.)

Captain HOLCOMB. The next item is "Advanced Saturn Supporting Facilities."

This project proposes construction of additions to the general support conditions on the new industrial area in Merritt Island required to meet the growing operational requirement. It includes a three-story addition to the LOC headquarters building, an addition of 40,000 square feet, to the present central supply building, 80,000 to the warehouse and a security building of 2,500 square feet.

Colonel GOULD. $39.1 million was authorized in fiscal year 1963 for site development, a contractor's building, an engineering laboratory, range support facilities, plus necessary equipment.

To what extent have these funds been obligated?

Mr. LILLY. On the Advanced Saturn supporting facilities, there have been obligations as of March 31, $5,685,000.

Colonel GOULD. As of March 31?

Mr. LILLY. That is correct.

Colonel GOULD. When do you anticipate you will have the balance of the fiscal year 1963 money obligated?

Mr. LILLY. The balance of it, to give it by month, will be $3,000 in April, $1,464,000 in May, and $5,525,000 in June, $4,641,000 in July, $2,725,000 in August, $4,929,000 in October, and $243,000 in November.

Colonel GOULD. The fiscal year 1963 authorizations or appropriations will be obligated by the end of November, is that right?

Mr. LILLY. On that item, yes, sir.

Colonel GOULD. When do you anticipate that the fiscal year 1964 money requested in the amount of $9.3 million will be obligated?

Mr. LILLY. On that one the final amount is planned for obligation in March of 1964.

Colonel GOULD. March of 1964?

Mr. LILLY. That is correct.

Colonel GOULD. Under the recent Department of Defense-NASA agreement, will the range support facilities be part of the Air Force responsibilities?

Captain HOLCOMB. Which facility are you referring to? Are you speaking to this in general?

Colonel GOULD. Yes, sir.

Captain HOLCOMB. Those things which support range functions will be funded in the future by the range. They provide instrumentation in support of our activities.

For example, if they were going to put a radar up on Merritt Island which was to support our operation, the building to house that radar

in the fiscal 1965 budget would appear in the Air Force budget, rather than ours.

Colonel GOULD. When was this agreement consummated?

Captain HOLCOMB. January 17, 1963.

Colonel GOULD. Does the fiscal year 1964 program coincide with the agreements that were reached in the DOD–NASA agreement?

Captain HOLCOMB. In general; it was made up, of course, prior to the time that the agreement was signed.

Colonel GOULD. Last year you indicated that your requirement for engineering and operations space was 65,000 square feet. Now your requirement is for an additional 197,000 square feet. This represents a 300-percent increase over your stated requirements last year. This will result in building of 262,000 square feet. What caused this drastic change?

Mr. LILLY. Actually, Colonel Gould, as you may recall, in our presentation last year, our planning was based upon citing certain facilities in the old cape area. After development of criteria, certain buildings were moved from the old area into the new and combined into this building.

For instance, we have included in the launch operations headquarters building the contractor's space, the engineering laboratory and operations space.

Colonel GOULD. What are you going to end up with now to meet this need if the fiscal year 1964 item is approved; how many square feet?

Mr. LILLY. The number of square feet in this total structure is 358,000 square feet.

Colonel GOULD. How many personnel will this accommodate?

Mr. LILLY. I believe the number of personnel is 2,030.

Colonel GOULD. What basis was used to arrive at this figure?

Mr. LILLY. The basis in terms of the number of gross square footage by person is 145 to 150 square feet per person. Of the 358,000 square feet gross I gave you, there are 53,500 square feet of space for special purpose areas. This was deducted to get the gross area per person that I mentioned. The special purpose areas include the print shop, library, and cafeteria.

Mr. DADDARIO. Have you had a comparable increase in the number of people, too, or is this just a moving of people into a more concentrated area?

Mr. LILLY. We are requesting increases in terms of the numbers of people we have now, plus an estimate of the number of people who will be employed at the end of this time frame. We are providing space for contractor personnel in this facility.

Mr. DADDARIO. When you say "increase," is it an increase in accordance with your original estimate, or has there been an increase in the number of personnel beyond that which has been originally planned for?

Mr. LILLY. I would have to check specifically to see what our original estimate was in terms of total personnel in comparison to what it is now. I don't believe there has been an increase.

Colonel GOULD. You mentioned a figure of 2,030 personnel. The personnel summaries indicate that only 1,200 personnel will be assigned by the end of 1964.

What is the end strength for LOC?

Mr. LILLY. Our LOC personnel, as such, Government employees?

Colonel GOULD. Yes.

Mr. LILLY. Do you have that, Rod?

Mr. DIAZ. No, I do not have that figure here.

Mr. LILLY. This building will house both LOC personnel, and other Government employees, that are detailed from Marshall and Houston, plus contractor personnel.

Colonel GOULD. Are we providing like facilities at the home station also?

Mr. LILLY. No, we are not.

Colonel GOULD. If you are building facilities at LOC for them, then you don't build them at Marshall?

Mr. LILLY. That is right.

Colonel GOULD. On the Storage and Central Supply Building, how much space was provided in fiscal year 1963?

Mr. DIAZ. In 1963 we programed for 33,600 square feet of central supply space, Colonel Gould.

Colonel GOULD. The budget justification in fiscal year 1963 indicated that 73,000 square feet would be built. Why is this different?

Mr. DIAZ. I would have to provide that for the record.

The budget justification in 1963 indicated that 73,000 square feet would be built. Why is this different?

(The information requested is as follows:)

The budget justification has not changed. The central supply building provides 33,600 square feet of 73,000 square foot requirement. The central supply facility, initially planned for the existing area and approved under the Project Supporting Facilities—Existing Area, is now included in the Advanced Saturn/Nova Supporting Facilities project and sited in the new area. The remaining approximately 40,000 square feet, for the total of 73,000 square feet, is for a supply shipping and receiving building that is included in the approved Project Apollo Mission Support Facilities. The 73,000-square feet of storage space was approved as two separate facilities and will be built in this manner.

Mr. DADDARIO. We can move along now. As to the balance of the items involved, Colonel Gould could ask specific questions in those areas where we have some questions, and then we can fill it in further with the staff's work.

Colonel GOULD. The next project—Cafeteria, $899,000.

Mr. DIAZ. The cafeteria project provides for a central kitchen and a 400-seat cafeteria of 15,000 square feet in the Merritt Island industrial area.

The central kitchen will have a capacity of preparing food for 3,000 persons per day.

Colonel GOULD. In computing your requirement for the warehouse facility, you used a figure of 6,500 personnel. Here you used half the estimated population.

Is there any reason for this difference, or is there an error?

Mr. LILLY. No; in coming up with this estimate, but in terms of this particular cafeteria, it was in terms of the 6,000 people who were to be taken care of in that particular area. We have provided facilities for 50 percent of the personnel. Studies made on the planning for this project indicate that about half of the personnel will use the cafeteria facilities.

Colonel GOULD. How much capacity do you have in existing cafeterias at LOC now?

Mr. DIAZ. Do you mean facilities to be built in the new area?

Colonel GOULD. Existing or authorized.

Mr. DIAZ. In the fiscal year 1963 program, approximately 20,000 square feet was authorized.

The next project, Calibration and Standards Laboratory, according to the DOD-NASA agreement, instrumentation calibration and standards laboratory service is a responsibility of the Air Force Missile Test Center; is this correct?

Captain HOLCOMB. What the agreement states is that they will normally provide the service as long as these meet our requirements. However, in this case, what we are talking about is a secondary standards laboratory which will be located closer than the 40-mile distance down to Patrick Air Force Base, where people will have ready access to calibration facilities for their meters and their equipment on a daily basis.

Mr. LOW. All primary calibration standards will be carried out by the Air Force for us at their existing facilities. Secondary calibration, the day-to-day adjustment of meters, and so on, will be done at this facility.

Colonel GOULD. What criteria was used to come to the conclusion that you needed your own facility at LOC when the Air Force normally provides this service?

Captain HOLCOMB. This requirement was actually placed upon us by the Air Force last year, and based on this we placed this item in our budget.

Colonel GOULD. You say it was placed upon you by the Air Force. Was this by consultation or by direct request, or how?

Captain HOLCOMB. In the terms of the Webb-Gilpatric agreement which we had at that time, it was our responsibility to fund for anything which took place on Merritt Island in support of the manned lunar program.

Colonel GOULD. Why couldn't these services continue to be performed by the Air Force at Patrick Air Force Base?

Captain HOLCOMB. We are talking about a different type of service here. The primary standards will be down at Patrick, and the secondary will be 40 miles closer in our own backyard in order to get at it during our day-to-day work.

Colonel GOULD. You will have to define "primary" and "secondary." I don't understand it.

Captain HOLCOMB. Your primary standards are your basic standards to which you calibrate the equipment which goes into your secondary standards which are used on a day-to-day basis to fix the meters and equipment that you must work with in all your shops and laboratories.

Mr. DADDARIO. Is it impossible to put them in the same place?

Captain HOLCOMB. It is not impossible, but it would be extremely awkward to have to travel the 40 miles each way to get this done on equipment which you were working with on a daily basis.

Colonel GOULD. We have learned recently that the Air Force is providing improvements and an expansion of their existing laboratory at Patrick. What is the relationship of this expansion at Patrick and the new facility proposed at Merritt Island?

Captain HOLCOMB. I am not aware of that.

Colonel GOULD. The next project is the Central Instrumentation Facility.

Captain HOLCOMB. This facility consists of a 2-stage primary structure, 94,000 square feet, and a small structure located a mile away to avoid radiofrequency interference. It will be located in the Merritt Island industrial area and provide the instrumentation capability needed to supply all the launch operations in the Merritt Island area. It is budgeted at $31,508,000.

Colonel GOULD. Why can't the existing Mercury control center be modified to take care of this requirement?

Captain HOLCOMB. The Mercury control center is not associated with this facility. You have to recognize the way in which ranges normally work. The whole concept of a range is based on having instrumentation and equipment which is used repeatedly. The range provides a range user with instrumentation services for the duration of a small period before launch, and the launch itself, and then they shift to another range user. They cannot afford to tie up equipment full time for one user to the exclusion of all others. In this particular case we are talking about a process in which—well, to compare it to what you are doing now in the cape area. You have your blockhouse and in it you have a minimum amount of equipment which you use for checking out the individual equipments on your space vehicle in serial fashion, one at a time. When you get these all to the point where you believe they are ready, you must verify that all of them will work together in concert.

After it has been verified that all of the equipment will work together, without crosstalk, without interference—this is something that takes a period of 2 to 3 weeks of constant use of the gear—then we are ready to switch over to the Air Force, verify that all of their equipment is tuned up on the same frequencies, and then we are ready to go with a launch in which the Air Force primarily gives us our instrumentation. Our instrumentation is redundant during the initial launch phase, but this is a necessary redundancy. This is an especially important part of your launch because you cannot afford to have any of the information dropout.

In the Mercury launch vehicle, for example, we have been getting about 80 pieces of information—telemetered back. On the Saturns we have been running in excess of 600 pieces of information. On the Saturn V we will have approximately 2,500. This represents a tremendous increase. Really, what we are doing with a central instrumentation facility is replacing and augmenting what we now have in hangar D in the cape area.

Colonel GOULD. What is going to be done with the existing facilities and equipment in the Mercury control center when the manned space flight center at Houston comes into operation?

Mr. LOW. First of all, the existing Mercury control center represents an investment in equipment which runs in the order of $6 million. Therefore, it does not compare in scope with this facility. To specifically answer your question, much of the equipment there will be used in the same sense as a down-range tracking station is used. The flight controllers are for Project Mercury and Project Apollo which will be located around the world, in addition to those in the control center, must also be located at Cape Canaveral for controlling the

flight while the vehicle passes over the flight. So it will be a down-range flight control station supporting the mission on control center at Houston, in the same sense that Bermuda is now a down-range station to the present cape.

Colonel GOULD. What have we been using to control and track the vehicle while it is going over the cape in our previous flights?

Mr. LOW. We are using the tracking equipment at the cape for Mercury flights tied into the Mercury control system directly. So the Mercury control center performs two functions, that of the overall control center, and the typical function of a remote site as well.

Colonel GOULD. You say they perform that as well?

Mr. LOW. Yes.

Colonel GOULD. When Houston comes into being, what will they perform?

Mr. LOW. Only the remote site function.

Mr. DADDARIO. What did we have in last year's program in place of the central instrumentation facility, Mr. Low?

Captain HOLCOMB. In place of it? I don't believe we had anything in place of it.

Mr. DADDARIO. This is a new conception?

Captain HOLCOMB. It is not a new conception. We have followed a practice throughout of funding these things in the year in which we need to have them and at the time when we are technically at a point where we can better describe what we do just to avoid this situation we discussed earlier of coming up with budgets which then later on turn out to be less than the money that we actually require.

We feel that we are now at a point where, first, we can technically describe what we need, and, secondly, it is within the time limit which will permit us to get the equipment, install it, and have it in operation to meet our launch schedules.

Mr. DADDARIO. I will have to doublecheck this, because some of the purposes intended for this facility involving prelaunch checkout, for example, seems to be quite familiar.

Captain HOLCOMB. You may have found some wording similar to that under the vertical assembly building. As we move from the cape area to Merritt Island, the function that we are doing on the cape in the blockhouse is being repeated in an augmented manner in the vertical assembly building.

Mr. DADDARIO. Do you use the word "prelaunch" in the same way as you use the word "preflight"? For example, prelaunch checkout, is that the same as preflight testing?

Captain HOLCOMB. I think this is correct.

Mr. DADDARIO. If I am not mistaken, last year we were talking about preflight testing at Canaveral.

Mr. LOW. Mr. Chairman, we are talking, I believe here, about a subsequent item, the manned spacecraft facilities at the Merritt Island area. These also include preflight checkout facilities for the spacecraft as opposed to the launch vehicle. Captain Holcomb has been describing the facilities for the launch facilities.

Mr. DADDARIO. In order for us to finish this section, I will doublecheck it and I will get my questions to Colonel Gould. There is something familiar about this.

Colonel GOULD. The next project is the "Launch Equipment Shop," page CF–6–61.

Captain HOLCOMB. The launch equipment shop provides a working area of approximately 20,750 square feet in the Merritt Island industrial area. It will house sheet metal and machines; maintenance and repair of launch equipment, such as your umbilical tower, swing arm attachments, communication, and cable equipment.

Colonel GOULD. What is being used to meet this need now?

Captain HOLCOMB. We don't have any facility comparable to this in the present cape area. We do a small amount of machine work in some of our own hangars and there is a machine shop as I understand it at Patrick Air Force Base.

Colonel GOULD. When will the first umbilical tower and arming tower be delivered to the site for Complex 39?

Captain HOLCOMB. I think the first umbilical tower will arrive in January of 1965. Actually, it doesn't arrive there. It is erected on the spot, and it will be completed in January 1965. You don't move that one down the highway.

Colonel GOULD. Shouldn't this type of activity be incorporated into the supporting facilities for complex 39 rather than as a separate entity?

Captain HOLCOMB. It could be. I don't know any specific reason why it should not be.

Colonel GOULD. The next project is "Modifications to Launch Complex 34," and immediately thereafter complex 37.

Captain HOLCOMB. In launch complexes 34 and 37, we have provided for adding a capability for the Saturn VI vehicle and providing a manned capability at both locations. The total runs to $1,310,000 for launch complex 34 and $3,435,000 for launch complex 37.

Colonel GOULD. After complex 39 becomes operational; what will 34 and 37 be used for?

Captain HOLCOMB. Saturn 1–B flights are planned to continue for some time. I expect continued use of both facilities.

Colonel GOULD. The justification indicates that when the 1964 modifications have been completed that Complexes 34 and 37 will have identical capability. Why do you need two launch complexes with identical capabilities?

Captain HOLCOMB. What we need out of these three pads that we have down there, is two pads configured for Saturn I–B because this is our largest work schedule. We need one pad for the Saturn I but we need to be in a position if a catastrophe should happen to that particular launch pad, that one of the two pads we have configured for the Saturn I–B can be converted back to accommodate the Saturn I within a reasonably short period, let us say 3 months. This we are building into the facilities.

Colonel GOULD. Will you define for us the so-called white room and what modifications to the surface structure are required?

Captain HOLCOMB. The white room is a room where the astronauts are held just prior to entering into the capsule.

Mr. LOW. Actually, it is a clean room at the top of the gantry with controlled environment so that the final spacecraft preparations—while the spacecraft is open—can be carried out, without getting the humidity and the salt spray, and so on into the spacecraft. It is also the room in which the astronauts enter the spacecraft.

Colonel GOULD. What have we used in the past to meet this need?

Mr. Low. From the Saturn gantries we have not yet had any manned flights. At Complex 14, for the Atlas, we added a white room to the existing Atlas gantry. We are now modifying the Titan II gantry to be used on the Gemini flight, itself.

Colonel Gould. How many launches are contemplated from 34 and 37 before 39 becomes operational?

Captain Holcomb. We will have a total of about 17.

Colonel Gould. The next project is "Optical Electronics Components Servicing Facilities."

Captain Holcomb. The optical electronics components service facilities provides for maintenance, repair, and storage of optical photographic equipment, and mobile instrumentation. It was originally a service provided by the range. In this one the Air Force withdrew their requirement after the NASA–DOD agreement. However, under the agreement, NASA received the responsibility of providing all engineering sequential photography at NASA launch pads. This is a facility where this equipment will be serviced, maintained, and stored. We will also carry out our photography development work.

Colonel Gould. Would it not be less costly to expand the existing technical laboratory at Patrick Air Force Base—speaking from an overall Government standpoint now—wouldn't it be less costly to expand the existing laboratory at Patrick to meet this requirement, and thereby eliminate a probable duplication?

Captain Holcomb. Engineering sequential photography is a special requirement. What you are talking about doing is turning the engineering sequential function over to the Air Force. The reason this was placed with NASA in the agreement rather than with the Department of Defense is that this is the equipment which is installed right in the pad area. Activity which takes place on the pad must be completely under the control of the launch controller. He must be able to make sure that he is the one who knows where all the cables are located and that no extraneous people can come into the area without his authorization to run cable. Many of the engineering sequential cameras are high speed. They run for a very short period of time and are triggered by a signal which is sent from the launch control complex during the last minute or two of the countdown. Control of the personnel is most critical. It was on this basis, and because this is really a different type of optical coverage than the metric, that it was determined that NASA should actually carry out this function, and this means that we must also service and take care of our optical equipment.

Colonel Gould. Do you have the capability of performing this service now within NASA?

Captain Holcomb. We have it to a certain extent. It is not to the extent that we will require when we move into Merritt Island, but this is true of many things that we are building up in the Merritt Island area.

Colonel Gould. What facilities are you using at the present time?

Captain Holcomb. I believe the Air Force is providing this service down in the cape area.

Mr. Daddario. Could the Air Force provide this service, Captain, despite the question of control? Do they have the foundation upon which the expansion could take place?

Captain HOLCOMB. They have an optical servicing facility down at Patrick Air Force Base. This is true. It was because of the operational problems that you would encounter, which are recognized by both ourselves and the Department of Defense, that it was determined that we need to go in this direction.

Colonel GOULD. The next project, please.

Mr. DADDARIO. Range Engineering and Administration Building.

Captain HOLCOMB. This project for $855,000 provides a two-story 25,000-square-foot engineering and administration building, where 150 contractor personnel perform the housekeeping operations at the Merritt Island area of the launch operations center. This is one of the things where the justification writeup changed slightly as a result of the agreement where, by the terms of the agreement, we are to provide the service in this area, but it is still required.

Colonel GOULD. Isn't the operation of the range the responsibility of the Air Force?

Captain HOLCOMB. It depends what you define as the range. The range, as you recall from the agreement, includes Cape Canaveral itself and the down-range stations of the Atlantic missile range.

Colonel GOULD. Exactly what is going to be performed in this building?

Captain HOLCOMB. This will house the contractors who perform the base operation of Merritt Island.

Mr. DIAZ. This facility is about the same thing, Colonel Gould, as a base engineer's office building.

Colonel GOULD. Don't we have an existing base engineering shop down there?

Captain HOLCOMB. Not at Merritt Island.

Colonel GOULD. Why can't this be serviced from the cape?

Captain HOLCOMB. This will be LOC.

Colonel GOULD. What is being used to meet this need on the other facilities that have to be maintained?

Captain HOLCOMB. Part of this is taken care of by Pan American down on the cape. This is their function. I think there are some janitorial service functions by NASA. In general, it is carried out by Pan American.

Colonel GOULD. How many contractual personnel are we talking about?

Mr. LILLY. There will be about 800 contractor personnel and about 150 personnel to perform the administrative management functions.

Colonel GOULD. Where are they located now?

Captain HOLCOMB. They are not. This is a function which is not now being carried out. We are only in the position now of doing dredging and foundation work on Merritt Island. We have no facilities to operate.

Mr. LOW. We do not yet have our maintenance and operations contract for the Merritt Island area.

Colonel GOULD. When do you anticipate that contract to be consummated?

Captain HOLCOMB. The policy in determining how we will operate Merritt Island we anticipate will be resolved within the next few weeks, and hopefully we should be under contract very shortly thereafter.

Colonel GOULD. Utility Installations project in the amount of $23.8 million; I have a considerable number of technical questions, Mr. Chairman, and I think these can be resolved between the staffs.

Mr. DADDARIO. You may follow that procedure.

Colonel GOULD. The next project is the "Vehicle maintenance and service facilities," page CF–114.

Captain HOLCOMB. This project for $1,561,000 will provide two facilities for the maintenance service, dispatching, and parking of up to 600 Government-owned motor and wheeled vehicles of all types. It includes body and overall shops, paint and fuel dispensing facilities. The added volume of work resulting from increased numbers of vehicles cannot be handled by the existing facilities at Patrick.

Colonel GOULD. When will you reach the volume of 600 vehicles?

Captain HOLCOMB. I would estimate that we should reach this by the latter part of 1964.

Colonel GOULD. Are the vehicles being used by NASA at the present time procured by GSA?

Captain HOLCOMB. We have several categories of vehicles down there. We procure special purpose vehicles (by that I mean cherry-pickers, heavy equipment), directly, ourselves. For passenger vehicles, which have been procured while we have been located on Cape Canaveral we have contributed to the Air Force budget each year, and with this they have procured a portion of the vehicles which they feed into their motorpool and with which they provide us support.

This includes buses and station wagons; that type of operation.

In addition to this, we have a lease for operation of strictly passenger-type vehicles with a local organization.

Colonel GOULD. Are there any Air Force vehicles included in this number of 600 that you have given us?

Captain HOLCOMB. Negative.

Colonel GOULD. How many of these will be contractor-owned vehicles?

Captain HOLCOMB. Vehicles in the vehicle service facility will probably be largely contractor-owned and leased by NASA in a similar arrangement to that which we now have.

Colonel GOULD. I am sorry, would you repeat that?

Captain HOLCOMB. In the vehicle service facility, probably quite a large quantity of the vehicles will be contractor-owned and operated under lease.

Colonel GOULD. Why is it necessary to provide separate automotive maintenance facilities for the range contractor and for general services?

Captain HOLCOMB. Because you have two different contractors involved. In one case you are talking about a lease operation where you have a dispatcher's office, filling station and storage space, and in the other case you are talking about the heavy overhaul of the mobile equipment with which we do to our technical job. It is a different type. In one case you are talking passenger vehicles, and in the other case you are talking heavy equipment.

Colonel GOULD. What did you use for standards or space criteria in arriving at the size of your shops?

Mr. Lilly, can you answer that question?

Mr. LILLY. Mr. Diaz can.

Mr. DIAZ. The size of this facility was based on DOD criteria.

Colonel GOULD. You did use DOD criteria?

Mr. DIAZ. Yes, it was used as a basis.

Colonel GOULD. Congratulations; it is the first one I have found where standards have been used. We skipped one project in going through here, the manned spacecraft facilities on page CF 6–64. Can you tell us a little bit about these facilities, Captain, please?

Mr. LOW. These are the checkout facilities for Gemini and Apollo spacecraft located in the Merritt Island area, adjacent to the launch operations center facilities. As you will recall, we started these facilities in fiscal year 1963 and we are requesting $6,512,000 for additions in 1964.

Colonel GOULD. There have been a total of $25.7 million authorized for these facilities. I believe they were previously called Apollo mission support facilities; is that correct?

Mr. LOW. That is right.

Colonel GOULD. What is the status of the obligations on these funds?

Mr. DIAZ. As of March 31, the obligations were $12.5 million.

Colonel GOULD. Is this actually under contract or committed to the Corps of Engineers?

Mr. DIAZ. These funds were in the hands of the Corps of Engineers.

Colonel GOULD. Do you know how much is actually under contract?

Mr. DIAZ. I believe most of this total is under contract.

Mr. LOW. The contract was awarded several months ago for the major portion of the buildings.

Colonel GOULD. What is the relationship between these facilities and those proposed in support of Complex 39?

Mr. LOW. In these facilities the Gemini and Apollo spacecraft will be checked out and prepared for flight prior to mating with the launch vehicle in Complex 39. The only work on the spacecraft in Complex 39 will be accomplished in combination with the launch vehicle or, in other words, the entire space vehicle will be checked out in Complex 39, but all the preparation of the spacecraft, the testing and vacuum chambers, the checking of the reaction control systems, the verification of the environmental control system, will be handled in the facilities we are discussing now.

Colonel GOULD. What type of tests are going to be accomplished here that can't be accomplished at the contractor's facilities or at MSC?

Mr. LOW. There are no types of tests that cannot and will not also be performed either at the contractor's facilities or at MSC. However, it has been our experience in Project Mercury, particularly, that the kinds of systems used in a manned spacecraft must be checked out and verified just before mating in the general location of the

launch area. A spacecraft normally spends about 4 to 6 months at the cape before mating for this kind of checkout.

Colonel GOULD. Why isn't the testing scheduled to be done at MSC rather than here?

Mr. LOW. The testing that is to be done at MSC, for example, in the environmental chambers or in the rest of the facilities, is the developmental testing on one spacecraft, one of a kind. For example, in Apollo, spacecraft No. 6 is scheduled for environment testing at MSC. It will be subjected to conditions of heat, cold, far in excess of the conditions it will undergo in actual flight. This kind of testing at MSC assures us the reliability that we must have in all spacecraft. It is developmental testing. At the cape the kind of testing that will be done is the final checkout to make sure that all the pieces of equipment in the spacecraft that will be launched, operate together; that they are hooked up together; that the reaction control jets indeed do work when the astronaut moves his control stick; that the guidance system works when the spacecraft is moved a certain way; that the environmental control system works properly; and so on. It is the kind of testing that has been done during the last few months on spacecraft 20.

Mr. DADDARIO. Do you need people of the same type at both places, or do you move the people around?

Mr. LOW. We do not move them around, because we have found that it is most important that the people who do the final verification, the final checkout at the Cape, are those people who finally take the responsibility, who say, "Yes, the spacecraft is ready to go." The man who has breakfast with the astronaut in the morning and pats him on the back is the guy that is responsible for the spacecraft. This personal confidence that we have been able to achieve in the final checkout, we feel, is one of the elements in getting the spacecraft ready.

Mr. DADDARIO. Are these all NASA people or are they industry people?

Mr. LOW. They are both our people and industry people. Actually, the detailed, everyday work is done by industrial people with very close and thorough NASA inspection. No one can remove a nut or bolt or wire from a spacecraft without having a Government inspector sign off on it and make sure it goes back in again.

Colonel GOULD. These tests that you are referring to, Mr. Low, have to be performed before the spacecraft is mated with the launch vehicles?

Mr. LOW. That is correct. Many of the tests are performed in test cells which are equipped for the hazardous propellants used in the vehicle.

Colonel GOULD. Why do we need two altitude chambers?

Mr. LOW. The requirement for two came about from looking at the detailed schedules, the work schedule on a day-by-day basis of where the spacecraft goes and how much time it has to spend in the altitude chambers. We will be checking out in this building, as was actually recommended by this committee, both Gemini and Apollo spacecraft

and the lunar excursion module. Each one of these must be in the altitude chamber for 2 to 3 weeks simulating the mission. Therefore, we must have two chambers.

Colonel GOULD. I have found it difficult to correlate the previously authorized items with the 1164 request.

When the staffs get together, I would like to go over these item by item.

That is all I have, Mr. Chairman.

Mr. DADDARIO. Any further questions?

(No response.)

Mr. DADDARIO (continuing). If not, I would like to thank all of you for staying with us for an extra hour.

This committee will adjourn until Monday morning at 10 o'clock in this same room.

(Whereupon, at 1 p.m., the subcommittee was adjourned, to reconvene at 10 a.m., Monday, May 6, 1963.)

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1964 NASA AUTHORIZATION

MONDAY, MAY 6, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON MANNED SPACE FLIGHT,
Washington, D.C.

The subcommittee met, pursuant to adjournment, in room 356, Cannon Building, at 10 a.m., Hon. Olin E. Teague, chairman of the subcommittee, presiding.

Mr. TEAGUE. The meeting will come to order. Just start where you left off on Friday, Mr. Holmes.

Mr. YEAGER. That would be volume II, "Aerospace Medicine."

STATEMENT OF D. BRAINERD HOLMES, DEPUTY ASSOCIATE ADMINISTRATOR AND DIRECTOR, OFFICE OF MANNED SPACE FLIGHT, NASA; ACCOMPANIED BY BRIG. GEN. C. H. ROADMAN, DIRECTOR, SPACE MEDICINE; DR. GEORGE M. KNAUF, DEPUTY DIRECTOR; GEORGE M. LOW, DEPUTY DIRECTOR (PROGRAMS); AND WILLIAM E. LILLY, DIRECTOR, PROGRAM REVIEW AND RESOURCES MANAGEMENT

Mr. HOLMES. We have with us this morning, in addition to Mr. Low, General Roadman, who is the Director of Space Medicine for the Office of Manned Space Flight, and his deputy, Dr. George Knauf. General Roadman is going to testify on this subject, with your permission, Mr. Chairman.

General ROADMAN. Mr. Chairman, members of the committee; it is our privilege to present to you today a report on our accomplishments during the past year in providing medical support for the manned space flight program. We will also outline for you the effort we will engage in during the coming year in pursuing our role in the national effort to land a team of American astronauts on the Moon in this decade.

You will remember that in our last report to you we noted that we were making the first such report after the reorganization of the National Aeronautics and Space Administration Office of Life Sciences Programs into three distinct biomedical components; the Office of Bioscience Programs in the Office of Space Sciences, the Directorate of Biotechnology and Human Research in the Office of Advanced Research and Technology and the one we represent, the Directorate of Space Medicine in the Office of Manned Space Flight. You will also remember that we called your attention to the fact that staffing of the other two offices had not been completed. For this reason our program, at that time, included certain tasks which would ultimately

become the responsibility of either the Office of Bioscience Programs or the Directorate of Biotechnology and Human Research as soon as they were able to take over.

We are indeed pleased to be able to report that considerable progress has been made along the lines of integrating the efforts of these three offices. As a result we have today a well-integrated National Aeronautics and Space Administration Life Sciences Program.

I think it is very important that this committee understand the functional responsibilities of these three offices (fig. 173). The Office

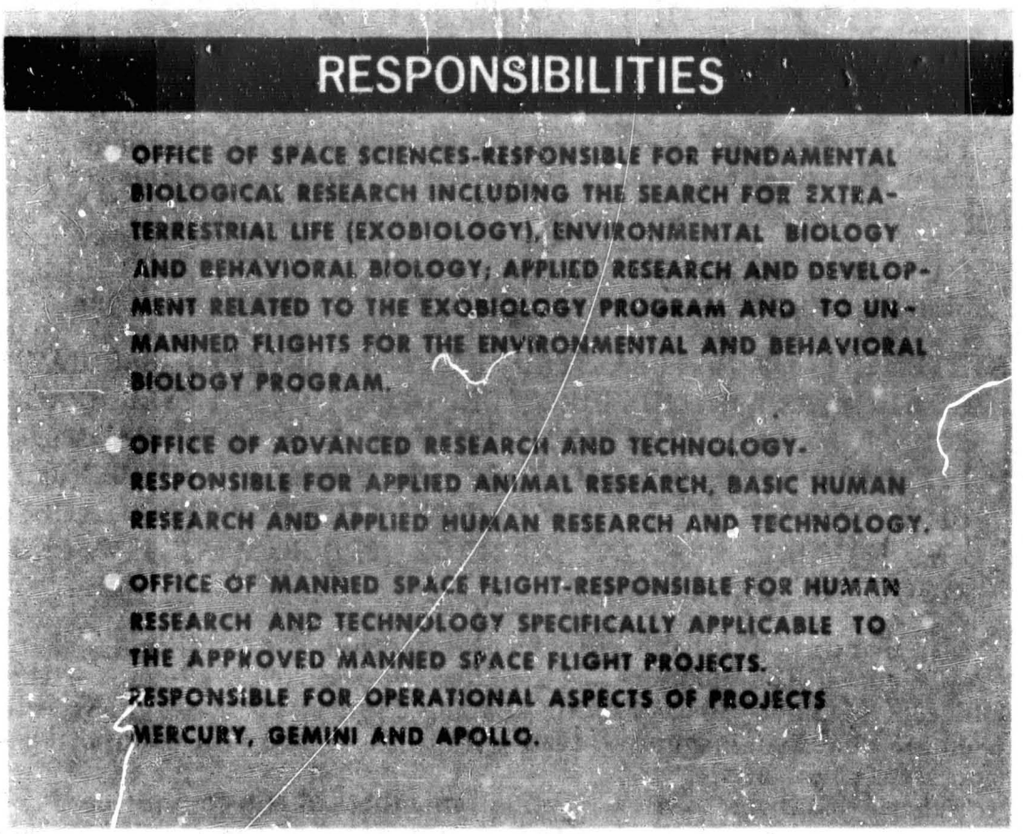

FIGURE 173

of Space Sciences is responsible primarily for the search for extraterrestial life. This can be classified as a basic biological research program.

The Office of Advanced Research and Technology is responsible for the advanced considerations over and beyond those which constitute our current manned space flight program in our area, applied animal research, basic human research, and applied research and technology. (fig. 174).

Our area of responsibility is for research and development specifically applicable to the approved manned space flight projects, as well as for their medical operational aspects. The currently approved projects, as you know, are Mercury, Gemini, and Apollo.

In the Manned Space Flight program, each office is charged with responsibility for its proper spectrum of activities. Effective use is made of the overall NASA flight program, both manned and un-

FIGURE 174

manned, and unwarranted duplication of effort has been eliminated. It is important to recognize that the precise definition of program responsibilities makes it now possible to fully use the support capabilities of other Government agencies, universities, and industry.

It is perhaps appropriate that we preface the discussion of our program with some general comments concerning the progress we have made in fitting ourselves into the biological community. The Man-in-Space Committee of the Space Science Board under the National Academy of Sciences was established to insure that our program made full use of the technical talent available in both the civilian and military community. There followed a period in which the Department of Defense expressed concern with our program planning. It was Defense opinion that, given an opportunity, it could provide such bioastronautics support as our program required. This problem area was approached by appointing a committee to study the situation and to draft a joint NASA–DOD bioastronautics support plan.

During the months that followed the creation of the Man-in-Space Committee and the NASA–DOD Bioastronautics Study Committee we resolved many problems. Participation of our people in the meetings of the Man-in-Space Committee working groups served to satisfy the scientific community that we were already seeking the advice and counsel of leading members of their particular scientific groups. Frequent meetings with our people, exchange visits to laboratories, and joint briefings on both program requirements and support capabilities resulted in a new level of understanding on the part of Department of Defense laboratory heads and staff agencies alike. The end result has been the development of a healthy understanding and cooperative effort on the part of all concerned. In January of this year, the Chairman of the Space Science Board dis-

solved the Man-in-Space Committee as being no longer needed. The NASA–DOD bioastronautics agreement, as formulated, did not come into being.

Mr. TEAGUE. Why?

General ROADMAN. I would like, if possible, to address myself to that specific question at a later moment, if I may, sirs.

Mr. TEAGUE. That is fine.

General ROADMAN. As the two groups developed a better understanding of the interests of one another, the list of things requiring reduction to a formal agreement dwindled. Last fall a bioastronautics office was established in General Ritland's office under Col. John Talbot, an Air Force medical officer. This office has helped materially to maintain the improved level of communications between ourselves and our counterparts in the military services. As an example, he recently arranged a meeting in our office in order that we might bring Department of Defense, Air Force, and Navy representatives up to date on our program requirements. To this was added, to assist them in their planning responsibilities, a forecast of the direction we believe our effort will follow.

In the case of the directorate of biotechnology and human research the situation is different. This office will eventually be the prime source of advances in technology upon which we will draw in order to fashion the components and systems for future missions. We have moved to realign our space-medicine program accordingly.

I think it is very important for this committee to understand that we now include in the space-medicine program only those things which may be reasonably considered to be in direct support of our approved manned space flight program.

In the course of accomplishing necessary research and development, while producing operational components for Project Mercury missions, a unique capability has been created in selected areas in the Crew Systems Division at the Manned Spacecraft Center (fig. 175).

Flight proven competence and responsibility in these areas does not exist anywhere else in government (fig. 176).

To complete this picture, we are presently engaged in reviewing our background of experience, gained in the conduct of our current series of manned space flight missions. This review is designed to point out areas where future projects will require advances in technology, areas where new components, advanced systems, improved fabrication techniques, or new materials might make it possible to conduct future missions with greater simplicity, economy, and reliability (fig. 177). The results of this review will be translated into a series of technical requirements to serve as a planning guide for future programs.

It might be well to add that the review has firmly established the fact that our Project Mercury flights to date have shown no significant physiological effects on the crews attributable to flight in the space environment. Indeed, we feel completely confident that the biomedical needs of the currently approved series of manned space flight projects can be met by the application of existing technology.

Our flight experience in Project Mercury has also adequately established man's ability to perform effectively in the space environment. Weightlessness, which was considered by some as a potentially grave obstacle, has engendered no serious problems in manned space

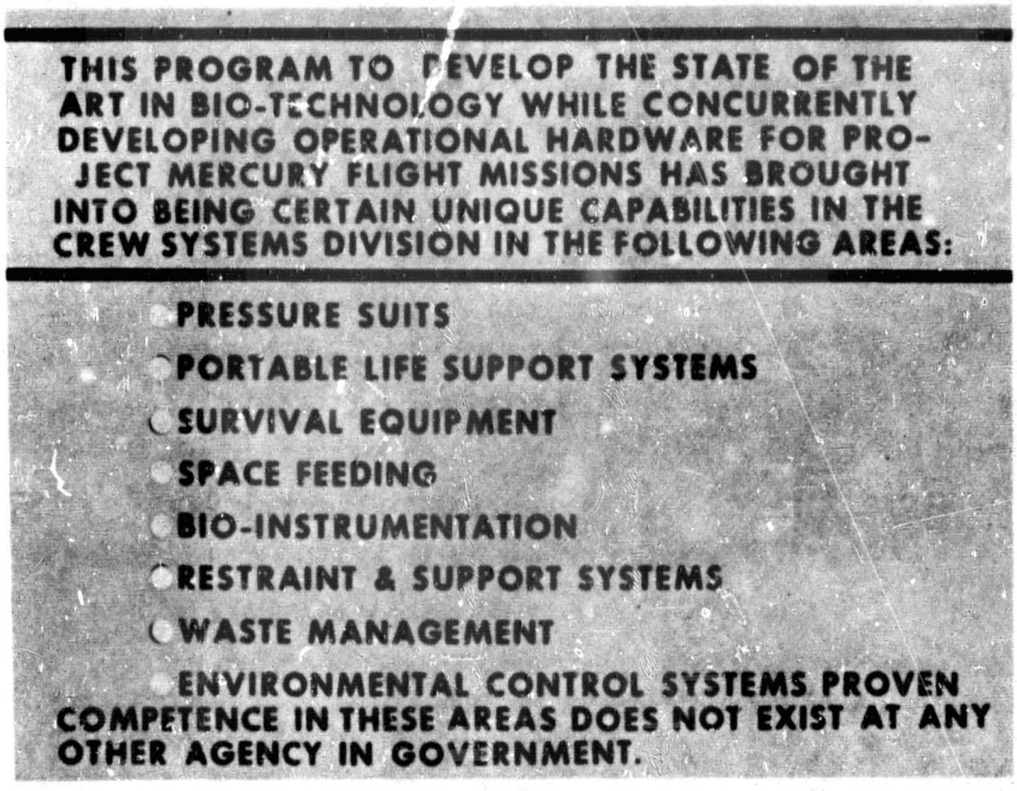

FIGURE 175

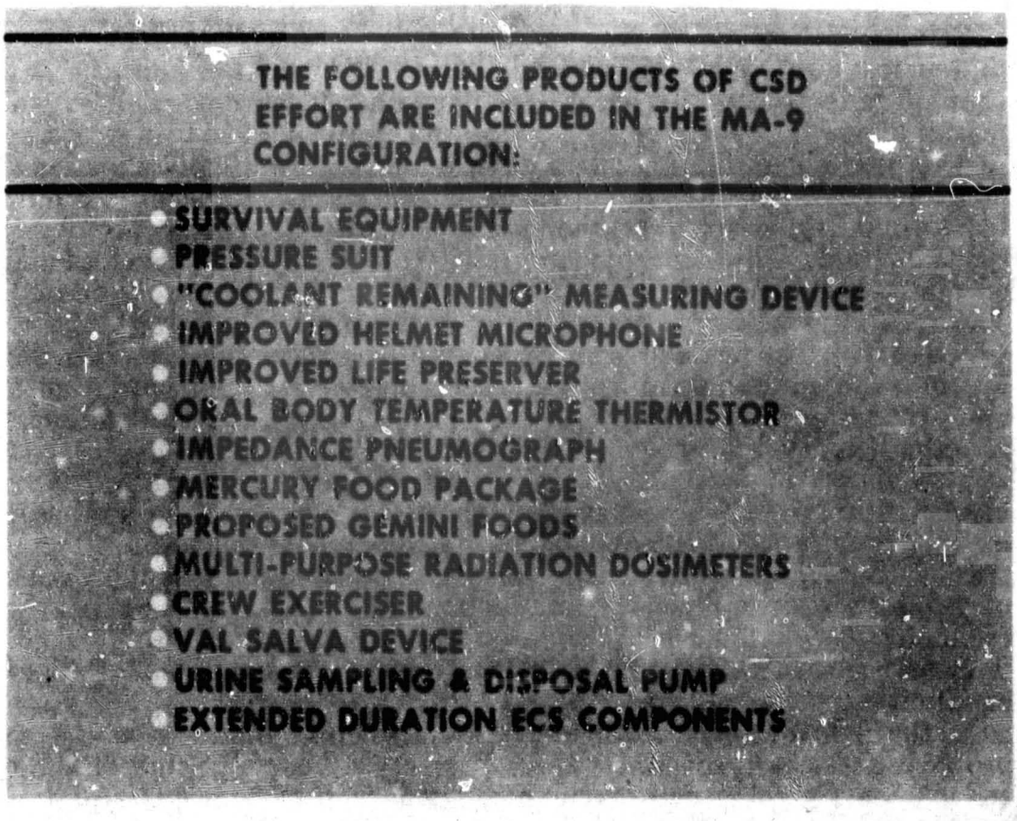

FIGURE 176

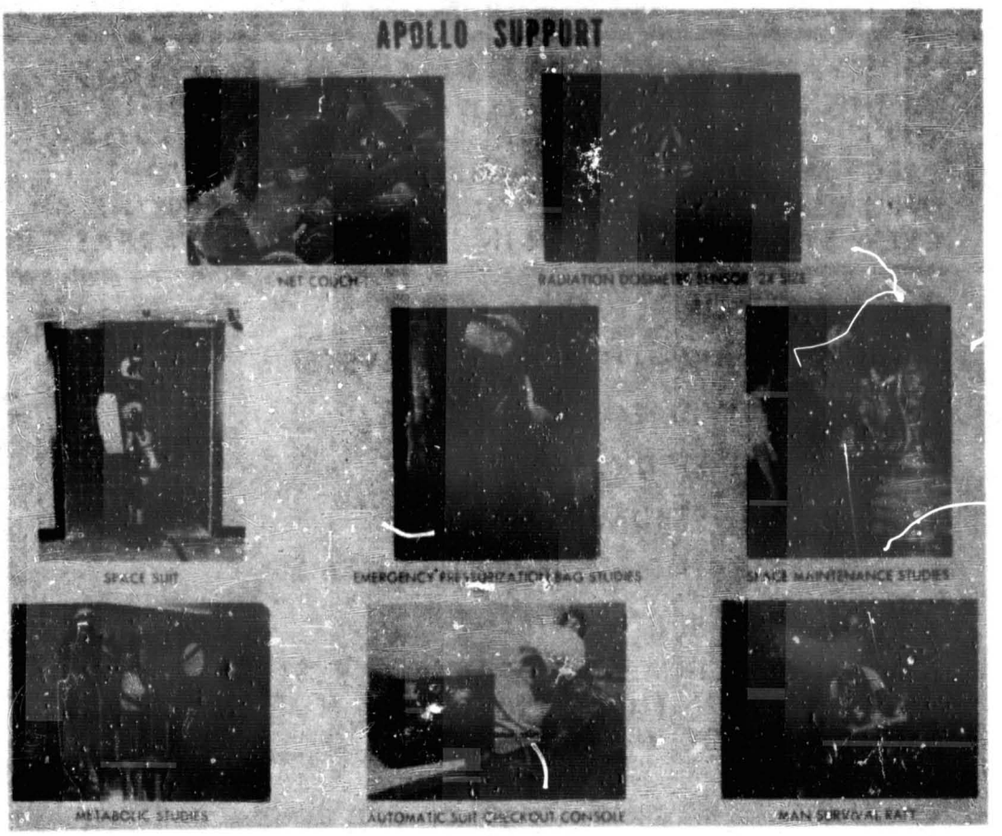

FIGURE 177

flights to date. While measurably reassured by our experience and that of others with the weightless phenomena, we nevertheless will maintain careful watch for any untoward results of prolonged exposure to this ingredient of the space environment. Our flight experience in Project Mercury has provided us with certain significant building blocks in our program to develop systems to sustain man on prolonged space flights. The concepts on which the design and development of our life support systems were predicated have been validated. The reliability of components in our environmental control systems, which early in the flight program gave rise to concern, has been brought up to an acceptable level. As a result, our development program is able to proceed optimistically toward providing adequate life support for crews engaged in prolonged space flight missions.

To achieve the national goal of a manned lunar landing the NASA has established a step-by-step development program. The next step in this program is Project Gemini. Project Gemini is an integral part of the overall program and has as its basic objectives increasing our operational proficiency and expanding our knowledge of the technology of manned space flight. It will also serve as a means of developing both rendezvous and long-duration manned space flight capabilities.

In the field of space medicine, Project Gemini flights give rise to problem areas not encountered in Project Mercury. Some of these can be dealt with by improvement or extension of concepts and sys-

tems which were developed, applied and validated in Mercury missions. In other instances a need for new approaches is foreseen. Questions still remain with regard to human tolerance to specific acceleration, deceleration and impact forces. The effects upon the astronaut of vibration in the newer and larger vehicles must be explored further.

Studies are being conducted in a Gemini two-man cabin simulator (fig. 178) to evaluate components of the life support system being de-

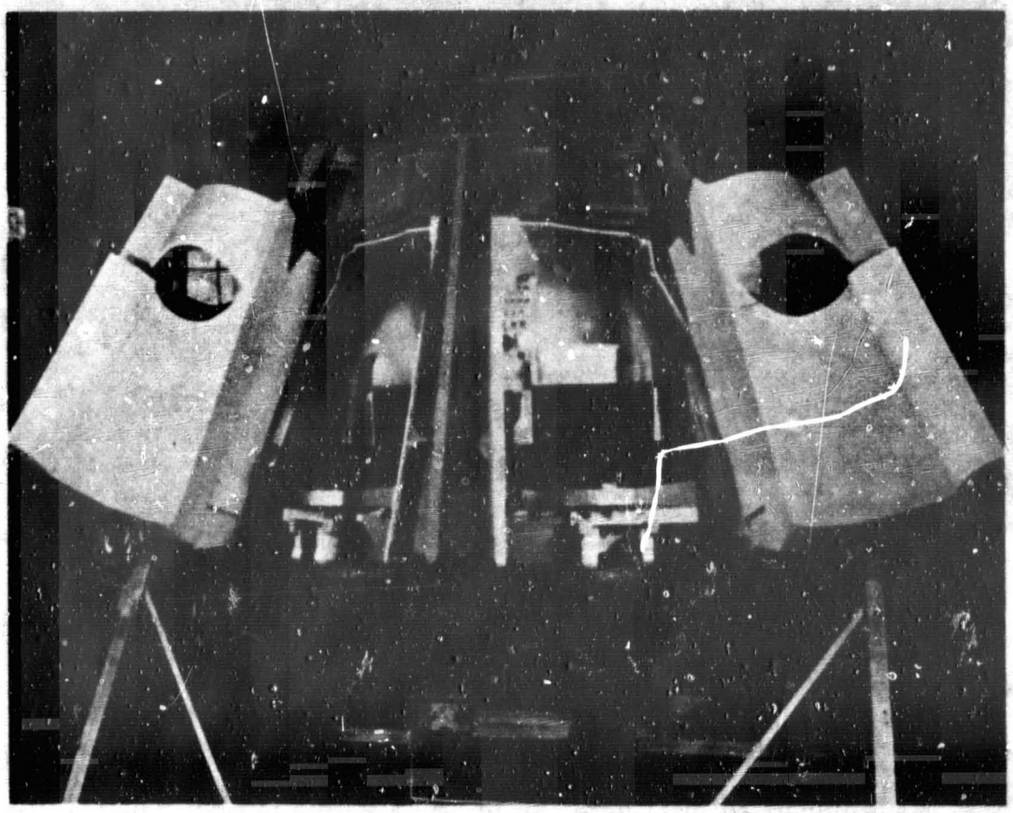

FIGURE 178

veloped for the long-duration Gemini flights. Similar studies are being carried out to explore various methods of removing carbon dioxide from the cabin atmosphere and of maintaining the desired carbon dioxide and water vapor control.

Gemini flights will include long-duration missions lasting up to 2 weeks. In these, we will investigate the physiological effects on the crew of zero gravity, artificial environment and limited mobility while carrying out various work plans for prolonged periods of time.

In other words, this program does offer an exploratory and an investigative capability with man. It is anticipated that the Gemini flight profile will require a space suit which differs markedly from that used in Project Mercury. The suit construction will permit the wearer to open it sufficiently to accommodate normal body functions. This development program is well underway. Preprototype suits have been evaluated at the Crew Systems Division and negotiations are nearing completion for the fabrication of a sufficient number of suits to meet test and training needs.

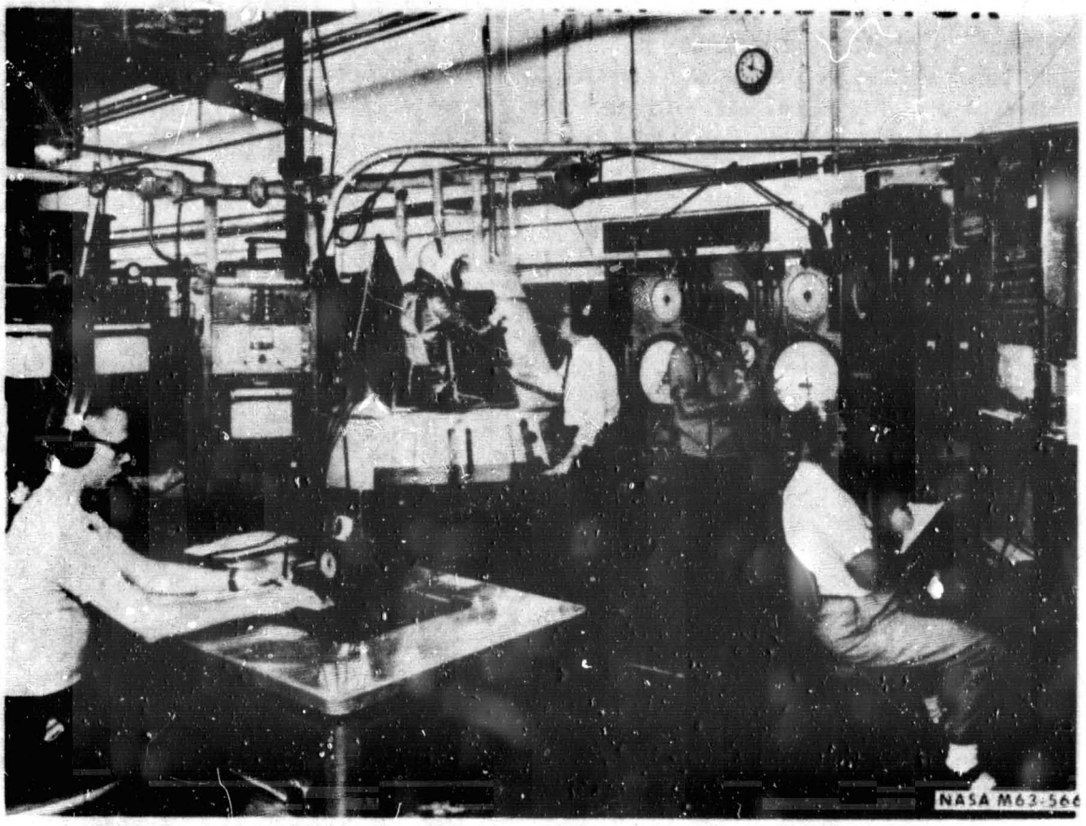

FIGURE 179

The Gemini space suit development program includes providing a capability for short duration life support outside the spacecraft. This extra-vehicular capability will provide us with a means of exploring the problems to be encountered in operations outside the spacecraft in Project Apollo.

It is significant to note here the progressive flight plan which provides information for future longer flights—the Apollo mission, as an example. In the coming year we will continue the development of an extra-vehicular suit, purchase production pressure suits, develop maintenance techniques and continue the development of food and waste management systems.

Concurrently with this effort in support of Project Gemini a broad spectrum of effort is being applied to satisfying the medical needs of Project Apollo.

For Project Apollo, a special space suit is being developed for lunar surface operations (fig. 180). In this suit, the astronaut, carrying his life support system in a pack on his back, will be able to leave the lunar excursion module to accomplish scientific and exploratory tasks on the surface of the Moon. In the area of space suit technology, work is currently being directed toward improving structural integrity, reliability and durability while at the same time providing greater stay time, functional capability, mobility and comfort for the suited astronaut. Studies are being made of the problems that may result from micrometeorite impact on the suit during lunar surface operations.

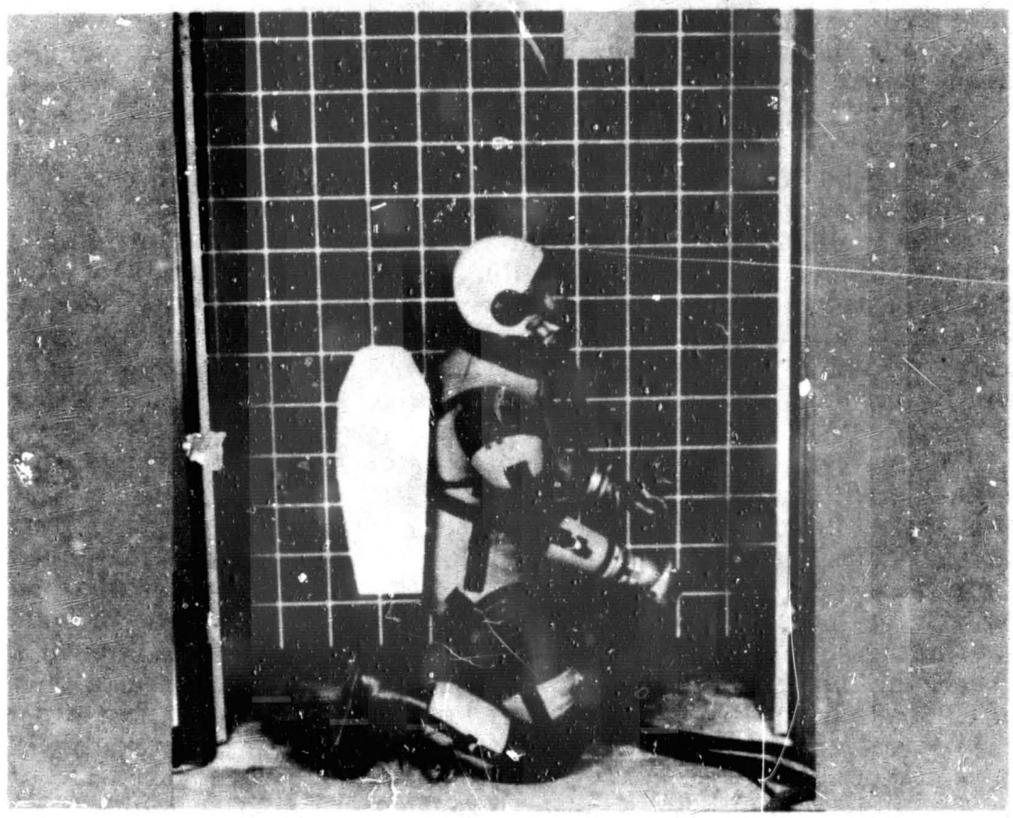

FIGURE 180

In another vein, studies are being conducted to explore man's ability to perform simulated vehicle maintenance functions while wearing a pressurized Apollo space suit. The mobility needed to engage in such activities will be provided by incorporating bellows-type joints in the design of the space suit. Exhaustive studies are underway to improve the prototype life-support back pack to extend the stay time on the lunar surface.

In the Apollo lunar mission we can expect to face a new problem area in the manned space flight program. This is the effect of the space radiation environment upon space crews traversing the cislunar space. NASA now is making every effort to adequately define this environment by means of data obtained from unmanned flights, together with recorded observations of solar flare activity. Shielding design criteria for the spacecraft have been established based on this information. Applying dose limits postulated by our biomedical people, assisted by the Space Science Board of the National Academy of Sciences, we feel confident that adequate shielding can be provided for the flight crew within the allowable weight limits of the Apollo vehicle. Dosimeters developed and tested in Mercury flights will be subjected to more rigorous testing in Gemini flights and then employed in Project Apollo lunar flights.

In addition to the foregoing highlights of our development program, work is being carried out to improve bioinstrumentation, to develop

improved feeding and waste management systems, to provide an acceptable personal hygiene system, for the crews on prolonged space flights, and to establish advanced selection criteria to be used in choosing astronauts for future space missions. The problems of emergencies in flight are being approached by an aggressive effort to develop advanced techniques to permit in-flight medical care and a continuing effort to provide improved survival gear.

In the implementation of this program every effort has been made to use to the maximum extent possible those resources available within the Department of Defense, in other Government facilities, in universities, and in industry. Our best estimate at this time indicates that approximately 12 percent of our research and development funds will be spent in Department of Defense facilities, 8 percent in other Government facilities, 10 percent within the university community, and 69 percent in various segments of the vast pool of resources available within industry.

It should be borne in mind that in large measure our program must take advantage of data obtained in flight and must be so streamlined as to make it possible to operate within the short leadtimes dictated by accelerated flight schedules. We must be prepared to provide continuous monitoring and to provide needed technical inputs in a timely manner. It can be readily seen that such an effort can only be carried out effectively by a closely knit team of people representing the several development interests. The need for an on-site team of development specialists is further accentuated by the necessity of having immediately at hand the people and facilities required to effect the day-to-day solution of unforeseen problems.

To meet this urgent need we have established in the Crew Systems Division at the Manned Spacecraft Center just such a quick reaction support organization. Working closely with project offices, this group is able to provide the type of support not normally available in a laboratory conducting a preplanned long-range program.

The Crew Systems Division is staffed at present by:

Physicians	7	Mathematicians	3
Psychologists	2	Electrical engineers	11
Biochemists	1	Miscellaneous engineers	62
Biologists	1	Technicians	22
Physiologists	7	Administrative personnel	15
Nutritionist	1		
Chemists and chemical engineers	8	Total	147
Physicists	7		

This, then, is a summary of the activities of our Crew Systems Division at the Manned Spacecraft Center. To better acquaint you with the day-to-day work carried out by this Division, we would like to show you a film which I believe will serve to clarify my attempt to paint a word picture of their operation.

[A film was shown.]

General ROADMAN. I have been asked, Mr. Chairman, to comment concerning the g. forces and the frequency on that portion to be conducted out at the Aerospace Medical Laboratories. The cycles per second were in the range of 0.5 to 1 g. That particular frequency and g. area is a matter of concern to us primarily in the Gemini program.

I have described the Crew Systems Division's functions and responsibilities, and hopefully have given you a word and picture portrayal

of their activities. I would like now to turn to the other half of our biomedical program in support of approved manned space flight programs. This is embodied in the activities of the Center Medical Operations Office at the Manned Spacecraft Center.

Here we have a carefully selected group charged with responsibility for the medical portions of the actual flight operation. Beginning with the medical selection of astronaut candidates, its activities include the medical training of those candidates selected, a rigorous medical maintenance program to insure the continuing physical fitness of these men during training, the medical preparation of astronaut crews for specific flight missions, the design of medical experiments to be performed in flight, the medical monitoring of crews in real time during the flight mission, the provision of medical support as part of recovery operations, and the physiological evaluation of the crew upon the completion of a flight mission.

One of the most significant contributions of the Center Medical Operations Office is the preparation of a postflight medical report in which is summarized all of the medical data pertinent to a given flight. This includes crew data acquired during training, base line data obtained immediately prior to flight, in-flight data developed by biotelemetry relayed to the ground and interpreted by medical monitors at tracking stations along the global communications network or recorded on board the spacecraft and analyzed during the postflight period, and the results of a searching medical examination conducted during the period immediately following completion of the flight mission. All of this, interpreted and evaluated, becomes a postflight medical report. In the hands of our own people, this report constitutes an invaluable aid in planning future missions. In the hands of the scientific community, it guides the planning of both basic and applied research. Here we document our progress toward our medical goal of establishing man's ability to live safely and perform effectively in the space environment.

The small group of National Aeronautics and Space Administration biomedical specialists making up the Center Medical Operations Office are assisted by a large number of carefully screened personnel made available by the Department of Defense (fig. 181). For an average orbital mission, 16 Department of Defense specialists function as medical monitors, 42 medical specialists and technicians assist the recovery forces, and a group of 16 top-level clinical specialists stand by at selected hospitals, alerted for deployment should an unforeseen emergency arise. There is no appreciable change foreseen in the need for Department of Defense medical support in early Gemini flight operations. However, as the flight safety problems incident to manned space flight are reduced by experience and increased vehicle reliability, it is to be expected that the need for extensive emergency medical support will be reduced accordingly.

Again, the subject of medical operational support of manned space flight is one that lends itself to pictorial description. To this end we have prepared a short film to help us describe the activities of this group.

[A film was shown.]

General ROADMAN. As our programs have taken shape we have become increasingly aware of a pressing need to safeguard and conserve our most critical resource—man. Maintenance of an acceptable

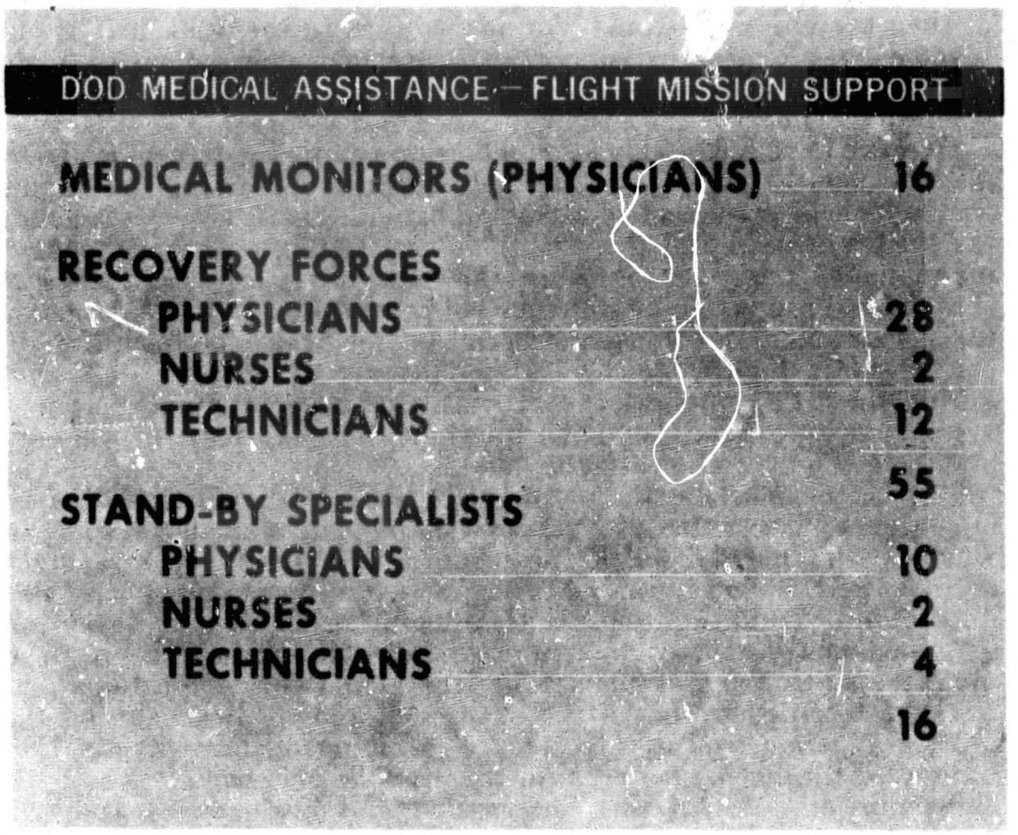

FIGURE 181

working environment for all of the people engaged in the many distinct facets of this program is critically important to our success. As vehicles grow in size and hazard potential, as missions grow in duration, and as ground control and tracking tasks become more arduous, we must take steps to insure the continued peak performance of each member of our technical team. To this end, we will establish an occupational health program specifically designed to meet the needs of operational space flight missions. Included will be studies of explosion, fire, blast, noise, and fragmentation hazards to support personnel in the test and launch of boosters. Means to protect operating personnel from such hazards will be developed. Work/rest cycles will be established for mission control personnel to insure peak performance during all phases of each mission. Criteria will be developed for the selection of individuals best fitted for employment in critical duties at remote stations. Finally, a program of preventive medical care will be instituted to reduce time lost by reason of preventable illness or injury.

From the foregoing, it can be seen that our space medicine responsibilities are expanding. Only a short time ago, we were dealing with the support of a single project—Project Mercury. Today we deal simultaneously with three projects—Mercury, Gemini, and Apollo. Activity in all three projects is being accelerated. Since these projects are stepping stones in a vast technical development program it is to be expected that they would increase in sophistication and technical complexity. Thus, our developmental responsibilities

are increasing accordingly. This growth, of course, finds expression in the dollar requirements to meet these demands.

After exhaustive study of our requirements to be certain that we have included only those things which in our best judgment can be reasonably expected to promise essential direct support of approved manned space flight programs, we believe we are proposing a spectrum of space medicine activity during the coming year adequate to meet the current needs of these programs.

We feel what we believe is justifiable pride in the progress made by our personnel during the past year. We look forward to a year of even greater accomplishments.

A forecast of these accomplishments is reflected in the work planned within the several segments of our space medicine program.

At this point I might draw your attention to the budget books. In the area of experimental studies (fig. 182), tasks will be applied to studying human tolerances to noise, vibration, acceleration, and impact as they pertain to our specific purpose and we will continue our studies to determine the optimum atmosphere for spacecraft cabins during prolonged missions.

Mr. DADDARIO. That is on page RDO 3–1, volume II, R. & D.?

General ROADMAN. Yes, sir; I believe that is correct.

Studies will be initiated to develop portable life support system components to increase mission time. Another major effort will be directed to the development of methods to control temperature, hu-

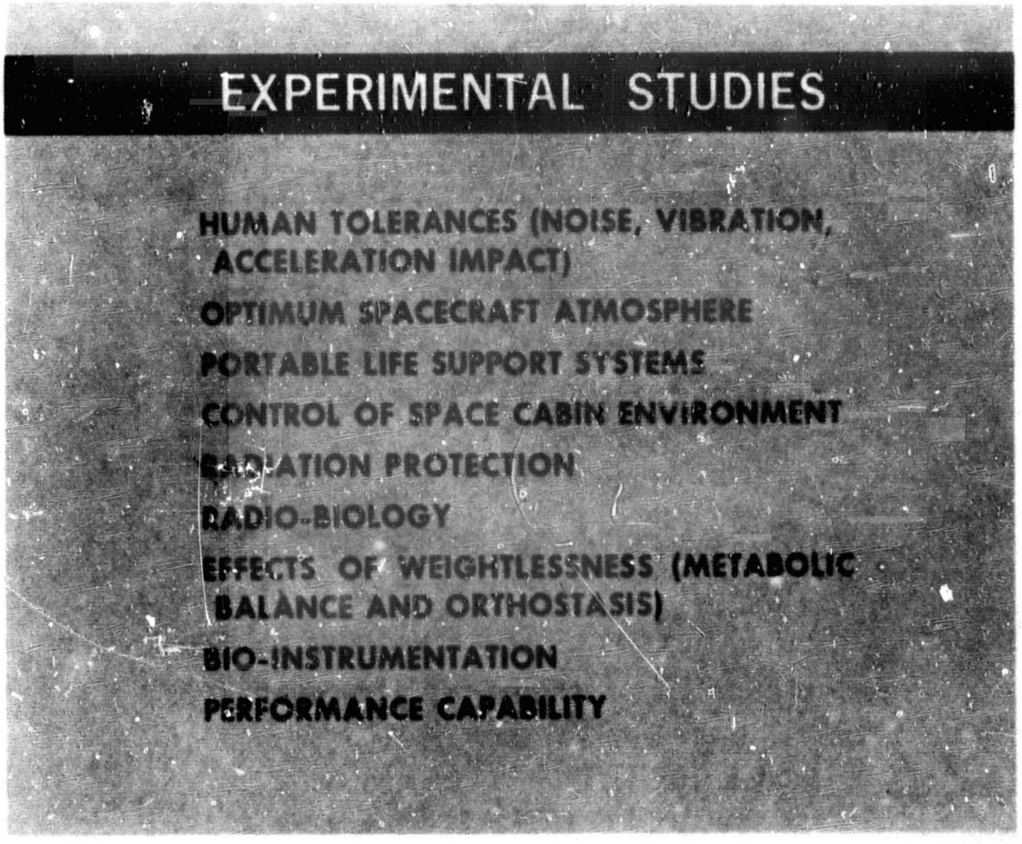

FIGURE 182

midity, and contaminants, including carbon dioxide, in the spacecraft atmosphere. Backup technology to improve the environmental control systems to be used in future manned spacecraft programs will, of necessity, be continued. Obviously, the radiation problems incident to space flight require additional study. In this area NASA will continue to study the interactions of primary protons with spacecraft materials. In the area of radiobiology a considerable effort will be applied to studies of eye changes, dose rates, biological subsystem effects, and methods of preventing and treating radiation damage in astronaut crews. Improved radiation bioinstrumentation, radiation flux measurements, studies of metabolic balance in the weightless state, analysis of environmental control systems by computer techniques, determination of orthostatic tolerances following prolonged weightlessness, and studies of measures to predict performance degradation occurring under conditions similar to those required in Apollo missions are typical of the work making up the remainder of the effort in this segment of our space medicine program for a total estimated cost of $8,125,000.

In the crew systems area (fig. 183) work will be initiated to develop space-suit assemblies suitable for use in free space and on the lunar surface, to improve both design and components for space suits and crew support and restraint systems, and to improve waste-handling systems. Development of a space suit for use in space environment simulators, development of improved survival gear, tests of prototype space-suit assemblies, development of reliable equipment for preflight and in-flight checkout of personal support and safety equipment for space suits, and the development of improved space feeding systems

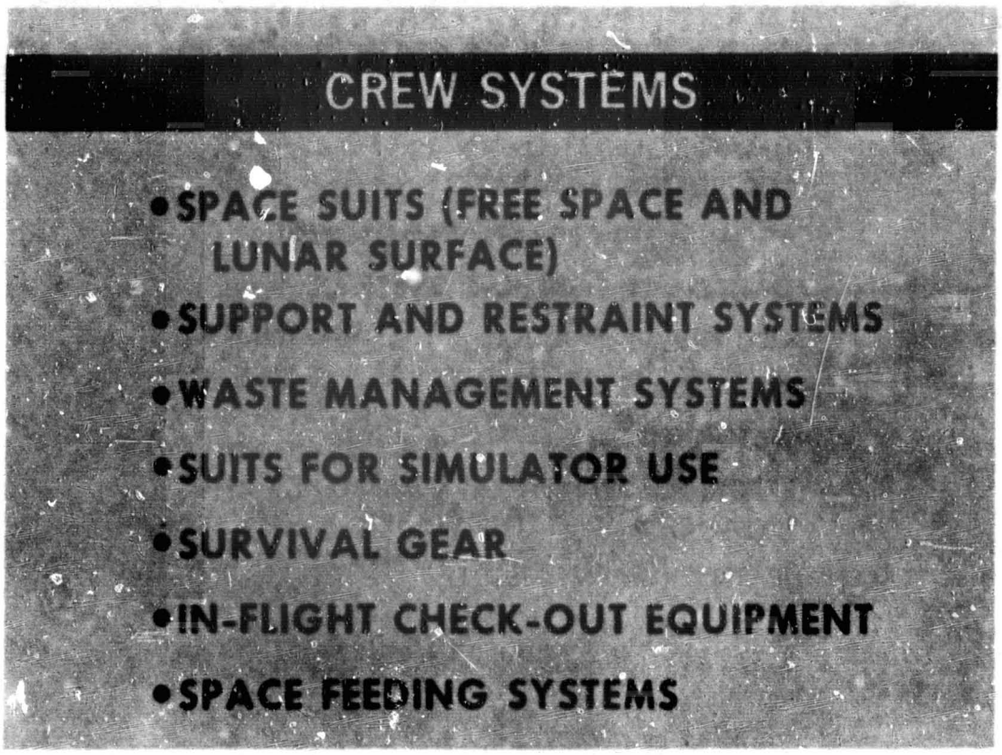

FIGURE 183

are typical of the tasks that will be accomplished within this area at an estimated cost of $3,950,000 in fiscal year 1964.

The launch schedule and the reliability of the system employed offer an opportunity to include certain experiments as part of the mission objectives for future flights. Under the category of biomedical in-flight experiments (fig. 184) will be developed instrumentation concepts and hardware to detect cabin atmosphere leaks and contaminants, establish potability of spacecraft water supplies, and develop specific gas sensors and measuring techniques. The development of sensors and instrumentation systems to permit space

FIGURE 184

flight crews to be monitored in flight will be continued. In-flight experiments to measure the physiological cost to the individual resulting from stress induced by space flight activities, for use in establishing selection criteria based on reaction to stress will be carried out. The establishment of rapid and standardized data reduction and analysis procedures for those biological systems associated with manned flight will be accelerated. It is estimated that this spectrum of work will cost $3,125,000 in fiscal year 1964.

In the area of medical operations (fig. 185) work will be started to identify and define the toxicological problems incident to the use of new propellants, to establish the noise hazard potential of large boosters and develop safeguards against this hazard, to estimate the blast hazards associated with launch operations and to devise protective techniques for support personnel. Studies will be accomplished to define optimum work/rest cycles for personnel engaged in critical ground control positions during prolonged space flights. This support effort is estimated to cost $1,500,000 in the year ahead.

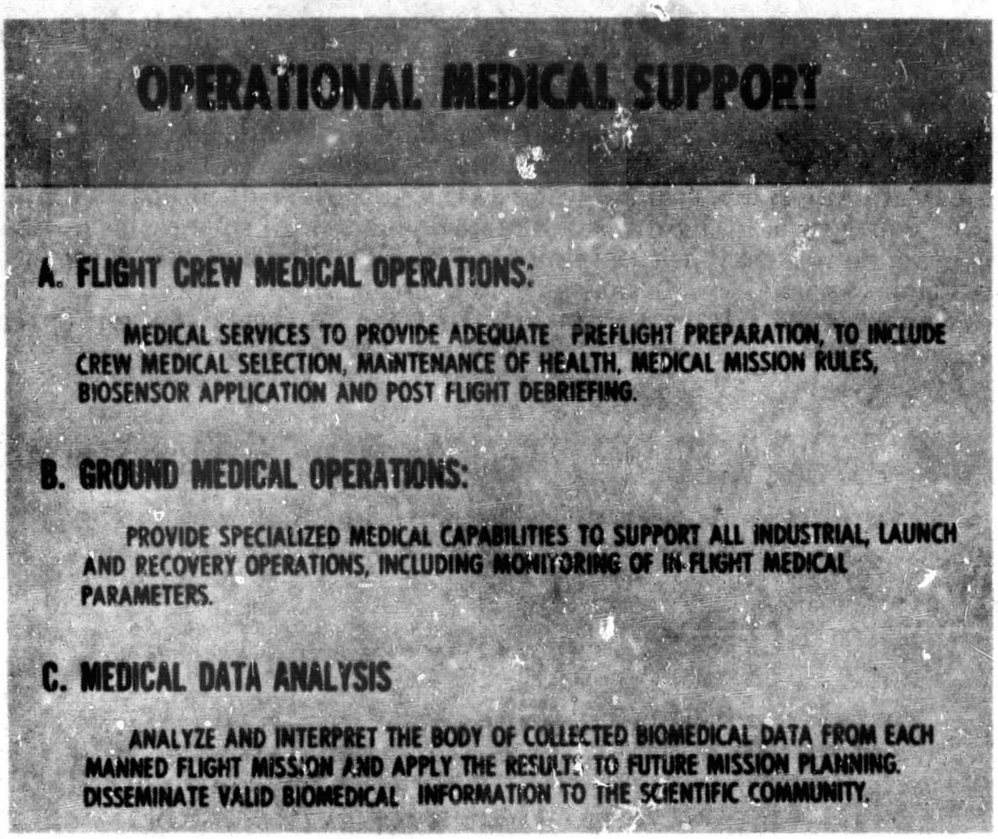

FIGURE 185

Mr. Chairman and members of the committee, I am indeed grateful for this opportunity to discuss our plans with you. We firmly believe we have presented to you a program which is sound and which reflects both definition and purpose. We have attempted to outline the plans we have laid to insure timely and effective completion of the tasks ahead of us. We have attempted to make clear our determination to use to the maximum extent feasible the personnel and facilities available in the Department of Defense, in other Government agencies, in universities and in industry consistent with our manned space flight requirements. Finally, we have pointed out the steps that have been taken to integrate our program with those of the other life sciences interests in the National Aeronautics and Space Administration to fashion a mature and purposeful approach to the medical support of our manned space flight missions.

Thank you, sir.

Mr. DADDARIO (presiding). Thank you. Mr. Yeager, do you have any questions?

Mr. YEAGER. Yes, sir, I do.

In volume V, page 14 you have a further breakdown of some of the figures you have just given us. Now, this shows, for example, in the life support system, a life support system item under each of the first three categories. I notice the Office of Advanced Research and Technology also has an item of life support and protective systems in the amount of $6.8 million. Can you give us an idea of how these differ, and why they should not be all carried out in a single office?

General ROADMAN. I would like Dr. Knauf to address himself to this question.

Dr. KNAUF. The Office of Advanced Research and Technology deal with those life support system responsibilities which are beyond the things we need in support of the current series of approved projects. Semantically, the titles are very similar. The definition of the tasks, however, indicates support of efforts in advance of our approved program.

Mr. YEAGER. The same thing occurs in the bioinstrumentation. The Office of Manned Space Flight has several items for bioinstrumentation, the Office of Space Science has a similar item on biological information, control and communication systems, and the Office of Advanced Research and Technology has a similar one on biomedical instrumentation.

Dr. KNAUF. The reason is the same. By and large, they are concerned with advanced systems over and beyond what we are planning to use in our current series of flights.

Mr. YEAGER. How about matters of radiation; the Office of Manned Space Flight has several items on radiation, and OART also has four different items listed in regard to high energy radiation effects from shielding. How would this differ?

Dr. KNAUF. I am not sure that I am familiar with the detail. Our radiation program is concerned with dosimetry. It includes the things we will be using in our program for the current plan of flights.

Mr. YEAGER. What are those, sir?

Dr. KNAUF. The specific items which will be used in the current series of flights.

Mr. HOLMES. This is repetitious, but I will say it in a different way: In NASA's Office of Advanced Research and Technology we have people who are studying some of the same general areas that we are studying. The significant difference is that we are trying to solve the immediate problem; we are trying to solve the radiation problem, relative to shielding, in order to build a safe and reliable Apollo spacecraft or Gemini spacecraft. What they are trying to do is not to solve the immediate problem, but to examine all the techniques for the future.

A certain percentage of one's effort in any development program ought to be directed toward the areas that are not an immediate need, but will be involved in the future. That is what OART's objective is. It has been my experience that this need gets completely consumed by the ongoing project if it is not set up organizationally. If one does not investigate these areas, the result is a rather sterile future.

Mr. YEAGER. There is not any duplication of the same type of experiments or developments that are going on in the Office of Advanced Research and Technology?

Mr. HOLMES. No, sir. We work very hard to see that there is not. There may be an occasional small point of similarity or duplication because of human error. However, we have made a very great effort to coordinate closely with OART—both my directors and me, and Dr. Bisplinghoff and his directors. If there is any duplication at all, it is a minimum.

Mr. DADDARIO. General Roadman, to which of these sections have you been assigned responsibility? Is it just aerospace medicine, or

do you also have responsibility in the bioscience and the human factors system areas?

General ROADMAN. Mr. Daddario, my sole responsibility is space medicine in the Office of Manned Space Flight.

Mr. DADDARIO. Will you give the committee a little history as to how the life sciences program at NASA has developed into these three sections? What are the reasons for its developing the way it has?

General ROADMAN. In reply to that, Mr. Daddario, I should point out first that within the life science area in NASA we have been endeavoring to identify those areas within the life sciences that closely aline themselves to the specific functions of major program offices.

Let me illustrate this. The Office of Space Sciences has primary responsibility for the exploration of space in unmanned systems. The biologist is interested in the effects of the space environment on biological organisms. We in Manned Space Flight are interested from the standpoint of man. Space Sciences is interested primarily in the more basic effects of the space environment on biological organisms; therefore, space biology is incorporated within the Office of Space Sciences. It is logical that if exploration of the space environment is a prime responsibility, the interests of space sciences must be directed not only toward the physical environment of space, but also to its interaction with biological organisms.

Mr. DADDARIO. Are you establishing a criterion, then, that not only does NASA have the major responsibility in our space program, but that also within the various sections of NASA, responsibilities have been assigned to those sections which deserve to be so isolated so that they have a program within themselves?

General ROADMAN. I believe it is logical that it be organized in that way, Mr. Daddario. For example, in the Office of Advanced Research, to complement Mr. Holmes' remarks, there are certainly requirements for research beyond the current programs, and certainly in the area of biotechnology.

Mr. DADDARIO. When the program was first proposed, it was my understanding that there would be one section which would take over all of the responsibilities and all of the life science areas for NASA. That has changed somewhat.

General ROADMAN. Yes, sir.

Mr. DADDARIO. I wonder if this is not only a proper way to do it, but is it the most economical way? Does it gather together the proper people in the most efficient manner to save both manpower and facility costs?

General ROADMAN. In my judgment, Mr. Daddario, the functional alinement of specific areas of biological or medical interests with the specific functions of the organization is logical. I think that it will provide a better program, and I further believe that the economies with respect to personnel and dollars are certainly worthwhile.

Mr. DADDARIO. When you say it is worthwhile, are you also saying that it is the most efficient way to do it?

Mr. HOLMES. In my opinion, it is. The manned space requirements are such that we should have, to be most efficient, a team of medically skilled people concentrating on what must be done to get man safely into space. I don't think it would be efficient to insert into that body of people, with this tremendous responsibility, the

advanced technologist—the research man who is not looking to solve immediate problems but is looking to goals 15 or 20 years ahead.

The third group, or second outside of this ongoing group of mine, are those who are interested primarily in the scientific aspect. Of course, they have a general interest that man goes up safely and they have a citizen's interest. But that is not their primary responsibility. They are primarily interested in what happens to various specimens in different environments. They are studying various scientific elements of bioinstrumentation not required for our immediate goal, but for science itself. I think that they are different types of people.

It is my belief that Dr. Seaman's decision to organize the life science program into three elements was a wise one. Further, I think that it is quite consistent with what has been done in the military—in the Air Force. We see all different types of people and they are not all under one commander. Of course, there may be a staff pulling together, which is a proper and good thing. But the people who are trying to solve the pilots' problems, as we look back over the years, are certainly different from the research scientist trying to solve a longer range problem of biology.

Mr. DADDARIO. What is your answer to the question?

General ROADMAN. I agree completely with Mr. Holmes.

Mr. HOLMES. You can certainly say that we have an organization.

Mr. DADDARIO. I do not find that unusual.

Dr. KNAUF. I think we have learned from the military that advanced research and operational suitability can't be effectively joined into a single unit. They must be, as they have been traditionally, handled separately.

Mr. TEAGUE. Could you use the decision on pure oxygen environment to tell us how this works?

Dr. KNAUF. That might be a good example. Do you refer to the Apollo environment?

Mr. TEAGUE. Yes.

Dr. KNAUF. We in the Office of Manned Space Flight are concerned with the suitability of a pure oxygen environment for a 14-day mission, our present program. By way of the studies that have been accomplished, we are able to satisfy ourselves that in fact man will be all right for 14 days in a pure oxygen environment, physiologically without reference to other things that might be considered. I don't think that any of us at this point in time are willing to say that the book can be closed. There is a need for further study with reference to the suitability of a pure oxygen environment for flights well in excess of 14 days, and that work must be carried out. But our real and immediate concern is: Can we use pure oxygen in the present series of missions?

Mr. TEAGUE. There are plenty of people who disagree with you. How does a group that disagrees with you get a chance to present its ideas?

Dr. KNAUF. There are two or three mechanisms. The manned Space Committee of the Space Sciences Board had a working group on this problem of pure oxygen environment. Here they heard comments and testimony from many groups of people. I think Dr. DuBois, who chaired that working group, was of the opinion that our position on a 14-day mission was probably sound. He cautioned,

and certainly we recognized, that additional work would have to be done to support a plan to go for prolonged periods of time. In addition to that, last week at the Aerospace Medical Association meeting on the west coast, we organized a separate session to provide to people concerned with this environmental problem the opportunity to express themselves.

I was not at that meeting, but I have talked with our people who were there. I think they all were agreed that caution should be exercised in looking at a hundred percent oxygen for long duration flights, but we felt there was no real disagreement with our intention to go with 100 percent oxygen for 14 days.

Mr. HOLMES. May I comment, Mr. Chairman?

It seems to me that this is a good question and serves as a good example to illustrate our organization, since you used it in that light. Here are people who disagree with what we are doing in the manned flight program from a space medicine standpoint. In my organization there is no confusion about what group is responsible for space medicine. There is one space medicine group within OMSF and it is concerned with requirements for manned space flight. It is not mixed up with people making studies of animal packs or future studies.

If anyone does not like our decision, I would suggest that they write my superiors or me and tell us in addition to telling it to the press. Frankly, it is disturbing to me to find how many Americans will stand on a podium and talk about what they think is right and what is wrong, without feeling the responsibility, relative to a national program of this nature to direct their comments in writing to the people in charge of the program.

I would suggest that anyone who doesn't approve of the use of pure oxygen should get in contact with General Roadman tomorrow.

Mr. TEAGUE. I appreciate your leaving out the politicians.

Mr. DADDARIO. It is, however, Mr. Holmes, a traditional way for Americans to air ideas through a scientific forum. You wouldn't be opposed to scientists and specialists in any area getting together and coming out with reports and putting into issue items which ought to be debated?

Mr. HOLMES. No, I don't. But I think that if they are concerned about something that is an integral part of an ongoing program, they would also benefit the United States greatly and certainly benefit our program by communicating with us directly.

Mr. FULTON of Pennsylvania. On that point, I can see that research scientists or engineers might not want to put their answer up against the whole NASA organization nor enter into a dispute. Don't you think, as Mr. Daddario suggested, that monographs or papers of a scientific nature based on reasonable assumptions are worthwhile? I am surprised that you complain about the publication of technical documents or magazines and associated publications. I think they are fine. I read them myself.

Mr. HOLMES. I was addressing myself not to the technical publications primarily but rather to the news media. We have more and more scientists and engineers in the news. In keeping with our open society, I believe that constructive criticism of national programs is healthy, provided that the critics also take the time to communicate their ideas directly to the people who are trying to carry out the program.

Mr. FULTON of Pennsylvania. The thing I think you are missing is, I don't think everything should be channeled through one source. There are a variety of news media and the differences in the approaches is what makes this thing interesting. If NASA had all the answers, I would say that is right. But let me tell you, if we look at science as approaching the unknown, maybe NASA is approaching the unknown too.

Mr. HOLMES. Let me say it this way, Mr. Fulton. It would help us greatly if anyone who has a reasonable suggestion which would improve our program would take the trouble to communicate this information to us.

Mr. FULTON of Pennsylvania. Of course, they know you are going to read the Missiles and Rockets magazine. You have seen this criticism, haven't you, on the pure oxygen environment approach?

General ROADMAN. May I comment, sir? I would like to state, and I am sure Mr. Holmes is certainly aware of this, that there has been no restraint on people honestly interested in this program in terms of coming in, or writing or talking with us concerning this particular matter.

Because our manned space flight program is new, it is extremely difficult for many of us in responsible positions to have all of the facts at hand prior to a particular flight. However, we have done everything possible to assure that we are not compromising or will not compromise man's position, and in the area of 100 percent oxygen I think it can be summated this way: We have many questions that we have initiated ourselves. In our investigations to date, we have no physiological information that would permit us to say that 100 percent oxygen is physiologically contraindicated in a 2-week mission. This is not to say that there are not many physiologists who would like more information concerning 100 percent oxygen over a time period, a point of view which we thoroughly support. In our program, we have found no one who would come up and give us, in the time period required and within the engineering considerations involved, any alternative, nor would they say it is dangerous to go with that decision.

In the advanced research area, for example, we are extremely interested that OART continue its investigations with 100-percent oxygen over prolonged periods of time. In our own program, with no physiological information that would say that we cannot go with 100-percent oxygen basis, we are pursuing the problem within the 14-day time scale and feel content that it is a decision that is perfectly acceptable.

Mr. FULTON of Pennsylvania. But there can be no real complaint by NASA when scientists, engineers, technicians, or even the average citizens air their views in the daily newspapers—the New York Times, the Space Daily, Missiles and Rockets. I don't believe they should all come into NASA.

Mr. RIEHLMAN. I think General Roadman has answered the question that I wanted to ask. I am satisfied with the answer he has given.

General ROADMAN. May I make one other comment. With reference to organization and to program. Perspective is extremely important. Let's look at organization. The biologist who is interested in the effects of weightlessness on sea urchin eggs and their fertilization raises a perfectly legitimate question. However, the biologist might say we should not fly man in space until we conduct all of the research

possible and answer all biological questions. Our program is not constructed that way.

However, our organization provides a biosciences basic research program in the Office of Space Sciences. Therefore, Dr. Reynolds can pursue a program in biosciences which has a broad scientific requirement, and this is a legitimate requirement. We are not tied to many unknown areas in manned space flight. Judgment and experience permits us to continue in a hopefully accelerated flight program. That is why space medicine is in the Office of Manned Space Fight. I feel that the prime requirement in the support of manned space flight is neither the biologist nor the physiologist, but rather those like myself who are trained and who have had experience in an operational program.

That is another reason for the organizational arrangement being as it is, and for the identification of specific areas of scientific or medical background.

Mr. DADDARIO. I am pleased to have your so wholehearted endorsement of the structure. I inquire into it, however, only because of the number of times that this program has changed within NASA, and I have concern as a result. For example, how long have you been with NASA?

General ROADMAN. Three years, sir.

Mr. DADDARIO. When you first came to NASA, what was the structure of the life sciences program?

General ROADMAN. It had been recently developed into the Office of Life Science programs, as a major program office similar to other program offices existing at that time.

Mr. DADDARIO. You succeeded Clark Randt?

General ROADMAN. Yes, sir.

Mr. DADDARIO. There had been a different conception of the life sciences program under Clark Randt. There was a change of direction, as I recall, as a result of inquiries made by this committee and as a result of conclusions, I imagine, reached by the directors of NASA. But hasn't there been a change even during the period of time you have been with NASA?

General ROADMAN. Yes, sir.

Mr. DADDARIO. Just following along on that line, you have mentioned the aerospace medicine objectives for Project Mercury, and said that these objectives have been achieved. You have also, in the course of your testimony this morning, broken down the present percentage of assistance that you receive from the other areas of the Government and industry. What was the percentage of assistance given to Project Mercury in the life sciences or the aerospace medicine area by the Department of Defense?

General ROADMAN. I believe it is safe to say that the medical support to this project at the beginning was practically a hundred percent Department of Defense.

Am I not correct in that, Mr. Low?

Mr. Low. From the outset Project Mercury, was guided by NASA people who initially were detailed from the Department of Defense. In that sense it was 100-percent Department of Defense support.

Mr. DADDARIO. So that at the start of Project Mercury, the Department of Defense was called upon to give 100-percent assistance through the facilities and personnel it had developed over a period

of time, excepting for some direction and integration of activities. At the present time in other programs this has gone down to some 12 percent. This committee has listened to testimony as to what extent NASA should develop its capabilities in this area. There have been various determinations as to maximum and minimum extents. Last year this committee had Dr. Dryden and Mr. Reubel of the Department of Defense before us, and it was our understanding that these gentlemen would get together and come up with an agreement which would spell out how the programs would integrate themselves in the future. To this time, we have not heard of such an agreement. Yet NASA has been constantly involved in all areas of the life sciences and the biosciences, and something else that you now call unified systems.

Would you give us your idea, first of all, as to why this agreement has not come about. Secondly, is NASA now participating to an extent beyond that which is necessary, taking into consideration the Department of Defense capability which you used almost 100 percent to support your Mercury program?

General ROADMAN. May I first comment on your previous question, Mr. Daddario. I would like to state for the record that I personally made the recommendation to the Administrator, the Associate Administrator, and the Deputy Associate Administrator on the current organization configuration of the life sciences activities.

I made the recommendation; they made the decision. I was responsible for working this structure out.

Mr. HOLMES. Let me comment on that point, too, if I may, Mr. Daddario. I think that what you have said is true. The organization has changed since General Roadman joined NASA. But the facts are that the organization has not changed since about 6 months after May of 1961, when the President established manned lunar landing and return within this decade as a top national goal. Our present organization is essentially the one which was established at that time. I think it does make a difference that the organization to take on the redefined mission has not been one that has vacillated. It has been stable. I thought that you would want that comment.

Mr. Low. I would like to add for a moment to my previous answer on the 100-percent support by the Department of Defense. It is true that when Project Mercury was initiated within NASA, NASA had no capabilities in its life sciences-space medicine area, but we also found very soon that the Department of Defense did not have the appropriate capabilities to support the Mercury program.

We also found in many of the areas that required support that this support had to be directly related on a day-by-day basis in the same area and the same location with the engineers who were developing the spacecraft itself. This was true of pressure suit development, of life support systems development, of all the things that are tied into an integrated system.

The capability existed nowhere to support a manned space flight program, and it had to be linked intimately with the on-going project. For these reasons, within the very first weeks of the Project Mercury organization, the direct support for Project Mercury was built up within the NASA Spacecraft Group, which was then located at Langley Field, but which is now at the Manned Space Flight Center at Houston.

Mr. ROUDEBUSH. You mentioned that the Department of Defense had an entirely different type of program going in this area. Could you describe in more detail what was different, and how it was different?

Dr. KNAUF. The Department of Defense program, generally speaking, has been an applied-type program, but not one operationally oriented to today's problem. I wonder a little bit if we don't confuse the issue with repeated references to the amount of our work which goes to the Department of Defense, leaving the impression that when we move from 100 percent to, say, 12 percent, that we have created a vacuum in the Department of Defense.

Mr. DADDARIO. Nobody has said that you have created a vacuum. Let's get that straight. I asked the question. What we are trying to get at is not whether we are creating a vacuum, but how this program has been integrated. Has NASA in fact utilized the facilities and personnel of this country to its best advantage, or is NASA, because it has been able to get the funds to support a program which is much larger than originally contemplated, now doing many more things than it needs to do, despite the fact that what you are doing may be very nice.

Dr. KNAUF. Let me rephrase my position. I think I am getting at the same thing you have in mind.

Mr. DADDARIO. You are not getting at the same thing if you are talking about a vacuum.

Dr. KNAUF. The 65 percent of the space medicine program which is to go to industry is going to the same contractors that the Department of Defense would use, in the main, were they given that responsibility. The discrepancy is not so great as it may appear.

Mr. DADDARIO. The discrepancy may not be as great; yet, it is a narrowing down of Department of Defense capabilities. NASA is developing a new capability. I think we ought to look into this as we go along; we have a whole series of questions and answers being mixed together here. In this particular instance, as NASA builds up its capability to deal with industry in this area, is the Department of Defense losing its capability, and is the national security being affected as a result?

Mr. HOLMES. Let me address myself, if I may, to your question. To the best of my knowledge, and in good part because of your interest and stimulation to our thinking, and I say that with all sincerity, we have provided enough liaison between the Department of Defense and NASA, particularly in the manned flight part of the program. It was my impression last year, after numerous meetings between the Department of Defense representatives and ourselves, including Mr. Rubel and Dr. Dryden, that we were all agreed that the Department of Defense was doing for NASA what it was logical for it to do. In addition, there was agreement that NASA was doing the things that were logical for it to do.

It is true that there were statements about a formal agreement. I regret that a formal agreement has not been reached, but despite that fact there is a very real agreement. There is very close liaison. Colonel Talbot, for instance, working in the Air Force for General Ritland, is located in our building. There is a very viable agreement and very close coordination to assure the very things that so concern you.

Mr. DADDARIO. General Roadman, you have stated that you made these recommendations after you came to NASA. Can you give us the reasons behind the recommendations?

General ROADMAN. Looking at the organization of NASA at that time, when reorganization was being considered, it was my opinion that great advantages would accrue to the organization and to the area of life sciences if they were identified in terms of their specific scientific interests and placed within the major program offices that had primary responsibility for the functional type of work involved.

For example, if advanced research is required in space medical activity, it seems to me that the office having advanced research responsibility throughout NASA would also have the responsibility for advanced research in areas of space medical activity. The same thing is true as far as manned space flight is concerned. It seemed very important to me that if space medicine activity is required in direct support of manned space flight, then, space medicine should be incorporated within the Office of Manned Space Flight.

Those were the basic reasons, Mr. Daddario.

Mr. DADDARIO. Does the country have the capacity to provide the type of personnel necessary for the NASA program and the program within the Department of Defense?

General ROADMAN. I believe it certainly does.

Mr. DADDARIO. Where are you getting your people from?

General ROADMAN. We have rather stringent requirements in terms of the types of people we need in the Office of Manned Space Flight, and these individuals come both from the private practice of medicine and from other areas within the civilian community. We have also procured people with special abilities on loan from the Department of Defense, specifically the Air Force.

Mr. DADDARIO. Could you provide for the record a breakdown of the personnel as to where you get them in the categories which you spelled out?

General ROADMAN. I would be happy to.

(The information requested is as follows:)

Of the 147 personnel cited earlier as being assigned to the Crew Systems Division at the Manned Spacecraft Center, there are:

Assigned Air Force officers	3
Assigned Public Health officer	1
Former Air Force civilian employees	10
Former Navy civilian employees	5
Persons formerly employed in the private practice of medicine, industry, universities, and the former NACA	128

Mr. DADDARIO. Before I get away from this, Mr. Holmes, I forgot a very important question. We have talked about this agreement, and you have regretted the fact that it hasn't been consummated. Can you tell us what the present status of it is?

Mr. HOLMES. I can tell you my knowledge of it. You might want to direct that question to Dr. Dryden or Dr. Seamans, because it covers all of NASA. It is my opinion that although we have reached agreement the matter of documenting it in a formal manner may have fallen by the wayside. The fact remains that we do have close coordination on a day-to-day basis.

Mr. DADDARIO. We will look into it.

Mr. GURNEY. Mr. Chairman.

Mr. TEAGUE. Yes.

Mr. GURNEY. Before we conclude this meeting, I would like to ask some questions on these figures.

Mr. TEAGUE. We must have another meeting on aerospace medicine. We had hoped to finish today, but we won't be able to.

Mr. DADDARIO. I want to get into other figures, too.

Mr. ROUDEBUSH. Will it be soon, Mr. Chairman?

Mr. FULTON of Pennsylvania. Would you yield for a question?

Mr. DADDARIO. Yes, I yield.

Mr. FULTON of Pennsylvania. I was concerned, too, about the fields that NASA was in, wherein I would imagine that the Air Force, the Army, and the Navy were already interested. For example, one of the items was survival equipment, I imagine the Navy has done considerable work on that.

My question is: Why is NASA in these fields as well? Other examples would be the raft and sea survival suit, the lightweight lifevest, and the surface radar signal device I would imagine that the Navy and the Air Force are certainly interested in that and has been doing much work on it.

Another item is automatic syringes and devices to eradicate pain and motion sickness and the dry electrode approach on sensory devices. Likewise the visor wiper development would seem to be pretty elementary on anything that the Air Force is doing. Another point that I would make is the yellow dye sea water markers. Any developments on those, it would seem to me, should be adequately covered by the Navy since we had those on carriers in World War II. One other field that I commented on this morning was the investigation of preventable illness and injury with respect to the astronauts. I believe that was on film. These various programs that are being developed in NASA certainly have seen adequate developments by the Department of Defense.

General ROADMAN. May I comment? For example, the development of the lifevest was the result of the situation occurring during Gus Grissom's landing. There was an urgent requirement for providing adequate flotation gear for the oncoming flight.

It is well recognized that the services have had major interest in the development and procurement and production of specific survival gear. I would like to point out to this committee that there is no one else that is faced with the particular type of mission and support we have in manned space flight. I need not call your attention to the small size of the space capsule. This presents a different problem than providing a liferaft capability for a B–52 crew.

Mr. FULTON of Pennsylvania. My point is, why are you doing it at NASA?

Mr. TEAGUE. Will the gentleman yield to me?

Mr. FULTON of Pennsylvania. Yes.

Mr. TEAGUE. We went to Pensacola and San Antonio last year, and you stated that you had teams working on each one of these things. If that is your program, if you would explain that, it would completely answer Mr. Fulton's question. There is complete coordination between NASA, the Navy, and the Air Force on all of these, is that not correct?

General ROADMAN. That is correct, absolutely.

Mr. FULTON of Pennsylvania. In your work on the Gemini suit, you have 62 miscellaneous engineers, 22 technicians, and likewise 3 mathematicians working full time. I was a mathematics fellow in my senior year in college, and I don't know how you use the time of three full-time mathematicians on a Gemini suit.

Mr. TEAGUE. There are a number of questions on personnel; so let's wait until tomorrow to do that.

We will be adjourned until 10 o'clock tomorrow.

(Whereupon at 11:55 a.m., the subcommittee adjourned, to reconvene at 10 a.m., Tuesday, May 7, 1963.)

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1964 NASA AUTHORIZATION

TUESDAY, MAY 7, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON MANNED SPACE FLIGHT,
Washington, D.C.

The subcommittee met, pursuant to adjournment, in room 356, Cannon Building, at 10 a.m., Hon. Olin E. Teague presiding.

Mr. TEAGUE. Mr. Low, did we finish the statement yesterday?

Mr. Low. Yes, we had.

Mr. TEAGUE. We were asking questions on personnel.

STATEMENT OF GEORGE LOW, DEPUTY DIRECTOR FOR PROGRAMS, NASA; ACCOMPANIED BY RICHARD S. JOHNSTON, ASSOCIATE CHIEF, CREW SYSTEMS DIVISION, MANNED SPACECRAFT CENTER, HOUSTON, TEX.; BRIG. GEN. C. H. ROADMAN, DIRECTOR, SPACE MEDICINE, OFFICE OF MANNED SPACE FLIGHT AND DR. GEORGE M. KNAUF, DEPUTY DIRECTOR, SPACE MEDICINE, OFFICE OF MANNED SPACE FLIGHT, NASA

Mr. Low. Today we brought along Richard S. Johnston who is the Associate Chief, Crew Systems Division, at the Manned Spacecraft Center, Houston, Tex. He will be here to support Doctor Roadman and Dr. George Knauf.

Mr. TEAGUE. I believe when we stopped, you were asking questions.

Mr. DADDARIO. I don't believe I was asking questions.

Mr. FULTON of Pennsylvania. The last one, I believe was mine; about this "miscellaneous engineers."

Mr. TEAGUE. The "miscellaneous engineers"?

Mr. FULTON of Pennsylvania. 62 of them.

Mr. Low. I thought if you wanted more about the personnel employment in the Crew Systems Division that Doctor Knauf could give that.

Mr. DADDARIO. Didn't we have a breakdown of that on the chart yesterday?

Dr. KNAUF. Yes, except for the single item, "miscellaneous engineers" which raised some question. I have that information today.

Mr. FULTON of Pennsylvania. I love that heading, "miscellaneous engineers."

Mr. DADDARIO. Why don't you clear that up?

Dr. KNAUF. We found out that the engineers don't like it either. The breakdown, however, for the miscellaneous engineers is: 54 mechanical, 1 industrial, 3 aeronautical, 1 geological, 3 textile.

Mr. TEAGUE. Doctor, will you please speak a little louder so everybody in the room can hear you?

Dr. KNAUF. Yes.

54 mechanical engineers.

One industrial engineer, three aeronautical engineers, one geological, and three textile engineers.

Mr. FULTON of Pennsylvania. How many physicists, chemists, and mathematicians—I think there are three mathematicians.

Dr. KNAUF. There are three mathematicians.

Mr. DADDARIO. This is the Crew Systems Division?

Dr. KNAUF. This is the Crew Systems Division at the Manned Spacecraft Center in Houston.

Mr. DADDARIO. How many doctors are involved?

Dr. KNAUF. Seven doctors are involved.

Mr. DADDARIO. Seven out of how many?

Dr. KNAUF. 147.

Mr. DADDARIO. It seems strange there are so few medical people in what is fundamentally a medical program. Could you explain why there are so few?

Mr. LOW. I might ask Mr. Johnston, who is the deputy chief of that division and also an engineer while the chief of the division is a medical man, to comment.

Mr. JOHNSTON. The predominant part of our work in the Crews Systems Division is hardware oriented.

That is, we are involved in developing life support systems, suits, and the like. Our work in the medical area is in the two main groups; environmental and physiological areas. The physiologists and medical doctors arrive at the systems requirements. That is, how much oxygen you need to breathe and what the acceleration tolerance elements are.

Mr. FULTON of Pennsylvania. Hasn't the Air Force done a lot of this with the X–15?

Mr. JOHNSTON. No, sir, we are getting into flight regimes. We are talking about flying men for long periods of time, where these requirements have not been fully satisfied.

Mr. TEAGUE. The X–15 doesn't use the pure oxygen environment, does it?

Mr. JOHNSTON. No, sir. There are many physiological requirements not satisfied by X–15 data. For example, landing impact load problem is typical.

Mr. DADDARIO. Before you finish answering, I'd like you to include something else in this.

You said "No, sir" to Mr. Fulton's question. I don't think his question applies in any of these instances to the point the Air Force or any other service in the Department of Defense is at the present time capable of doing this. The question is do they have the kind of people who have been working in this area and upon whom the added responsibility could be developed? This is the important point.

Could you better develop these programs on the existing foundation, rather than start anew? Isn't this the point?

Mr. FULTON of Pennsylvania. Yes; that is the point.

Mr. JOHNSTON. Mr. Fulton, I think in the programs we pursued in the last fiscal year that this has been our prime method of operation in the area of environmental physiology. We have worked with

the School of Aviation Medicine at Brooks. We have worked with the Navy's Equipment Laboratory and Johnsville Centrifuge. We have worked with the Armed Forces Institute of Pathology.

We are utilizing DOD. We are not, in these requirements areas, trying to duplicate.

For example, if we need to run impact tolerance tests, we are not specialists in this area. NASA does not have this capability. We are, in fact, going to DOD. We try to bring together the people within the Department of Defense who have the capability. We establish a test protocol common to all so that when, say, Wright Field and Holloman and the Air Crew Equipment Lab have completed their work, we will have a common base. The same type of equipment will have been used and the same measurements taken.

So, for once, this type of physiological data will have a common base and when you finish the job you will have all the parameters taken care of.

I think in answer to your question, sir, we are in every case we can, trying to make full utilization of DOD capability.

Mr. FULTON of Pennsylvania. Hasn't the Air Force and Navy done work with water markers to improve the kit that the Navy has had for years. I question what you are doing. NASA is supposed to deal with space and here it is developing a better die marker package.

Mr. JOHNSTON. I think that a part of our program in providing crew equipment has to be for earth survival situations.

Mr. FULTON of Pennsylvania. Hasn't the Air Force and Navy done just about all that needs to be done in this area?

Mr. JOHNSTON. The thing we are involved in is trying to tailor specific pieces of survival equipment to meet our mission.

If I can give you an example, it takes 100 pounds of booster to put 1 pound of equipment in orbit. It takes 1,000 pounds of booster to put 1 pound on the Moon and bring it back. So our problem in all our equipment is unique in that we are trying to achieve both the minimum weight and volume we can achieve in our rafts and life vests and other pieces of equipment of this sort.

There is a need for increasing the capability of survival equipment and I think that our requirements in many instances are unique throughout our programs in that we are attempting to devise equipment that is lightweight. Our equipment will have probably a single usage as compared with that developed by the Navy or Air Force.

They are trying to develop something that is durable, that can be used year after year. Much of the equipment we are talking about is for single flight use.

Mr. FULTON of Pennsylvania. Couldn't the DOD develop a better die marker system for you, rather than NASA setting up an independent program?

Mr. JOHNSTON. We in the crew systems division are not really working on developing sea die markers. The things we are working on in the survival area are things like trying to build a specialized raft for the Apollo Mission. We are working on trying to build integral flotation into the Gemini pressure suit.

Mr. FULTON of Pennsylvania. I disagree. I saw your die marker program in a NASA film.

Mr. JOHNSTON. That was in a training film.

Mr. FULTON of Pennsylvania. The film certainly gave me the idea you were doing research on it.

Mr. JOHNSTON. Well, perhaps the film was misleading in this area.

Mr. FULTON of Pennsylvania. Mr. Daddario and I are not saying for you to stop work. We are saying that NASA should use whatever capabilities there are in the Department of Defense and other agencies, rather than instituting individual programs.

I think it's a very legitimate source of inquiry.

Mr. LOW. I think, Mr. Fulton, the fact we only have seven physicians in this area is proof that we are making use of capability where it exists. A small group like this couldn't do all the work in-house that has to be done for space projects.

Mr. DADDARIO. Could we apply ourselves, Mr. Low, to this theory? I think this is what we are getting back to. This committee does not feel that NASA shouldn't have a competence in this field. The question is what this competence ought to amount to.

We have been concerned because of the expense of these facilities. We also have been concerned about the expense of building up a large manpower pool and the effect that this may have on the national security effort within the Department of Defense, and the dilution of effort in industry itself. Likewise, we have been concerned about the effect that large programs within NASA might have upon development of medical people in our schools.

This whole question concerns use of personnel. It has, at least, been admitted in the past that this in an area in which there is a shortage of supply.

I would like, if I may, Mr. Chairman, to go back just a bit to see what has happened. We have a program today. If you take these three sections, it encompasses something in the vicinity of a thousand people.

The Bioscience Advisory Committee, chaired by Dr. Seymour S. Kety, issued the basic report on which the science's door opened for NASA.

Mr. FULTON of Pennsylvania. What was the date of the report?

Mr. DADDARIO. The report goes back to 1960.

In June 1960, during a hearing before this committee on "Space Medicine Research," Dr. Clark T. Randt, Director of the Office of Life Sciences, NASA, stated that: "The overall guidelines for this area were provided in the Kety Report." He indicated that this program should include in the neighborhood of 60 professionals. Later, Representative Walter H. Moeller asked if this might soon develop to 90 or 120. Dr. Randt replied that, "I sincerely do not believe so."

In answer to a question that I asked him, Dr. Randt replied that: "We wish to have internal competence to provide leadership."

Implicit in the entire discussion was the idea NASA would not be getting into the actual development phases of these programs, but rather would provide the leadership and the direction to other agencies already involved.

Brig. Gen. Don Flickinger, assistant for Bioastronautics Headquarters, Air Research and Development Command, U.S. Air Force, referring to this, said:

We have been seeing over the past 2 years a tremendous growth in our national biomedical space effort.

Programs are being pursued on a near individual basis without benefit, in many instances, without advice of interested and knowledgeable people. As a consequence we are, in fact, diluting our national talent to such an extent the future may not hold much more hope for real success and understanding than the past and the record of the past is not necessarily one of sound and rigorous scientific achievement.

Now, I bring this up to add perspective to our present discussion so we might be advised as to what has happened since the Kety Report was issued and since the first statements were made by NASA to develop a program in this area. This program now involves many more people than was the original intent of either NASA or of the committee. NASA is doing so much of this work itself that I have the feeling that it is, in fact, in conflict with the Department of Defense.

There has not been any agreement worked out by which this Committee can see exactly how you are operating with the other agencies. It is not just NASA and DOD involved. The FAA and NIH also have work of a comparable nature going on. When I say "comparable" I don't mean exactly the same work, but certainly they have the people who have the capacity to do the same kind of work.

What has happened, Dr. Roadman, to blow this up to this size?

Mr. FULTON of Pennsylvania. May I add something?

When the budget for fiscal year 1962 is $10 million and the budget request for fiscal year 1964 is $21 million in this field, I believe this underscores Mr. Daddario's comment.

Mr. LOW. May I make a general comment first, and then turn it over to General Roadman?

Mr. FULTON of Pennsylvania. Yes.

Mr. LOW. At the time the Kety Report was written, I believe in 1960, we did not have a major manned space flight program. In fact, Project Mercury was the only program we had at that time. Then, for example, the space task group, which was a predecessor of the Manned Spacecraft Center, had in the order of 250 or 300 people, including a small percentage of life systems people. Since that time our manned space flight program has vastly expanded. We have as a national goal the manned lunar landing program. We have since that time started Project Gemini.

An index of the management effort required to run this program is the growth of the Manned Spacecraft Center to a number approaching 4,000 at this point in time. We've had more than a tenfold growth in the overall management force. We needed, then, also in the same time period a concurrent growth in managers in the life sciences area. I don't know what the total number of people in that area was in 1960.

Mr. JOHNSTON. About 18.

Mr. LOW. Mr. Johnston says about 18.

Growth to 147, I think, is about what is needed to support the expanded Manned Spacecraft Program. I do think that one more general point is pertinent. Insofar as possible we are making use of an existing capability both in DOD and in industry to do the things Mr. Johnston described—the atmosphere validation, the impact tolerance levels and so forth. This is why we need only so few people.

There are other areas where we need quick reaction time, where we need a detailed close relationship between the life systems people and

the project offices developing the hardware, or where we must have in-house capability.

Mr. DADDARIO. Mr. Low, when you say you use DOD and industry to the fullest capacity, you are not saying that you are building on top of capacities and facilities and abilities which already exist, are you?

The big fear that I have is that rather than passing some of these requirements that NASA has to some of the other agencies, you have built up a separate laboratory of your own. For example, the Ames Research Center is already much larger than originally contemplated.

General ROADMAN. Mr. Daddario, may I comment—and pardon me for interrupting. Your question is certainly correct in viewing the testimony of Dr. Randt and the record, but that was looking at the total life sciences area.

Ames, for example, is not a consideration in our program in support of manned space flight as we are projecting it to you.

Mr. DADDARIO. I understand that, Dr. Roadman. Yet it is very difficult for this committee to close its eyes to the development at Ames, simply because Ames is not directly involved in manned space flight program. The people may be looking to other accomplishments but they, again, are people you could be using in the manned space program. They are the people who have this ability. How many are available? How many could you hire, and how many agencies and divisions and departments could you put them in and still maintain a competence throughout the country?

General ROADMAN. I believe this is a pretty fundamental question in the review of our program and in our total consideration of manned space flight. I'll use the term "biomedical interests."

There is a fallacy, at least in my judgment, to consider bioastronautics in toto. It's extremely difficult to define, but using the term "bioastronautics" as all the bits and pieces that are required in manned space flight, our program is much more selective.

I would like to attempt to clarify some of the basic problems running through your questions and our answers.

I would like to read to this committee the mission of the Crew Systems Division. I would like to keep in our minds the number and types of people that we have in this Division to support Mercury, Gemini, and Apollo.

I don't think there is anyone in this room who underestimates the responsibility and the difficulties involved in our medical area in the support of these missions. I don't believe statements made in the year 1960 are directly relevant.

But let me read the mission of our Crew Systems Division and then look at the people we have.

Mr. DADDARIO. When you say they are not directly relevant, you mean that the size of the NASA program was not taken into consideration at that time?

General ROADMAN. I believe that to be true.

Mr. DADDARIO. I believe if you review the Kety report you will find that it did look to the future and that it took into consideration the tremendous enlargement of NASA. Its recommendations were not based on NASA beginning and ending with the Mercury program. I personally believe that it was a very broadly gaged program and not a limited one.

Therefore, if your premise in arriving at that conclusion is that it was a narrow program, I would have to disagree with your conclusion.

General ROADMAN. I am speaking primarily as it reflects support of manned space flight. There was very little thought or organizational planning for a Gemini and an Apollo at that time, Mr. Daddario.

May I read to you the mission of our Crew Systems Divisions? First, to provide technical review of project biomedical needs. These project needs emanate from Mercury, Gemini, and Apollo.

Second, to provide technical assistance by preparing biomedical specifications and work statements. In other words, a definition, a determination of requirements, and identifying these requirements.

Third, to accomplish necessary test and evaluation programs. I would submit to this group that we look at 147 people and look at the success of Mercury. This group in providing a research, development, test and evaluation and certification in support of these projects, has accomplished a rather monumental task with a rather small number of people.

Now the fourth. To monitor the effort of biomedical contractors.

Fifth, to accomplish lab and shop fabrication of selected hardware specifically required in our flight programs.

Sixth, to maintain an in-house quick reaction capability responsive to project needs—specifially to Mercury, Gemini and Apollo. I would submit that there is no one else in this country who is actually conducting such a program and that we must have a capability within NASA to provide this support.

Seventh, to conduct an adequate program in supporting technology. Again, realizing that we are writing the book, so to speak, as we proceed in this course, in this mission.

Eighth, to prepare justifications for medical funding for inclusion in project budgets or overall supporting technology budgets.

Ninth, to manage the Manned Space Craft Center biomedical funding program.

And, last, to prepare program schedules for inclusion in project schedules.

Now, if you look in detail at these broad areas of responsibility it seems to me that we have done very well in efficient utilization of numbers of people to achieve efficient management of a program of this magnitude, particularly when one considers that this was a new type of program. By that I mean a development program along with an operational program.

Now, I would like to divert a minute to comment on the programing and our efforts with the Department of Defense; specifically, to give this committee information concerning what we have done with the Department of Defense in coordinating the program.

On April 20, Mr. Daddario, at the request of Dr. Seamans and Mr. Rubel, we organized a small committee which I was directed to chair with Col. John Talbot, who was then in the Department of Defense, as cochairman. We formed what was called the Bioastronautic Planning Group, to look at the biomedical requirements specifically pertaining to the support of Mercury, the support of Gemini, and the support of Apollo.

This was a joint NASA–DOD effort and reports were issued in the April and May time period of last year.

Now the significant point is that the Department of Defense prepared a bioastronautics program, as the Department of Defense bioastronautics capability inventory, listing programs, people, and facilities and NASA did the same.

The group rules were to look at what was required to support Mercury, Gemini, Apollo and DynaSoar. We felt it was appropriate to view these programs collectively and to determine together the requirements to support this program.

We immediately identified some areas that were not pertinent to these particular ground rules.

For example, animal experiments in orbital flight were not considered as a pertinent program area because, in fact, our program is one of manned space flight.

Crew performance prediction, as such, as another area, we did not feel was pertinent.

Training research and advanced R. & D. for future manned space flights projects were also considered beyond the limits established.

In other words, we limited our discussions to Mercury, Gemini and Apollo.

In the conduct of this planning group we met between the 2d and 6th of May. The results of this action, primarily, were the identification of 89 tasks within the Department of Defense and within NASA which were felt to be critical to the 1963 program in support of these specific projects.

Fifty-six of these utilized DOD facilities and/or technical personnel.

Although agreement on identifying the essential tasks was complete, there was, however, some variation in the estimate of the magnitude of individual tasks.

In other words, there were honest differences of opinion as to the amount of effort required in a particular program.

As we looked at this program, we found that the program based on the requirements we generated for the specific NASA missions was a $19.4 million program.

Of this $19 million requirement, we agreed on the fact there were approximately $11 million we had identified as specific requirements for NASA, for Mercury, Gemini, and Apollo in the 1963 time period.

Among the requirements agreed upon there were $2.1 million worth of program in the Department of Defense specifically required in the support of Mercury, Gemini, Apollo, and DynaSoar.

In our general planning and agreement, NASA agreed to fund, if possible, that $2.1 million on the basis of requirements in our manned space flight program.

Although we were unable to fund the entire amount, wherein we had the immediate requirement, we tried to fund it.

But in the careful review of our program I think the significant points are that the Department of Defense is, in fact, pursuing its program on the basis of Department of Defense requirements and wherein we have a requirement within their program to support our flight missions, we will fund it.

This we have agreed upon. But, in fact, we came out with the general recognition that the Department of Defense programs, in effect, complemented our program.

It was in this program effort and specific requirements to support manned space flight which, in effect, showed the Department of Defense did have a broad-based research and development program. Not all of it, however, directly required in the support of manned space flight.

To come back to the basic point; I do not feel you can tie onto a broad bioastronautics program and say: That is all that is needed for manned space flight. The Department of Defense has a good program and it should be supported, but there is not the conflict, the inroads, or the taking away of programs that seem to worry some people. Out of a $28 million initial Department of Defense program, which was labeled bioastronautics and which, in their view, was needed to support manned space flight, only $2.1 million was identified in agreed-upon judgments between Department of Defense and NASA as directly supporting manned space flight.

Mr. FULTON of Pennsylvania. Was the $2.1 million exclusively NASA? Could that be? Where and what was the agreement?

General ROADMAN. Let me answer it this way, Mr. Fulton:

The report of our study was prepared and submitted to Dr. Seamans and to Mr. Rubel. This report was signed by myself and by Colonel Talbot who were requested to cochair this committee.

Mr. FULTON of Pennsylvania. When was that?

General ROADMAN. It was submitted the 10th of May.

Mr. FULTON of Pennsylvania. This year?

General ROADMAN. 1962.

Mr. FULTON of Pennsylvania. Was it a joint report?

General ROADMAN. Yes, sir.

Mr. LOW. You have the title?

General ROADMAN. "Report of Joint NASA–DOD Bioastronautic Planning Group."

Mr. TEAGUE. Is there objection to that report going into the record?

General ROADMAN. I would certainly have none, sir.

(The information referred to is as follows:)

REPORT OF JOINT DOD-NASA BIOASTRONAUTIC PLANNING GROUP

On April 20, the joint DOD–NASA bioastronautic planning group presented a preliminary integrated DOD–NASA plan for the support of Projects Gemini, Apollo, and Dyna-Soar. This preliminary approach was general in nature and did not include specific Dyna-Soar support requirements.

After reviewing this preliminary program, Dr. Seamans and Mr. Rubel directed that steps be taken to provide more detailed information to support specific areas in the general plan. In point, it was directed that:

A. Project Dyna-Soar bioastronautic support requirements be obtained and built into the integrated plan.

B. Elements of the program be presented in the manner outlined.

The following elements of the "DOD preliminary plan for the support of Apollo" were identified as being outside the province of the Director, Aerospace Medicine, Office of Manned Space Flight:

1. Animal experiments in orbital flight.
2. Crew performance prediction;
3. Training research; and
4. Advanced R. & T. for future manned space flight projects

It was determined that these areas would be the basis for separate studies to be presented at a later date.

In addition, the two controversial items cited in the original plan were concurred in as requiring resolution at a level other than this joint DOD–NASA planning group.

Members of the DOD–NASA planning group met at the Manned Spacecraft Center, Houston, Tex., on May 26 for the purpose of revising the original plan to include the data outlined above.

On the following pages there is displayed a graphic outline of this proposed integrated DOD–NASA program to provide critical bioastronautic support for Projects Gemini, Apollo, and Dyna-Soar. The support included in this presentation is limited to that required in fiscal year 1963.

The program elements presented were arrived at by joint discussions between the selected DOD technical area experts and the corresponding experts at the Manned Spacecraft Center. In general, these discussions evidenced little or no difference of opinion as to what categories of support are critical to the projects under consideration. As might be expected, the estimates of required manpower and funds do show differences of opinion. It should be noted that, for the most part, these differences of opinion regarding required resources fairly well approximate the divergence that might be anticipated in any consumer-producer approach to a commodity or service transaction.

A summary of the program data contained in the body of this report points up certain salient features of the current and proposed programs to provide critical support for Projects Gemini, Apollo, and Dyna-Soar in fiscal year 1963:

1. Of 89 tasks felt to be critical to the fiscal year 1963 support of these projects, 56 utilize DOD facilities and/or technical personnel. There is great variation in the magnitude of individual tasks.

2. In fiscal year 1963, the national pool of bioastronautics resources will support Gemini, Apollo, and Dyna-Soar with about $19,400,000 and 686 man-years of professional and technical talent. Of the $19,400,000, approximately $11 million will be funded by NASA and $8 million by the DOD. Of the total, DOD will disburse about $10,500,000, including $2,110,000 of NASA funds. DOD will supply 518 man-years, NASA 168.

3. The remaining NASA program totaling $8,909,000 is to be divided among NASA centers, universities, industry, and Federal agencies other than the DOD.

4. The DOD has sponsored a $8,382,000 program in addition to that requested by NASA.

5. The total NASA- and DOD-sponsored efforts within the DOD constitute a $10,492,000 share of the $19,400,000 total program to utilize national resources in support of Gemini, Apollo, and Dyna-Soar in fiscal year 1963.

6. This DOD–NASA program within DOD then represents an integrated effort to provide 56 percent of the dollars required to support critical requirements for these projects.

7. The NASA centers, universities, industry, and Federal agencies other than the DOD divide 44 percent of the total fiscal year 1963 dollars.

8. The 56 percent planned for the DOD program does not include $2,512,000 in additional funds proposed by DOD for the support of the three projects involved.

9. The additional work for which the above $2,512,000 of additional funds are needed requires 125.7 additional man-years of effort in the DOD. No increase is anticipated in the NASA manpower requirement in fiscal year 1963.

Brig. Gen. C. H. ROADMAN,

USAF, MC, Director, Aerospace Medicine, Office of Manned Space Flight, National Aeronautics and Space Administration.

Date: May 10, 1962.

Col. JOHN M. TALBOT,

USAF, MC OSC, D.D.R. & E., Chief, Biological and Medical Sciences.

Date: May 10, 1963.

Mr. FULTON of Pennsylvania. Was the report ever acted on by NASA and DOD as Government agencies?

General ROADMAN. This report was reviewed by Dr. Seamans and Mr. Rubel and——

Mr. TEAGUE. Isn't the budget the result of it?

General ROADMAN. Sir?

Mr. TEAGUE. Isn't the budget the result of what you are presenting?

General ROADMAN. Yes, sir; it was a primary consideration in our 1963 program. So far as our efforts are concerned in fiscal year 1964, I would like to point out the working relationship between our Manned Spacecraft Center people and Department of Defense individuals.

For example, General Bedwell, last November visited the Manned Spacecraft Center.

General Ritland has been there, as has General Bohannon, Deputy Surgeon General of the Air Force. They have personally commented to me on our program, the conduct of it, and their lack of concern as to duplication of Air Force facilities or programs.

Mr. TEAGUE. Mr. Roadman, in your opinion, which will be ready to make the trip to the Moon first—the man, or the machine?

Mr. Low. It's a difficult question to determine, Mr. Chairman.

Mr. TEAGUE. Well, is this program going to be ready when you get your machines ready to go?

Mr. Low. Yes, sir.

Mr. TEAGUE. What is your answer, Dr. Roadman?

General ROADMAN. There is no question in my mind regarding our capability to support man in this mission.

No question at all. Everyone is entitled to his opinion, and there are many. In my judgment, however, we'll be ready when the equipment is ready.

Mr. TEAGUE. Is it your opinion that the program is as well coordinated between DOD and NASA as it is possible to do?

General ROADMAN. Yes, sir.

Mr. TEAGUE. There is agreement between DOD and NASA?

General ROADMAN. I can say from my personal experience as Director of Space Medicine, and as it relates to the NASA Manned Spacecraft Center Crew Systems Division and Center Medical Operations Office, and our interface with Colonel Talbot—our program is, in fact, coordinated. This is not to say there are not those who have differences of opinion.

Mr. TEAGUE. I understand.

You are an Air Force officer and will eventually leave NASA and go back to the Air Force. However, you are satisfied that this program is coordinated so far as DOD and NASA are concerned?

General ROADMAN. Yes, I am, as it pertains to working level people.

I cannot make this statement, Mr. Chairman, with respect to NASA–DOD per se. I can speak from a specific technical program level, and it is to that I address my remarks.

Mr. FULTON of Pennsylvania. That was the point of my previous question. At what level has this agreement been reached? This is the first that I have heard of a so-called agreement.

What has the DOD or NASA agreement been at the level of Dr. Seamans, Mr. Webb, Mr. Rubel, and Mr. McNamara?

Mr. Low. Mr. Fulton, this report, as Dr. Roadman pointed out, was submitted jointly to Dr. Seamans and Mr. Rubel.

Mr. FULTON of Pennsylvania. What did they think of it?

Mr. Low. To the best of my knowledge, they accepted the agreement and requested that it be implemented by NASA and DOD, and it, in fact, forms today the basis for the working arrangements between NASA and DOD.

Mr. FULTON of Pennsylvania. All right.

Mr. Low. They did not formally, on a piece of paper, ratify the agreement.

Mr. FULTON of Pennsylvania. When was that done, so we can get a point in time when this coordination occurred?

Mr. Low. In May of 1962.

Mr. FULTON of Pennsylvania. This is the first we've heard of it.

Mr. Low. Is this correct?

General ROADMAN. That's right.

Mr. DADDARIO. I think the important point is that since everything is so harmonious, and since all differences have been reconciled between NASA and the other agencies of Government; why has there not been an agreement signed by Mr. Rubel and Dr. Dryden as they promised this committee a year or so ago?

Mr. Low. The only answer I can provide to this, Mr. Daddario, is that because there was complete agreement on the working level, because there were no differences, and because the two agencies were indeed working together without any differences of opinion, there was no need for a formal piece of paper that said, "You shall work together the way you have been working together."

Mr. DADDARIO. If everything is that harmonious, Mr. Low, it would have seemed to be the easiest thing in the world to then come to an agreement.

The fact remains we have asked for that agreement time and time again, and we keep getting advised, as the testimony in the record shows, that there are still some differences that have not been reconciled. The nature of these differences, however, we have been unable to get to.

I don't think any of you gentlemen can answer that question. Neither of you can speak, of course, for Dr. Dryden or Mr. Rubel. I am not concerned about anybody taking anything from NASA, the Department of Defense, or from FAA or NIH, or any other agency of the Government. What we are concerned with is how these efforts can be best coordinated.

General ROADMAN. And to this, I completely agree with you, sir.

Mr. DADDARIO. Now the point is where should we direct our attention, and this is an entirely different thing than to say everybody is in complete harmony. If Congress appropriates enough money and people are engaged in new experiments throughout the country, they may be happy they are working together, but this does still not mean they are working efficiently.

We have over $61 million invested in medical installations such as Brooks Air Force Base, and the Pensacola installations. Going back to your previous statement, do you believe those facilities are being used by NASA to 100 percent of its capability?

General ROADMAN. It's important that we think of the program required to support manned space flight and to support specifically Mercury, Gemini, and Apollo.

Mr. DADDARIO. I would not like to confine myself to manned space flight but rather talk about the entire medical program in NASA, not just aerospace medicine but the bioscience program and also the human factor systems.

Take into consideration the School of Aviation Medicine and the Naval School at Pensacola, Wright-Patterson Air Force Base, Holloman Air Force Base, the new laboratories built by FAA and NIH, are all these now being used to their most efficient extent?

General ROADMAN. What was your question again, sir?

Mr. DADDARIO. The question boils down to are the facilities which exist in the Government being used in the most efficient manner, and are the capabilities being used to 100 percent capacity by NASA?

General ROADMAN. I don't mean to evade your question but let me answer it this way.

As it pertains to my area of responsibility, I am convinced that we, NASA, are utilizing the Department of Defense laboratories and capabilities consistent with our requirements to the maximum.

Now, I would like to point out that there are many people who develop requirements but who do not identify these requirements, specifically, as applicable to manned space flight.

My answer is yes, in terms of our requirements in manned space flight.

Now, I'll give you my personal opinion regarding the utilization of these facilities in other areas. I am not responsible for them nor do I have detailed and specific information.

I feel that in the area of advanced research, particularly with reference to the utilization of facilities, much of the program in the Department of Defense more directly affects advanced research, in a bioastronautic sense, than our manned flight space program.

To my knowledge, the other two offices are making every effort to work closely to identify programs and program capabilities within the Department of Defense wherein they can support these requirements.

Whether we are, in all areas of NASA, utilizing the Department of Defense to maximum efficiency is a very difficult question to answer, Mr. Daddario.

Mr. DADDARIO. Well, don't you think it's important that an agreement be spelled out so that it can be shown they are being used to the maximum efficiency?

General ROADMAN. I am speaking personally here.

I am not so interested in formal agreements as I am in the technical people arriving at judgments in terms of requirements and agreeing upon working closely together in a technical sense.

I, personally, am a little disturbed by agreements at such high levels, I am speaking purely personally. They may be required. In some instances they are.

I am speaking of the illustration I gave you as a far more effective means for getting the jobs done than all the high-level agreements in the world. I don't mean to be critical, but I think we should look at what we are trying to do. Are we, as U.S. citizens getting the maximum efficieney and benefit for this country. I think that's what is important.

Mr. FULTON of Pennsylvania. Doesn't it strike you as important when two of us on this subcommittee have been trying to find out what coordination and correlation there has been between NASA and the various elements of the Department of Defense. We have been told time after time that there was no agreement, and that they had not come up with any measure of agreement so we could see that there was a proper correlation in the use of these facilities?

That brings me to this question. The first I have heard of an agreement at any level, whether policy or working agreement, was when, unfortunately, I had to cross examine and ask "who, what,

when, and where" to get the statement by NASA that there is such an agreement at a working level and it had occurred in May 1962.

Surely nobody in this committee is sophist enough to feel we must have a certain type of agreement at a certain level or there isn't correlation. However, I'm certain that, for me as well as others on this committee, it has raised a real concern in our minds as to whether there was adequate correlation. We never heard of the agreement until you mentioned your joint report making the recommendations.

General ROADMAN. Yes, sir.

Mr. TEAGUE. Aren't there undoubtedly hundreds of such agreements between NASA and DOD with the programs you are carrying on together?

General ROADMAN. There certainly are, sir.

Mr. TEAGUE. I would think it is a very commonplace thing and I, for one, am not excited about it. I don't know how you could carry on your business without continual agreement between NASA and DOD.

Mr. FULTON of Pennsylvania. I would be surprised if there were hundred of agreements. This is the overall agreement involving 87 or 89 separate instances where you must come up with a correlation and some sort of a joint planning. Isn't that correct?

General ROADMAN. Yes, sir.

Mr. TEAGUE. Dr. Roadman, will you ask Mr. Webb to give us a list of as many agreements as possible at this level that have been reached between NASA and DOD, and we will put the information in the record.

Mr. Yeager, will you ask Mr. Webb for that?

Mr. FULTON of Pennsylvania. I'd like to have it. That is what Mr. Daddario and I are trying to get.

Mr. DADDARIO. Dr. Roadman, do you feel that the number of people coming into this program will in any way affect the overall national strength by diluting the effort within the Department of Defense or within industry to accomplish other national objectives by the size, scope, and type of people involved in the NASA program?

General ROADMAN. I can't see, myself, how the numbers of people that we have can dilute other organizations to the point of criticality. That's a personal opinion, Mr. Daddario.

Mr. DADDARIO. We must admit the program is much larger than originally contemplated. There is no question about that. You must also admit that it includes within it a great deal more than was contemplated in the first instance. Isn't that correct?

Mr. LOW. Other than was contemplated before the lunar——

Mr. DADDARIO. By the Kety report.

Mr. LOW. Yes, sir.

Mr. DADDARIO. My observation is that the Kety report did take into consideration the future size of the NASA program.

Have we reached the point in the development of this program where we ought to combine all of our activities in the life sciences bioastronautic area—however you want to call it, to develop a central national capability?

Should we bind together Houston and the School of Aviation Medicine and all of these other capabilities and facilities and manpower under one head, whether it is NASA or Department of Defense, so

that the requirements to satisfy each of these agencies could be fed into these facilities taking into consideration the amounts of moneys already expended and the number of personnel who have had long-time training in these areas?

Mr. Low. Mr. Daddario, I do not believe that such a national facility could support our ongoing programs in the manner in which they need be supported.

I can say this about the space medical area and about any one of our engineering areas. For example, the Air Force must develop heat shields for its ballistic missiles and for Dyna-Soar. Yet, we must have within NASA our own competence for the development and testing of heat shields for particular application to Mercury, Gemini, and Apollo. In the same sense we must also have our detailed capability to support the space medical area, the life systems area.

Perhaps, Mr. Johnston could answer better than I, by giving you a typical example of the type of work his division does on a day-by-day basis.

One example comes to my mind, which he discussed with me a year ago, on the Schirra flight. There was the modification of the heat exchanger in the life support system for the Mercury spacecraft to allow better temperature control than we had been able to achieve in Glenn's and Carpenter's flight. This was a detailed program which Mr. Johnston and his people had to carry out to enable us to accomplish Schirra's 9-hour mission. With your permission, Mr. Johnston could speak to that point for a minute or two.

Mr. JOHNSTON. A comment I would like to make briefly is that we are in the manned space business and one part of this is bioastronautics. There are certain support activities, as Mr. Low has indicated, that we do have to provide.

Now, as an example in Gordon Cooper's flight——

Mr. DADDARIO. You mean you have to provide it even though it may be possible that this could be done for you somewhere else?

Mr. JOHNSTON. The competence to do the task has to be included as a part of the team, as it is in any other technical facet of the manned space flight effort.

Mr. DADDARIO. You mean even though it may be a requirement which somebody else can do for you?

Mr. JOHNSTON. Where we can have these types of things done, sir, we do have them done.

If I might, I'd like to give you a few examples of the types of things we are doing for Gordon Cooper's flight.

I think during your recent visit there you saw we had a Mercury environmental control test capsule.

In the past several months we have conducted qualifications tests for components which will allow this 34-hour flight, like the establishment of the life of the CO_2 removal system. We have developed the water transport systems which are required to extend this flight.

These things are not something you can write down on a piece of paper and say, "Give to Wright Field" and tell them "On the 14th of May have this at the cape."

The coordination and the constant exchange between our project office, the people at the cape, and the astronauts themselves are taxing to our division.

It's a monumental task to meet these deadlines, even working right in Houston with the Mercury Project Office.

We are supporting three projects in this way and the thing that concerns me in this whole area is the fact that there are specific things, among them suit development and life support development, which I do not think in all honesty—and I've been a part of the manned space flight development for 4 years—that we can task to another agency and at the same time also be responsible for flying the programs and doing it in a timely way. I think our experience in Project Mercury well verifies this. I can assure you that we are not trying to duplicate things that are over and above the requirements that are essential to our program. Perhaps I shouldn't say this, but I sometimes wonder why we are on the defensive for; say, our space suit development or our life support development.

We have the charter to do these things and I think that experience has shown that we need to do them. I think that the money we've expended in fiscal 1963, if you look at it in detail, has, by and large, bought things directly project oriented and that is really our task.

General ROADMAN. Let me add a few comments, Mr. Daddario.

I know that this committee in reviewing the record delayed until I arrived discussion of the question that we have in the medical field concerning the possible decalcification of bone in a prolonged weightless flight.

Let me use that example to show you our program philosophy requirements and so forth.

Our astronauts are now assigned to Manned Spacecraft Center. We must do a considerable number of biochemical studies on the astronauts prior to their flight to get what we call baseline information. This will determine the calcium factor for the past 6 months. We put him in a space environment and measure the calcium after the flight.

There is a requirement for doing more research in the problem area of demineralization of the bone. This research is not necessarily time phased, in the sense that we have to do it right now. We do have to determine a requirement that work should be done and we have such a requirement, based on proximity or geographical problems related to the astronauts. This problem is a day-to-day assessment prior to flight.

I use this as an illustration pertinent to your question you asked concerning a central facility.

We must provide and must have a capability to develop and utilize the baseline information on the astronauts where they are working day to day. There is, of course, a considerable amount of work being done in a research sense at other places throughout the country.

Let me cite one. For example, studies on demineralization of bone being conducted at the Air Force hosiptal at Wright-Patterson, using ground-base studies of 30 days' duration with controls.

This is a legitimate way to provide information relative to demineralization. We do not intend to build up a capability to conduct such studies.

We will go out under contract, or support, or work with any one who particularly wants to do this. This can be done any place in the United States and should be done by independent investigators. We can relate their research information to our analyses of decalcification in the astronauts as our responsibility in conducting space flights.

There is not, in my mind, a direct correlation in this broad program area.

There is a continuum, however, in the research, development test, and operations.

It is a continuing program.

However, you have to take another slice at it and realize the conduct of research is one thing, the operational aspect another.

I don't think a general amalgamation of research effort can meet all the requirements in the type program we have developed. We need a capability in the Manned Space Craft Center, and I know you agree with this, Mr. Daddario.

We are not impinging, in this, on any other area of research in the Department of Defense, NIH, or other Federal unit. Their activities are legitimate in their own right.

Mr. FULTON of Pennsylvania. I would say one reason why the NASA witnesses seem to be on the defense this morning, has been the answer to Congressman Moeller's question in 1960. Mr. Moeller was a real prophet because within 1 year of his being told, "No, NASA would not build this group up by 60 or 120 personnel," NASA increased the group to 137 personnel. In fiscal year 1963, there were 199, and in fiscal year 1964, there were 244. Likewise, the budget went up from $10 million in fiscal year 1962, to $10.8 million in fiscal year 1963. In fiscal year 1964 the budget required is $21.8 million.

Now the question is: Have you changed your philosophy? I believe you have, because you are doing performance and operational matters since you answered Congressman Moeller's question.

The second question is where does this progression end? Are NASA's plans correlated with the Department of Defense? I think that's a very legitimate question. What are you building for? How many personnel do you want next year, and the year after? How much money will you want next year?

What would happen this year if we didn't give you an extra $11 million, and kept you at the $10 million dollar figure you had in fiscal year 1963.

Mr. TEAGUE. If NASA plans to go to Mars and Venus and other places, I would think your program would continue to expand.

General ROADMAN. I would certainly expect it to do so.

Mr. FULTON of Pennsylvania. How above 1965 and 1966, what are you doing in personnel and dollars?

Mr. LOW. Projections at this point in time, Mr. Fulton, for the next 2 or 3 years, are at approximately the same level as our 1964 request.

Mr. FULTON of Pennsylvania. So, you are leveling off?

Mr. LOW. Yes, and this is generally true in our whole program.

I think you noted before there is a marked increase in all of our projects in the Apollo spacecraft project I described several weeks ago.

Mr. FULTON of Pennsylvania. It would seem difficult for you to explain how you more than doubled your budget between fiscal year 1963 and fiscal year 1964.

Mr. LOW. This is in general proportion.

This is, of course, not the way the budget is arrived at, but it's in general proportion to the increase in the requirement in our spacecraft funding in the development of the Gemini spacecraft and in the development of the Apollo spacecraft. Our entire program is reaching in 1964 a plateau or level which is needed to reach our goal before the end of this decade.

Mr. TEAGUE. Mr. Bell?

Mr. BELL. Mr. Low——

Mr. DADDARIO. Mr. Bell, could I just finish up?

Mr. BELL. Yes.

Mr. DADDARIO. I recognize, Mr. Johnston, the strength that NASA needs to accomplish its program. When you say that this is a competence that they must have, I think it does in some way affect the strength of this Nation. If other agencies could satisfy this requirement in the first instance that you are developing manpower and facilities for, it means to me that we are not using to a proper extent the capability which exists. If we do not use this capability, then in some way we do weaken ourselves.

Once again, I go back to the statement made by Admiral Haywood, and on that I'm going to close. Referring to the amendments of the Space Act; Admiral Haywood was asked who should decide whether or not NASA would also get into aerospace medicine. He said:

> I would say they should not get into aerospace medicine. The Department of Defense will do any of the aerospace medicine they need. There are people involved, and we have the people and the facilities and documents involved and the work force at the present time in the Navy and Army. I think the decision, between the Secretary of Defense and doctors, would be the Department of Defense would do it, that NASA would not get in it.

I believe what Admiral Haywood said on that date was correct. I am disturbed by the fact that NASA keeps building up these requirements, not because it's against their charter or because they do not have this responsibility, but because it is also within the Space Act that NASA should use the scientific capabilities of the other agencies of the Government wherever they may exist. In my opinion, in this area there has been a constant conflict, and I think that it's adding to the expense of the entire space program.

Mr. TEAGUE. General Roadman, did I understand you to say a while age that there were 89 problem areas that NASA and the DOD reviewed together, and that you reviewed the facilities to see which one would make those decisions?

General ROADMAN. That is right.

Mr. TEAGUE. May that be put in the record?

(The information requested is as follows:)

> Support of the following 56 tasks, out of a total of 89 tasks agreed upon by representatives of DOD and NASA as being critically important to either Projects Gemini, Apollo, or Dyna-Soar, utilized DOD facilities and/or technical personnel:

- Radiation:
  - Radiation environment, data collection.
  - Dose limits, dose criteria for shielding design.
  - Flight dosimetry.
  - Flight dose minimization.
  - Apollo instrument package.
  - Radiation flux penetration.
  - Emergency procedures.
  - Material interactions.
  - Biological research.
  - Depth dose studies.
- Life support systems:
  - Atmosphere selection:
    - Validation of 7 p.s.i, 50 percent O_2N_2.
    - Validation of Gemini atmosphere.
    - Habitable atmosphere.
  - Instrument development:
    - Respiratory environment systems.
    - O_2 supply.
  - Toxic hazard:
    - Toxicology.
  - Crew protective equipment:
    - Personal protective equipment.
  - Waste management:
    - Waste and water management in spacecraft.
    - Waste storage.
    - Waste disposal.
  - Food and water:
    - Nutritional requirements for operating crews during space flight.
    - Sustenance.
- Weightlessness and acceleration:
  - Noise and auditory communications:
    - Measurement of noise environment.
    - Tolerance to acoustic stress.
    - Tolerance to continuous noise.
    - Communication stress.
  - Vibration:
    - Vibration tolerance (Supine).
    - Biodynamic body response.
    - Performance under vibration.
    - Vibration protection.
    - Five degree motion simulator.
    - Measurement of vibration.
    - Acceleration tolerance.
    - Effects of pressure breathing.
    - Effect of prolonged exposure to oxygen on acceleration tolerance.
    - Effect of acceleration on respiration.
    - Astronaut acceleration training.
    - Interaction of task complexity and performance techniques.
    - Dynamic test of equipment.
    - Effects of zero gravity on acceleration tolerance.
  - Impact:
    - Model of man protective system.
    - Impact tolerance.
    - Impact protection system.
  - Escape:
    - Escape system R. & D.
  - Support and restraint:
    - R. & D. testing.

Weightlessness and disorientation:
Disorders in animals during orbital flight.
Observation of astronauts in flight.
Short exposure to zero gravity.
Simulated weightlessness.
Slowly rotating environment (effects of rotary motion on man).
Study of disorientation and prevention.
Laboratory studies involving combined stresses.
Studies of combined stresses in actual space flight.
Crew medical selection and monitoring:
Gemini selection.
Dyna-Soar selection.
Data assessment of selected personnel.

Mr. BELL. Dr. Roadman, Mr. Daddario came pretty close to asking my question. As you know, the Air Force and the Navy have a long background in bioastronautics and aircraft medicine. Why wouldn't it be possible to use some of the Air Force facilities like in Brooks Air Force Base, rather than have NASA build its own? For example, you might use Ames, inasmuch as it's my own home state.

Why wouldn't it be just as well to use some of the facilities that already exist?

Mr. LOW. Mr. Bell, as we have pointed out here before, we, in the Office of Manned Space Flight, do not have program responsibility for the effort at Ames, so I must disqualify myself from addressing myself directly to that point. I believe this is being discussed as part of the advanced research program with another of the subcommittees.

Insofar as the effort in Houston is concerned, the Manned Space Craft Center, we are not building any major new facilities there to support the space medicine effort. We are building, certainly, office facilities to house the 147 people we have discussed. We are building small laboratories for them to do the detailed support work that has to be tied in with the development on a day-to-day basis.

We do use, in many instances, the Air Force, the Navy, and the Army facilities. Specifically, for instance, the medical examinations of our last group of astronauts were conducted at Brooks Air Force Base at the School of Aviation Medicine. In fact, whenever one of our astronauts has a major medical problem or major dental work, we send him to San Antonio to have the work done there.

I don't think we are duplicating any major facilities in existence elsewhere in the manned space flight program.

Mr. BELL. Do you want to comment on that?

General ROADMAN. Yes, sir. I would like to put into the record the DOD support to our program. One is a project titled "Specialized Space Suit Testing." This is at Wright-Patterson Air Force Base.

Mr. TEAGUE. What does "Specialized Suit Testing" mean to the ordinary layman?

Mr. JOHNSTON. If I might answer that for Dr. Roadman, there are at Wright Field, unique thermal test capabilities we do not have at Houston.

Mr. LOW. Could you describe one of those facilities, Mr. Johnston?

Mr. JOHNSTON. Yes, they are small altitude chambers in which you can put a man clothed in a space suit and take him to elevated temperatures to find out how the plastics and rubber and nylon and things from which the suit is constructed will behave in those environments. As part of our Gemini environmental programs, suits were taken to

Wright Field and were tested by the technical people at Wright Field in this simulator.

They also have unique capabilities to test the effectiveness of the ventilation system. For example, to test how well the ducts work. These are inside the suit, and assist in cooling and handling the metabolic load during stressful periods.

These are types of things we did with Wright Field.

Mr. TEAGUE. What temperature is this done at, and why do you test plastic? Does it come apart in space or melt or change its characteristics in any way?

Mr. JOHNSTON. For any component environmental specifications have been established, as for example, for the reentry period.

The space suit, like any other component in the spacecraft, has to be tested at elevated temperatures to insure they will behave properly. In Mercury we tested the suits up to 170° Fahrenheit. We thought early in the program that the reentry heating pulse would go up around 150. Theoretical data was more or less disproved by practical measurements. We actually find the cabin goes up to 105° Fahrenheit, but you have to have a safety requirement.

Mr. TEAGUE. What difficulties are there?

Mr. JOHNSTON. 150° Fahrenheit and minus 150°. I was speaking primarily of the Gemini suit for the tests Dr. Roadman referred to.

Mr. TEAGUE. Go ahead, sir.

General ROADMAN. In addition to this, particular components of space suit development. Mr. Johnston may wish to comment on that, if you wish, in more detail. We also had the carbon dioxide collection and contaminant control also at the Naval Research Lab.

Mr. LOW. You want us to amplify on each one of these, Mr. Chairman?

Mr. TEAGUE. I wish you would, Mr. Low, because some of the things you mentioned don't mean anything to the average layman reading the record.

General ROADMAN. Mr. Johnstonwill comment on these for the committee. I think it important to draw your attention to the fact these are specific requirements in support of manned space flight. In addition to these requirements, there are research interests in many other areas related to this broad area. This has generated requirements in terms of research work that's going on particularly in the Department of Defense, very legitimate research work, and we, in our program, are interested that it be continued. We are not funding for that type of research program, but we certainly are responsible for encouraging such effort, utilizing personnel and facilities within the Department of Defense, in specific support of our manned space flight program.

I'd just like to add one other word.

There are interests and requirements in the bioastronautics field that go from A to Z, and they are perfectly legitimate in terms of need or scientific information. All of these are important, but we, in NASA manned space flight cannot be responsible for the total area. Much of this work is being done in the Department of Defense.

I think it's important that you, as a committee, have confidence that we, as the operating group, have honed down on our specific requirements. Although there are differences of opinion, although there are those who like to talk about bioastronautics from A to Z and although

there are many legitimate requirements, we are not undertaking so broad a program as that in manned space flight.

Mr. BELL. You are, are you not, increasing some facilities in this area in your fiscal year 1964 budget request?

General ROADMAN. We have no facility requirements in the fiscal year 1964 budget, sir.

Mr. BELL. I thought that you were building a laboratory of some kind at Ames.

Mr. LOW. That is not in the manned space flight budget, Mr. Bell, if there is such a laboratory. It would be part of another program. We are not responsible for a laboratory at Ames. I am not aware what is in the Ames budget, as a matter of fact.

General ROADMAN. There is a stated requirement for an Ames laboratory, sir. This, however, is under the combined program interests of the Office of Biosciences and the Office of Advanced Research.

Mr. GURNEY. You are not constructing any facilities at all? You are simply using manpower. Is that right?

General ROADMAN. Our facilities requirements to support the crew Sytems Division and Center Medical Operations Office was in the 1963 budget, sir.

Mr. BELL. How much did that amount to?

Mr. LOW. I did not bring my facilities book with me, Mr. Bell. I believe, to be correct, it was in the fiscal year 1962 budget that we requested $60 million for the initial buildings in Houston. This included $26 million for large vacuum chambers for spacecraft, which was not a biomedical requirement. The remaining $34 million were for 13 or 14 buildings and laboratories, 1 of which is for the Crew Systems Division at Houston.

Mr. BELL. You weren't in any way, so far as you can recall, duplicating anything of the other services by building these facilities you spoke of?

Mr. LOW. This is a general-purpose office building and laboratory. I am sure there is equipment in these laboratories that exist in hundreds of other places in the country, but it is general-purpose-type equipment. While we are on the subject, in our fiscal year 1963 budget, we did request funds for a centrifuge at Houston and this will be used for, among other uses, biomedical studies in support of this effort. This was in the 1963 budget.

We have recently completed a detailed study of centrifuge requirements in this country within the military services and within all NASA organizations and have determined that all of these centrifuges will be fully used at the time they become available.

Mr. BELL. What is the cost of these centrifuges?

Mr. LOW. I believe we budgeted $10.8 million for the Houston centrifuge in 1963.

Mr. TEAGUE. This testimony on centrifuges is in last year's hearings, including where they will be located, the way NASA expects to use them, and how much they will cost.

Mr. DADDARIO. Just so we might clarify it further, Mr. Bell, it is in the record that there is not just one centrifuge at Houston. NASA has maybe four or five.

Mr. BELL. Do you believe the duplication aspect was explained adequately to your satisfaction?

General ROADMAN. I think it is important for the committee to have this in the record and I think it's important for the committee to have sufficient detail of the work being done by the Department of Defense in support of our program.

Mr. DADDARIO. Dr. Roadman, when you said a moment ago that the committee ought to have confidence since you people are watching it very carefully, we have more confidence when we watch it very carefully.

Mr. TEAGUE. It is important for this committee to understand what we have been discussing.

When one reviews the record sometimes it is necessary to study a sentence for 5 minutes to make any sense out of it. The technical terms which are used don't mean anything to a layman outside the committee.

Mr. DADDARIO. Mr. Chairman, I don't want to talk about centrifuges any longer, but to keep the record straight; I said four or five.

How many centrifuges did NASA have in the budget last year?

Mr. LOW. I believe in last year's budget there were two centrifuges capable of man participation.

Mr. DADDARIO. Don't bother going into what they are going to be used for because this is always an argument.

Mr. TEAGUE. It isn't a fair question, unless you do.

Mr. LOW. I'd have to provide the number for the record. There are centrifuges at Goddard, I know, for small scientific payloads. There is one at Ames for manned use and there's one at Houston for manned use.

(The information requested is as follows:)

The following information concerning centrifuge facilities programed in the fiscal year 1963 CF budget is submitted for record:

Facility	Location	Amount
Flight acceleration facility (manned)	Manned Spacecraft Center, Houston, Tex	$10,630,000
Space flight guidance facility (manned)	Ames Research Center, Mountain View, Calif	9,790,000
Launch phase simulator (unmanned)	Goddard Space Flight Center, Greenbelt, Md	3,915,000
Total		24,335,000

Mr. DADDARIO. Aren't there two at Ames?

Mr. TEAGUE. Let General Roadman continue.

General Roadman?

General ROADMAN. I would like to have Mr. Johnston continue and give you specific details, Mr. Chairman.

Mr. JOHNSTON. The next item Dr. Roadman has listed "Space-suit development." We have a program with Wright Field which involves a rather revolutionary approach in space-suit design.

Mr. TEAGUE. This is Air Force–NASA coordination?

Mr. JOHNSTON. We jointly funded a contract on an advanced suit. The state of the art is such we do not feel it will be available for Apollo, but we are participating with the Air Force under a joint funding arrangement.

I can go into detail, if you would like to know what the suits are all about.

Mr. TEAGUE. Just a little.

Mr. JOHNSTON. Basically, it involves a material which will be permeable to air. That is, it will allow air to pass through it when you have equal pressures on both sides of the material. When there exists a high pressure on the interior of the suit and vacuum on the outside, the material has the capability, we hope, of swelling and forming an impermeable layer. This way you get away from the need for elaborate ventilation systems and suit design is greatly simplified.

Mr. FULTON of Pennsylvania. Is this a suit for men or women—these advanced suits?

Mr. LOW. The materials could be used for either.

Mr. DADDARIO. Mr. Johnston, where in NASA is there the same kind of capability to test these space suits as the Air Force has at Wright-Patterson?

Mr. JOHNSTON. At Wright Field.

Mr. DADDARIO. I'm sorry.

Mr. JOHNSTON. Right now, there is no existing capability within NASA to do this testing.

Mr. DADDARIO. Aren't you developing a capability at Houston?

Mr. JOHNSTON. We have a small altitude chamber which we picked up "surplus" from the Air Force. We used this for our altitude simulation and it is the prime thing we use for suit testing at altitude. We also have a series of mockups which we use in our suit development program and testing program.

Mr. LOW. These facilities, I believe, are used to tie particular Mercury, Gemini, and Apollo suits in which mockups or actual environmental control systems that are used in these programs. The detailed integration of the suits, with their spacecraft hardware, takes place at Houston.

Mr. JOHNSTON. In the impact tolerance area, we are trying to extend the knowledge of how much deceleration load a man can experience. We are working with the Air Medical Field Laboratory at Holloman, with Wright Field, with the Navy's Aviation Crew Equipment Laboratory, and with the Armed Forces Institute of Pathology in this area. We expended around $350,000 in this effort last year.

In atmospheric validation, we worked extensively with the School of Aviation Medicine, with the Aviation Crew Equipment Laboratory, and with Johnsville in this program.

Currently, we have a program with the Food and Container Group Institute of the Armed Forces, which is our prime, if you will, associate contractor in developing food packaging and preservation methods.

We have a program at Wright Field to better define man's tolerance to vibration when supine—that is, in the launch position on his back, as in the Mercury system. There is a void on the literature for this type of information.

In addition, we have programs now at Brooks. One, in trying to have a better understanding of man's metabolic processes in cooling when working in a pressure suit. How to properly cool the body is one of the big problems in suit design. If you put too dry air through too low temperature, you cause him to oversweat. This can cause problems.

We also have a program we just initiated to extend our knowledge of man's experiences in pure oxygen atmosphere. These will be 30-day tests.

We have a program with the School of Aviation Medicine to better define selection criteria, that is, to arrive at a better set of physiological data which will assist us in screening potential astronauts.

Mr. FULTON of Pennsylvania. Before you leave that, why is pure oxygen atmosphere necessary? Why don't you use some other mixture?

Mr. JOHNSTON. There are several considerations. I think the chief one is we have run an extensive program and have not found any significant physiological reason why we cannot go to it. Now, there are many operational considerations in selecting the atmosphere. The prime one is that the cabin atmosphere, that is the normal habitable area of the cabin, must be compatible with pressure suit operations.

If you run the cabin to some elevated pressure and if decompression occurs, then the astronaut will be sustained within his pressure suit. By necessity this has to be at low pressure so the man is capable of degrees of movement while pressurized. This is one prime consideration.

In addition, the complexity of the system is greatly reduced by having to control a single gas as opposed to trying to control the partial pressures of two separate gases. This means you can cut down the number of components in your system. You can also cut down and increase the reliability of the system.

These are, I would say, the prime reasons we have gone to pure oxygen.

Mr. ROUDEBUSH. Would the gentleman yield, please?

Mr. FULTON of Pennsylvania. Yes.

Mr. ROUDEBUSH. What about anemia associated with the breathing of pure oxygen? I have read several articles where a great deal of fear is expressed as to the danger of breathing pure oxygen over a long period might produce——

Mr. JOHNSTON. We had a contract with Republic Aviation as part of our validation of the atmosphere. In the course of these tests there was one subject who had a marked decrease in blood hemoglobin. This individual was found, after the test was over, and Dr. Roadman or Dr. Knauf can give you the medical term for the condition, to exhibit a particular type of anemia characteristic of people in the Mediterranean area. There were findings of a minor nature in two or three other subjects, but they were not significant.

Mr. LOW. Is the point, Mr. Johnston, that the man who had anemia after, did, indeed, have anemia before?

Mr. ROUDEBUSH. I can't imagine why a person or individual of this type would be subjected to tests.

Mr. LOW. I think, Mr. Roudebush, a mistake had been made in this one test. The man should not have been subjected to it. He was subjected by mistake and it only showed up after the test.

Mr. ROUDEBUSH. My point is that if susceptibility exists for anemia, it could be aggravated by the breathing of pure oxygen.

That is the explanation I have read in the articles on the subject; however, I am not a practicing doctor, I can assure you.

Mr. LOW. General Roadman would like to comment on this.

General ROADMAN. This is one of the areas receiving widespread attention and rightly so, sir.

I would like to state that in view of our program and planning, it is necessary to arrive at decisions as early as possible in the design phase of the development of a spacecraft. This is typical of one. At the present time, considering all aspects as it relates to weight, volume, reliability, complexity and requirements, the current decision is to go with the 100 percent oxygen for Apollo.

I would like to state to this group that our decision on this was not just a NASA judgment. It is a judgment we have had a number of experts look at and look at in terms of the total problem—which some other experts have not. The result was the decision to go to the 100 percent oxygen.

This does not mean we are not interested in and will not continue research to get statistics on the judgment of other experts.

Mr. ROUDEBUSH. General Roadman, let's be perfectly candid. There is a possibility that individuals, due to their biological makeup, could develop anemia by breathing oxygen for long periods of time. That possibility does exist, doesn't it?

General ROADMAN. That possibility does exist. As a matter of fact, I didn't have too much information to speak on. We are very interested, yes, sir.

Mr. FULTON of Pennsylvania. I take it from this that cigarettes and cigars are out for the Apollo trip. If somebody decides to light up——

General ROADMAN. They may take them along, but not smoke them.

Mr. ROUDEBUSH. That is all I have.

Mr. WAGGONNER. I don't know who would care to answer this particular question, but it concerns the space posture hearing held on Monday, February 25, 1963. Mr. Webb made the statement that:

> With respect to the manned space flight activity, the budget level is set at the lowest level which would permit us to maintain target dates that give us a margin and still permit us to assure the President, and we hope, to assure the Congress, that we will do the manned lunar exploration within this decade, barring some situation, such as the fact that zero gravity will not permit men to live and work in space for the time required.

Now, I don't know how he intended that. Do you have any idea what Mr. Webb meant by "barring some situation"?

Mr. LOW. Mr. Waggonner, many of the things our astronauts will encounter on the way to the Moon we can and do simulate on the ground. One of the things we cannot simulate, on the ground or in airplane flight for more than 45 seconds, is the effect of weightlessness on a human being. In Mercury we have gone up to 9 hours of weightlessness with no deleterious effects on the man. A week from today, if all goes well, Astronaut Cooper will start a flight of 34 hours to get more physiological data on the effect of weightlessness. We know the Soviets to date have flown up to 4 days in the weightless environment, without having reported to us any bad effect on the human physical functioning due to weightlessness.

The lunar mission itself will take approximately 7 days. As of now we have no data at hand to indicate that there will not be any harmful effects of weightlessness for these longer missions.

Mr. WAGGONNER. On the same tone, do we have any information that leads us to believe there will be?

Mr. Low. No, that was the point I was going to make. All our indications are to the effect there will not be any such effects. The first time we can get data for our long missions will be in the Gemini program in 1964. We then will know with certainty whether there are any effects or not. We don't anticipate any, but we don't really know yet, for sure.

Mr. WAGGONNER. Do I understand you correctly then, that you do not anticipate any problems of this nature?

Mr. Low. That's right.

Mr. WAGGONNER. And not anticipating any difficulty, I am led to believe that nothing in our aerospace medicine research has given us any indication that man will have trouble with weightlessness or any other physical problem such as the report, which I know must be fragmentary, that the Russians issued indicating that there was a calcium bone defect after the flight of their last two astronauts.

Mr. Low. General Roadman?

General ROADMAN. May I comment on that, sir?

We do not have the detailed information. However, some sources allege that statements were made that there was a higher than normal calcium excretion in the urine. That's considerably different than the statement that there was a problem in the bone calcium.

After Schirra's flight we reported a blood pressure differential beyond the baseline information obtained before the flight. These considerations are being investigated in detail. Conclusions can only be reached as a result of examinations and a careful observation of the astronaut in flight.

We are certainly looking at factors. They are of mainstream consideration in space medicine, but there have been no reported findings that would tend to cause us to say we couldn't go.

There are those prophets of doom who would raise questions, perhaps legitimate questions. We are trying to find out.

We may not know today, but we are gaining information as we put more men in space. We have considered, as Mr. Low has stated, time periods in zero gravity which are greater than will be found in the man mission profile in Apollo. Again, I think there must be a step-by-step development, an orderly sequence of progression toward the manned space flight goal to which we are committed.

Mr. WAGGONNER. The point I was trying to make by reading this statement was that we have had some criticism of some of the statements which have been made recently and they were passed off as, "Well, that was a slip," or "It was an error."

I want to determine whether this was a slip or whether there was some basic fact that was being withheld. Your answer, as I understand it, indicates that nothing is being withheld, and that you have every reason to believe that man can survive for extended periods in space, and that NASA is proceeding on this basis.

Mr. Low. Yes, sir.

Mr. DADDARIO (presiding). Mr. Gurney?

Mr. GURNEY. In view of this extended discussion we had about the importance of the in-flight experiments, I am curious about the $3,125,000 you asked for this coming year for in-flight experiments. Last year it was a quarter of a million.

That's an increase of over 12 times last year's figure. Now, as I understand it, you had three in-flight experiments last year. This year there will be two flights; one next week, and the first Gemini flight at the end of the year.

What is the explanation for as great an increase in this amount when, actually, you are having fewer in-flight experiments?

Mr. Low. The general explanation, Mr. Gurney, was that in fiscal years 1962 and 1963, the funds requested were for the completion of the Mercury program.

Most of the biomedical sensors and the carbon dioxide sensors to be used in our on-going Mercury program, and some others, were developed in fiscal years 1960 and 1961. The increase in 1964 is for additional effort toward projects Gemini and Apollo. These will not be needed until fiscal 1964 funding becomes available.

Mr. GURNEY. I still don't understand why there is the increase? Put it this way, is your description, "biomedical experimentation" an accurate one? Are you talking about in-flight experiments? It is difficult for me to understand an increase of 12 times the money if you are doing less flights. It doesn't make sense.

Mr. Low. General Roadman?

General ROADMAN. Mr. Gurney, there has been criticism of some of our measurements—what we are measuring and how we measure it. In terms of the evolution of manned space flight, probably years from now there will be looked upon as rather crude. Among them, devices to measure blood pressure and temperature and so forth. It's apparent to us, if we are looking for the effects of prolonged space flight on man, we should be looking at, very critically, specific systems, for example the circulatory system or the nervous system. We are interested in the performance and in the survival of man in space. In this context we consider it a requirement to improve and extend the techniques of measurement on man. In-flight experiments fall in the category of extending and refining physiological and performance measurements of man and his life support equipment for the future.

A specific example, is the development of the means to measure adequately brain wave activity of man while in the space environment.

Mr. GURNEY. Now——

General ROADMAN. We have to develop a capability. There is a difference measuring brain waves in a doctor's office and measuring brain waves in a spacecraft. It's in this area tht we are very interested in expanding our medical knowledge of man in space through various types of experiments. We need more information as to what we should measure and how we should measure.

This is what we are trying to do.

Mr. GURNEY. Granted, that's true. I still ask you the question that you haven't answered as yet. When you speak of "biomedical experimentation" do you mean in-flight experiments?

Are you talking about money that is being directed for the flights that are going to be held 1 week from now and one at the end of the year?

Mr. Low. No, sir; we are talking specifically about equipment that must be developed for in-flight experiments, equipment to be developed on the ground during this fiscal year for in-flight experiments for future years in Gemini and the Appollo.

Mr. GURNEY. That's what I was trying to get out. I don't think the explanation in your budget proposal, particularly RDO 3-3, is accurate. If you read what you plan to do here, it talks about your experimentation and obtaining knowledge from orbital flights, and directs the whole point of the matter toward the weightlessness problem, and that sort of thing which you can only obtain from the actual flights.

I think you can expand upon this explanation for the record and mention what you are actually going to spend this money on. It doesn't make much sense if you direct it to in-flight experiments and have fewer flights this year than you did in the past.

Mr. Low. May I say we will provide for the record a better and more expanded explanation.

(The information referred to is as follows:)

IN-FLIGHT BIOENGINEERING TEST AND EVALUATION (FORMERLY BIOMEDICAL IN-FLIGHT EXPERIMENTS)

This area includes the design and development of devices, carried as ancillary spacecraft equipment, to conduct in-flight experiments required to obtain information on the physiological effects of space flight, as well as in-flight performance data on advanced life support systems and/or components. Space flight produces an environment which in many respects cannot be duplicated on earth, such as extended weightlessness.

In fiscal year 1964, new tasks are to be initiated to obtain current information on the biomedical aspects of weightlessness and to test crucial hypotheses regarding weightlessness effects in the Gemini flight program. Improved life support components designed to give increased performance and flexibility will also be tested in Gemini flights. Design and development of equipment to be used for in-flight experiments during future Gemini flights must be undertaken with sufficient lead time to insure their availability simultaneous with the spacecraft. The longer mission times for Gemini will provide the environments required to conduct many more in-flight experiments than was the case for Mercury. Since Gemini will be a two-man vehicle, more complex experiments will be possible.

Mr. DADDARIO. Mr. Roudebush?

Mr. ROUDEBUSH. Dr. Roadman, I ask this question somewhat in a humorous vein, but I noticed an article that appeared in one of the publications very recently about an item of a $247 Buck Rogers chair in NASA headquarters. I wonder if it was under your direction or your prescription that these chairs were purchased for NASA executives.

General ROADMAN. I must disclaim all responsibility, sir.

Mr. ROUDEBUSH. And all knowledge of those chairs?

General ROADMAN. I am not sure I know which chairs you are referring to. I don't have one.

Mr. ROUDEBUSH. My investigation is complete at this point in the record; but I might say I have directed inquiries as to why NASA executives need these type of chairs. It has been reported in a number of publications that a large amount of these chairs that cost $247 each has been purchased to improve the posture of our NASA executives. I was just curious whether this came under the realm of aerospace medicine.

General ROADMAN. I was not consulted.

Mr. DADDARIO. Mr. Roadman, getting back to this activity in telemetry, is this coordinated with other agencies of the Government also experimenting in this field?

Mr. Low. I will refer to Mr. Johnston for the specifics of the work.

Mr. JOHNSTON. Coordinated in what way, sir?

Mr. DADDARIO. Well, for example, General Roadman has said in-flight testing of——

Mr. Low. Brain wave.

Mr. DADDARIO. Cardiographs, for example. The Air Force is doing work on this at Brooks and other places. That is what I mean "coordinating" with other people operating in the same field which you are operating in.

Mr. JOHNSTON. Yes, sir. We have a program in brain waves at Brooks. The program has just been funded and the contract hasn't been let, but it will be in this fiscal year.

Mr. Low. The work then, Mr. Johnston, will be done by a DOD agency for NASA.

Mr. JOHNSTON. They are obtaining for us basic control data on a large group of healthy individuals.

I think that so far as our bio-instrumentation and telemetry development is concerned, this is coordinated.

There is an exchange with Wright Field, with NIH, and with various university groups. In fact, a large percentage of our effort in this area is conducted through university and industry contracts.

Mr. Low. I might add, this is one area where some of the developments of the Mercury program are now being used in other Government agencies and in hospitals. I refer particularly to the way of fastening electrodes to the skin for electrocardiograms. We found early in Mercury that the ways then available caused skin irritation. Because there was a need for an immediate solution to this problem, our medical people came up with a different kind of paste or a different way of mounting the electrodes which, I think, is now in general usage.

Mr. FULTON of Pennsylvania. The answer has been given earlier as to the various reasons why the United States should proceed with the Moon program. Several of the witnesses today have each given individual reasons for the necessity for the U.S. Moon program. These men were Mr. George M. Low, Deputy Director of Programs, Office of Manned Space Flight; Gen. Charles H. Roadman, Director of Space Medicine, Office of Manned Space Flight; and Dr. George M. Knauf, Deputy Director of Space Medicine, Office of Manned Space Flight. I would like to, with the chairman's permission, ask this team to put in the record at this point 10 good reasons why the United States should proceed on the moon flight.

You are the men actively in the program and carrying it forward. I would like you practical people to give us 10 good reasons why the United States should continue with the Manned Space Flight program.

Mr. Low. We'd be happy to provide such a statement.

(The information requested is as follows:)

Much has been written on this subject in the past, and it is difficult to express concisely all of the reasons for undertaking the manned lunar landing program. Our thoughts were recently expressed rather precisely in a speech made by Mr. D. Brainerd Holmes. Mr. Holmes said:

"We believe that the United States should be first in space, just as it is first in most other things that matter.

"We believe that the United States can be first in space, if we persevere in our present efforts.

"We believe that economic benefits will flow to those who are among the first to exploit this technology, and that the endeavors to master it will provide a stimulus to national growth.

"We believe that there is not a status quo for peoples of the world—that they grow or they shrink; and that the management skills we require will enable the United States to undertake even more challenging tasks in the future.

"We believe that this knowledge can be used for good or ill, and that only U.S. preeminence can give assurance against its misuse in the furtherance of a system we abhor.

"We believe that sharing the adventure of exploring space can provide inspiration and a sense of national unity not normally experienced in time of peace; and that the achievement of our goals is essential not only to these national purposes, but to world leadership and prestige.

"We believe that we can be first on the Moon, although this we cannot guarantee.

"Finally, there is one thing we know. If we do not make these efforts, we will not be first on the Moon, we will not be first in space and, one day soon, we will not be first on Earth.

"With the support of the American people, and with the help of God, we will not be second."

All of us involved in NASA's manned space flight program fully subscribe to these thoughts.

Mr. PATTEN. Mr. Chairman, I noticed an interesting editorial in this morning's Washington Post.

Mr. LOW. Yes.

Mr. PATTEN. We may not give you specialists or scientists as much credit as Mr. Fulton just suggested as to whether we might go to the Moon. Maybe there are men in Congress who may have a better idea of whether we should go to the Moon or not. You are in the science field, but we are back with the people and there is a big difference. You may not be able to judge what the public wants. The Washington Post brings it out in a wonderful editorial this morning. You ought to read it.

Mr. LOW. Yes, I saw that. It's a very good article.

Mr. PATTEN. It supports the program.

Mr. GURNEY. Mr. Chairman, that is a good question and certainly the answer to it is useful not only for us, but to orient this national program.

I wonder if it could be amplified to give the reason why it is more important to spend the larger amount of money on the lunar landing program than we are spending, for example, developing an effective space platform. Could we have that also?

(The information requested is as follows:)

The President established manned lunar landing and return as a national goal within this decade in May 1961. The Congress endorsed the President's recommendation. The skills and operational techniques developed in Project Apollo will have multiple uses in space, including manned space stations. NASA is currently conducting studies to determine the feasibility of a manned space station.

Mr. FULTON of Pennsylvania. I'd be glad if you would add that on, because I, too, have wondered why NASA does not have a space platform in its current budget.

Mr. PATTEN. Are you familiar with the Harvard University inquiry which is being mailed out asking the questions that Mr. Fulton——

Mr. FULTON of Pennsylvania. Repeat that again?

Mr. PATTEN. Harvard University has sent out a questionnaire raising 25 points and asking people answer them.

Mr. LOW. No, I'm not familiar with that.

Mr. PATTEN. That might be the answer to the question Mr. Fulton is asking you to give.

Mr. FULTON of Pennsylvania. Having gone to Harvard myself, I don't think we need that adjunct of the Democratic Party answered.

Mr. PATTEN. You know, we think we have as many Princeton men in government as Harvard.

Mr. GURNEY. As a matter of fact there are more.

Mr. ROUDEBUSH. I think it is time for us to adjourn.

Mr. DADDARIO. General Roadman, the Bioscience Advisory Committee which I referred to earlier and which spelled out the life sciences needs for NASA in the first instances is no longer in existence. What has replaced it as of the moment?

General ROADMAN. Which committee are you referring to, Mr. Daddario?

Mr. DADDARIO. Bioscience Advisory Committee which was appointed by the NASA Administrator in 1959.

General ROADMAN. The Kety Committee.

Mr. DADDARIO. That is the official name of the Committee which came to be known as the Kety Committee.

General ROADMAN. Yes, sir.

I understand that its purpose was to provide recommendations to the Administrator of NASA pertaining to the administration of life sciences activity.

That committee made its report, with which you are familiar, and was then abolished, after having completed its mission.

No committee, to my knowledge, has supplanted it, sir.

Mr. DADDARIO. Wasn't there a Space Science Board which was established sometime after that?

Mr. LOW. The Space Science Board, Mr. Daddario, is an element of the National Academy of Sciences. I believe. It is a body that is still in being and it does advise NASA in all areas on a continuing basis, including the biomedical area.

Mr. DADDARIO. As of the moment, NASA has no committee of its own?

General ROADMAN. To my knowledge it does not, sir.

Mr. DADDARIO. Any further questions, gentlemen? Yes, Mr. Yeager?

Mr. YEAGER. General Roadman, last fall, I believe it was, there was a meeting of the International Academy of Astronautics which dealt in astroscience and biospace areas. I think several NASA people attended it and also a number of Russian doctors. Did you learn anything from that meeting about what Soviets may be doing?

Was there any interchange of information on the results of the flights of the Russian cosmonauts?

General ROADMAN. I think any information that we get even though scanty, is important information. We do, in fact, get some information through our personal contacts with people interested and capable in our program.

We do not get all the information that we would like, as you well know.

Mr. YEAGER. You do feel that you get some of it?

Mr. Low. I think we get the information that they feel we can have without hurting their program. It is, certainly, only the information they want to give us.

Mr. GURNEY. How much do we give them in return?

Mr. Low. Our entire program, as it is being conducted today, is in the open, with published reports containing all the results of our flights to date.

Mr. DADDARIO. General Roadman, could you provide, for the record, the number of people you have hired out of the 241 you are asking for? We would like to have a breakdown as to where you stand so far as personnel are concerned?

General ROADMAN. We will supply that for the record.

Mr. FULTON of Pennsylvania. Mr. Chairman.

Mr. DADDARIO. Yes.

Mr. FULTON of Pennsylvania. On RDO 12–1 there is the figure 393 personnel for bioscience, and on page RDO 17–1 there is the figure 388 for human factor systems for the fiscal year 1964. Would you kindly correlate the three figures, the one Mr. Daddario said and also the two that I've mentioned and break them down and show their necessity?

Mr. DADDARIO. Can you analyze that, Mr. Low?

Mr. Low. Mr. Fulton, the latter two figures are not the responsibility of the Office of Manned Space Flight.

We would be happy to get the other offices to provide information though.

(The information requested is as follows:)

Out of a total of 1,022 personnel required by the end of fiscal year 1964 in support of the above life science programs, 362 personnel will be serving in a support capacity. The remaining 660 direct personnel will be directly occupied in the various research and development projects under these three programs. A correlation of the 660 direct personnel and the necessity for these spaces, including increases in fiscal year 1964, are as follows:

1. *Aerospace medicine.*—The 149 direct personnel in this program will generally be occupied in developing and monitoring biomedical knowledge and equipment for accomplishing successful manned space flights, and for developing aerospace medicine and technology for approved manned missions. In addition, these personnel will monitor development contracts, under the cognizance of the Office of Manned Space Flight, and develop life support and protection systems. The increases requested in fiscal year 1964 are required to resolve new problems specifically associated with the Gemini and Apollo manned space flights. Essentially, these problems include: (1) Increased radiation associated with long-range flights; (2) more extensive periods of weightlessness; (3) greater vibration and acceleration tolerances; and (4) long-term isolation and confinement. Finally, other increases will be required: (1) To provide a timely analysis of final Mercury and 1-day mission data and to adapt to early follow-on needs of the Gemini and Apollo flights; (2) to cope with complex problems of the first multimanned flights; and (3) to evaluate and monitor medical aspects of the Gemini and Apollo projects prior to and during flights.

2. *Bioscience.*—The 274 direct personnel in this program are required to develop, direct, and execute programs to study the effects of the space environment and separation from the terrestrial diurnal cycle on biological processes and organisms. The additional personnel requirements in fiscal year 1964 reflect fulfilling the effort planned on the development of the orbiting biosatellite, and increases general level of effort in supporting research and technology, emphasizing laboratory research in the general life sciences and processes, as well as studies on extraterrestrial life-detection methods and problems.

3. *Human factor systems.*—The 237 direct personnel will be utilized to plan, direct, execute, and evaluate the advanced research and technology program

accomplishment. The efforts of this program are concentrated on the understanding of man, his support equipment, and his utilization in space and atmospheric flight, and other operations in future aerospace missions. The fiscal year 1964 personnel needs reflect increased effort in the study of the functions of human-body systems in relation to the aerospace environment during longer missions. Additional work is required to establish the limitations and capabilities of the human under environmental conditions which will be encountered in advanced missions. Increased effort is also required in extending the capabilities of the present life support and protective systems to 30 days, 6 months, and beyond. This involves research and development of advanced pressure suits, oxygen regeneration, water reclamation, etc. Additional effort is required in simulation and testing to ascertain if the advanced equipment will function as designed. Human requirements must be integrated with the life support and protective equipment into an advanced system. This necessitates extending the program for ground and flight testing of complete systems.

Manpower requirements in fiscal year 1964 for aerospace medicine, bioscience, and human factor systems

Program/Personnel	*Number*
Aerospace medicine:	
Direct personnel	149
Support personnel	92
Total personnel fiscal year 1964	241
Estimated on-board May 3, 1963	183
Additional requirements June 30, 1964	58
Bioscience:	
Direct personnel	274
Support personnel	119
Total personnel fiscal year 1964	393
Estimated on-board May 3, 1963	275
Additional requirements June 30, 1964	118
Human factor systems:	
Direct personnel	237
Support personnel	151
Total personnel fiscal year 1964	388
Estimated on-board May 3, 1963	276
Additional requirements June 30, 1964	112

Mr. DADDARIO. Yes, we'd like you to do that because, as I said earlier, they have importance to this committee in that they are a breakdown of the life sciences program as originally contemplated. They are in different areas but they still fall within the category of interest.

This committee will adjourn until tomorrow morning at 10 o'clock in the same room.

(Whereupon at 12:05 the subcommittee was adjourned until 10 o'clock the following day.)

1964 NASA AUTHORIZATION

WEDNESDAY, MAY 8, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON MANNED SPACE FLIGHT,
Washington, D.C.

The subcommittee met, pursuant to adjournment, in room 356, Cannon Building, at 10 a.m., Hon. Olin E. Teague presiding.

Mr. TEAGUE. The meeting will come to order.

Mr. YEAGER. I believe we start on RDO 5–1. Then we go back to the previous section which is RDO 4.

Mr. TEAGUE. Mr. Holmes, we hope you had a good trip to St. Louis and Texas.

We start with section RDO 5–1, "Systems engineering."

Mr. HOLMES. Sir, I would like to make an opening statement, if I may, Mr. Chairman.

STATEMENT OF D. BRAINERD HOLMES, DEPUTY ASSOCIATE ADMINISTRATOR AND DIRECTOR, OFFICE OF MANNED SPACE FLIGHT, NASA; ACCOMPANIED BY DR. JOSEPH F. SHEA, DEPUTY DIRECTOR (SYSTEMS)

Mr. HOLMES. I have here with me this morning the Deputy Director for Systems, Office of Manned Space Flight, Dr. Joseph F. Shea. With your permission he will handle the majority of the testimony this morning.

(The biography of Dr. Shea follows:)

DR. JOSEPH F. SHEA

Dr. Joseph F. Shea was appointed Deputy Director for Systems of the Office of Manned Space Flight, National Aeronautics and Space Administration, on January 8, 1962. Dr. Shea is in charge of the entire systems engineering effort for the manned space flight program. He came to NASA from the Space Technology Laboratories, Los Angeles, Calif., where he had been Space Program Director.

Dr. Shea was born in New York City on September 5, 1926. He attended the University of Michigan, receiving his bachelor of science degree in mathematics in 1949, master of science degree in engineering mechanics in 1950, and doctor of philosophy degree in engineering mechanics in 1955.

From January 1959 to August 1961, Dr. Shea was with the A.C. Spark Plug Division of General Motors, Milwaukee, Wis., where he served as director of the advanced system research and development division and manager of the Titan inertial guidance program. Prior to that he was employed by Bell Telephone Laboratories, Whippany, N.J., as military development engineer. He has also served as an instructor in engineering mechanics at the University of Michigan.

His military service was an ensign with the U.S. Navy from 1944 to 1947.

Dr. Shea is a member of the American Institute of Aeronautics & Astronautics, the Society of Mechanical Engineers, and the Institute of Radio Engineers.

Dr. Shea and his wife, the former Beverly Price, and their five children live at 7300 Nevis Road, Bethesda, Md.

However, I would like to say a few words about systems engineering and, if I may, about integration and checkout. Then Dr. Shea will discuss the two areas in turn.

In running the manned space flight program and, more specifically, the program of taking this country to the Moon and back within this decade, the most significant organizational changes of all have been those of initiating both systems engineering and integration, checkout, and reliability organizations, both supported competently by industry.

If one looks at the NASA organization—and I don't consider it to be particularly different or unique from other Government organizations, particularly the Department of Defense, in the way that it is organized, it would have been very difficult to pull together an integrated effort of analyzing how one should go to the Moon, in detail, and then to monitor the progress of that program, as well as the entire manned space program, from a technical or systems engineering standpoint without one central engineering organization with both the responsibility and the authority to do that job.

In view of this situation, very early in the program, after NASA's reorganization of November 1, 1961, we established Dr. Shea's organization for systems engineering. The responsibility of this group is to decide just how one should undertake these missions; what method should be used in going to the Moon or into space; how should one implement the decision insofar as equipment and other requirements are concerned. It is to this subject that Dr. Shea will address himself.

Further, after considerable study it became apparent that it would not be possible, within the structure of Government salary levels, to build an in-house competence in systems engineering that could carry this vital responsibility. It did, however, appear to be possible, within these limitations to build a competent group, capable of making the final decisions on how one carries out this program of systems engineering, and then to support such a group with an equally competent technical organization outside the Government.

After surveying the field which was, of course, industry, we approached the American Telephone & Telegraph Co. and asked it to establish Bellcomm to support this systems engineering operation. A.T. & T. responded as much in the interests of national service as for any other reason. In fact, it had grave doubts as to whether it should undertake this work.

Now, I think that it is worthwhile to point out, and clearly establish that this arrangement is unique. It is a different arrangement than has been established in the past, where we have gone to either a profit or nonprofit contractor and had them support an administrative office with a technical body.

In the case of my office, that would have been similar, for instance, to establishing Dr. Shea's operation outside the Government, to establishing an outside technical group as the technical directors for the program. This has happened in Government in the past.

I am not critical of this practice. I'm just saying the NASA arrangement is different. We have the in-house technical competence, I believe, to make the decisions for this Government in our great en-

deavor, and that in-house group is supported by technical analysis and technical competence to contribute to and give information upon which these judgments can be made. We have established in industry the people who will contribute information, leaving the decisions for in-house Government people.

Turning to integration, checkout, and reliability area as distinct from systems engineering but it is one which equally needs this overall management approach if we are going to go into this program in an efficient and meaningful way. We have a central integration and checkout operation, once again, built in-house, and supported by the General Electric Co., to say: "Yes, we are effecting the program in the way this conceptual design was established."

Let me repeat, to make that difference clear: On one hand, we have the systems activity supported by Bellcomm, concerned with conception.

On the other hand, we have the integration, checkout, and reliability operation supported by GE, concerned with monitoring and integrating the practical implementation of the operation.

There are three major portions of tl 's job; first, establishing an integrated checkout approach. This involves testing the equipment that has been built to this overall system plan; testing to see that it is reliable and that it does meet the specifications, and building complex test equipment so that it can so do.

If you are going to check out the entire system, if you are going to check out the designers of this equipment of many thousands of parts; then you are in an excellent position to do the other things.

The second function in this general area is to establish what reliability does one really have. Once again, there is a contrast with related work on the systems engineering side where we ask: What reliability must one achieve? What redundancy must one have?

On the integration and checkout side we ask, Do we have it? What is the needed reliability of this specific item of hardware and this equipment? What are the mean-time failures? How do we establish this on a statistical basis across the entire program working with the centers?

The third thing—or the second additional thing—one is in position to do, if one does check out is integration as we have called it.

All these tasks are a form of integration, but this specific integration task is to be in a position to see to it—as we have described to this committee before—that the interfaces are thoroughly analyzed and, indeed, we do not have interconnections that marry in a sterile fashion.

If one brings together two different equipments, two different operations, as they are brought together—they bolt together. Not only that, but they fit the panel, the electrical connections, the same size wiring or the same "impetus levels" or the hydraulics line going across properly or any mechanical signals might go across the interface. Anyone who does the checkout has to go into each element of the equipment and is then in an excellent position to know where all these interfaces are.

This is the job we have established, once again, under Dr. Shea, but headed up more specifically by Mr. Sloan in my organization, called integration, checkout, and reliability. My presentation was not in that order. I hope that the order does not confuse you.

Mr. Chairman, I would like to ask Doctor Shea to address himself to the systems engineering aspect, including what we are doing in that organization, and what the funding levels are to carry out that program.

The following information is submitted for the record in order to provide a better understanding of the General Electric (GE) role in the areas in which they are working for NASA under contract NASw-410.

CHECKOUT

The checkout system can be considered a special information processing system which performs functions such as controlling, displaying, routing, retrieving, warning, evaluating, and compiling. The checkout system is to give accurate and consistent results and provide for rapid testing and evaluation of the space vehicle. It will also provide basic growth capability to meet future mission requirements. This will be accomplished by the checkout equipment which will be used at the Merritt Island launch area and called the integrated launch control and checkout system (ILCCS). GE's main role in the checkout area is to supply (engineering support) design, display, fabrication, installation, maintenance and operation, and logistics provisioning for the ILCCS at the Merritt Island launch area and for ILCCS related equipments at contractor plants. GE also has a responsibility in the checkout standards area through which will be achieved better reliability and maintainability and cost savings.

INTEGRATION

The integration function is to insure compatibility of major system elements with each other and insure that the system specifications are implemented during the design. Integration also requires initiation of rapid corrective actions and positive communications procedures to assure that necessary corrective actions are taken. Integration activities are concerned with detailed interface requirements, specifications, designs, fabrication, training, tests, and operations. In the integration area GE provides assistance in interface integration, configuration control, documentation, and data handling. Many of these activities are produced in direct support of the NASA centers by GE working directly with them. Some specific examples of the type of assistance which they perform have been; formulation of system descriptions, terminology standards, interface books, and functional line diagrams. In the interface integration area they have developed an interface control plan which insures identification of the interface, records the assignment of responsibility for the interface and establishes a procedure which insures proper documentation, reporting and timely solution of problems. Plans such as the interface control plan preserve the technical authority of the NASA centers which have responsibility for the equipment (stages and spacecraft modules). In configuration control, GE has studied other missile and space programs, including current NASA systems, and is developing plans and procedures for adoption by NASA and its Apollo contractors.

GE is developing and implementing an integration engineering documentation system that will improve communications and reduce time, errors, and costs. This program documentation system will minimize the amount of documentation required and maximize the usefulness of that documentation which is prepared. In accomplishing this task for NASA, GE is developing a documentation model based on the experience of past programs and studies. Existing documents may be modified and where there are voids new ones will be developed.

In support of their coordinating functions, GE provides support in the preparation of contract data requirements, drafing manuals, standard qualified parts lists, drawing specifications, test methods and procedures.

RELIABILITY

In reliability, GE emphasis is placed on mission reliability and safety assessment, reliability program plans and procedures assessment, assistance to NASA Centers for reliability tasks and pyramiding reliability estimates of the Apollo program.

In mission reliability and safety assessment, GE is developing a reliability model which includes defining of terms and mission phases and events. They

study functional flow charts, alternate missions and aborts, and phases and events.

GE is also conducting mission failure effects analysis to define the effects of equipment failure or performance degradation and system interactions on mission reliability and flight safety. Through this effort NASA will obtain the probabilities of mission and safety success, trade-off considerations and identification of critical problems and areas where improvements should be effected.

The reliability and failure data system being developed by GE will be used in conjunction with NASA center and NASA contractor data systems. As part of this effort, standard reporting procedures will be effected to collect, consolidate. and process data to be used in the reliability models to generate the estimates. It will consolidate and process center and contractor model estimates for use in mission reliability safety studies and will provide status information useful for both management guidance and for program improvement.

In the design, manufacturing, test, and operations area, GE has been developing survey techniques, check lists and scoring methods which can be used by NASA in the review and assessment of the NASA contractor reliability and quality programs in these areas. Special analysis will be conducted by the equipment builder on critical and major failures. The methods and techniques developed by GE such as the failure analysis system will provide for control of discrepancies, parts and components which require further analysis and corrective action. This tool, it is expected, will highlight areas where possible improvement can be achieved.

SUMMARY

In summary, the original conceptual decisions in all three areas of work—checkout, integration, and reliability assessment—are being made by NASA, drawing upon in-house NASA technical support. Supporting conceptual studies are accomplished by Bellcomm. Implementation of specific NASA decisions is carried out by the General Electric Co. Across-the-board efforts performed by GE are directed by the Office of Manned Space Flight. GE's work in the three areas discussed, that is closely associated with the NASA centers' responsibilities, is directed by the appropriate NASA center.

Dr. SHEA. I am not sure there's much left to say, Mr. Holmes, but I will start. I think, as Mr. Holmes pointed out, the systems engineering role is as we define it, somewhat different than the approach used in the ballistics missile program.

We do what we call systems engineering, but we don't engage in the technical direction of the contractors themselves.

We have the centers with NASA, centers possessing very competent technical staffs and the large amount of manpower required to monitor, day-by-day, the activity of the contractors to see that things are indeed being done in accordance with the over-all systems concept.

This lets us concentrate on what you might call the basic requirements and the major flow, the concept of the mission; therefore, we do not get into the very heavy manpower levels required to physically direct the contractors.

We do systems engineering, but not technical direction.

Now, it might help if I illustrated a few of the things that we do, the kind of activities that we focus on.

I think the first of these, and in fact the first job thrust upon us when we started the program, was the mission mode decision for Project Apollo. I think you are all familiar with the background of this. A little more than a year ago there had been a large amount of study work done and there were still three competitive ways of going to the Moon under consideration: one, called earth orbit rendezvous; the second, Lunar orbit rendezvous; and a third, direct flight.

There were strong protagonists within NASA and within other parts of the Government for each of these approaches. What we pro-

vided was a way to focus the study activity and to provide what you might call an impartial study activity, which is the key to a successful Systems Engineering function.

Engineers and even scientists are basically like everyone else in the world. If they have a particular idea, they tend to become very strong protagonists of this idea. You can't always prove that one way is better than another way strictly by equations, or mathematics, or analysis, or anything else. You wind up in a situation where technical judgment very often has to come into play in making the final decisions. You just can't solve the problem with equations alone.

I think the thing we provided in the case of the mode decisions and the thing we tend to provide in the execution of the overall manned space flight program, is a group that is technically impartial. We are not committed very heavily to any particular approach. We have strong, competent, people from a wide variety of technical backgrounds. We are trying to meld together this competence so that no single background is predominant. These individuals are in a position to judge how a given task the thing ought to be done independent of any preconceived notions.

Mr. DADDARIO. Mr. Shea, when you say a group "technically impartial," what are you referring to?

Dr. SHEA. My own in-house groups, the Directorates who report to me; one is called systems engineering under Mr. John Gautraud; the other is systems studies under Dr. William Lee; that program is supported by the Bellcomm operation under Dr. Hornbeck.

Mr. DADDARIO. It is a combination of the civil service people to whom Mr. Holmes has referred to?

Dr. SHEA. And Bellcomm personnel.

Mr. DADDARIO. The outside company, Bellcomm, but not including GE?

Dr. SHEA. GE is another consideration which I'll explain when we examine the overall GE operation.

Mr. DADDARIO. When you say "group," would you please mention to whom you are referring. It is important, at least in my way of thinking, that we know how these various groups effect the final conclusions reached, or the effort being made.

Dr. SHEA. Let me talk a little bit about this relationship, because I'm sure it has been——

Mr. TEAGUE. For the benefit of the committee, we are going into systems engineering, Bellcomm, and then the Aerospace Corp.

Dr. SHEA. Mr. Teague, Aerospace works for the Air Force.

Mr. TEAGUE. I know. We want to know whether you are familiar with the corporation.

Dr. SHEA. I am acquainted with Aerospace, sir.

Mr. FULTON of Pennsylvania. Where does Mr. Sloan fit into this picture?

Dr. SHEA. Mr. Sloan reports to me as Director of Integration, Checkout and Reliability, and that is the GE-supported part of the overall system activity that Mr. Holmes described previously.

I might, just for a minute, try to draw up the thing in perspective and talk about the system. In effect, what we do in systems engineering, as distinct from the integration and checkout activity, is try to define broadly what needs to be done. I'll give you some examples of how we do this in a minute.

In the integration, checkout and reliability areas, we do a lot of things that are defined by systems engineering, and we also provide in the program what you might call a check and balance to be sure that the things which are being done are, indeed, being done correctly.

In a program as vast as Apollo there are many opportunities for mistakes. As Mr. Holmes said, a contractor or even a center can design an interface with a plug that contains seven wires; if you are not careful, another contractor who may be working for another center can design the mate to that plug with eight wires. Or, what's even more subtle, when they connect the wires into the back of the plug you may wind up with right wires going to the wrong terminals, and when these plugs are assembled you wind up doing what we call a smoke test the first time you hook the things together, electrical connections being such that things might burn out.

What we are trying to do is to prevent that kind of occurrence, and a large part of the GE activity in the integration area is associated with checking and double-checking to see that everything, indeed, is going to go together properly. That's over and above the checkout responsibility, which is essentially a part of the reliability verification of the overall system; and then, the reliability activities are again a check on the program, if you will.

It's an attempt to identify every failure that exists or that is experienced in the entire test program, measure that failure, understand why it happened, be sure what corrective action has been taken so that cause of failure is removed from the program and at the same time sort of "bookkeep" on how well we are doing so any instant in time we know how reliable the system is.

Now, to go on then with the Apollo mode decision discussion. As we got deeper into the study on the mode decision, it turned out that many of the arguments were as emotional as they were technical, particularly with respect to the lunar orbit rendezvous mode.

The key question was how difficult would rendezvous be in the vicinity of the Moon. You may remember back about a year ago that this was a hotly debated technical issue, and there were some arguments made, for example that it was much easier and much safer to rendezvous in the vicinity of the Earth because you can use all the help available from the Earth. You have ground tracking stations close by. In the vicinity of the Earth it is easy to abort, and so on.

When we went through an analysis, step by step, of how you rendezvous in Earth orbit, and, step by step, how you rendezvous in lunar orbit, it turns out to be essentially the same kind of maneuver. The ground tracking stations didn't play a determining part in the Earth orbit rendezvous nor would they play much of a role in lunar orbit rendezvous. We were able to deduct, subsequently, that it was no more difficult to rendezvous in the vicinity of the Moon than it was to rendezvous in the vicinity of the Earth.

In addition, when we broke down rendezvous maneuvers into constituent parts, we found the things that would have to operate for rendezvous would be the things that had to operate for a successful mission in any case. In other words, the propulsion system had to be able to burn so you could adjust the flight path. The attitude control system had to operate so you could control orientation of spacecraft. The guidance system had to operate to get back home again.

As a matter of fact, the guidance requirements for lunar orbit rendezvous, when you came off the lunar surface to meet the other ship in orbit, proved to be a lot simpler than anticipated. You didn't have to work the guidance system quite so hard. It is a good deal simpler to rendezvous than to come all the way back home again with the single pass.

All those things, when you put them together, indicated that rendezvous was one more step in a very complex overall mission. We broke the mission down into some 40 individual, identifiable steps in which combinations of all these systems had to work. The adding of one more step, rendezvous, would only change the reliability estimate by a very small amount—1 part in 40, or in the order of 2 percent.

We traded off that additional small complexity against the problem, for example, of launching two complete Saturn V vehicles from the Earth, and doing a tanking operation in Earth orbit to transfer fuel from a previously-launched tanker to the injection vehicle, the Saturn's IV–B stage, which would have been in orbit with the spacecraft. These looked like much more complex operations than the lunar orbit rendezvous maneuver. The net result of all this was the verification of the fact that there were no insurmountable technical difficulties in the lunar orbit rendezvous mode (LOR).

The LOR mission required only a single launch and, therefore, was a much simpler overall mission. We were able to say in addition to those considerations that indicated, in effect, that it wasn't a more complex or less safe mission, it also would turn out to give us a somewhat less expensive program, our competitive study showed this mode to be on the order of 12 to 15 percent less expensive, and further that a lunar rendezvous mission could also be accomplished in a shorter time.

A third part of that study looked at the direct flight mission. You remember when we had the Nova vehicle in the plan. We found that the requirements for the Nova vehicle, and the length of time it would take for design, would delay us in the order of 1½ to 2 years in the accomplishment of the lunar landing mission. In addition, it would be a more expensive program.

After the detailed analysis had gone on regarding lunar orbit rendezvous itself, we were also able to say that there were no major technical uncertainties in the program and that, for example, you didn't need to carry on the approaches discussed previously—earth rendezvous and direct flight.

Because there were no technical flaws in the lunar orbit approach, we certified the fact that you didn't need the Nova vehicle and therefore didn't require a direct flight operation. This, I think, simplified the overall program and I suspect saved you gentlemen a little bit of additional monetary concern this year.

Mr. GURNEY. As a matter of interest, how many people worked on this? How long did it take for you to arrive at your decision?

Dr. SEIFA. The historic studies which started just after President Kennedy announced manned lunar landing as a national goal, began about May of 1961. When we came aboard—our office was formed in January of 1962—we had at that time several studies done both within NASA and within industry. There were some "holes" in these studies; some of the estimates looked optimistic, and we really hadn't gotten into details of rendezvous yet. We conducted some additional

studies; both in-house, within my own organization, which was forming at that time, and within the Centers—both Marshall and Houston—and at one contractor, Chance-Vought Corp.

By about June of that year, we assembled substudies, made comparisons, reliability estimates, cost estimates, and technology estimates, if you will. At that time there had possibly been close to a million hours of competent engineering study put into the overall project.

You probably recall there was a little bit of perturbation on the decision about that time. We did some additional studies through the summer. By last fall, when the decision was finally certified, it represented the concentrated activity of a large number of people—over about a year's period of time.

The mode decision was really just the first of the areas into which we have pushed. Once the mode decision was made, we had developed then, a nominal, rough-cut mission profile for Project Apollo.

The problem then was to go back and certify, in the light of that decision, the design approach we were taking for Apollo in order to define the specifications for the lunar excursion module and to say, in an overall way, how we wanted the program run.

One of the first documents that we developed was the "Apollo System Specification Ground Rules." This was prior to the actual issuance of the overall Apollo specification. Perhaps I might leaf through this document to give you a feel for the kinds of things we had to consider.

The first item was what we call a technical policy statement, if you will. I think you are aware that in an engineering program, as with a budget or anything else, you have to balance things off, and normally these things are somewhat competitive, one against the other.

We developed, therefore, an ordering of the importance to us of the various technical criteria in the program and of the three things that we selected as being most essential; the first was crew safety and mission success and that the system should be designed in such a way to maximize both. It turns out you can handle this consideration mathematically in the system design; it should be designed in such a way as to maximize the number of mission successes per fatality.

Perhaps it sounds a little gory to talk about fatalities. When we talk about the mission we are trading off how successful the mission itself is versus how safe it's going to be for the astronauts. To give you an example, in the limiting case. You could have a very, very, safe mission, one in which all the abort systems work and so on; but you might never get off the pad, so you have a 100 percent safety record, but you'd have a pretty poor mission success record.

As you design the systems for the various duplicate components—what we call "redundant elements"—that exist within the spacecraft, different decisions must be made, for instance, if you have a failure in a particular system such as one of the spacecraft's fuel cells. We have three fuel cells aboard the Apollo spacecraft, any one of which can provide sufficient electrical power for the mission. If, as you design your mission profile, it turns out you have a failure in one of those fuel cells you have to make a decision—depending on where you are in the mission—whether you are going to continue with the mission or whether you are going to come back home again.

Using this criteria of success per fatality you can make some decisions on just what your mission ground rules ought to be, and in certain cases how many "redundant elements" you ought to carry with you.

Now, the second——

Mr. FULTON of Pennsylvania. Could I just comment on that?

Dr. SHEA. Yes, sir.

Mr. FULTON of Pennsylvania. Some people measure the number of bad apples in the barrel and others comment on the number of good apples in the barrel. To me, I do not think it is productive to comment on the number of successful missions per fatality. I think it's a bad approach and I think you just ought to talk about the constructive and the successful rather than measure it the other way around.

Dr. SHEA. The point here is that you must balance your system design to account for not just the straightforward way of going to the Moon in the case where everything works properly; you also have to have the abort systems that are capable of taking care of the astronauts in the event that some problem exists in the overall system.

Mr. FULTON of Pennsylvania. People don't sell automobiles on the number of casualties a year.

Dr. SHEA. Yes, sir.

Mr. FULTON of Pennsylvania. We are trying to put forward a constructive program, and I think it's better to have as high a reliability and a safety factor as you can even if you lose mission after misssion, rather than have any injury or fatality.

Mr. HOLMES. I think that's right, Mr. Fulton. I think Dr. Shea's point, however, was we must address ourselves to, at least, a failure in the vehicle and what we do in order to abort so that we will not have any fatalities.

Mr. FULTON of Pennsylvania. That's what I like to hear, but I don't like missions and fatalities geared together. I think that is the point.

Dr. SHEA. Yes, sir. The next criteria, after mission safety and success is the schedule of the program and the fact that, next to safety, this is the most important element we have; the third and last one is what you might call "growth potential"—the other things that the Apollo spacecraft and the launch vehicles may be able to do as a part of the national space program itself.

The design policy that was stated with respect to crew safety was the fact that we would like as a design goal—since you always have to be ready to accept a failure in an individual element, even though you check it and test it and do everything you possibly can to be sure it won't fail- -the ground rule, if you will, was that if we can possibly do it, no single failure of any element in the system will cause us to have to abort the mission. That's a difficult design goal to meet.

For example, you can't have two separate vehicle structures, and if a structure got punctured by a micrometeorite you'd be in some element of difficulty; therefore, those structures or those elements of the system that can't be made redundant are made that much safer. That is, they operate with a larger margin of safety.

Again the final ground rule—which is an absolute one—is that no single failure of any single element in the system could cause an abort, so that the astronauts can always get back from a single failure.

In the area of rendezvous, which is one of the aspects we paid particular attention to, we were able to design the mission in such a way there is sufficient fuel aboard the lunar excursion module (LEM) to execute the rendezvous in the normal course of events.

We designed the system so that there are two guidance systems aboard the LEM; if one guidance system fails, the second one can take over with the help of the astronauts and actually execute the rendezvous maneuver.

In addition, because this was such a critical maneuver, we found we could balance the system design in such a way that we could put sufficient fuel aboard the service module so that it could go down, if needed, and complete the rendezvous.

For instance, after the LEM comes off the lunar surface and is on a trajectory to coast up with the command and service modules, if at that time there's any problem you can't handle—if the control goes out, or both LEM guidance systems fail—there is sufficient propulsion capability aboard the command and service modules, and the design of controls are such that the single astronaut up there can handle the command and service modules and it can come down to the trajectory the LEM is on and complete the rendezvous.

These are the things we have been able to determine and know that they fit within the overall program.

The Apollo system specification itself—I am holding the first draft here—is about 50 percent complete at this time. Perhaps I might give you a feel for what it contains. In addition to the general program policy, which I mentioned, it specifies the mission command and control. The fact that command control resides on the ground at the mission control center at Houston, and that we delegate to the astronauts what you might call "tactical command" of the spacecraft, they are always tied back to the ground.

The mission profile, which as I mentioned during the time of the mode decision, consisted of some 40 steps, has now been expanded to about 94 steps. We have defined each of the critical events that happen throughout the mission, in the program, and examined each of these to determine what requirements they place on such systems as the attitude control system, the propulsion system, the life support system, the communications systems, the guidance system, and others.

Once this nominal mission profile has been defined, we move into the calculation of the trajectories themselves.

This is what you might call a nominal designs trajectory—it tells us when you can launch from the surface of the Earth, at what angles, how long it's going to take to fly to the Moon, how much fuel you have to provide for each step along the way, how much contingency fuel you need in order to "open up" your launch window, and then the entire class of what we call abort trajectories.

I think you can realize that once, for instance, you are injected on the way to the Moon, you have a tremendously high velocity; and you don't have sufficient fuel in the service module to slow yourself down immediately and come right back.

What we are doing here involves making computer runs to determine how far out you should coast before you turn yourself around, light the engine, and kick yourself back to the Earth again. We are also studying the circumstances: What sort of a trajectory do you

come back to the Earth on? Where are you liable to land? Where do we have to locate tracking stations? What sort of recovery operations are likely to be involved in things like a mission abort? These are some of the factors that we have to determine.

We then go down through each of the subsystems in the launch vehicle and in the spacecraft and define, in effect, the requirements on those subsystems.

As an example in the guidance area, there is aboard the spacecraft what's called an "inertial platform." It's a self-contained measuring device, consisting of three gyroscopes which maintain the platform stable in space, and some pendulums on this which measure the acceleration of the vehicle. That information is sent back into a digital computer, also aboard the spacecraft, that can calculate where the vehicle is at any point in time.

When the service module's engine is burning and generating thrust, you particularly need this guidance system to maintain "real time" control to define the direction in which you want the thrust vector pointed, and the length of time you want the engine to burn.

We can specify the requirements for this component; for example, how accurate the platform gyros and the accelerometers have to be in order to give us the proper amount of control. We also analyze the relationship between the on-board guidance system and the ground control stations, because you are also tracking the spacecraft from the ground. Although the ground stations can't control the actual burning of the spacecraft's engines, they can, soon after the burning, reestablish the trajectory on which the spacecraft is going, and so there is a tradeoff then between the accuracy of the ground system and the accuracy required in the flight system.

It's a similar tradeoff between the size of the flight computer, how much computation it can place aboard the spacecraft, and how much computation you want on the ground. Again, we balanced this off, and have determined that if you have too much computation on the ground you have a very heavy data length requirement and have to have what we call a wide bandwidth and in essence a lot of power to go from the ground up to the spacecraft. If you have too much computation done abroad the spacecraft, you wind up complicating the computer and the computer turns out to be too large.

There is system balance here on what you do on the ground and what you do in space. These are the kinds of things that are involved.

Ordinarily you can analyze these points independently, knowing what the exact configuration is. For instance, with the digital computer, we know from just past experience if we need to store 25,000 words in the computer's memory and if we have to compute at a certain speed, that this is going to turn out to be such and such a size of computer, almost independent of exactly how it's designed, which isn't too important.

Another consideration is the kind of radiating power required to get information from the ground to the spacecraft. These are the kind of things we can study before you decide to commit systems to the actual designers, so that we know what we are doing, balanced within the current state of the art.

There are other things we do. I think somebody noted at one time that for Apollo itself we will probably generate sufficient paper that

if we piled it up it would get to the moon before the Apollo spacecraft did and we are on our way—as you can see.

Actually we thought that was a good idea but it turns out the structure was a little unstable. That is one of the "modes" we abandoned earlier.

Mr. HOLMES. I didn't agree.

Dr. SHEA. Just off the record—one of the men in our group said we couldn't use astronauts on the Apollo, we'd have to use pageboys.

Mr. FULTON of Pennsylvania. The way it's going, the $1,000 bills being spent will reach from here to the Moon before the Apollo spacecraft.

Dr. SHEA. That's a very unstable structure. Now, continuing with some of our tasks, we are also involved in the definition of what the Apollo reliability program ought to be.

We are studying what the effects of radiation, meteorites, and so on will be; what the design ought to be to cope with the environment, as we understand it; what the lunar characteristics are, pulling together the best information from the best scientists around the country, based on the observations and experiments that have been made.

We have a strong tie with NASA's Office of Space Sciences to determine what things we need from these unmanned programs in order to certify the Apollo design and let us pick a landing site.

We are looking at some of the advanced considerations, such as what we need on the Moon, and what scientific missions will Apollo itself accomplish.

In fact, once the Apollo specification has been completed, we turn out to be something like a team of technical troubleshooters on the project. When special problems come up, related to the Apollo mission itself or to the capability to do the mission, Mr. Holmes would ordinarily turn to us to provide him with the analyses to say what the solution is.

I think you recognized that our programs are extremely complex and, as a result, we really exist to resolve problems. You expect these problems, and what you need, really, is a competent team of people who can solve the problems as expeditiously as possible. Although it seems impossible to think of everything, we try; we've learned that you have to understand the system as completely as possible in order to know what to do when any particular problems occur.

Mr. GURNEY. What kind of system do you have to put the information together? To whom does it go? Is it a set list?

Dr. SHEA. It is a set list and in general involves all the Center people in key spots working on the program. It's made available to their contractors and distributed fairly widely throughout the Office of Manned Space Flight.

Mr. FULTON of Pennsylvania. You know that stack of paper you are speaking of is really no joke, because a $1 billion stack of $1,000 bills is 100 feet higher than the Washington Monument. The monument is 555.6 feet. So, that's 655.6 feet and for $20 billion would be about 131,000 feet, or 26 miles of $1,000 bills stacked up; as the cost of this Moon program.

So, if you are talking of piling your papers up, we have to think, too, of piling the taxpayers' papers up and the taxpayers' burdens.

Dr. SHEA. Yes, sir.

Mr. TEAGUE. Go ahead, Doctor.

Dr. SHEA. I think we might get into the budget, if I have given you some idea of what we do.

Mr. TEAGUE. Any question before we get into the budget?

We have a long way to go this morning. I hope the members will limit their questions to things which are pertinent because we will not get very far unless we do.

Mr. YEAGER. May I bring one thing up? You mentioned the possible contamination of extraterrestrial bodies and converse contamination of the Earth from such planets as the Moon. Could you give us some information to fill us in on what NASA is doing on this, and what you are going to coordinate with other scientists in this area?

Dr. SHEA. Yes. The problem of contamination of the Moon itself, or of back contamination from the Moon, does not seem to be a major technical problem now. In the design of the spacecraft and in the handling that we give the spacecraft at the cape, we take as many precautions as we can without damaging the equipment, without subjecting the equipment to too severe an environment simply in order to keep the contamination level down.

If you really talk about sterilizing the spacecraft, however, the nominal way of doing this is to subject the spacecraft to temperatures of 250 to 300 degrees fahrenheit for long periods of time, in the order of 24 hours or so, and wash it down first with a gas which is composed of ethylene oxide and later with a gas called Freon. The gas wash isn't too bad, but the temperature "soak," with the kind of components we are using today in our electronic systems, for example our valves and so on, turns out to be detrimental to the reliability of the equipment and so we are not subjecting the Apollo hardware itself to any sterilization projects.

We are taking particular care that human contamination remains inside the spacecraft during the time the astronauts are on the lunar surface, although there is probably a small leakage of air which undoubtedly contains biological organisms from the astronauts' suits. We keep this down to the absolute minimum we can get away with. That is about the way we are handling this problem for Apollo.

I think the problem of sterilization for the planetary missions is somewhat different; we need some design work, and to actually design and do development testing on components that indeed can be truly sterilized. I don't think for the Apollo mission we can afford to compromise mission safety by any rigorous sterilization of the spacecraft.

Mr. HOLMES. I think we might add that it's literally impossible to sterilize man completely, since he carries many, many, bacteria. In addition to the problem of having them operate in a space suit there and not contaminate the Moon, should there be an accident—and God hope there is not—you certainly are going to contaminate the Moon. It's a most difficult problem to go there and expect to really assure you are going to go in a sterilized approach.

Mr. YEAGER. Mr. Chairman.

Mr. TEAGUE. Yes, Mr. Yeager.

Mr. YEAGER. May I, at this time, ask permission to file for the record 10 questions and the witness' answers when submitted, and also incorporate a brief staff memorandum on the problems involved?

Mr. TEAGUE. Very well.

(The information referred to is as follows:)

QUESTIONS REGARDING POSSIBLE CONTAMINATION OF EXTRATERRESTRIAL BODIES

Question 1. Please identify those persons within the Government who are working on problems of preventing contamination by sterilization of space vehicles. Scientists? Engineers? Administrative officials? Those in NASA, the Department of Defense, the Department of State (space law) or other agencies?

Answer. The following is a representative list of key individuals who are working on this problem:

Scientists:

NASA:

Headquarters: Dr. John Clark.

Centers: Dr. Leonard Jaffee (JPL), George Hobby (JPL), Dr. Lawrence Reed (JPL), Norman MacLeod (GSFC), and Ralph Hastrup (JPL).

Department of Defense: Dr. Charles Phillips (Army), Dr. Briggs Phillips (Army), Dr. E. Staten Wynne (Air Force), Dr. R. Mitchell (Air Force), and Joseph Cordaro (Air Force).

Engineers:

NASA:

Headquarters: David Liberman.

Centers: L. E. Richtmyer (GSFC), E. Rich (GSFC), E. MacKannan (MSFC), Dr. W. Lucas (MSFC), J. Maclay (JPL), W. Lockyear (JPL), and W. Shipley (JPL).

Administrative officials:

NASA:

Headquarters: Dr. Homer Newell, E. Cortright, Dr. Orr Reynolds, Dr. Freeman Quimby, Oran Nicks, James Miles, and Paul Tarver.

Centers: Dr. Harry Hoett (GSFC), William Stroud (GSFC), Robert Parks (JPL), Dr. Frank Goddard (JPL), Paul McGiven (JPL), Dr. Ernst Stuhlinger (MSFC), and Thomas Kinser (MSFC).

Question 2. Who are the nongovernmental specialists involved with this problem? In the National Academy of Sciences-Space Science Board? In universities and laboratories?

Answer—

Industry: A. M. Nowitsky (Lockheed), Dr. H. W. Rose (Lockheed), and Dr. Martin Koesterer (Wilmot-Castle Co.).

Universities: Dr Gerald Silverman (MIT).

Space Science Board: Harry H. Hess (Chairman), Lloyd V. Berkner, Allan H. Brown, Harison S. Brown, John W. Findlay, Herbert Friedman, Leo Goldberg, William W. Kellogg, Hugh Odishaw (Executive Director), Gordon J. F. MacDonald, Richard W. Porter, Bruno B. Rossi, John A. Simpson, James A. Van Allen, and George P. Wollard

Working Subgroup on Space Probe Sterilization:

A. H. Brown, Chairman, University of Minnesota.
C. W. Bruch, Schwarz Labs., Mount Vernon, N.Y.
A. Chorkin, Don Baxter, Inc., Glendale, Calif.
H. J. Curtis, Brookhaven National Laboratory.
A. Dessler, SCAS, Dallas, Tex.
H. M. El-Bisi, University of Massachusetts.
S. W. Fox, Florida State University.
H. D. Hedberg, Princeton University.
C. R. Phillips, U.S Army Biological Laboratories, Fort Detrick.
C. E. Sagan, University of California.
E. W. Six, State University of Iowa.
Wolf Vishniac, University of Rochester.
G. Derbyshire, Space Science Board Secretariat.
J. Y. Roshal, Space Science Board Secretariat.

In addition, nongovernmental experimenters from universities, research laboratories, etc., will, at a later date, be invited to develop and supply sterilizable

instruments for measuring scientific attributes of space during the interplanetary journey and of the planets Mars and Venus after arrival there.

Question. 3. Has the Space Science Board furnished a report on sterilization of space vehicles to the National Aeronautics and Space Administration or any other agency of the Government? If so, will you please furnish the committee with a copy of the report.

Answer. The Space Science Board conducted an intensive review of this topic during June, July, and August of last year (1962). A copy of their report, "A Review of Space Research," NAS–NRC Publication No. 1079, is attached. Attention is invited to chapter 9, in which the purposes of the exobiology program and the necessity for sterilizing lunar and planetary spacecraft are discussed, and to chapter 10, in which techniques and problems of space probe sterilization are described.

Question. 4. Do all the different groups working on this problem, or affected by it, know of other activities in the same area? Do the scientists and engineers know about the discussions and commitments made in the United Nations? Do they know of commitments made by the U.S. scientific community in participation with COSPAR's Consultative Group on Potentially Harmful Effects of Space Exploration?

Answer. One cannot presume that all members of all groups working on this problem know all of its aspects. However, from our contacts, we are sure that common and functional knowledge is available to representatives of all groups.

Representatives of these groups are familiar with COSPAR's Consultative Group on Potentially Harmful Aspects of Space. Representatives of NASA will attend a COSPAR meeting at Warsaw, Poland, in June of this year.

All groups who are working within or for NASA are aware of what the others are doing. In addition, a NASA-wide committee of those involved has been meeting and will continue to meet regularly and frequently to exchange information, and to formulate and reshape the program as necessary. The engineers and scientists not only know about the extra-NASA discussions and commitments, but, in most cases, they participate in them.

Question. 5. Is there any conflict between U.S. national policy on the sterilization-contamination problem and U.S. international policy as conducted through the United Nations?

Answer. No.

Question 6. If the impression given by recent publicity is that we have shifted from maximum sterilization of lunar space vehicles to no sterilization, is it possible to present the technical facts so that the degree of sterilization will be established?

Answer. We have never really had a policy of "maximum sterilization" for lunar spacecraft, although there is a set of procedures being developed and studies being made in this direction. The procedures that have now been adopted for lunar missions are not to achieve sterility, but are to accomplish a degree of decontamination by means of ultra-clean-room assembly.

The exact degree of sterilization is difficult to establish on any single complex solid object such as a spacecraft no matter what assay techniques or methods of killing bacteria are utilized.

Clean-room procedures on some parts have yielded sterile surfaces. Internal decontamination can be accomplished only with the application of dry heat at or in excess of 135° C. at 24 hours.

Question 7. Is there any truth in the implication that "nonscientific considerations" have been responsible for reducing sterilization procedures for lunar landings?

Answer. It is true that "nonscientific considerations" have affected the procedures for sterilizing lunar probes. The nonscientific considerations involved may be summarized in the single phrase "engineering reliability after being subjected to heat sterilization." Dry heat is the only technique of sterilizing now known to be biologically satisfactory for complete sterility and at the same time to offer adequate promise of technological feasibility. The current state of this technology is now inadequate, but a full-scale effort to develop heat-sterilizable, technologically reliable hardware is being mounted and appears to be an attainable objective in time for the 1966 Mars mission.

To illustrate some of the problems that must be resolved, consider the following. One of the instruments intended for the detection of life on the surface of Mars contains a liquid (a culture medium) that boils at a temperature below

that which would sterilize that instrument. Current versions of television tubes fail at temperatures that would kill bio-organisms. The electrolyte solutions within spacecraft batteries boil and the case leaks at these temperatures.

Rangers III, IV, and V were not sterilized in the strict sense of the term, but they were decontaminated; that is, the total number of terrestrial micro-organisms was substantially reduced to a minimum believed to be consistent with mission success.

The International Council of Scientific Unions set up a Committee on the Exploration of Extraterrestrial Space (CETEX) in March 1959. CETEX held its first meeting in May 1958, and its second meeting in March 1959. The Committee took the position "that the presence of life of any type on the Moon is extremely unlikely and decided, as well, that the possibility that free radicals in explosive amounts exist on the Moon is remote."

The Committee also stated, "that it may not be possible to avoid all types of contamination."

A CETEX report in ICSU Review, volume I, 1959, stated that "there is no possibility of the introduction of cells such as spores or bacteria might give rise to life on the Moon of the same type (that is containing DNA) as on Earth which might confuse later investigations. There are no cells on Earth which grow or multiply in the absence of water and at the high vacuum of the Moon no water can exist."

In the connection with the matter of dead contaminants on the Moon, that is extraterrestrial macromolecules, the Committee's recommendation is that "a simple precaution against endangering future studies is to limit the areas of landing on the Moon and thereby localize the effects—if any—of terrestrial templates."

Dr. Carl Sagan, in proceedings of the National Academy of Sciences, volume 46, 1960, calculated that if a Spacecraft of 10^4 kilograms were contaminated with 10^6 micro-organisms per kilogram (a total of 100 trillion micro-organisms), there would ultimately result an average of only 1 viable micro-organism per 100 square meters on the Moon. This organism would be undetectable either on the Moon or on the Earth by any known method (unless this or these organisms multiplied, which it or they could not do on the lunar surface). He further states that the amount of organic matter deposited as micro-organisms by impacting vehicles is completely negligible compared to the amount of indigenous organic matter which has already survived from the early history of the Moon.

This latter organic matter is probably at a depth of tens of meters and would be contaminated only if terrestrial microbes reach this level, which he regards as a remote probability only in the event of the impacted deposition of large populations (10^{24}) one or more members of which might reach such depths.

Dr. Sagan also concludes "that the probability is very low that deposited terrestrial micro-organisms and organic matter will be confused with indigenous lunar organisms or organic matter." He suggests that explosive reproduction of terrestrial organisms at depths where lunar organic matter may exist, is "remote but nonnegligible."

Present plans for lunar spacecraft are to use assembly techniques in clean rooms and under environmental conditions similar to surgical operating facilities. These procedures will not make the spacecraft sterile but are expected to reduce the total population of viable organisms by order of magnitude below otherwise expected quantities. As stated earlier, the natural environment of the Moon is believed suitably hostile to the propagation of Earth-like organisms to such an extent that any contamination will be contained in very local areas.

No plans are envisaged for sterilizing manned vehicles to the Moon. There are four reasons for this: (1) Although man's microbial population can be reduced by appropriate antibiotics and although his space suit can constitute a potentially effective contamination barrier, he is not in a practical sense a sterilizable part of any system. (2) Sterilization in the overall Apollo configuration introduces an additional challenge to reliability which cannot be tolerated where man is concerned. (3) Reliability, which is an absolute must in manned lunar missions, is an effective way of preventing lunar contamination, since a properly operating "bug" and space suit would be "self-sterilized," or nearly so, by lunar environmental conditions. (4) Contamination of the Moon from the "bug" and air leaks from the pressure suit would be temporary and inconsequential. It is fully expected that the Apollo crew and any subsequent successfully landed man on the Moon can obtain lunar soil samples from known areas

and known depths which will be considerably less "contaminated" than any kind of sample obtained anywhere on our own Earth.

Question. 8. Have sterilization procedures been relaxed for protecting the Earth from contamination of Moon substances?

Answer. The problem of preventing contamination of the Earth on return trips from the Moon is believed to be entirely separate and unrelated to the question of lunar contamination. Studies will be made of the possibilities of back-contamination and appropriate actions taken on the basis of these studies. It does not appear obvious at the moment, however, that early return flights from the Moon would represent hazards to Earth because of the superficial contact with the Moon and the unlikely probability that organisms exist of a nature which might thrive in the Earth environment.

Question. 9. Could effective sterilization procedures be developed for the lunar program if the target date for reaching the Moon was not set for this decade?

Answer. The procedures described above, for sterilizing lunar probes are considered "effective." They conform to the NASA policy and, as stated above, are considered to comply with both the biological objectives and technological constraints.

If complete decontamination (absolute sterility) were required, the present schedule for lunar missions would be seriously affected, though probably not to the extent of preventing lunar exploration in this decade.

A delay in the landing of a spacecraft on the Moon consistent with the development of technology for the more rigorous sterilization policy for Mars exploration would permit the use of the rigorous sterilization procedures for lunar spacecraft. However, as noted above, these rigorous procedures are not necessary for lunar spacecraft.

Question. 10. How does the contamination-sterilization problem for lunar landings affect future scientific development plans for investigating Mars?

Answer. The program of developing sterilizable, reliable capsules for the Mars 1966 and complete spacecraft for later missions is underway and is expected to be accomplished on time. A substantial background in this was achieved during the Ranger program. Our resolve is to accomplish the necessary developments to assure the launch of spacecraft capsules that are both sterile and technologically reliable for the 1966 Mars opportunity. This is to be the first U.S.-launched spacecraft that will enter and/or land on the surface of Mars.

Staff Memo re Significance of Preventing Contamination of the Earth and Moon in the Lunar Exploration Program

Sterilization of space vehicles designed for manned and unmanned lunar landings and return to Earth is significant because of several interrelated factors: (1) the protection of the Earth from any contamination brought from the Moon, as well as the protection of the original Moon environment for purposes of scientific investigation; (2) the relation of Government to the scientific community in the decisionmaking process; and (3) the impact of science on foreign policy in the United Nations and other international bodies.

The possibility that the Earth might be contaminated by substances brought from the Moon and outer space, as well as the necessity of protecting the Moon from harmful earth-originated organisms, was recognized as a problem during the International Geophysical Year and became the subject of study by the Committee on Contamination of Extra-Terrestrial Exploration (CETEX) which was created by the International Council of Scientific Unions (ICSU). CETEX ceased to function in 1959, largely because of the difficulty of dealing with the problem which next arose specifically in connection with objections to Project West Ford, the orbiting of copper needles by the United States.

In May 1962 the Committee on Space Research (COSPAR), established by ICSU in October 1958, created the Consultative Group on Potentially Harmful Effects of Space Exploration. This committee of six broadly representative scientists, operates in accordance with the following resolution:

"It is expected that this consultative group will act as a focal point in ICSU for consideration of all questions regarding potentially harmful effects of space experiments on scientific activities and observations, and that in this capacity it would (1) examine in a preliminary way all questions relating to possibly harmful effects of proposed space experiments, including but not restricted to questions referred to it by any of the ICSU Unions; (2) determine whether

or not any serious possibility of harmful effects would indeed result from the proposed experiment; (3) in consultation with appropriate Unions, appoint and arrange for convening an ad hoc working group or groups to study any expected effects which are considered to be potentially harmful, such working group or groups to include competent scientists in the appropriate specialized disciplines; (4) receive and consider conclusions or recommendations of these ad hoc working groups in a timely manner; and (5) prepare final recommendations to the COSPAR Executive Council for its further action.

"Positive or negative recommendations or studies considered appropriate by the Council for dissemination would then be made available to all COSPAR adherents, the ICSU Bureau, the appropriate Unions of ICSU, and to appropriate bodies of the United Nations or its specialized agencies.[1]

The United States works with COSPAR through the National Academy of Sciences, and particularly the Space Science Board, which is often consulted by the Government with regard to space policy. All the literature from the beginning of the space age has emphasized that public health and safety require protection against contamination from outer space, and until quite recently there has been no question but that the U.S. scientific and technical programs have been conducted so that space vehicles are sterilized to avoid contamination. It was reported on September 30, 1958, for example, that the United States had agreed to CETEX recommendations to control contamination.[2]

U.S. scientists contributed toward identifying the contamination problem when the report was being written by the United Nations Ad Hoc Committee on the Peaceful Uses of Outer Space. The following paragraph of the report describes the scientific problem and is significant because it became the basis for identifying one of the legal problems arising from space exploration:

"B. PROTECTION OF PUBLIC HEALTH AND SAFETY; SAFEGUARDS AGAINST CONTAMINATION OF OR FROM OUTER SPACE

"29. The Committee took note of the apprehensions that have been expressed that activites in outer space might bring to these regions, by inadvertence, living or other matter from the Earth capable of interfering with orderly scientific research. It was agreed that further study should be encouraged under appropriate auspices to specify the types of risks, the gravity of dangers, and the technical possibility, as well as the cost, of preventive measures. Such a study should also cover safeguards against similar contamination of the Earth as a result of space activities as well as protection against other hazards to health and safety that might be created by the carrying out of programs to explore outer space. These studies could be undertaken with a view to the possible formulation of appropriate international standards."[3]

As recently as December 3, 1962, Senator Albert Gore, appointed U.S. Representative to the General Assembly, made a speech on "United States Policy on Outer Space" containing the following commitment:

"We encourage prior international discussion concerning experimental activities in space which may have undesirable effects, and we are prepared in the future, as in the past, to consult with scientists of other countries as well as U.S. scientists wherever practicable and consistent with our national security.

"The problems of possible harmful effects of space experiments are difficult at best. They must be studied by competent and objective scientific bodies. To this end we welcome the creation of a consultative group for this purpose by the International Committee on Space Research, COSPAR. The United States will continue to conduct its space program, with a high sense of responsibility in this respect, making available to the world scientific community, both before and after the experiments which it conducts, as much scientific data as is possiblbe. We trust that other nations will do the same."[4]

A prominent astronomer, Dr. Carl Sagan, formerly of the University of Chicago and more recently with the University of California, Berkeley, pointed out that—

"* * * any biological contamination would be an 'unparalleled scientific disaster.' It could wipe out important chances to study the early history of the solar

[1] Committee on Space Research, "Report of the Fifth COSPAR Meeting," Washington, D.C., Apr. 20–May 9, 1962, pp. 19, 20, 91.
[2] Sullivan, Walter, "U.S. To Sterilize Lunar Vehicles," New York Times, Sept. 30, 1958, p. 13L.
[3] United Nations Document A/4141, July 14, 1959.
[4] Department of State Bulletin, Jan. 7, 1963, p. 24.

system and the origin of life on Earth, and even to assess the possibilities of life beyond Earth." [6]

In August 1962 when a conference of leading space physicists on lunar exploration was held at Virginia Polytechnic Institute, Dr. Sagan again pointed out the "tragic possibility" that lunar germs might be brought back to contaminate the Earth.

"Mr. Sagan told a lunar exploration conference here that, unless proper safeguards are taken, hardy microorganisms that have survived throughout the ages on the Moon might multiply and spread rapidly in the rich environment of the Earth.

"He compared the results to the violence of the venereal disease epidemics that raged through Europe in the Middle Ages, or to the measles that took a heavy death toll when it was introduced into Polynesia.

"He said that both the Soviet rocket Lunik II and the U.S. Ranger IV carried germs to the Moon when they smashed into its surface." [6]

On April 25, 1963, Dr. Colin S. Pittendrigh, professor of Biology at Princeton University, and a member of the Space Science Board of the National Academy of Sciences, said that sterilization of lunar vehicles was being relaxed in view of the "prestige race." Dr. Pittendrigh was quoted as saying that:

"Big science, including the vast machinery of our space program, plus political considerations have produced an almost irresistible drive to reach the Moon first." [7]

Speaking as an individual rather than consultant to the Space Science Board, Dr. Pittendrigh did not criticize NASA.

"In fact, he approved the decision to relax procedures for sterilization of Ranger vehicles that are to crash on the Moon. One must recognize, he said, the 'political facts of life.'" [8]

Perhaps something of the tone of the atmosphere in which the decisions were made is revealed by the findings of the scientists who worked on the subject of "Space Probe Sterilization" at the summer study group held from June 17 to August 10, 1962, at the State University of Iowa. This "Review of Space Research" was sponsored by the National Academy of Sciences' Space Science Board. The two pertinent findings are as follows:

"Finding: Because of the program schedule imposed on the lunar program by nonscientific considerations, time probably will not permit development and incorporation of certain advanced sterilization concepts. Waivers have been provided for critical components which could not be made sterile internally without serious degradation of their performance. Such waivers should continue to be issued where necessary. In general the lunar sterilization program should continue in force in order to keep contamination of the Moon low and thus to interfere as little as possible with future biological study and only secondarily in order to advance the state of the art of sterilization.

"Finding: At the present state of the art it is not possible to assign a quantitative measure of the degree of degradation in reliabiltiy of a spacecraft that results from sterilization procedures. Opinions differ on this point, but they are only opinions; to a large extent the matter probably will remain a topic for speculation." [9]

Dr. SHEA. If I may go ahead with the items listed under "System Engineering" on page 16, the first one is "General Mission Support." This is——

Mr. TEAGUE. Which page was that?

Dr. SHEA. Page 16, sir.

Mr. HOLMES. Volume II has the overall presentation and then the breakdown for that into several elements is found in volume V.

Mr. FUQUA. Where in volume V, Mr. Holmes?

Dr. SHEA. Page 16, in volume V.

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[6] Schmeck, Harold M., Jr., "Moon's Organisms: Preventing Contamination Poses Problems in Lunar Landings," New York Times, May 1, 1960, p. E9.

[6] "Scientists Sees Peril in Germs From Moon," New York Times, Aug. 18, 1962, p. 5L.

[7] Sullivan, Walter, "Moon 'Race' Held To Ignore Germs," New York Times, Apr. 25, p. 12L.

[8] *Ibid.*

[9] "A Review of Space Research," National Academy of Sciences—National Research Council. Publication 1079, 1962. Ch. 10, p. 5.

Mr. HOLMES. RDO 5–1 in volume II is for the total description. A more detailed breakdown of RDO 5–1 is on page 16 of volume V.

Dr. SHEA. Sir if, I go down through that, the total requirement is $37 million. This is broken down into what we call "General Mission Support." This is basically the Bellcomm operation itself, for $12.7 million. I think we have described how Bellcomm works with us in this activity. In addition, in the systems engineering area—and that's the direct support of Apollo itself—we budgeted another $2 million for additional special studies over and above those that Bellcomm or ourselves would have manpower to do. We have conducted several of these this year. The study by Chance Vought, for example, on the lunar orbit rendezvous mode, was primarily a preliminary design of the LEM itself. We also have a contract with the Rand Corp. for additional studies on checkout systems and how you can actually measure the effectiveness of checkout systems. This type of activity is termed "Special study," in that some particular contractor in the country would have a specialized capability.

I didn't talk much about the advance studies area in my preamble. The advance studies area is essentially our commitment to the future so far as manned space systems are concerned. I think we all recognize that the very heavy commitment we have made to our present programs means that new programs are going to be slow to start. We do feel, however, that we can't ignore the new programs that are coming along.

We know, generally, what they may be, the space station; a possible lunar base; the lunar logistic system, which would be in direct support of Apollo after the initial landings; and the planetary programs. These are all things that are coming down the pike.

What we are doing in this area, with the $11.3 million indicated, is to study these missions in detail so that when the Nation decides to make a commitment to new space programs we will have available a much sounder set of information, including how to accomplish that program, what mode to go with, what the general system specifications are, what the approximate costs will be, and what the schedule will be, than we've been able to develop in the past. As you know, requirements have been thrust upon us so quickly in the past that advanced planning was not possible.

Mr. HOLMES. Let me add a few words here. There is, in my opinion, nothing more important than doing effective advanced planning if we expect to gain preeminence in space and to go deeper into space. Indeed, if our foresight had been as clear as our hindsight, we would have saved a great deal of time and money, if we had done preliminary advanced studies on the systems for Apollo 2 years before we actually initiated them.

Mr. RIEHLMAN. Will these be done in-house or be contracted with a company such as Bellcomm?

Dr. SHEA. They will be done in two ways: A small part would be spent with Bellcomm. Most of the money, however, would be spent, either directly from our office or through the centers, with contractors doing what are conventional advanced study programs.

We are trying to provide a much tighter control of the advanced study programs than I think has been the case in the past so that—for instance, in terms of the planetary mission which we are not going to

get around to deciding on for perhaps 4 or 5 years—year by year we block out additional areas of study.

The first year is primarily trajectory work to get rough estimates of trajectory and to determine what the radiation effects are. The following year we would take up the problems that showed up in the previous year's study, and analyze them in more detail. In effect, over the course of 4 or 5 years, we would do the analog of the studies we had to do following the decision to go to the Moon, so far as Apollo was concerned. We must make the mode decisions before we go—before we commit ourselves to the program.

Mr. RIEHLMAN. You do not have capability in-house to do this job?

You have listed here $11,300,000, and you must have some idea who the others are going to be that will participate.

Are portions going to be given to Bellcomm?

Dr. SHEA. No, we don't actually know at this time. We have our people block out the areas we want investigated. For example, we want trajectory studies run of missions between the Earth and Mars. For the time period 1970 to 1980, we can pretty well define what we want. Then, we would normally conduct a competitive evaluation; industry is made aware of the proposal.

Mr. HOLMES. I think that is Mr. Riehlman's point.

We do go out for the request of quotations. We don't know the extent it will be, Mr. Chairman.

Mr. RIEHLMAN. You have to have something to base the cost on.

Mr. DADDARIO. Dr. Shea, would we have saved this time and money on Apollo by having a stronger advanced study program 2 or 3 years ago? Stretch that analogy out a little bit and tell us if there are programs underway that ought to be deferred pending a closer examination by your advanced studies division?

Mr. HOLMES. No; I don't think there are, Mr. Daddario. My remarks were addressed to the fact that, as you know, a year ago we came before your committee giving you the best information we had, which was not really very definitive, and said, "We are going to the Moon. We have let many contracts, but we don't know which method of flight we will use to go." We assumed that we were going by the Earth orbital rendezvous or direct-flight mode. I am certain that the cost of such studies 2 years earlier would have been a very small percentage of what one spends carrying out such a program. If we had been able to have these advanced studies, we would be in a much better position to say what we wanted and there would have been less reprograming of funds. There would have been more timely contracting and, in general, greater efficiency.

However, I do think that with what we had in the way of information the space agency aggressively pursued letting contracts it knew it could adapt or apply to any one of these mission modes. Certainly, that's not as good as if one had a whole plan to start with before initiating action.

Mr. DADDARIO. You had had changes in programs including the Nova, the last item on the list. Should that properly fall under advance studies? Especially since we know the M–1 engine which we talked about the other day has been changed considerably in design and capability?

Mr. HOLMES. It's somewhat——

Mr. DADDARIO. As a result of the information you have, where does this belong?

Should Nova be separate and apart or should it be included under "future activity" to be studied by the advanced studies division?

Mr. HOLMES. Nova, as used here, is a little misleading in that it does not any longer define this large vehicle which we were talking about last year when we discussed the direct-flight mode for Apollo. In this instance, Nova defines the next generation of vehicles for which we are now doing work as you described with the M-1 engine.

I think Nova, since it represents the next generation of launch vehicles, does belong in Dr. Shea's organization. I think, further, it should be noted that much of the support for Dr. Shea's organization comes from our groups at the Marshall Space Flight Center at Huntsville, and the Manned Spacecraft Center at Houston.

The whole manned spaced flight operation participates, more often than not. In fact, in the large majority of cases, such as the Nova, the work is done at these centers. I think it does belong here, but I think it describes—and Dr. Shea will comment too—the next generation vehicle which we have not defined.

Mr. DADDARIO. Nova, as used here, does not mean what we understood "Nova" to mean a year ago?

Mr. HOLMES. Yes, sir; that is correct.

Dr. SHEA. The term "Nova" is really a historic term as we understand it now, a term representing the studies leading to the definition of the next generation of launch vehicles. It's not the Nova that we talked about last year.

Mr. DADDARIO. The word "historic" is a mild term.

Dr. SHEA. I beg your pardon?

Mr. DADDARIO. The word "historic" is a mild term.

Dr. SHEA. There is a wonderful definition that comes from science about Nova. I have forgotten exactly how it goes, but I think it says, "Nova is often the brightest object in the sky for a short period of time, and then it wanes."

Mr. FULTON of Pennsylvania. This committee helped put that particular Nova program into history. It went into history around this table.

Dr. SHEA. Yes, sir.

Mr. TEAGUE. Mr. Gurney?

Mr. GURNEY. How do you break down this $11,300,000? How do you propose to spend it?

Dr. SHEA. We have it broken down as follows:

The orbital systems studies, essentially those studies relative to space stations and other operations in Earth orbit, but primarily space stations, and the uses and design of space stations, will take about $4 million.

We are studying lunar bases to see what's involved in being able to keep men on the Moon indefinitely. The studies will involve lunar transportation systems, the design of the base itself, and the use of indigenous lunar materials; this effort totals about $3 million.

We plan to commit $2 million to planetary missions next year; and, for what we call general program support—really additional studies over and above these we have in mind at the present time—about $2.3 million.

All of this totals $11.3 million.

Mr. GURNEY. Of that, how much do you plan to spend on personnel?

Dr. SHEA. In-house?

Mr. GURNEY. In-house.

Dr. SHEA. I'd say about 70 percent of this will be contracted by the centers to industry; the rest of it will be contracted directly from the Office of Manned Space Flight to industry.

All the money that is listed here, I think you recognize, is money outside of our own salaries and internal expenses which are handled differently.

Mr. GURNEY. How do you arrive at the breakdown of $4 million for space stations, and $3 million for a Moon base?

Some people might think that it may be more important to study and spend more money for space stations and proceed more quickly to determining what ingredients go into a space station.

Dr. SHEA. That is in the sense of the level of effort here, Mr. Gurney. It does represent the urgency of the program as well as the degree of difficulty involved; the space station money listed here is sufficient so that by the end of fiscal year 1964 we will have available a preliminary design of an Earth-orbiting laboratory or station capable of sustaining four to six men in orbit for prolonged periods of time, and which could be launched with a Saturn I or Saturn I-B vehicle.

Mr. GURNEY. What you are saying is that the funds which are earmarked are about as ample as you need to conduct these studies?

Dr. SHEA. That's right. The target of study of the space station studies is, by the end of fiscal year 1964, to have a well-defined program available. I realize there's no commitment to the ongoing program as yet.

Mr. HOLMES. I'd like to say when we put into the record figures for advanced studies, I would not want us to review this area next year and have it considered reprograming because that's impossible in industry and most impossible in government. That's one reason why we haven't broken it down further.

Dr. SHEA. These are first-cut figures. The study is still in the process of being redefined.

Mr. HOLMES. May I comment on that? I think one way one can look at it, just as you are getting at it, Mr. Gurney, is on a level-of-effort basis. It is difficult to say what the continuous level of effort will be. It is difficult in this level to say whether or not it's going to be $3 million or $3.2 million.

Dr. SHEA. We have to have some contingency to pursue good ideas that come up, either from industry or from ourselves. We are very much involved in an evolving technology. The difference between a "brute force" systems approach and a sophisticated approach may be the ideas generated in the next several years.

Mr. TEAGUE. Mr. Fuqua?

Mr. FUQUA. Mr. Shea, the $7.9 million program you have in 1963, how are you spending this money? In what type of research are you spending it?

Dr. SHEA. Essentially in the same area.

Mr. FUQUA. This is what I want to know. Is it in the same area you propose to spend the $11.3 million?

Is it a continuation of that type of work?

Dr. SHEA. Yes, sir. That's right.

Mr. FUQUA. How soon do you plan to have the $11.3 million under contract?

Dr. SHEA. The $11.3 million will get out under contract during the end of fiscal year 1964. Some of the studies will not be defined until the fiscal year 1963 studies are completed, and I would say there would be a relatively uniform distribution for contracting of those funds during the entire fiscal year 1964 period.

Mr. FUQUA. In other words, you are going to be spending about $18 million then in this field.

Dr. SHEA. It is a continuing commitment. In 1965 the level would be probably again about $11.3 million. What we are doing here is continuing to look ahead. Certain things are not well defined relative to the things we are currently looking at.

Mr. FUQUA. Are you using all the $7.9 million in fiscal year 1963?

Dr. SHEA. Yes, sir.

Mr. FULTON of Pennsylvania. How much have you obligated of the $7.9 million in fiscal year 1963?

Dr. SHEA. Let me refer to my advanced studies book.

Mr. HOLMES. As of the 20th of March in total systems engineering we had obligated $11.8 million.

Mr. FULTON of Pennsylvania. I didn't hear you.

Mr. HOLMES. We had obligated $11.8 million of the $26.5 million as of the 20th of March. We don't have a final breakdown of that here. I could update that figure for you.

Mr. FULTON of Pennsylvania. I notice for fiscal year 1963 "Nova study," $3,005,000. What, to date, has been committed or obligated on that money?

Mr. HOLMES. The only figures we have here with us, Mr. Fulton—and I could get you the other for the record—is of the total. We have obligated some $11.8 million and that's out of $26.5 million authorized in fiscal year 1963.

Mr. FULTON of Pennsylvania. When you look at an advanced studies, generally, and advance Nova study, they are both in the realm of the quite distant future.

Dr. SHEA. Yes, sir.

Mr. FULTON of Pennsylvania. Secondly, they are in the early stage of idea.

Dr. SHEA. They are in the early stages.

Mr. FULTON of Pennsylvania. Likewise, they are not in the development of hardware or even advanced technology, are they?

Dr. SHEA. They are, in effect, in the area of advanced technology because what we do with these studies is to examine things that are becoming available in advanced technology to determine how applicable they are to the missions of interest, or to the particular vehicle design we are talking about. Really, this area we are discussing is the one—the means by which things become available in advanced technology that are introduced in our program.

Mr. FULTON of Pennsylvania. The $3,005,000 has no part in it for the development of the M–1 engine?

Dr. SHEA. No, sir; it does not.

Mr. FULTON of Pennsylvania. The proposed $5 million for fiscal

year 1964 has no part in it for the development of the M–1 engine?

Dr. SHEA. No, sir; not the hardware.

Mr. FULTON of Pennsylvania. What is the study on the Nova? Is it simply concept? Is it systems engineering, or does it get much more in detail?

Dr. SHEA. It goes through what I would call preliminary design in certain cases. In the Nova area, for the next fiscal year, we'll be studying not just the application, for instance, of the M–1 or F–1 engines as advanced chemical propulsion systems. We'll also be looking at the application of the solid booster, a development program which has started. We'd examine where we would use the solid vehicle, how you'd size the vehicle, what the facilities would be, what the transportation problem would be, what the payload capabilities would be, and, in general, what missions you could perform with this particular vehicle. In addition, we would be looking at the extension of what I'd call our present approach versus the problems of bringing in a reusable booster, the problems of nuclear propulsion and where it would apply, how big the gains could be realized from these types of things.

Mr. FULTON of Pennsylvania. You could go ahead with development of the M–1 engine without the developments for 1964 for Nova because that has no part on it.

Dr. SHEA. That is right.

Mr. FULTON of Pennsylvania. If you were cut the $3,005,000 for fiscal year 1964 would it hold you back on the development of the second-stage booster for Nova?

Mr. HOLMES. To my mind if you aren't going to spend this kind of money in advanced technology systems, you might as well not do any development on the engine.

Mr. FULTON of Pennsylvania. If we did this, how much of the $45 million should be cut then for 1964?

Mr. HOLMES. Let me say it this way. We had Nova funds for 1963. It is my opinion, in trying to run this program for the country and for you, that it was absolutely essential to form a systems engineering group and fund it this way. Those dollars came out of other parts of the program, very badly needed. Yet we haven't spent a single dollar in the manned space program that has been more important than the manned space flight systems engineering effort. If you cut money like this we would be forced to cut out the program or not do the job for you.

Mr. FULTON of Pennsylvania. We are not cutting money, for example, on the advanced study of $7,900,000; or $11,300,000 for 1964——

Mr. HOLMES. I see.

Mr. FULTON of Pennsylvania. Rather on the concept of the Nova.

When you were up here last year, there was every urgency for the Nova and you felt you couldn't get along without it. You needed the money. You must have it, and it was absolutely necessary.

This committee cut the funds and my feeling is that if we are going to do the study on the components that's fine, but when we come to design and advanced technology, it is a case where we must look at Nova closely this year.

Dr. SHEA. Mr. Fulton, may I answer here? You recall when I broke down the advanced studies area, I did not include any vehicle

studies. The reason for that is because the vehicle studies are essentially lumped under the term "Nova." I think the terminology in the book is probably a bit unfortunate, but we cannot guide——

Mr. FULTON of Pennsylvania. You mean the vehicle studies on Nova?

Dr. SHEA. When we say Nova study here, what we mean are those studies which will help us define what the next generation of launch vehicles will be.

It is not the Nova launch vehicle in the conventional sense not as we understood Nova a year ago. If we don't accomplish studies such as the Nova studies, we don't know how to best direct the advanced technology area.

Mr. FULTON of Pennsylvania. Page RDO 2-1 you have the M-1 engine set out specifically for $45 million.

Dr. SHEA. That's right. The M-1 engine is one of the components that may be used in Nova. This is a point we went over last week.

Mr. FULTON of Pennsylvania. That's all.

Mr. HOLMES. I do regret that this entry says "Nova." I think Mr. Fulton's point is well taken. I think it is misleading. It does say "advanced Nova studies." We all know how tardy we have been in this country in developing advanced boosters and thrusts. If it stated that fact, it would be a lot clearer.

Mr. DADDARIO. This problem doesn't include the M-1 does it?

Mr. HOLMES. No, it does not.

Mr. DADDARIO. So it's even more misleading.

Mr. TEAGUE. Now these people have traveled thousands of miles to be at this hearing this morning. We can go back to this point at any time. We should have stopped 15 minutes ago.

I understand, Mr. Holmes, that you have a statement involving Bellcomm and General Electric. Are you familiar with the letter I have from Mr. Paul Dembling?

Mr. HOLMES. We prepared that letter in my office. I didn't have any prepared statement concerning them, other than that which I included in my introductory remarks.

Mr. TEAGUE. Then I believe you should read this letter into the record.

Mr. HOLMES. Yes, Mr. Chairman.

Mr. TEAGUE. I understand that the representatives of General Electric and the representatives of Bellcomm are here. If any wish to ask questions, we will accommodate you.

Mr. HOLMES. Mr. Chairman, may I submit this letter which was addressed to the Subcommittee on Manned Space Flight April 26 and signed by Mr. Paul Dembling, Director of the Office of Legislative Affairs for NASA?

Mr. TEAGUE. I think you should read it into the record.

Dr. Shea, you say that the Aerospace Corp. works for the Air Force. We went to California and listened to Aerospace Corp. and we come away with the impression that the Air Force has given them the same problem which NASA has given to Bellcomm.

That is the point we are interested in since both NASA and the Air Force are interested in Gemini. Bellcomm is solving problems for NASA, and Aerospace is solving problems for the Air Force. They testified here and intimated that they didn't even know about it.

Dr. SHEA. Yes, sir.

Mr. TEAGUE. I think you ought to read this letter.

Dr. SHEA. Do you want it read aloud?

Mr. TEAGUE. Nobody has seen it except myself. You better read it aloud.

Dr. SHEA. Dear Mr. Chairman, this is in response to your recent request of Mr. D. Brainerd Holmes, Director, Office of Manned Space Flight, for information concerning a description of the work Bellcomm, Inc., the General Electric Co., and the Aerospace Corp. are doing in providing technical assistance for the manned space flight program in the fields or systems engineering and checkout, reliability assessment, and integration.

In responding to your request, it might be appropriate to review briefly the Bellcomm an General Electric efforts in support of Project Apollo. The Aerospace Corp., a contractor of the Air Force, is different in concept than either Bellcomm or General Electric. In addition to providing systems support, as is the case of Bellcomm and General Electric, Aerospace is providing actual technical direction to the space program of the Air Force. Inasmuch as Aerospace is an Air Force contractor, you may wish to refer any questions regarding the contract to the Department of the Air Force.

The systems engineering function includes the determination of system specifications and conceptual designs of major elements of the program; the review of ongoing programs to identify and evaluate possible alternative courses of actions; study of the impact of funding, schedule, and technical changes on the overall program; development of the overall reliability and system test plans, and preparation of long-range plans; implementation of long-range studies, and participation in project development plans for future manned space flight projects.

Typical of this type of activity was the selection of the mode of flight for the first manned lunar landing, in which the Office of Systems occupied a central role. As the subcommittee knows, three possible ways of implementing the program were studied in great detail—direct ascent, Earth orbit rendezvous, and lunar orbit rendezvous.

The Office of Systems reviewed the data available and——

I would suggest that we skip that for a minute, because that's really what we covered a minute ago.

Mr. HOLMES. Perhaps you ought to read the whole letter.

Dr. SHEA. The Office of Systems reviewed the data available and defined the additional studies required to provide mission data. These studies were conducted both at NASA centers and by contractors under the direction of the Office of Systems. By June 1962, the results of all the previous study activity had been analyzed against the criteria of mission success, safety, schedule, cost, complexity, and growth potential. The analysis of more than a million man-hours of technical work showed that lunar orbit rendezvous was the most desirable mode of flight.

The Office of Systems now has about half of its planned total complement of 125 members of the technical staff on board. In February 1962, NASA requested the American Telephone & Telegraph Co. to assist in this systems engineering effort. NASA asked A.T. & T. to

provide an organization of experienced men able to employ the most advanced analytical procedures necessary to develop the factual bases needed by responsible NASA officials to make the wide range of decisions required for the successful execution of the manned space flight program.

A.T. & T. responded to this request by forming Bellcomm, Inc., in March 1962.

As of this date, Bellcomm consists of 97 technical people and a supporting staff of 64. In terms of educational background of the technical staff, 24 percent have a Ph. D. degree, 46 percent have an M.S. degree, and 29 percent have a B.S. degree.

That is, parenthetically, a very high percentage of advanced degrees.

NASA anticipates that by the end of this year the Bellcomm organization will comprise about 250 people—two-thirds technical personnel and the balance administrative staffing level.

For the 18-month period ending September 30, 1963, the estimated amount of the NASA contract with Bellcomm is approximately $8.5 million. Bellcomm provides skilled and experienced assistance to enable NASA systems engineering to exercise its responsibility and authority in an effective manner.

It is important to note that Bellcomm, Inc., assists and supports a technical office within the Government rather than an administrative office. This important distinction makes it possible for the Government to carry out properly its total technical responsibility, utilizing a contractor for assistance, but maintaining the final technical, engineering, and procurement judgments within the Government itself, to be made by Government employees.

The capital stock of Bellcomm, Inc., which at present is $700,000, is owned jointly in equal amounts by A.T. & T. and the Western Electric Co.

The board of directors is comprised of a chairman, Mr. R. R. Hough, vice president, engineering, A.T. & T. and eight others—two from A.T. & T., two from the Western Electric Co., two from the Bell Telephone Laboratories, and two from Bellcomm, Inc. It was intended at the outset that the board be a working board in both a technical and business sense. For this reason it contains highly qualified technical people and people with extensive business experience.

The president of Bellcomm, John A. Hornbeck, and the heads of its two technical divisions came from Bell Telephone Laboratories.

Its vice president and general manager came from the long lines department of A.T. & T. The other officers are a comptroller and a secretary-treasurer, the former from A.T. & T. and the latter from the Western Electric Co.

In February 1962, NASA selected the General Electric Co. to play a supporting role in Project Apollo—to concentrate on checkout, reliability assessment, and integration.

It is appropriate to indicate some of the reasons why such support is required. To carry out a manned lunar landing mission, it is necessary to verify the readiness of all of the needed system elements to properly perform. In order to develop high confidence in NASA's readiness to take the next step in a mission, each piece, part, unit, subsystem, stage, spacecraft module, space vehicle, and ground facility must be checked out most carefully.

Within the framework of organization for the Apollo project, no single contractor could do the entire job of developing checkout equipment and procedures and supplying the equipment for a uniform programwide approach. Therefore, NASA asked General Electric Co. to begin this work under Letter Contract NASw-410.

The knowledge gained in the uniform design of checkout equipment and procedures is the same information required to insure detailed integration of major systems, such as the electronic, electrical, and mechanical linkages. The checkout process of necessity delves into almost every system in great detail. Consequently, it was decided to combine the integration assignment with that of checkout.

Another related task is reliability assessment. The success of Apollo will require detailed knowledge concerning the present and projected reliability of the critical system components. This knowledge must be continuously acquired throughout the design, manufacturing, test and operational phases of the program to enable NASA to make an informed judgment about system reliability and safety levels.

The first phase of the work consisted of a series of studies aimed at more specifically analyzing and defining the scope and content of the work. The study phase was completed last fall. The implementation phase of work was begun immediately and continues. Negotiations on a definitive contract have proceeded, and NASA is confident that agreement on all of the provisions of this definitive contract will be reached in the near future.

In the implementation phase, General Electric's work will be in two broad categories. There will be continuing engineering support, which will be required by the Office of Manned Space Flight and the NASA centers in their respective areas of responsibility for integration, reliability assessment, and checkout. Secondly, General Electric will furnish specially designed checkout hardware, including that which will provide for the integrated launch control and checkout system.

General Electric engineering support is now building up as needed at the Manned Spacecraft Center, the George C. Marshall Space Flight Center, and the Launch Operations Center. The organizations at each center call upon the Apollo Support Department at Daytona Beach, Fla., where a staff has been established to support across-the-board tasks. Common use of the Daytona Beach services assures a common approach to checkout, reliability assessment, and integration.

As the program progresses, General Electric will gradually increase the proportionate scope of the Daytona Beach effort as the engineering center of gravity shifts from concept and design to the production of checkout equipment. As the reliability and quality data begin to build up, the General Electric central data effort will also grow. Integration support effort by General Electric will continue at the NASA centers and at the General Electric headquarters to provide assistance to NASA throughout the life of the program.

It is important to note the difference between systems engineering, an activity that requires a relatively small organization of very highly qualified individuals, and checkout, reliability assessment, and integration, which, because of the massive amount of technical detail which must be handled, require large manpower efforts.

In systems engineering, NASA has developed the system concept and is now writing the overall specifications for Project Apollo. A

portion of these specifications will include the general requirements on the checkout system, definition of the requirements for reliability assessment, and technical monitoring of the program. Bellcomm supports NASA in this work.

NASA has asked General Electric to provide support in areas in which the details require many people. General Electric is implementing the checkout system, beginning hardware production, and undertaking comprehensive work in integration and related data gathering and processing, which will help to insure that the overall systems engineering requirements are being met in detail.

Annex A and annex B attached are copies of the statements of work contained in the Bellcomm and General Electric contracts.

We believe that the above supplements and summarizes the previous testimony given to your subcommittee on these subjects by Mr. Holmes on March 6, 7, and April 9, 1963, by Dr. John A. Hornbeck, president of Bellcomm, Inc., and Mr. Richard L. Shetler, general manager of the Command Systems Division of General Electric and acting general manager of the General Electric Apollo Support Department, on March 20, 1963, and by Dr. Robert C. Seamans, Jr., Associate Administrator of NASA, on April 9, 1963.

It is our understanding that the transcript of the briefing given by members of the Apollo Support Department, General Electric Co. Daytona Beach, Fla., on March 29, 1963, has been transmitted to you and will be made a part of the record of your subcommittee hearings.

Mr. TEAGUE. Without objection, the transcript will be incorporated in the record. (The transcript referred to is shown in app. C.)

Likewise the letter from Mr. Dembling with enclosures will also be incorporated in the record. (The letter with enclosures is shown in app. D.)

Mr. TEAGUE. It is my understanding that the people from General Electric have come a considerable distance. I would like to entertain questions concerning General Electric. Do you have any questions, Mr. Daddario?

Mr. DADDARIO. Can you tell us, Dr. Shea, what the overall amount of money is likely to be that General Electric will receive during the course of this entire contract?

Dr. SHEA. It is likely to be about $635 million for the entire contract, Mr. Daddario.

Mr. DADDARIO. $635 million.

Dr. SHEA. That's the current round estimate.

Mr. DADDARIO. Does that include just General Electric's participation in this part of the program or does it include other activities that GE is involved in? For example, GE does other work for NASA, does it not, at the Mississippi test facility, Mr. Holmes?

Mr. HOLMES. This estimate does not include General Electric participation, either in elements of the program or at Mississippi test facility. It is a rounded estimate over the period through this decade what the reliability assessment, integration, and checkout might amount to.

Mr. DADDARIO. How much is the contract that GE has at Mississippi? What is that likely to amount to over the course of the program as you conceive it at the moment?

Mr HOLMES. General Electric does not have a contract there. We are negotiating with GE for a contract. It is a support services contract both in the technical and administrative support areas. In its present throught and scope, it includes very little, if any, equipment. The dollar values are considerably less than this. I can't really tell you what the dollar values are until we have both defined the contract further and had General Electric Co. estimates on it. Indeed, that is the stage it is in right now.

Mr. DADDARIO. Even though it is still being negotiated, it will, most likely, be consummated and once consummated will extend itself over the course of many years and will involve many millions of dollars in addition to General Electric's participation in this program?

Mr. HOLMES. That is true. It is our present plan to establish a 5-year contract in which we plan to operate, but negotiate yearly fee and work scope for the following years and, of course, it would be subject to normal termination if that should be to the benefit of the Government.

Mr. DADDARIO. Do you have the same type of service contract with other independent contractors at all the other NASA centers?

Mr. HOLMES. Yes, in doing services. In this case, General Electric would be the contractor to run the Mississippi test facility for the Government in a manner analogous to the way Pan-American is servicing the Air Force at Cape Canaveral.

Mr. DADDARIO. Yet, despite the fact General Electric has a contract of this magnitude in systems engineering and is going to be in charge for a period of probably not less than 5 years, and most likely many more years at Mississippi, it still negotiates with NASA as an independent contract or by offering its services for bid in many other ways, does it not?

Mr. HOLMES. Yes, it does.

Mr. DADDARIO. How do you keep General Electric apart? How do you prevent GE from supervising its own bid, and how do you prevent it from gaining advanced knowledge which will be beneficial to it when it does put forward bids or when it negotiates with NASA?

Mr. HOLMES. Well, we have given that matter a great deal of thought.

I would like to first make it completely clear, we don't have a contract with General Electric at the MTF. In the discussion we are talking about, I don't think that matters.

Mr. DADDARIO. We can assume you will have.

Mr. HOLMES. We can assume we will have. We have a clause in this contract we are negotiating for integration, checkout, and reliability that would make General Electric ineligible to bid on the Apollo system either as prime contractor for the hardware for Apollo—defined as the manned lunar mission as presently conceived, or for major Apollo subsystems. Exceptions to this could be made either by the Administrator or the Deputy Administrator for the interests of the Government.

Examples of this have been General Electric Co.'s declining to bid on the lunar excursion module where indeed they had thought they were going to make arrangements for a joint bid with the Aerospace Co. They declined because it would not have been consistent with their working under these contracts under the arrangements or agreements we had.

Mr. DADDARIO. Did they decline voluntarily or was it suggested?

Mr. HOLMES. There was discussion, but they declined voluntarily.

Mr. DADDARIO. After the discussion?

Mr. HOLMES. After the discussion. Whether they would have before the discussion, I can't say. If we look at another example—I want to be fair with the General Electric Co.—I feel that in the last year, if anything, our strict adherence to this rule has been to the detriment of that company, certainly not to its advantage. Let me give you a good example.

They certainly would under a normal situation be a qualified company to bid on the Mission Control Center in Houston.

However, we felt this was borderline under the policy; therefore, we did not say, "You cannot bid." We indicated, however, we felt there would be more difficulties for us in managing that contract with General Electric than there would be with someone who didn't have this other job. As it turned out, GE just declined to bid on its own initiative.

I do believe that if one man can examine how this has operated to avoid giving the General Electric unfair advantage, we will observe that it has operated very well from that standpoint and, perhaps, gone just a little bit on the other side of the line.

Mr. DADDARIO. Mr. Holmes, with such a complicated arrangement, do you think the people in charge of NASA's centers know what General Electric's function is at each of those centers?

Mr. HOLMES. Yes, sir; I think they do.

The integration of this very large program is a complicated arrangement in many ways. We have discussed this particular contract and arrangements at numerous times in the Manned Space Flight Management Council, where as you know, we have as members the heads of each of these centers most intimately involved in the program. Those discussions, supplemented by NASA's circular from the procurement offices to all centers establishing this, have made communications such that I think it is clearly understood by all our centers how this is to operate.

Mr. DADDARIO. When this committee visited the North American Aviation plant, this confusion was quite obvious and it's unfortunate we didn't make arrangements to have that meeting recorded. As I recall, it went something like this: North American had a list of subcontractors for the Apollo program and they had listed GE as one of the subcontractors. Some of the NASA people there gave conflicting testimony as to whether General Electric was a subcontractor or part of the management integrating the whole program or both. When the meeting was over, no one had been able to definitely ascertain in what particular category General Electric was involved. To this day, I don't think the committee has been able to get to that point to decide just what part General Electric played. I am sure that there is no intention to have General Electric's work conflict in any of these programs, but it was obvious at that time that there was confusion and I think it is important for GE and NASA to avoid as quickly as possible the problems which may arise because of this conflict.

Mr. HOLMES. I certainly agree with you.

Mr. DADDARIO. Can you offer any suggestion as to how this might be done?

Mr. HOLMES. I really think that it is today clear in the centers. I regret that there weren't people at that particular meeting who were informed and, certainly they should have been informed, if they were responsible NASA officials dealing with North American, as to the role General Electric Co. is playing. I think we have gone a long way in trying to establish definitively with the centers and in turn with the other contractors with whom we are doing business, just what GE's role in assisting us in integration checkout and reliability is. It is true that over the past months there have been questions and so forth.

However, I feel that these questions have been fairly well answered now, and in the last quarter of the year very much fewer questions have been directed to my office from industry and other people concerned, about just what this arrangement is—how we do business with General Electric—and so forth.

Mr. DADDARIO. Perhaps we could help clarify it here, Mr. Holmes.

A chart that North American showed us included General Electric as a subcontractor as well as, as I recall, Pratt and Whitney, Grumman, and couple of others. Since the chart did show this, can you tell us what part General Electric plays in the Apollo program as related to North American? Should it be listed as a subcontractor to North American or should it be listed somewhere else and, if so, where? Furthermore, what are its functions in the Apollo program, specifically, those in reference to North American?

Mr. HOLMES. General Electric Co. does not have any subsystem that I know of and they are not a subcontractor of North American that I know of, nor is Grumman for that matter. But they may be, and are allowed to be, a vendor of supplies to North American. If they are shown as a subcontractor, Mr. Daddario, I can't understand it, since the exclusion clause prohibits this situation. I am sure that GE is not a subcontractor to North American. I think I'd have to know in what area they are shown in order to discuss this intelligently.

Their relationship now, addressing myself to the other broader part of your question—their relationship to North American as to all of our contractors in the Apollo program is that of being responsible for overall integration; that is, the interfaces; overall checkout of the equipment made by North American or the other contractors; or reliability assessments of these pieces, including what North American makes. I don't believe they are a subcontractor for North American. I believe you were misinformed at that meeting.

Mr. DADDARIO. We were definitely misinformed then. I think we could supply the names of your people who were there if you would like.

Mr. HOLMES. I would enjoy having them.

Mr. DADDARIO. You could get in touch with North American and ask them for a list of the charts they showed us that day.

Mr. HOLMES. We will do that.

Mr. DADDARIO. And that chart, I am sure, will bear out what I said about General Electric being listed as a subcontractor.

Mr. HOLMES. I am sure that is the case and, with your permission, I would like to get that chart and discuss it further with you, and perhaps I can talk in a more intelligent manner about it.

Mr. DADDARIO. I wish you would.

You have something more to say, Dr. Shea?

Dr. SHEA. No.

Mr. DADDARIO. Yes, Mr. Riehlman?

Mr. RIEHLMAN. To get a specific illustration, Mr. Holmes, why don't you tell the committee what your experience has been with General Electric, say, at Cape Canaveral or Marshall? How has their work been integrated with NASA in those two areas?

Mr. HOLMES. I'd be glad to, Mr. Riehlman.

Mr. Riehlman, the question has arisen whether this work has taken place in an orderly manner and whether or not NASA employees associated themselves with General Electric's activities and responsibilities.

I think it would be well for the committee to know, in those two areas, what the experience has been.

Mr. FULTON of Pennsylvania. Could I add a pleasant note at this point? On my experience with Daytona Beach, I thought General Electric was making a good start on the contract.

Mr. RIEHLMAN. Let's have what Mr. Holmes has to say.

Mr. HOLMES. I think there has been difficulty as in any new organization in the very early days, such as in the period of establishing General Electric Co.'s relationship with our centers. They would say that. I certainly think it's true.

I think it is true General Electric Co.'s efforts integrated with our efforts through the centers makes for a very valuable working relationship. I think that GE's Daytona establishment is going. I think establishment of the procedures by which we managed that helped.

For the operation at Huntsville, for example, we have a large number of General Electric Co. engineers working intimately with the Marshall staff in the development of the checkout equipment; in this case for the launch vehicles. They will carry out final engineering design and a good part of the fabrication at the Daytona plant. There are similar activities in different areas occurring with the Manned Spacecraft Center representatives. Their representatives for this service also handle fabrication at the cape with the Launch Operations Center representatives. I believe that it is proceeding in an orderly fashion and is going to make a major contribution to the efficient accomplishment of this job.

Mr. RIEHLMAN. I think it was important to have on the record what has been accomplished to the present time and how successful it has been.

Mr. DADDARIO. Mr. Roudebush.

Mr. ROUDEBUSH. I would like to continue this line of questioning.

You used the words, Mr. Holmes, "vendors of supplies" to us. Could you tell me, briefly, the nature of these supplies? Would they be just General Electric equipment and so forth?

Mr. HOLMES. I was distinguishing between a subcontractor who we think has a subcontract and somebody who sells components. I could get you a list of that; I couldn't tell you off the top of my head. It would be light bulbs to circuitry, I'm sure, and probably to more major components. I would think, primarily, there would be off-the-shelf-type items.

Mr. ROUDEBUSH. In other words, it would not be any item that would be unique? Many companies would make off-the-shelf items?

Mr. HOLMES. I would think that would be true in the majority of cases. I think in some cases GE would be in a vendor class for these off-the-shelf items, but I'd have to get you the specifics.

Mr. ROUDEBUSH. Would these supplies you mentioned, the off-the-shelf items, be purchased on open bid or advertised bid?

Mr. HOLMES. In general, competitively, yes. In specific cases, I am sure there are exceptions to that.

Mr. ROUDEBUSH. I see. Mr. Chairman, it might be interesting to note the type of equipment that North American is buying from General Electric in the way of supplies; just in a general sense, Mr. Holmes. I don't want to know the number of 100-watt bulbs you purchased, but I think it would be helpful for the committee to know some of the general items in this area.

Mr. HOLMES. Yes, for the record, I will try to get that. Generally they are bought competitively. It would be a normal practice but, when one gets to small parts, you don't necessarily have competitive bids unless it's large numbers. It depends on the operation.

(The information requested is as follows:)

North American Aviation will utilize, as Government-furnished equipment, automatic checkout equipment built by General Electric for in-plant spacecraft checkout. Direct purchases by North American Aviation from General Electric for the Apollo project, other than incidental items such as light bulbs, switches, and similar items, have been the following:

Television and relay equipment	$21,055
Test services	10,000
Engineering services	16,430
Experimental heat shield material	30,772

Mr. ROUDEBUSH. That's all I have.

Mr. DADDARIO. There is another question that comes to mind. I wonder if you might reconcile this kind of situation. General Electric finds itself in this situation with you. NASA has a company, say for example Avco, which worked on reentry problems. Is General Electric in a position where Avco would have to turn over its knowledge and know-how to General Electric so that General Electric could perform its integration and checkout function properly?

If it does, how do you protect Avco's propriety rights and knowledge in this area from sometime in the future when General Electric could be involved in a contract where it could usurp some of Avco's knowledge and divert it to its own use?

Mr. HOLMES. It is my opinion that the General Electric Co. in a large percentage, over 90 percent of the activities in which it is involved, would not gain any additional knowledge which would be to their advantage and to the detriment of the contractor. There is very little proprietary information in the program. Companies claim proprietary but to my mind if all the work done has been used by the Government and it is paid for by the Government there's nothing proprietary and we'll use it as we see fit. I've been on the other side of the fence and claimed proprietary and I've been overruled.

Mr. DADDARIO. Let's not go into that; there's a lot of disagreement on that point.

Mr. HOLMES. There are some cases in which companies have done development on their own funds and it is theirs. We have made this clear, that they should bring this to the attention of the responsible Government operation. In this case it would be one of our

Centers or my office. When I say: "my office"—probably to Dr. Shea—and not submit the information to General Electric Co. We will make a determination. We haven't had a single case of this to date.

I do not think that a real problem exists. I believe that our major contractors who have prime contracts, such as North American or Grumman or Boeing or Douglas, all have some information of this very same nature; just because they are working in detail in the program. General Electric is perhaps in a more sensitive position because they do go across-the-board.

To date, it hasn't been such a problem that any single company, to my knowledge, has brought to our attention that it is giving to General Electric proprietary information in order that General Electric Co. can carry out the program.

Mr. DADDARIO. It would seem to me, if that is not the case today, it could very well be in the future.

Going back to our previous discussion, I would think it would be wise if GE's position could be spelled out, and I wonder if some thought might not be given to eliminating it from any competitive position at all in this program, taking into consideration its management position?

Mr. HOLMES. I think, Mr. Daddario, that we have essentially eliminated the General Electric Co. from competition in the overall Apollo Program either as a prime or a subsystem contractor. Since our agreement on this point, General Electric has been excluded from bidding or has ceased and desisted from bidding in any of these areas.

Mr. TEAGUE. Mr. Waggonner?

Mr. WAGGONNER. Mr. Holmes, I think you have gone a long way down that road, but how are you going to disseminate this information to people who don't believe that's the case?

How are you going to erase the doubt from the minds of these other companies?

Mr. HOLMES. Our attempt to do this, Mr. Waggonner, has been to circularize the agreement we have with the General Electric Co., where we expect them to work, where we expect them to be excluded from the Apollo Program. We have made this information available through all our Centers, to all the major contractors we are doing business. We haven't gone farther than that. Any suggestions on going farther than that would be certainly welcome.

Mr. WAGGONNER. Mr. Holmes, it was stated that the GE "40" contract would probably be in the vicinity of $635 million. How many other Apollo contracts will exceed this total figure?

Mr. HOLMES. I prefer to give you that information in executive session, Mr. Waggonner. I'm not dodging the question, I feel that it would be wiser to give that to you in executive session. I could give you that data for several contracts such as the North American contract, now but if I gave it to you for other contracts in which we have contract prices presently from contractors that are less than this but the Government thinks it's either going to add scope or it didn't believe the figure negotiated. I'm afraid that I'd put the Government in an embarrassing situation.

Mr. WAGGONNER. We can say at this point, there would be few indeed, wouldn't there?

Mr. HOLMES. I would think there would be under a dozen.

Mr. TEAGUE. Mr. Gurney?

Mr. GURNEY. Mr. Holmes, we have discussed this a good deal indicating that there may be a problem. In an attempt to resolve it, I think there is another consideration. Have there been instances in General Electric's program where the other contractors working on the Apollo program have either refused to give General Electric information or have given it with reluctance? Has that happened?

Mr. HOLMES. To my knowledge, Mr. Gurney, it has not happened.

Mr. GURNEY. My recollection is that General Electric said either that there is that problem or that there might be that problem.

Do other members of the committee recall that?

Mr. TEAGUE. Yes.

Mr. HOLMES. It's not a problem that has come to my attention. You might ask Mr. Shetler; he is here.

Mr. GURNEY. I assume it probably would not come to your attention since there may be a reluctance on the part of contractors to go directly to NASA.

Mr. HOLMES. I hadn't noticed it in the past, Mr. Gurney.

Mr. GURNEY. Well, put it this way, there is a problem, at least the General Electric people told us there was.

I simply throw that out, thinking, as you get further along that you might take this into consideration. I know this is just beginning, but it is certainly something you might need to resolve.

Mr. HOLMES. Yes, Dr. Shea would like to comment, Mr. Gurney.

Dr. SHEA. My comment would be a general one. Each time that you introduce a new management concept of the type we talked about here with Bellcomm, you implicitly, and sometimes explicitly, take away from other individuals—be it contractors or even our own center people—some of the prerogatives they had or thought they had in the past. There's no way of getting around the fact that doing so results in a difficult operation; people drag their feet. Occasionally, it's a kind of resentment. It's a management problem for us to get over this. Frankly, in the last year we have had to educate people in what we meant by the program. We have tried to accommodate it to the structure that existed. During the early phases there was, indeed, on the part of the contractors and our center people, a type of resentment.

I think now we understand and General Electric understands what is entailed. Our contractors know who is doing what and who has what responsibility. The working relationship is now finally easing itself out, but again it can only come about from contacts on the working level, technical contacts between the GE people, the Bellcomm people, and both centers and their contractors, so that you finally establish a technical respect to make these contracts go.

We had, in the ballistic missile program, the same thing when STL was the technical director. I happened to be on the receiving end of their technical direction and I said, in effect, "Go away. Don't bother us"; until we finally developed a mutual respect and could work on problems jointly.

After a couple of years we all worked as members of the same team, all trying to do the program job. The relationship is very viable.

We have to realize that people are people, whether those people are businessmen, scientists, or Representatives.

Mr. GURNEY. I think we have gotten the feeling in talking about this particular phase of the program that there is a problem, and you can't sweep it under the rug.

Mr. HOLMES. Since you raised that question, which I very much appreciate, I certainly expect to find out who said what, and what the problem is, and if we can do something to alleviate it. I would like to say something to correct the record to correct an erroneous impression on the GE contract I may have given.

When I referred to a rough estimate of $635 million through the decade, that estimate should be distinguished from any contract that exists or that we intend to write. It's a very broad estimate.

Even now, I'm rather sorry to give this because General Electric Co. may feel this is a very definitive type of thinking on NASA's part and it's not.

The definitive part of the General Electric contract in fiscal year 1963 will be an estimated $30 million out of the total $38.5 million for "Integration and checkout." In fiscal year 1964 the requirements for this GE effort will be in the order of $100–$125 million.

They are not plans for the future years. It certainly is going to run in fiscal year 1965 something like fiscal year 1964; but this other rough figure is a broad guess through the decade. Whether or not we actually definitize a contract with General Electric for this amount, I just want to make that clear. It's different than any of these dollars which we have in definitive contracts. There will be a number of contracts less than 635.

Mr. DADDARIO. It's difficult coming to such a conclusion because once you take the first steps in the next 2 or 3 years, you are committed to General Electric for the life of the program; even though it's a large figure and even though it may come in amounts of $30 or $40 million a year. Nevertheless, the committee must take into consideration the fact that once committed it will be NASA's obligation to fulfill this contract over the course of the years. I think this is specially important. We can save millions of dollars with studies being made now and by proper management techniques being brought into play. We must take into consideration the cloudy atmosphere that has been created and see if we can in some way or other eliminate the confusion and come to some kind of definitive understanding as to what the overall relationships are.

It seems to me that as difficult as this is, it can be done; and because of the confusion that exists in everyone's mind, including your own representatives who have not been able to explain it, some study ought to be made and some understanding be arrived at.

Mr. HOLMES. I agree, Mr. Daddario.

My only reasons for remarking about $635 million is we do not have a contract with anyone that extends out through fiscal 1969 and I didn't want to be misleading with respect to these other contracts that are for much shorter periods of time.

Mr. DADDARIO. I understand that. Is it very difficult for you? We have the manned lunar landing program and we are not going to stop it between now and its accomplishment.

Mr. Waggonner?

Mr. WAGGONNER. Of course, I raised the point about the eventual amount of the GE contract simply to show for the record that GE is not being discriminated against, and will not be denied too much of an opportunity if they get somewhere in the vicinity of $600 million out of a total program costing about $20 billion. They are going to get a fair share in their phase of industry of this overall money.

Mr. HOLMES. I think this is a fine contract for the GE Co.

Mr. TEAGUE. Mr. Holmes, if I understand the contract with General Electric, they are going to, in effect, write the textbooks about every problem involved in the space system?

Mr. HOLMES. "Task" books?

Mr. TEAGUE. Textbooks.

Mr. HOLMES. On all the problems in the program?

You were probably told this and probably it is a true statement, but in the light I am thinking of it I can't agree. Maybe you can clarify it, Mr. Chairman.

Mr. TEAGUE. For example, General Electric will collect all the information available from all over the world concerning the surface of the Moon. That will go into a textbook or a book.

Mr. FULTON of Pennsylvania. I have already read the book. It's already there.

Mr. TEAGUE. Isn't the same thing going to happen on every major problem in the space program?

What I am getting at is that if General Electric is going to do this, the only way to do an adequate job is have all the available information. We were in California and asked a company about certain new concepts or new ideas, and if this was going to be passed on. They said, "Certainly not by us. Maybe the company who builds our machines will sell this or try to build their own machines. We are not going to pass this on."

If this is what GE is going to do, did NASA consider setting up in-house capabilities to write the specification on all those problems we are going to run into?

Mr. HOLMES. We have not given the General Electric Co. an assignment of writing books on the Moon, that I know of. Certainly not of publishing data as compilations about the system lunar environment or going to the Moon. They will have certain areas of reporting both in reliability and the equipment.

The primary responsibility for establishing what we think that information is doesn't exist with us at all, except in Dr. Shea's office, supported by Bellcomm. I am not clear on this.

I don't expect General Electric Co. to become the publishing outfit for all the data of the space program.

Dr. SHEA. That particular textbook was really a bibliography of reference materials that exist, and I don't think there was a large amount of editing in it, it was more of a collection.

Mr. FULTON of Pennsylvania. The problem is that when you have such a tremendously complicated program, how do you "ride herd" on the integration, automatic checkout, and the reliability factors?

As a matter of fact, I believe it should be under one head, because these various facets are all interrelated. Secondly, there are suppliers of every kind and variety in these various fields that the space industry is interested in. In most cases the components and hardware are

off-the-shelf and over-the-counter sales of regularly manufactured equipment so that in this tremendously large field, I do not see that there is any competition of a nature which would be called adverse.

The systems engineering portion of the Apollo program is where the new concepts and new hardware or any "trade secrets" are developed. Actually I would have thought you would say that in that relation Bellcomm would be the company that the first information would be given to, rather than the firm which is doing the practical work of integration, checkout, and reliability. I think from your own point of view it might be better for you, on your management concept, to relate it on these advance systems and new ideas, to systems management so that within your own management area you, by your own administrative procedures, can say there is no practical problem.

Mr. HOLMES. Bellcomm——

Mr. FULTON of Pennsylvania. If I can make this suggestion, having been in the corporate law business, maybe your problem is that they have to pass the word down to some of your other people, and these people haven't got the word on the extent of this tremendous contract or the context of these divisions.

Mr. HOLMES. I think that's an excellent way to state it and I'm going to restate the word.

Now, Bellcomm, as I think you know, Mr. Fulton, was picked because of its great background of technical competence.

Mr. FULTON of Pennsylvania. If NASA's procedures are quickly disseminated to the industry the practices can be solved within your own management levels.

Dr. SHEA. GE is limited in their area of activity to the present Apollo program and those things that bear on Apollo. They are not involved in any of our advanced program planning at all. A matter of sober truth, because of the exclusions which would result in the advanced studies areas, I don't think they want to be.

Mr. FULTON of Pennsylvania. I think that very well solves the problem.

Mr. TEAGUE. Does the committee want to hear more about General Electric or Bellcomm?

Mr. DADDARIO. I'd like to hear more on Bellcomm.

Mr. TEAGUE. The Bellcomm people were here this morning. Could you come back at 10 a.m. tomorrow, Mr. Holmes, so that we might have the opportunity to hear the people from Bellcomm? I believe we are finished with General Electric and they may go back to Florida if they wish.

Mr. HOLMES. Yes.

Mr. FULTON of Pennsylvania. Mr. Chairman, could I make a request at this time?

I would like the General Counsel of NASA to submit to the committee a short statement for the record. This does touch upon legal problems and I think we should have that incorporated.

Mr. HOLMES. Pardon me?

Mr. FULTON of Pennsylvania. I would like Mr. Johnson, NASA's General Counsel, to outline where this touches on legal problems.

Mr. HOLMES. In reference to GE and Bellcomm?

Mr. FULTON of Pennsylvania. In reference to GE and Bellcomm, specially in the area of unfair competition or adverse competition to NASA's other activities.

(The information requested is as follows:)

STATEMENT SUPPLIED FOR THE RECORD IN RESPONSE TO CONGRESSMAN FULTON'S REQUEST FOR A SHORT STATEMENT ON THE LEGAL ASPECTS OF THE GE AND BELLCOMM CONTRACTS TO BE SUPPLIED BY JOHN A. JOHNSON, GENERAL COUNSEL, NASA

In response to the request by Congressman Fulton for information on this subject, the following information is presented to the committee concerning the issue of possible competitive advantage accruing to Bellcomm, Inc., and the General Electric Co. as a result of their performance of contracts NASw-417 and NASw-410, respectively.

At the time these contracts were first contemplated, it was recognized that in each case the resulting close relationship between the contractor and NASA would mean that the contractor might well receive information regarding current and future plans and programs of NASA that could give it a competitive advantage on other NASA procurements. Accordingly, by exchange of correspondence between the Administrator of NASA and the president of each company, and by further more detailed negotiation in the case of General Electric, appropriate restrictions were agreed upon in each case. Specifically, each contractor is precluded from competing for other NASA contracts in those instances in which under this contract it has acquired the kind of information which might give it a competitive advantage, such as information concerning design requirements, program planning or scheduling, procurement planning, or budgeting and financial operating plans of NASA. In the case of Bellcomm, because of its close affiliation with other companies in the Bell System, these restrictions were made applicable to the entire Bell System.

In certain types of procurements in which competitive advantage was deemed likely to occur, the contractor is precluded from competing, irrespective of whether competitive advantage can be actually pinpointed. In other types of procurements for which competitive advantage is less likely to occur, the contractor may participate only upon a clear showing that no information has been obtained which would give it a competitive advantage.

It is not intended, however, to deny unnecessarily to the space program the unique resources and talents of the above companies. Such a course of action would be contrary to the national interest. Accordingly, provision has been made to allow both contractors to compete for and participate in individual NASA procurements where the Administrator or Deputy Administrator determines that the contractor possesses a unique capability, the utilization of which is required in the national interest.

The above restrictions regarding both Bellcomm and General Electric have been set forth in NASA's regulations.

Mr. TEAGUE. Dr. Hornbeck, you cannot come back tomorrow, can you?

Dr. HORNBECK. No, sir. I am performing one of the duties of speaking in Chicago at the Space Conference as requested by NASA.

Mr. TEAGUE. There must be someone else.

Dr. HORNBECK. All things being equal, I would prefer to do it.

Mr. TEAGUE. We would like to have you, too. I'm sorry it worked out this way, but we couldn't help it.

Mr. PATTEN. Well, could we continue for another half hour? Is that possible?

Mr. TEAGUE. General Electric may wish to submit some information for the record. If you would like to, you are quite welcome.

Mr. RIEHLMAN. Do you want to make any statement?

Mr. SHETLER. Mr. Chairman, I don't think we have a statement to add to the record this morning. We would like to have the opportunity, perhaps, to say something at a later time.

Mr. TEAGUE. That is acceptable to the committee. The committee will be adjourned until tomorrow morning at 10.

(Whereupon at 12:09 p.m. the subcommittee was adjourned until 10 a.m. May 9, 1963.)

1964 NASA AUTHORIZATION

THURSDAY, MAY 9, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON MANNED SPACE FLIGHT,
Washington, D.C.

The subcommittee met, pursuant to adjournment, in room 356, Cannon Building, at 10 a.m., Hon. Olin E. Teague presiding.

Mr. TEAGUE. The committee will come to order.

Mr. Daddario?

Mr. DADDARIO. Dr. Hornbeck, would you explain to us Bellcomm's position in regard to NASA and General Electric Co.? What is your function, and how do you operate?

STATEMENT OF DR. JOHN A. HORNBECK, PRESIDENT, BELLCOMM, INC.

Dr. HORNBECK. Well, Mr. Daddario, with respect to NASA our obligation is to support the systems engineering work in Mr. Holmes' and Dr. Shea's office by doing technical studies of a broad variety and kind and giving the results of these studies to them. So we are in the nature of a technical support group to Dr. Shea.

With respect to GE, I think our relationship to GE is basically that of any systems engineering group or support group to another part of the program. Namely, we are concerned with the broader systems aspect whereas GE is concerned, as I understand it, with implementation of more specific phases of the program.

Mr. DADDARIO. Do you make the decisions as to what technical studies ought to be made, or does Dr. Shea or Mr. Holmes do that?

Dr. HORNBECK. I think it frequently comes from both. Dr. Shea frequently suggests what we do and often these suggestions are put in written form and actually become a part of our contract.

I don't think it is their desire—they are here to speak for themselves—that we not undertake some studies of our own, studies that we think can contribute to the program.

Mr. DADDARIO. When you say it is put into the contract, do you mean that your relationship with NASA can fluctuate from time to time, and that it is a flexible working arrangement which you have with them?

Dr. HORNBECK. These specific tasks we are working on will change from time to time or will be increased from time to time.

Mr. DADDARIO. And that means that the number of personnel you will assign to these responsibilities can fluctuate, as well?

Dr. HORNBECK. On specific tasks; yes, sir.

96-504—63—pt. 2b——21

Mr. DADDARIO. In the letter which Mr. Dembling sent to the chairman of the subcommittee, he refers to building your organization up to 250 people?

Dr. HORNBECK. Yes, sir. It could say that. I haven't——

Dr. SHEA. It does say that.

Mr. DADDARIO. Yes. It states that—

NASA anticipates by the end of this year, the Bellcomm organization will comprise about 250 people.

Is that your own estimate, as well?

Dr. HORNBECK. Yes, sir.

Mr. DADDARIO. Mr. Yeager, do you have the annexes to the report? In one of the annexes, it refers to the fact that, through special arrangements to be made with NASA, people from A.T. & T. can be assigned to certain studies, we will say, which Bellcomm undertakes. Therefore, we can expect that on occasion you will be using over 250 people and that these will be a mixture of both Bellcomm people and others assigned by special contract through this special arrangement with A.T. & T.?

Dr. HORNBECK. Yes, sir; could I clarify that slightly?

Mr. DADDARIO. Yes, I wish you would.

Dr. HORNBECK. It was contemplated from the beginning that the Bell System would support NASA in this effort and the instrument, Bellcomm, was chosen as a means for doing this. It was not contemplated this would exclude getting help from other parts of the Bell System, other than Bellcomm.

As a part of our contract with NASA, there is a provision that we can ask Bell Laboratories to help us. If they consent, this would take place without the approval of the contracting office.

We do have now, and have had for some time, additional support from the Bell Laboratories on three tasks which we are now carrying out. So we have a working relationship with Bell Laboratories and we expect that this is a profitable one and that it will continue—by "profitable," I mean, that it will aid in the carrying out of the project.

Mr. DADDARIO. Then, even though you have not reached the full complement of 250 people, you already are using this other ability that's written into the contract to assign, under separate contract, Bell System personnel to NASA problems?

Dr. HORNBECK. Yes, sir; except it's not under a separate contract.

Mr. DADDARIO. It is under a separate arrangement of the original contract.

Dr. HORNBECK. Yes, sir.

Mr. DADDARIO. Could you, Dr. Hornbeck, discuss how Bellcomm, Inc., was formed, who owns the stocks, and how those stocks can be transferred from the people who are now the owners of them?

Dr. HORNBECK. Sir, I think you will find most of that in the record already. Our stock is owned jointly in equal amounts by the American Telephone & Telegraph people and by the Western Electric Co.

Mr. DADDARIO. All right. Now what arrangements are there, or how is the corporation established so far as transfer of ownership of the stock is concerned? What are the prospects there?

Dr. HORNBECK. There is no intent, that I know of, to transfer the ownership of the stock to any other parties.

Mr. DADDARIO. Well, I'm not so much interested in the present intent as I am in whether it is possible under the corporate structure for this to come about. Is there any inhibiting language in the charter of incorporation which prevents it?

Dr. HORNBECK. Which would prevent A.T. & T. from selling a part ownership in this?

Mr. DADDARIO. Yes.

Dr. HORNBECK. I know of no restraint that would prohibit them from doing so, but I can assure you its not their intent.

I might point out, sir, that our stockownership situation is identical to that of Bell Telephone Laboratories which is 50 percent owned A.T. & T. and 50 percent by the Western Electric Co. and I believe that is the reason—I mean following the Bell Laboratories' pattern—that Bellcomm arrangements were set up as they were. We are a Bell System Co. and there is no real possibility, I think, of the ownership going to other parties.

Mr. DADDARIO. Well there is no possibility only because it hasn't been done before, but there is no language which so limits the possibility?

Dr. HORNBECK. That is correct.

Mr. DADDARIO. Looking to the years ahead when we have accomplished certain of our objectives in space and the time comes when this contract will be terminated, what will then happen to Bellcomm, Inc.?

Dr. HORNBECK. Sir, I have stated before and will state again, here, that when the Space Agency has no longer any need for Bellcomm services then we and A.T. & T. want to terminate our services with the Government. In other words, we have no interest in staying here any longer than we are needed.

Then there is a separate question as to, if and when our services are terminated, what would become of Bellcomm.

Bellcomm, being a Bell System Co. and having as owners A.T. & T. and Western Electric, the decision as to what uses our owners wish to make of Bellcomm, presumably, would be made at that time or before that time, seeing the termination coming up.

They may well have other needs for the corporation than just supporting NASA.

Mr. DADDARIO. Even though Bellcomm has been formed for this particular purpose and although it may, over the course of years, gain experience in this field, when the time comes for the contract to be terminated, the corporation would not be disbanded. It would most likely continue in some form or other, depending upon the Bell Co.'s desires?

Dr. HORNBECK. It would depend on the Bell Co.'s desires. It might or it might not be dismantled.

Mr. DADDARIO. Although it is not contemplated at the present time, as I understand it, that there will be many tangible assets purchased by Bellcomm, Inc., let's suppose this changes and Bellcomm does purchase equipment and other facilities, to whom would these belong?

Dr. HORNBECK. The facilities purchased by Bellcomm through moneys furnished from our capitalization would belong to the company. Anything that is purchased in the nature of supplies and so on that are paid for by the Government would, the ownership

in that would, reside in the Government and they would be given to the Government.

Mr. DADDARIO. Is there language which specifically sets that forth, or is this an informal working arrangement or your understanding?

Dr. HORNBECK. I think it's a matter of normal business practice.

STATEMENT OF D. BRAINERD HOLMES, DIRECTOR, OFFICE OF MANNED SPACE FLIGHT, NASA, ACCOMPANIED BY DR. JOSEPH F. SHEA, DEPUTY DIRECTOR (SYSTEMS)

Mr. HOLMES. I believe that this provision is in NASA's contract with Bellcomm. I'm sure it's in our Government contract that what belongs to the Government remains within Government ownership.

Mr. DADDARIO. Can you explain that, Mr. Holmes?

Mr. HOLMES. Yes, Mr. Daddario. In our normal contractual procedure, it is customary to include clauses which state that facilities and other equipment often classified as capital equipment which is purchased at the expense of the Government, returns to the Government for its disposal at the termination of the contract.

Mr. DADDARIO. As I understand it, the Aerospace Corp.'s contractual assets that it develops of any nature, kind, or description would, when the contract terminates and the company disbands, revert to the Government. The idea behind this is that all the assets which were developed, were developed as a result of the Government activity and the nature of the contract itself, and there is no division of what belongs to Aerospace and what belongs to the Government.

I recognize there is a difference here, NASA has asked that this corporation be formed, but there will develop certain assets, as I understand your testimony, which will require some determination at the end of the contract as to whether it belongs to the Government or belongs to Bellcomm.

It will not all fall into the Government's lap automatically.

Mr. HOLMES. That's probably true, although I think it would be to a minor degree. Certainly the facilities provided by Bell System capital as an organization or by Bellcomm capital would be their equipment. This would be true with all the contractors with whom we do business. If Aerospace had any capitalization other than Government funds, I would think that the same rule would apply. As far as I know, the Aerospace structure is such that the entire source of funding is from the Government.

Dr. SHEA. I might comment on that point, Mr. Daddario.

Mr. DADDARIO. Yes, Dr. Shea.

Dr. SHEA. I think that the way in which Aerospace got their capitalization—I'm not sure, but I think this is right—was by advanced payments against their contract. Therefore, in essence, everything that Aerospace has in terms of assets, working capital, and so on, was furnished by the Government. There is a fairly detailed discussion of this in one of the Holifield subcommittee reports which delves into the whole nature of the capitalization of Aerospace.

Mr. DADDARIO. I recognize that. This is one of the reasons I have some concern and want to develop for the record exactly what the intentions of all parties concerned are. When we look back on it sometime in the future, we will know exactly what the agreement was in the first instance.

Dr. Hornbeck, how do you control the hiring of people within this contemplated figure of 250? How do you decide who will be working for Bellcomm and who you will hire under the special arrangement of the contract, who will be doing work for NASA but will not be Bellcomm people, but rather Bell people?

Dr. HORNBECK. Sir, that isn't really a problem we run into. Bellcomm, as a separate corporation, does its own hiring. Therefore, the people that we hire are totally working on this contract. When we asked the Bell Telephone Laboratories to assist us on specific tasks, they agreed to do this knowing the people are on their payroll and can be freed to do this work.

Mr. DADDARIO. It may not offer a problem to Bellcomm or to the Bell Co. but——

Dr. HORNBECK. Might I——

Mr. DADDARIO. Why wouldn't these people be hired by Bellcomm rather than under this special arrangement?

How do you determine what is in the best interest of Bellcomm and NASA—or rather, how do you determine what is in the best interests of NASA?

Dr. HORNBECK. To clarify the matter, sir, I think you'd find that the Bell Telephone Laboratories would not, itself, hire people especially to work on the jobs which Bellcomm has assigned to the Bell Telephone Laboratories.

Dr. SHEA. I might comment——

Mr. DADDARIO. I don't understand that.

Dr. HORNBECK. Perhaps I don't understand your question; but there are several thousand engineers in Bell Telephone Laboratories and there are, perhaps, 20 or 30 engineers working on Bellcomm work in Bell Telephone Laboratories, so it would not even occur to them to hire additional people just on account of Bellcomm's drawing on their people.

Dr. SHEA. Mr. Daddario, could I comment?

Mr. DADDARIO. Yes, Dr. Shea.

Dr. SHEA. I think we might place this in proper perspective. The intention is to have Bellcomm develop its own technical staff and in our original sizing studies we determined that Bellcomm's technical staff ought to be in the order of 170 to 200 people. The rest of this total of 250 is made up of overhead supporting personnel. Because of the nature of our work, we wind up having special workloads at particular periods of time. For instance, a difficult problem may arise or a study may be required in which the total number of people that we have on board just isn't sufficient to handle the job. In addition, we may not have on board the exact, specialized competence we desire to do the job. If such a situation arises, there is a large body of talent at Bell Telephone Laboratories. The arrangement with BTL is essentially one of helping us ride through the peaks or else providing us with a specialized kind of study capability. As a result, it is actually complementary to the Bellcomm operation and does not affect their mainline staffing.

Mr. DADDARIO. Then what you are saying, Dr. Shea. is that you have established Bellcomm to provide a service to NASA which NASA could not really provide for itself, taking into consideration the kind of people that you need and that over and above that, you still need additional assistance.

Dr. SHEA. Yes, sir. That is correct.

Mr. DADDARIO. It really boils down to the fact that you do not have within Bellcomm a complete unit that can take care of all these responsibilities, and you will be getting constant assistance from the Bell people under this special arrangement over the course of the years ahead whenever you reach a peak.

Dr. SHEA. It is not a constant amount. There will be occasional studies for one or two things put into the Bell Telephone Laboratories. The purpose will be to ride through a peak or to take advantage of readily available competence which the BTL people might have in a specialized field.

Mr. DADDARIO. In those instances, Dr. Shea, how would you determine that Bell Co. ought to provide the service rather than somebody else?

Dr. HORNBECK. If the job were assigned to Bellcomm from the Government, then we have options of doing the job totally within Bellcomm or asking Bell Telephone Laboratories for assistance if that is the desirable course.

It could be that some skills within the Long Lines Department of A.T. & T. are needed on occasion, and we might go to them and ask for their assistance in carrying out a task.

What I'm trying to say here is that Mr. Webb and NASA have asked the Bell System for support and we are not restricting that support just to the number of people in Bellcomm, but that we have the freedom to call on other parts of the Bell System when they are needed in carrying out a problem.

Mr. DADDARIO. Doesn't this put the Bell System into a favorable position? Although Bellcomm was established for certain purposes, if Bellcomm is unable to handle a certain problem, it automatically goes to the Bell System rather than to some other company which may be competent.

Aren't you creating a monopoly of knowledge in this area by this arrangement? Bellcomm is a separate company; even though it is owned by A.T. & T. and Western Electric in equal parts, why does that prevent you from going to other places for assistance?

Dr. HORNBECK. Sir, it doesn't prevent us from going to other places for assistance and we have, in fact, done this. I think it's natural for us, if we are asked to carry out a job and we agree to do it, to do it within the framework of the people we have. It is natural we try this.

If there is a special contribution or competence some other organization can make, we go to them immediately. We have, in fact, done this. We have gone to Space Technology Laboratory and gained their assistance and help in some trajectory computations. They gave very fine help and have done a good job.

Mr. DADDARIO. I think it is the natural, and maybe the easiest method to go to Bell System, but the question arises whether it is the best method. I am pleased to know that you already have gone to other companies. The record should show that you have, and it is your intention to do so in the future in the event this possibility arises.

Dr. HORNBECK. That is correct, sir.

Mr. DADDARIO. Mr. Shea?

Dr. SHEA. Mr. Daddario, I might add another point here. Since my office assigns these tasks, we make a determination as to whether

a particular task will be given to Bellcomm to execute for us, either in-house and within the Bell System or by subcontracting, or we decide that we will actually contract for particular tasks directly from NASA.

I think you noticed yesterday a line item in the budget of something like $2 million which are funds for special studies which we require over and above those which we wish to assign to Bellcomm. We have two or three such studies out at the present time. One is placed with the Rand Corp. and one with the Bissett-Berman firm in California to take advantage of special competencies which those firms have.

Mr. HOLMES. Mr. Daddario, could I comment?

Mr. DADDARIO. Yes, I wish you would.

Mr. HOLMES. It appears to me that we have inaugurated a unique and useful management concept. With Bellcomm we do have the support of this on-board systems engineering competence; we can contract directly to industry and are contracting to industry for special support studies when it is not economical to have a full-time staff on the payroll but special talents are needed for short periods of time; in addition, we have the tremendous advantage of being able to call on other talents in the Bell System.

If, indeed, if we wished to go, on a task basis, to the Bell Telephone Laboratories, which I consider certainly one of the strongest and most fully equipped laboratories this country has in industry, we probably would not be able to do it. They are not interested in doing business on a task basis, since it is not to their advantage. However, under our existing arrangement, we can, through Bellcomm, have that specialized assistance for short periods of time to solve unique problems. There are areas in which the Bell Laboratories are not the best qualified and I think would be far from the intention of Bellcomm—Dr. Hornbeck may want to comment—and certainly, the intention of NASA, to turn to them for rocket engine studies or something of that type.

As I mentioned before, it is very much to the advantage of the Government to be able to call on BTL's recognized competence when its special talents are necessary to support Bellcomm.

Mr. DADDARIO. I don't think there is any question, Mr. Holmes, but that you made a good case for establishment of Bellcomm. As I read that particular section, it makes great sense, too, that you leave the door open so you can use the special talents of Bellcomm.

This is one of the reasons why I and other members of the committee supported this program that you established last year. But I do not think that because it is natural and because there is this tie, that when there might be an opportunity for someone else to compete, that the best thing would be to go to the Bell System. It seems to me that NASA should take a special interest to see that where there is the possibility of competition, that the competitive system be utilized in every possible occasion. I am pleased to hear testimony this morning which indicates that this is the case, or that it is your intention that it will be the case, and I would hope that Dr. Hornbeck would overcome the natural impulse in this situation to turn immediately to the parent company. I think it's important that Dr. Hornbeck be as objective as possible in this particular area.

I remember last year when we talked about this, Mr. Fulton brought up a question that has stuck in my mind ever since. Mr. Fulton asked how long Bellcomm would keep the people it had hired

He also asked if there is the danger that Bellcomm will use this as a training ground at the Government's expense, and then put the people back into the Bell System where they will have additional and special knowledge as a result of this unique contract with the Government; thereby putting your company in an even better position than it now finds itself.

Dr. HORNBECK. Sir, we have brought a number of experienced people down from Bell Telephone Laboratories and other parts of the Bell System into Bellcomm so that it has initially some technical competence of its own and ability to solve problems we are asked to solve. So we are starting out with a reservoir of technical knowledge and experience.

Now, the Government didn't pay for this training that all these people had, but rather, in the main, the Bell System did. So I think the Government is starting out and is paying for these services in a natural sort of way.

To the extent we augment our staff——

Mr. DADDARIO. Could you explain that "paying for these services in a natural way"?

Do you mean by paying Bellcomm or by paying the Bell System?

Dr. HORNBECK. Paying Bellcomm—it's current expenses.

Mr. DADDARIO. These are people who now are Bellcomm people and not Bell System people?

Dr. HORNBECK. They are Bell System people and Bellcomm people, and they came from other parts of the Bell System, the reservoir I am talking about, primarily Bell Telephone Laboratories so we start with some experience and technical competence.

If some of them, one or more, should go back to Bell Laboratories as we contemplate from time to time, they will carry with them any new experiences they have learned down here.

We have also hired some people from outside the Bell System and they will be getting experience and at the same time they will be contributing to the job, but the only people we have hired from the outside have been experienced people. We have not hired people fresh out of college—engineers, for example. Our need is to have experienced people who can contribute immediately.

So I'm trying to address myself to your point about a training program and I don't think it's our intent nor does it, in fact, work out that way that we are training people at Government expense to help the Bell System.

Mr. DADDARIO. How many people do you have on board now, Dr. Hornbeck?

Dr. HORNBECK. We have about a hundred technical people and about sixty-five supporting.

Mr. DADDARIO. When you said you had both Bellcomm and Bell System people providing the nucleus of talent, how many Bell System people are involved at the moment helping to put the talents together which will eventually amount to 250 people in Bellcomm, Inc.?

Dr. HORNBECK. Sir, two-thirds of our present staff came from other parts of the Bell System.

Mr. DADDARIO. How many of those are still Bell System people?

Dr. HORNBECK. By definition, any employee of Bellcomm is a Bell System person, just the way anybody who is a member of Bell Telephone Laboratories or Long Lines or——

Mr. DADDARIO. They never lose their identity?
Dr. HORNBECK. As Bell System people?
Mr. DADDARIO. Yes.
Dr. HORNBECK. Not as long as they are on the payroll; no, sir.
Dr. SHEA. This applies to all the operating companies of the Bell System, as well.
Mr. WAGGONNER. It is simply because it is a wholly owned subsidiary.
Dr. HORNBECK. That is right.
Mr. DADDARIO. How do you determine which ones will be paid by Bellcomm through its contract with NASA, and those who you will pay for doing special studies for NASA? Ones who never come to Washington but who rather stay at their own desks in the Bell System laboratories?
Mr. HOLMES. Could I comment on this? I think that it is a little confusing, although accurate, to state categorically that the Bellcomm people are "Bell System people." They are Bell System people and Bellcomm people in the sense that Bellcomm is owned by the Bell System and they enjoy the benefits of belonging to overall Bell System. However—and it is important to make this distinction—the Bellcomm people clearly though are on the Bellcomm payroll. It is understood that Bellcomm is an organization to support NASA.
Mr. DADDARIO. This, I think, ought to be spelled out. The question of identity is important.
Mr. HOLMES. That is correct. I think the identity is really clear. The primary responsibility of Bellcomm—and Dr. Hornbeck may want to comment—is to support NASA. They further have a responsibility to NASA and to the Government, that we can deal with them on matters completely, freely, and openly, in a different way than we would deal with, for instance, the Western Electric Co., which is also part of the Bell System.
Mr. DADDARIO. How can we spell this out since Dr. Hornbeck feels they don't lose their identity, and you feel they do? How can we know when a break has taken place? Can a Bellcomm man become a Bell System man by Dr. Hornbeck's deciding this to be the case?
Mr. HOLMES. No, that is not the case.
Dr. HORNBECK. No.
Mr. HOLMES. I think what we meant to say, Mr. Daddario—and I certainly can understand the confusion—is that a Bellcomm man is a Bellcomm man. However, the whole Bellcomm Co. is a part of the Bell System and in that sense they are Bell System people, not in the sense that they are worrying about the telephone business.
Dr. SHEA. I think what you did was touch Dr. Hornbeck's "esprit de corps" button so far as the Bell System is concerned.
Mr. DADDARIO. It is a fact that Bellcomm people are Bell System people at the same time in a purely technical sense, but when one of these people comes into Bellcomm he's on the Bellcomm payroll, is he not?
Dr. HORNBECK. Readily identified and only responsible to assist NASA.
Mr. DADDARIO. And beyond that, there are people in the Bell System whom you hire under this special arrangement, and who will be paid not by Bellcomm, but by NASA?

Dr. HORNBECK. When you are speaking of the Bell Laboratories people working on a task assignment from Bellcomm, they get their salary check from the Bell Telephone Laboratories and the Bell Telephone Laboratories bills Bellcomm and we pay them.

Mr. DADDARIO. Bellcomm bills NASA through that special ——

Dr. HORNBECK. As part of our regular monthly bill.

Mr. DADDARIO. But it's a separate fluctuating kind of arrangement?

Dr. HORNBECK. Identifiable.

Mr. DADDARIO. And identified, as such?

Dr. SHEA. We might talk about the level of effort involved here, too.

Mr. DADDARIO. Would you?

Dr. SHEA. It is our intention that this kind of support that Bell Telephone Laboratories would provide, or the Bell System might provide, would be in the order of 30 technical staff members, compared to the roughly 170 to 200 members of the technical staff that Bellcomm will have in their steady-state organization.

Mr. DADDARIO. I am not concerned whether it be 30 or 20 or 50, because I think that Mr. Holmes has spelled out one of the important features of this program in that you can call on the Bell System to solve a problem as it comes up; notwithstanding, the number of people involved, and whether it is 30 or 50, or more, depending upon how serious the problem might be.

I think that when you do it, we ought to know what the bill is and how this bill is arrived at since the bill comes to a certain amount of money for these special reasons, and that it is separate and apart from the overall Bellcomm arrangement. We should be able to see how the company works on a day-to-day basis, and how you use Bell System to help out when you run into a unique problem. As Mr. Holmes said, it is important that Bellcomm has this capability, but this committee should be aware of what it entails.

Mr. HOLMES. Yes, sir; I agree with you completely, Mr. Daddario and I do think we have a responsibility in Dr. Shea's office, specifically to see to it that contracting from a NASA standpoint with the rest of the Bell System is done on an objective basis. Not that I have any doubts, but I think we have that responsibility. Further, I think it is well understood within Bellcomm and within NASA that Bellcomm is a clear-cut, different, and separate organization from the rest of the Bell System and, indeed, we can feel free within NASA to look to people like Dr. Hornbeck and his key people to consult with us on the detailed parts and planning of the systems engineering for the Government to a degree that we couldn't possibly do, despite our respect, with any outside company or corporation, and I include "outside" meaning "other parts of the Bell System."

Does that help any, Mr. Daddario?

Mr. DADDARIO. Yes, sir; it is very helpful so far as I am concerned. I agree with one of Mr. Hornbeck's earlier statements in which he said that the Bell System has trained people over the course of time, and that the Government is taking advantage of this. This is very important. It's important under our system of government that this be the case so that this capability within private industry may be allowed to grow rather than to be inhibited by government activity of one nature or another. This is certainly a step in the right direction.

It is, however, important from a contractual point of view to keep the lines clear and know exactly what we are doing, and to spell out

here and now how it's going to work. We must make certain that we do not allow one company to be placed in a position where it can develop an unfair competitive advantage, taking into consideration other companies which would like to participate, simply because of this special and unique contract. This, I think, places a greater burden on all of you, and specially Dr. Hornbeck, to make the decisions in the future which will allow other companies to competitively participate.

Mr. HOLMES. Yes, sir.

Mr. DADDARIO. Thank you, Mr. Chairman.

Mr. TEAGUE. Mr Fulton?

Mr. FULTON of Pennsylvania. The present contract expires in September of 1963, doesn't it?

Dr. HORNBECK. Yes, sir.

Mr. FULTON of Pennsylvania. That is an 18-month contract in the amount of $8.5 million?

Dr. HORNBECK. Yes, sir.

Mr. FULTON of Pennsylvania. What is the estimate of NASA and Bellcomm, Mr. Hornbeck, as to the amount of money required for the coming 12 months?

You have previously stated that the next contract is expected to be for about a 12-month period; but you were not able to give any estimate of the amount of funds required when you appeared before this subcommittee in March.

Dr. HORNBECK. Are you addressing your question——

Mr. FULTON of Pennsylvania. To both of you.

I would like to know the present status of the negotiations on the new contract.

Dr. HORNBECK. They have not started, sir.

Mr. FULTON of Pennsylvania. When will they start?

Dr. HORNBECK. Next month.

Mr. FULTON of Pennsylvania. What funding does NASA have within the present budget request for the oncoming contract with Bellcomm?

Dr. SHEA. Approximately $12.7 million, Mr. Fulton.

Mr. FULTON of Pennsylvania. So, you are actually increasing the total amount by a third, and reducing the total time by a third?

Dr. SHEA. Yes, sir, but I think you do recognize that the current 18-month contracting period in the past was the buildup time for Bellcomm and the organizational staffing plan is pretty much a straight-line function, trying to add between 10 and 15 members of technical staff per month.

We are now at a point of about 100 technical people on board. Growth will continue throughout the rest of this year, and we'd expect to peak out at approximately 170 people by about January or February. Is that right, Dr. Hornbeck?

Dr. HORNBECK. Yes.

Dr. SHEA. You can see what we are doing now, as we budget for the next fiscal year, to approach the steady-state condition of Bellcomm.

Mr. FULTON of Pennsylvania. If my mathematics is correct, you are then increasing the rate at about a 33⅓ percent; applying that monthly, the contract with Bellcomm will increase from about $750,000 a month to about a million dollars. Is that not right?

Mr. HOLMES. Yes, that's right, Mr. Fulton; but it didn't go in a linear fashion. In the first few weeks of Bellcomm, the bill was comparatively small because we only had a few people, a dozen or so, on board. As we added people, the bill rose accordingly.

Mr. FULTON of Pennsylvania. That brings up my next question. What is the rate of the flow of funds for the 100 technical people and 65 supporting Bellcomm? What is your current rate and how is the buildup?

Dr. HORNBECK. The current rate is $450,000 to $500,000 per month.

Mr. FULTON of Pennsylvania. Then why would you increase, in the year beginning September 1963, to the rate of a million dollars a month, which is about double your current rate, as distinguished from your average arithmetical rate during the period of the previous contract?

Dr. SHEA. I might comment on your question, Mr. Fulton. There are two factors. In addition to the increase in personnel which is almost a factor of 70 percent over what we presently have, we will be bringing into being a computational facility during the fall and early part of next——

Mr. FULTON of Pennsylvania. A what?

Dr. SHEA. A computational facility, a fairly large digital computer, capable to do trajectory analyses.

Mr. FULTON of Pennsylvania. Isn't that NASA and not Bellcomm? This is the first I have heard NASA was supplying anything like laboratories or equipment. As a matter of fact, in previous testimony, they specifically said they had no laboratories or practical equipment and would use the equipment of the Bell Telephone System when they needed it; such as the 20 people at the Bell Telephone Laboratories at New Jersey.

Mr. HOLMES. I think it must have been a misunderstanding. From the very initiation of this systems engineering contract, we had anticipated that a computer would be necessary, located in an office building—not really a laboratory. In today's systems engineering, or any engineering, as I know you are well aware, Mr. Fulton, the tasks are far too complicated to rely on a slide rule or tables. Today's engineers are trained to use computers and the most efficient way to use such systems engineers is to have computing facilities available at their physical location.

Therefore, the computer we are talking about would be located in Washington, in the office building in which Dr. Hornbeck's Bellcomm organization is housed.

Mr. FULTON of Pennsylvania. It isn't a question of whether they need computers or not. It is a question of whether or not we have, in other Government agencies, computers and facilities that could be used on a part-time basis. Is Bellcomm going to have equipment and items of that type beyond general office supplies and furniture? How far as you going on that type of equipment?

My feeling is this: You are working on systems engineering in Bellcomm which would put you on the level of a combination of accountants, technical engineering, and attorney-type professional work. Coming from a large corporation law office in Pittsburgh which represents banks with 37 branches, I would be surprised if they put a computer system of one of the companies in your office. I am

very surprised that within the professional range of the advice being given, we are now going to build up a computer system. I thought Bellcomm was giving the advice while NASA was doing what I would call the engineering, drawing, specifications, and layout work.

Mr. HOLMES. No, Mr. Fulton. It has always been our intention that Bellcomm would have a computer in residence. It's absolutely necessary for Bellcomm to have available a computational facility to do the technical analyses which support our mission judgments, such as the mission profile analysis and other studies.

We have looked at the possibility of using other computers in NASA for this purpose or even using computers in the Bell System. It appears to us to be the most economical approach and the most efficient approach for Bellcomm to have a computer which can be used by their personnel and by NASA's systems personnel for the systems engineering studies as contrasted to studies of design of hardware and equipment which is done primarily in the field, as you have noted.

Mr. FULTON of Pennsylvania. Once NASA gives Bellcomm a computer, aren't you therefore putting them in business permanently so that instead of a 1-year contract ending in September 1964, you are really contemplating a permanent installation over which NASA has no control, either of the computer, its use, or the furniture, or the books, or the equipment, or the personnel?

Mr. HOLMES. No, I don't think that we are. It's our anticipation that this contract has to run over a period of several years. The length of time will depend materially on the ability of the Government to build a systems engineering organization and the legislation that affects this which, of course, is, as you know better than I, a broad program involving all departments of Government and the salaries we pay people.

Mr. FULTON of Pennsylvania. Let's go ahead on that.

We have been around computers long enough to know that the programing is the main thing, and that an engineer doesn't sit and watch while a girl feeds the information into the computer. It's outlined ahead. Why can't we do that in this instance? Why do we need another installation with computers?

Dr. HORNBECK. Sir, it might help if I comment; this computing facility we are talking about is a leased facility. It is not owned by Belcomm.

Mr. FULTON of Pennsylvania. How much you paying for it?

Dr. HORNBECK. We have not got it installed yet, but my recollection is it will be in the amount of $100,000 per year. We are now using other computing facilities around Washington, several of them.

Mr. FULTON of Pennsylvania. What kind of equipment are you talking about? What type of computer?

Dr. HORNBECK. Excuse me, sir. There was some question about my estimate. The yearly rate is nearer a million dollars. I'm sorry. I was thinking in terms of the monthly rate.

Mr. FULTON of Pennsylvania. Your rental cost will be a million dollars?

Dr. HORNBECK. $900,000.

Mr. FULTON of Pennsylvania. On the computer?

Dr. HORNBECK. Yes, sir.

Mr. FULTON of Pennsylvania. That certainly brings up a question as to the full use of the computer. This is the first time we have heard anything of this nature going beyond the technical and engineering advice on a systems engineering basis.

Mr. HOLMES. This is the only efficient way they can give us technical and engineering advice. We couldn't possibly have systems engineering going to the Moon or going into space without a computer for full-time use.

Mr. FULTON of Pennsylvania. I certainly agree, but the question is, Where shall you have the computer, and who will use it, and who has the use of it in the spare time? Is it being adequately used? Are we duplicating an existing Government function?

I am willing to go to the Moon, but I certainly don't want to produce a computer. I'll tell you that.

Mr. HOLMES. We looked into this matter very carefully. We analyzed the advantages of an onsite computer versus NASA computers. All your questions, which are completely logical, were reviewed in detail. We came to the conclusion that this was the most economical method for the Government.

Mr. FULTON of Pennsylvania. If you will look through the testimony previously given, and if you find any reference to a cost of a million dollars a year for a computer in Bellcomm, I would like to see it.

Concerning the 20 technical people at the labo' tory in New Jersey, who monitors their time since they are working part of the time for Bellcomm, and part of the time for Bell Telephone.

How is their time computed, and what rate is charged to NASA? What is the overhead? Would you supply that for the record?

Mr. HOLMES. We'll submit that information for the record.

(The information requested is as follows:)

I. SUPERVISION, TIME CHARGING AND AUDITING

Of the 20 technical employees at Bell Telephone Laboratories (BTL) in New Jersey, most are assigned full time to Bellcomm work, and are not devoting time to other projects. The work of these employees is governed by the technical direction which is issued by their immediate BTL supervisors. These supervisors are included in the number 20. BTL's work is reviewed and discussed at frequent intervals with the Bellcomm task managers responsible for these projects.

With respect to accounting for time worked, each Bell Telephone Laboratories' employee submits on the first working day of every week a timecard recording the number of hours worked each business day of the previous week on the project (or projects) to which he is assigned. These timecards are reviewed and signed each week by the employee's immediate supervisor. The Bellcomm task managers review each month the man-hours of effort charged by the workers at Bell Telephone Laboratories.

Under Bellcomm's prime contract, the timecards referred to, as well as other cost records, are available for audit by NASA representatives. We are advised that NASA has arranged with the cognizant Government agency (Army) to have the resident auditors at BTL verify that proper accounting treatment of time charges has been followed. These auditors make spot floor checks of time utilization and charging.

II. DIRECT SALARY AND OVERHEAD RATES

Under Bellcomm's prime contract with NASA, Bellcomm's payments of the Bell Telephone Laboratories' charges for work performed are allowable to the extent that their charges are not in excess of allowable cost, as determined in accordance with part 2, section XV of ASPR, with indirect costs established by the application of final overhead rates which have been negotiated with the contracting officer.

Hours worked on Bellcomm orders are charged at the actual hourly rate of pay of the individual performing the work. Pending the negotiation of final overhead rates, the contract provides that provisional overhead rates may be used for billing purposes. These provisional rates are agreed to by the cognizant Government agency and require contracting officer approval for each of the different departments of Bell Telephone Laboratories. The average of the various BTL departmental rates applicable to Bellcomm's work is currently running at about 120 percent of direct salary.

Mr. FULTON of Pennsylvania. The next point is this: In the Bell Telephone System there is a method of profit rating which is supervised by various States.

Dr. Hornbeck, would you put in the record Bellcomm's rate of profit on this particular capital contribution. Do it on a cost basis. I think we should have at some point, the method of fixing the fixed fee for the Bellcomm contract.

(The information requested is as follows:)

I. RATE OF PROFIT ON CAPITAL CONTRIBUTION

The Bellcomm contract is a service-type contract under which NASA is purchasing experienced technical judgment and advice. In such a contract, capital investment requirements are extremely low and the fee bears no meaningful relationship to the dollar investment, but is rather related to the value of the service performed.

However, the capital contribution involved in the performance of the Bellcomm contract can be broadly identified and it consists of three principal elements:

1. *The capital investment in Bellcomm.*—At present, this is $700,000 and it is expected that this will be increased to $1 million in the near future.

2. *The investment in Bell Telephone Laboratories (BTL) applicable to the effort of those technical employees engaged in Bellcomm work.*—The overall investment of the Bell System for the Bell Telephone Laboratories is well over $100 million. It is not practicable to allocate to Bellcomm work the appropriate portion of that total investment.

3. *The investment underlying the training and experience of the individuals who have transferred from the laboratories and other Bell System companies to Bellcomm and who are now solely engaged in performing the work for NASA.*—It is from these people that the experienced technical judgment and advice is received. There is no satisfactory way of computing the amount of this investment and it would be impractical to make an estimate.

II. RATE OF PROFIT ON COSTS

In the present Bellcomm contract, the fixed fee amounts to 7.87 percent of the estimated costs. The actual determination of Bellcomm's profit, with respect to the actual costs, must await both the completion of the contract period, plus any results forthcoming under the fee adjustment provision of the contract.

Mr. FULTON of Pennsylvania. I would like to have from NASA the perimeters and basis of knowledge on which the fee was fixed and whether it is relevant to other people working in a systems engineers advisory capacity.

Mr. DADDARIO. Isn't that spelled out in the contract, Mr. Holmes?

Mr. HOLMES. Yes, sir; for the present contract, it's spelled out.

Mr. FULTON of Pennsylvania. I want the basis of their judgments.

Mr. HOLMES. It goes in for each contract period.

Mr. FULTON of Pennsylvania. I am asking for the basis of your judgments.

Mr. HOLMES. The basis is not spelled out. The fee itself is spelled out.

Mr. FULTON of Pennsylvania. And the comparisons for similar work in this field.

Mr. HOLMES. It is a very modest fee for what has been paid for this type of work in the past.

Mr. FULTON of Pennsylvania. In addition I would like to have the necessity for the increase above the 165 personnel presently at Bellcomm. Why must that, within a year, increase to 250 people?

Mr. HOLMES. Do you want that for the record?

Mr. FULTON of Pennsylvania. This is for the record.

We should also have in the record the programs that will be required to be furnished for the Apollo contract that Bellcomm will be required to work on.

Likewise, we should have for the record the accomplishments under this contract; what work has been given to Bellcomm, what have been the results to NASA, and what are the benefits to the various programs, either in time, money, or efficiency; that NASA has been able to obtain through this contract.

(The information requested is as follows:)

NASA originally estimated that Bellcomm's effort would require in the order of 200 technical personnel. Subsequent experience has confirmed the validity of the initial estimate. The fiscal year 1964 requirement of 250 total personnel, including technical and administrative personnel, is based on the level of effort necessary to provide systems engineering support for the Office of Manned Space Flight. The fact that Bellcomm has not yet completed its planned staffing is due to its deliberate selection of the best scientific and engineering talent available.

Under the technical direction of the Office of Manned Space Flight, Bellcomm has accomplished or is working on important studies related to Project Apollo. The following list reflects Bellcomm's major assigned studies (analyses) in support of Project Apollo:

1. Support in the preparation of documentation defining the Apollo mission and specifying system characteristics. The first Apollo system specification has been issued. Estimated completion date, September 30, 1963.
2. Preliminary study of checkout and launch from the lunar surface. Completed January 31, 1963.
3. Study leading to the classification and characterization of the natural environmental hazards to Apollo mission success. Completed January 31, 1963.
4. Support in the development of a mission assurance program for Apollo. Completed: February 15, 1963.
5. Formulation of the systems requirements and development of a broad implementation plan for the Apollo communications and tracking system. Estimated completion date: September 30, 1963.
6. Apollo trajectory analysis and coordination. Estimated completion date: September 30, 1963.
7. Assistance in evaluating an in-flight test system. Estimated completion date: September 30, 1963.

In addition to these examples, Bellcomm has been and will continue to be engaged in supporting the Office of Manned Space Flight in many varied systems analysis and engineering activities. To date, it has provided support on such subjects as guidance and navigation systems, radiation and meteorite effects, mission assurance techniques, logistics support to Apollo, mission mode comparisons, flight simulation by computer programing, and crew performance in space missions.

As a result of Bellcomm's support, the manned space flight program is gaining the immediate benefit of a highly qualified and experienced team of scientists and engineers. The availability of this specialized scientific and technical talent in the formative stages of the program has been of invaluable assistance. The studies mentioned above will contribute immeasurably to the efficiency and engineering soundness of the program. The quality of this relatively small but extremely vital systems engineering effort is a key factor in the effectiveness of the overall program.

Mr. FULTON of Pennsylvania. Now that we have ascertained the fact that there is equipment, I think we should have a list of all of the equipment that Bellcomm is obtaining to set up this contract so that we can see the extent of it.

(The information requested is as follows:)

The only equipment Bellcomm has acquired (other than the computer configuration which is on order and general office supplies and furniture which was mentioned previously) is comprised of ordinary business machines, such as typewriters, copy machines, calculators and the like.

Mr. FULTON of Pennsylvania. Likewise, we should have a comparison of the rental charges on this particular type computer equipment at a cost of a million dollars a year to see that it is an ordinary, fair and just expenditure.

(The information requested is as follows:)

Rental charges for specific items of computing equipment are generally standard throughout industry. The rentals that Bellcomm will pay for computing equipment to support the manned space flight program are identical to those equipment rentals that would have been paid by any Government organization. Before the Space Administration approved Bellcomm's rental of the equipment, these costs were reviewed by NASA and were found to be consistent with standard rentals of identical equipment.

Mr. FULTON of Pennsylvania. Likewise on the rent, we should know what rent Bellcomm is paying on the premises because the cost will eventually fall on the Government when there is a cost-plus-fixed-fee contract.

(The information requested is as follows:)

The monthly rental for Bellcomm's premises at 1100 17th Street NW., Washington, D.C., is $25,335. The rate on an annual basis is $5.99 per square foot, which is average for comparable space in the area according to an appraisal made by H. G. Smithy Co., an experienced Washington realtor, under date of June 11, 1962.

Mr. FULTON of Pennsylvania. Also, Mr. Roudebush, I'm sure you would like to know if they bought any $247 chairs, or was it $257?

Mr. ROUDEBUSH. $247.

Mr. FULTON of Pennsylvania. $247 chairs and, if so, the number.

Dr. HORNBECK. The furniture, sir, was purchased by Bellcomm out of its own funds.

(The information requested is as follows:)

No office chairs at or in excess of $247 have been purchased by Bellcomm. A review of our purchase orders indicates that the average price paid for office chairs is about $62.

Mr. FULTON of Pennsylvania. Sure—but we want to know what price you are paying for your furniture.

We don't want you to get into any of these NASA chairs. I'm sure Mr. Brainerd Holmes doesn't have one.

Mr. HOLMES. I have a stool, Mr. Fulton.

Mr. FULTON of Pennsylvania. I am very glad that when the question first came up, Mr. Holmes said: "What chairs?"

Now then, on page 404 of the transcript of the hearing on March 20, on behalf of Bellcomm, there was the statement:

I hope we will be able to make contributions of a general nature in terms of reliability, quality control, and such important things.

"We don't have any control over the"—I am just quoting from memory now—"awarding of the contracts or the judgments of NASA." Briefly, that is how the statement finished.

Under those circumstances, the question comes up. What is the difference between the Bellcomm contract and the General Electric contract? It has been my feeling that the General Electric contract

was not on this basis of systems engineering and that Bellcomm was not in the field of integration, checkout, and reliability, and quality control. The two should be kept separate. I'd like that carefully in for the record, not just answered here.

(The information requested is as follows:)

The Bellcomm and General Electric contracts in support of the manned lunar landing program are distinguishable from one another in the following manner. Bellcomm, under the technical direction and supervision of the Deputy Director of Manned Space Flight (Systems), provides systems engineering support to develop the factual basis which responsible NASA officials require to reach a wide-range of decisions on the definition and specification of technical programs. In contrast, the General Electric Co., following the established systems definitions and specifications, verifies the readiness of all fabricated systems elements to perform effectively. General Electric, therefore, implements the detailed integration of major systems, such as the electronic, electrical, and mechanical linkages; insures a checkout process which examines every component of the system in detail to assure proper functioning; and provides continuing reliability assessment of the critical system components.

Bellcomm and General Electric activities are separate and distinct. Bellcomm is involved in the determination of mission profiles, systems specifications and other systems engineering functions; whereas General Electric is involved in the implementation of standards to assure proper integration, reliability, and checkout of hardware.

Mr. FULTON of Pennsylvania. The question has come up of how you were given the perimeters of your work in Bellcomm. Who is it that sets them? How are they set? How are the requirement sheets given to you, and how do you report back, and through whom?

The question has come up—I ask this of Mr. Holmes—of the Office of "Assistance" of NASA. Can you put in the record what that is and how that works? Who uses the Office of "Assistance"?

Dr. SHEA. I think that is the Office of "Systems."

Mr. FULTON of Pennsylvania. In the Office of "Assistance." I hadn't heard of it.

Dr. SHEA. There is no Office of "Assistance." I think that's probably a mistake in the record. It refers, of course, to the OMSF Systems group.

Mr. FULTON of Pennsylvania. The Bellcomm contact is with the "Office of Systems." I'd like you to proceed to lay out just how it works.

(The information requested is as follows:)

A principal technical contact between Bellcomm and the "Office of Systems" is the Deputy Director (Systems) Dr. Joseph F. Shea. Assignments of work are transmitted to Bellcomm by Dr. Shea, or a specifically designated NASA representative. Bellcomm's progress and results are reported regularly. The work entails special studies of a continuing nature and informal discussions and consultations on the variety of technical subjects that are encountered in day-to-day systems engineering activities. In this relationship Bellcomm provides technical staff assistance, on which the Deputy Director (Systems) and other NASA officials responsible for manned space flight can make sound decisions. Management responsibility rests clearly with NASA.

Mr. FULTON of Pennsylvania. Then, with Bellcomm or any Bell System, I'd like a list of the contracts with the Government above $25,000.

Dr. HORNBECK. Bellcomm has only one contract.

Mr. FULTON of Pennsylvania. No, but the Bell Telephone System does. What contracts do you have with the Government, otherwise?

Your employees think they work for the Bell Telephone System——

Mr. RIEHLMAN. I don't think we can ask that question of the gentleman with Bellcomm.

Mr. WAGGONNER. Certainly, we can't ask that question and expect him to be responsive, unless we place a time we expect this to be effective.

Mr. FULTON of Pennsylvania. Well, we have to look here for diverse interests. I would like to see what there might be by way of diverse interests, such as the Bell System supplying equipment which Bellcomm recommends be used.

Dr. HORNBECK. There is no such instance.

Mr. FULTON of Pennsylvania. I want to make sure there isn't. If you want the amount higher than $25,000, I'd be very glad to do it.

Mr. RIEHLMAN. Mr. Chairman?

Mr. DADDARIO. Yes, Mr. Riehlman.

Mr. RIEHLMAN. May I ask if this line of questioning is confined to Bellcomm? I think we must confine the questions to Bellcomm. That is what we are talking about, and whether Bellcomm has contracts with other agencies.

I just don't see how we can go in the background of the other companies of the Bell System. If we did, we would have to ask the very same thing of General Electric.

Mr. FULTON of Pennsylvania. There seems to be disagreement on the committee. I would like to have, within reason, a statement from the Bellcomm people, and the Bell Telephone System, so that we can judge that there are no adverse interests. Second, I would like a statement that Bellcomm is not making judgments on engineering systems which then require the use of certain equipment of the Bell Telephone System.

Mr. HOLMES. I think, Mr. Fulton——

Mr. DADDARIO. Mr. Holmes, since there is some question as to what this amounts to, if the committee could take that up by itself in executive session, we can discuss it then and make a determination.

Mr. RIEHLMAN. May I get this in the record. I have no objection to getting every bit of information that is necessary for this committee to pass judgment on the activity of Bellcomm, but I think this is something which we ought to consider further before we ask Bellcomm and NASA to try to give us information that I don't think is possible.

Mr. DADDARIO. We will come to the determination of that within the committee itself, and then decide if the question should be asked.

Mr. FULTON of Pennsylvania. The question can be asked.

The question is whether they shall be required to answer. The question has been asked, which I, representing my district, have the full right to ask because the taxpayers in our area pay $1,250 million a year to the Federal Government. I am certainly very interested in seeing how our money goes on this type of contract and——

Mr. RIEHLMAN. Mr. Chairman, that——

Mr. FULTON of Pennsylvania. I haven't yielded—if there is any case where a company in an advisory capacity recommends the use of equipment manufactured by subsidiaries without outside bidding and without outside design and engineering I want to make sure that we are not running into such a case here. One of the charges against this program is that certain companies are being given the inside track. I would rather not have that. We are not going into it, and I am prevented from even asking the question.

The other point I want to say is this——

Dr. HORNBECK. May I make a comment that might ease your problem?

Mr. RIEHLMAN. Before we go further, Mr. Chairman, I want the record to show that there is no implication by the gentleman from Pennsylvania that we don't have an interest in the people in our district, just as he has.

No one is trying to protect anyone, or to keep from this committee the knowledge that it needs to act in good judgment on these matters.

Mr. WAGGONNER. Would the gentleman yield, for one brief statement?

Mr. FULTON of Pennsylvania. Could I just say, before we get into an argument among ourselves; in answer to this, because my name has come up, that each of us has the full responsibility for the taxpayers' money. We simply look at it differently.

I look at this particular issue as a major point which perhaps others would not, and I do not mention any other person on the committee. I speak only of my own responsibility. Of course, it is natural that we vary as to our points of emphasis. I want to make sure that there is no company in an advisory capacity which is able, by the advice it gives on engineering systems or design, to even have a tendency toward that company's specific products, components, or hardware of any type, without giving everybody in the industry an adequate chance to compete.

Mr. HOLMES. We would like to make a statement for the record in response to that point. I think we can tell you about NASA contracts and about Bellcomm contracts. I don't think it's within our responsibility to tell you about anything except NASA contracts. We can certainly indicate in a statement how we operate so that Bellcomm is not in a position to do this work.

Mr. FULTON of Pennsylvania. That's what I want to hear.

Mr. DADDARIO. That is exactly the point to which I made my suggestion that we confine the question to that area within which NASA has the responsibility and the knowledge to spell out an answer to the question made by the gentleman from Pennsylvania.

Mr. FULTON of Pennsylvania. We are not too far apart.

Mr. DADDARIO. We are not apart at all.

Dr. HORNBECK. May I make a comment, sir?

Mr. DADDARIO. Yes, sir.

Dr. HORNBECK. In the hope that this might ease your problem, I would volunteer to submit for the record the contracts of Western Electric, which I think are as pertinent as any other thing, with NASA since Bellcomm was formed. I would willingly offer this, if it would help solve your problem.

Mr. HOLMES. I think if any contracts for NASA are given, they should be given by NASA. We can cover a broader scope.

Mr. FULTON of Pennsylvania. I agree to that.

Mr. DADDARIO. I think this is the extent to which the question should be confined.

Mr. FULTON of Pennsylvania. We do want any other contracts of the Bell Telephone System with NASA.

Mr. DADDARIO. This will be given, "with NASA," and I understand that is perfectly agreeable with you, Mr. Fulton?

Mr. FULTON of Pennsylvania. Fine.

(The information requested is as follows:)

With the exception of normal communications services, the following list reflects prime contracts in excess of $25,000 released by NASA to A.T. & T. divisions and/or subsidiaries since the formation of Bellcomm, Inc.:

Western Electric Co.

Contract No.	Contract date	Cumulative award (through April)	Description
NAS 5-2058	Sept. 27, 1962	$180,000	Furnish radiation packages and analyze data.
NAS 5-4656	Mar. 29, 1963	42,840	Special purpose data transmission terminal.
NAS 8-5142	Oct. 5, 1962	55,721	Cover panels, cabinets, etc.
NAS 8-6006	Nov. 21, 1962	253,355	Communication components.

Mr. DADDARIO. Let's get on with the next question.

Mr. FULTON of Pennsylvania. What would happen if you kept the personnel at the same rate in fiscal year 1964, as you now have in the work you are doing at Bellcomm?

Dr. HORNBECK. I believe that we were already asked that question in slightly different words and the answer is in the record. The simple answer is that we wouldn't be able to do the job which NASA expects us to do.

Dr. SHEA. I think that we ought to realize that we are in the process of building the organization. The reason that it's at the current level is that we are strengthening it as fast as we can without diluting the present high quality and standards.

Mr. FULTON of Pennsylvania. There is one point I don't understand. Why is Bellcomm hiring people from the outside in competition with NASA? At least one-third of the personnel of Bellcomm are from the outside. Why don't you have people of that nature hired by NASA?

Mr. HOLMES. We do, within the limitations of salary and government employment that we have. I think the direct answer is that we cannot build this full strength in Government for several reasons.

I don't know of any case where we compete directly for people with Bellcomm. Certainly, indirectly one does. Nor do I know of a single case where there has been any proselyting or transferring of people from our payroll at NASA to Bellcomm. We have been very careful to take action to guard against such a situation.

Mr. DADDARIO. Certainly, it is encouraging that you have been building Bellcomm in that way.

Mr. Waggonner?

Mr. WAGGONNER. I personally concur with the idea of not building an in-house capability within NASA to do the work Bellcomm is doing. I think we ought to utilize industry in the best way possible as we are doing with Bellcomm and as we are doing with General Electric.

The idea is sound, and I think the only thing that remains for us to do is to define clearly the limitations of this contract. A contract must be written which will preclude the possibility of anything happening along the way which can be subject to question by other people in industry, or which will reflect on everyone concerned and will, in the end, disrupt our program.

I agree completely that some equipment in the way of computers is needed for Bellcomm or for anyone else to do this job. Bellcomm needs something other than a slide rule, adding machine, and calculator, the same as General Electric does.

In situations with regard to procurement of computers in cases which involve either a subcontractor or a prime contractor, does NASA employ the competitive bidding principle in procuring these computers or does it negotiate lease contracts for these computers.

Mr. HOLMES. Wherever possible, in these areas, we do use competitive bidding. More often than not, in today's computor business there are machines that are of known requirements that are rented pretty much off the shelf at a known rate. In that case, I imagine one might say that one is negotiating by knowing these facts and obtaining the necessary machines.

That's pretty much like buying off-the-shelf equipment or renting off-the-shelf equipment when one does that.

Mr. WAGGONNER. You would say it is the practice, wherever possible, to use the bid procedure?

Mr. HOLMES. Yes; Mr. Waggonner, it is the practice in any case where it appears to be in the best interests of the Government, which is most cases, to proceed by the bid procedure.

Mr. WAGGONNER. I believe last year we heard testimony to the effect that seven or eight companies furnish computers to the Government. Is that still the case? Are we still doing business with a number of suppliers?

Mr. HOLMES. With a number of suppliers; yes. I don't know the total number, but I would think it would be at least seven or eight.

Mr. WAGGONNER. Could you, Mr. Holmes, furnish for the record the names of the companies which are doing the contract work or selling computers to NASA?

Mr. HOLMES. Yes; Mr. Waggonner, we can do that.

(The information requested is as follows:)

Principal suppliers of computer and computer services to NASA at the present time include the following:

Remington-Rand Corp. (Sperry Rand)	Computron, Inc.
General Electric Co.	Computer, Products
RCA	Computer, Laboratories, Inc.
Burroughs Corp.	Computer Dynamics
IBM Corp.	Computer Control Co.
International Data Systems	Computer Applications

Mr. WAGGONNER. I think that is a matter on which we can agree that we are following a double standard in some respects, although I don't think it is quite as extensive as some would believe with regard to computer procurement policies. We are buying some computers, and we are leasing some computers.

I believe that Mr. Holmes or Mr. Low testified the other day that a study was being conducted by NASA and the General Accounting Office to determine what the best policy would be with regard to future computer procurement. Could you give us any idea what the status of that survey or study is?

Not only what the present status is, but when you expect to complete such a study and have a firm policy to follow? I personally believe that we are going to find that in the end it is better to buy in some cases and better to lease in some cases Could you tell us what the status of that overall study is?

Mr. HOLMES. I think that your conclusion is correct; a specific case will govern more than anything else the decision whether to buy or to lease. Certainly, for many of our installations we expect to update

continually the installation or we expect to vary the program materially for the particular computer and wish to have the basic program elements be such that it can be used in the future. Therefore, we would want to assure ourselves either by purchase of the computer or by renting the computer that it wouldn't be made obsolete in the near future.

Now, the specific case which I mentioned the other day was the Integrated Mission Control Center at Houston; we are using computers there in considerable number and magnitude. We actually need four very powerful machines, and we have conducted a study to determine where the cost break-even point would be in terms of purchase versus rent.

In this case, it appears to be somewhere in the year 1966. That is to say, if we purchased the computers, we'd be ahead by 1966; whereas if we rented the computers and used them beyond 1966, we'd be losing money by paying more out in rent. I think that study, however, is going to indicate that it is better to rent than it is to purchase.

It would be better to rent over this period of time and then be able to update by changing the machines and not keeping the same ones and being forced to rent new ones. It will be more economical for the Government.

But this conclusion could change from situation to situation.

Mr. WAGGONNER. Could you give us any information as to what you believe the turning point is with regard to buying or leasing?

What computers do you feel that we should now lease, and should continue to lease in the future?

Mr. HOLMES. I think I can answer it in a general way. I can't answer in a specific way.

Mr. WAGGONNER. Just general.

Mr. HOLMES. In a general way, if we have an operation where we can buy a computer that will do the job properly and won't require updating for a number of years, it's certainly going to be cheaper to buy the computer and pay only for maintenance contracts.

If the reverse is the case, if we want to keep it up to the latest state-of-the-art of computers and we believe this capability would be changed in a few years, capital investment would be the foolish way to go and it would be better to rent it.

Mr. WAGGONNER. You believe the state-of-the-art in computers is such that NASA could now enter into an arrangement for computers that would be sufficient to meet the needs of the Apollo program through to a successful conclusion, or is it more probable that we are going to have to continue to update these computers as this Apollo program draws to a climax.

Mr. HOLMES. In many cases the demands on the computers are so great that we would wish them to do more either by a higher rate of speed or greater memory and it would probably be better to upgrade them as improvements are made.

I think in relatively few cases, the computer requirements are going to be so static that it would be more efficient to buy the machine and keep it over a long period of time.

Mr. TEAGUE. Doesn't the Bureau of the Budget have an established policy which NASA must follow insofar as electronic equipment is concerned?

Is there a general policy throughout the Government, or is it left to each agency to decide?

Mr. HOLMES. Are you referring to a policy of purchase versus rent?

Dr. HORNBECK. There is a general policy.

Mr. TEAGUE. That answers the question.

Mr. HOLMES. On what? On what subject—purchase versus rent?

Dr. HORNBECK. On that subject. On the acquisition.

Mr. HOLMES. I don't understand either the statement or the question.

Mr. TEAGUE. I assume that with regard to all the electrical equipment within our Government there is a general policy to give you some guidelines as to how you are to handle your electronic problems, whether you purchase or whether you rent?

Dr. HORNBECK. On the acquisition.

Mr. TEAGUE. Mr. Yeager, will you try to obtain that information for the record from the Bureau of the Budget?

Mr. YEAGER. Yes, sir.

(The information referred to is shown in app. E. See also app. F, report to the Congress of the United States entitled "Study of Financial Advantages of Purchasing Over Leasing of Electronic Data Processing Equipment in the Federal Government," by the Comptroller General of the United States, dated March 1963.)

Mr. WAGGONNER. Just one other question and this is in line with the question the chairman has just asked.

Do we have a disposition policy with regard to purchased computers? Are there guidelines from the Bureau of the Budget which dictate the disposition policy?

In other words, is the trade-in value so extremely low that actually we lose money by training the men and could profit more, for example, by having a reasonable surplus property disposal procedure which would allow us to place these in our institutions of higher learning and other areas from which we could all benefit?

Mr. HOLMES. May we get that for the record, Mr. Waggonner? I don't really know.

Mr. WAGGONNER. Yes.

(See app. E and F mentioned above.)

Mr. TEAGUE. Mr. Riehlman?

Mr. RIEHLMAN. I have no questions, Mr. Chairman, but I would like to say that I think our distinguished gentlemen, Mr. Fulton and Mr. Daddario, have gone to great depth in this Bellcomm contract which I think will resound in very useful and valuable information for the committee in the future.

Mr. FULTON of Pennsylvania. That is very kind.

Mr. TEAGUE. I agree with the gentleman from New York and I would like to say to the witnesses that these facts will be very helpful when we take this bill to the floor of the House. The Members of Congress can't say that these contracts have just been glanced over and not covered in detail.

Mr. Gurney?

Mr. GURNEY. Everyone is making a statement here, and I would like to make one also.

I concur wholeheartedly in what Mr. Waggonner said in his opening statement. I think in this day of big government it's certainly re-

freshing to me to see NASA, a Government organization, using private enterprise in this fashion by means of this Bellcomm contract.

I think this committee should certainly examine the extent of the contract as it has today. Such examination might show; one, that other businesses in this scientific endeavor are not being frozen out and are, in fact, given equal opportunity. It can be extended to them. I think the thing that we really haven't gone into at all today, and I would like to ask a question or two about this, is whether there is any duplication in the Bellcomm contract and in the General Electric contract.

I believe this was mentioned when we first began the testimony this morning, but I think we ought to go into it a little further. For example, we have developed the fact that a part of Bellcomm's effort is to establish systems requirements, establish a uniform set of design data, and define the technical approach. Yesterday, we also learned from examining the General Electric contract that it had something to do with conception and design of systems that go into the lunar landing program.

Well, I don't quite understand that. I wonder if you could define more specifically where the Bellcomm people are working and where the General Electric people are working. For example, take the onboard guidance system which you talked about yesterday. I hesitate to bring in the word computer again because we certainly settled that hash today, but we did talk yesterday about a computer aboard the command module, I believe, and then we also talked yesterday about the fuel system of the LEM. All of these are design requirements as I understand it. What does Bellcomm do in these fields, and what does General Electric do in these fields?

Mr. HOLMES. Could I present a hypothetical case for a moment? I think that it might help to clarify Bellcomm's role and General Electric's role in support of our program.

If we talk about building an automobile which is to run not on the Moon but on a little known, unmapped part of the Earth—suppose we say that it has to run on a hypothetical area in Africa, which was not studied in great depth. Our objective, then, is to build an automobile that will operate in this environment.

In this hypothetical case, the Bellcomm people are going to work with Dr. Shea in order to determine various concepts: What is the environment? Is it muddy? Is it wet? Is it dry? Is it cold? All these factors have to be investigated. As part of its assigned tasks, Bellcomm is going to study what speed is involved and what loads are required, and other factors, which are involved in carrying out the mission of making this automobile work in the environment; then Dr. Shea's group, supported by Bellcomm, will specify what the automobile will be, what type of roads it will be using, whether or not it should have wheels, or what type of power or type of fuel capacity it will have. All these general concepts will have to be established.

Then the General Electric role comes into the picture. G.E.'s function is to implement these concepts, to assist us in seeing that the contractor parts function well, together and separately. Pieces and parts have to be carefully tested and, of course, specialized test equipment has to be built to accomplish this. G.E.'s effort will also include reliability analyses, to take tests and data on sparkplugs, if that's the way the engine is being run, on tires, on all the parts—to

study all parts of it so that we can assure that this machine is going to operate reliably when all the parts are assembled.

Further are the interfaces: How these pieces fit together. Are the windows going to fit? Will the windshield fit? All these questions have to be answered.

On one hand you have the concepts and on the other you have monitoring and testing as these concepts are brought into reality.

Mr. GURNEY. Thank you. That means a good deal to me, and I understand it much better. Take the specific instance I mentioned on the fuel systems of LEM; I take it that you would come up with a figure that you need so much thrust, or that the engine must burn for so long a period of time, and then General Electric designs where the fuel tank is going to be and how big it will be. Is that it?

Dr. SHEA. No, sir. That's not quite it, because the General Electric people don't physically do the design. The design is assigned to the contractor through one of our centers. In the case of the LEM, through the Manned Spacecraft Center in Houston to Grumman. Grumman carries out the design.

The G.E. people would, in effect, in this instance, review the test procedures that are going to be implemented with respect to the engine to be sure that those test procedures reflect the over-all requirements in terms of thrust level, number of times the engine has to be able to operate, the ability to throttle the engine over a certain range, and related areas.

They would assure that the test procedures are proper and when the tests are run, we'd expect them to get the data in parallel with Grumman and Houston and again examine the data to be sure the tests as run, did indeed, conform with the overall specifications.

In addition, they'd get data on every engine test and from that data would be able to estimate the reliability of the overall engine and feed that particular estimation of reliability back into our overall calculation for the entire mission. Now, it turns out that an engine doesn't have much of an interface with the rest of the overall system. It's pretty well contained.

If I might take another 2 minutes, I might address myself to your first example, which I think is a good one, and which will illustrate how G.E. works on the interfaces as well.

The guidance system has a computer but I hasten to add a special-purpose computer for flight purposes. It's really a special development job. That computer must be able to guide the spacecraft and then, in effect, send signals to the control system and the engine aboard the spacecraft. But it also, for redundant purposes, has to be able to guide the launch vehicle.

The kind of analyses that Bellcomm would do would be to say how fast the computer has to operate, how much memory capacity is needed—in other words, how many different things it has to be able to do and what signals it should send. The kind of thing that would come out of Bellcomm would say the guidance computer ought to send pitch, roll, and yaw steering signals to the spacecraft guidance system and to the launch vehicle guidance signals. It ought to be able to send signals to the engines to cut off the engines at a precise instant. Bellcomm might say: You have to send the signal so fast.

The next problem is one of design. The people who design the guidance computer might come up with what you might call the first cut of the design.

Now, you have the problem that the output of the computer has to go into an automatic control system in order to be able to control the vehicle. It actually has to go into two systems. One is in the spacecraft and the other is in the launch vehicle. Now the launch vehicle people and the space vehicle design people would have been working together trying to design what you call a common interface.

What do they mean by this? The voltage that comes out of the computer—in order to give a certain roll command, we might have to control it by the voltage or the magnitude of the voltage—would be proportional to the signal you want to give.

The GE people would check that interface to be sure the voltage coming out of the computer, the things you want to define, such as the wavelength, etc., will feed both the spacecraft and the launch vehicle so that they get down to what we call, in our jargon, a mechanization level.

Then there's still another level to which they have to go. This is what you call the detailed design level. Finally, out of the computer you come up with a terminal board and on the terminal board there is a multitude of wires. Certain signals are supposed to appear on these wires. Another related terminal board would exist elsewhere in the spacecraft, in the attitude control system, for example, and in the launch vehicle's attitude control system.

When drawings of these boards are made, GE will get a copy of those drawings and check them to be sure that each wire comes from the right place and goes to the right place. Does that help to clarify the roles of Bellcomm and GE?

Mr. GURNEY. Yes.

Mr. RIEHLMAN. In that area, would they not also have the responsibility to bring into being new designs for consideration?

Dr. SHEA. In general, no, sir.

Mr. RIEHLMAN. They wouldn't?

Dr. SHEA. Their responsibility is one of checking. When they find the problem, they bring it to the attention of either the NASA center involved or to our office.

They may suggest a solution to the particular problem that exists. In general, we don't look to GE to solve those problems as much as we look to them to check that everything is, indeed, proper.

Mr. RIEHLMAN. I see.

Dr. SHEA. It is a check and balance function rather than a matter of original design.

Mr. PATTEN. Mr. Chairman, the research centers, the men associated with Bellcomm, are located in my state and I have visited both of them. I was always under the impression that Murray Hill was the first, the biggest, and the best in the whole world. They operate that in Monmouth County in Homedale, and both institutions dwarfed anything I have seen in NASA in this same line of communications.

Mr. FULTON of Pennsylvania. That is really saying something, too.

Mr. PATTEN. Now in New Jersey, Bell Telephone gives us the service of their people continuously and for free. Bell has always lent us their top people to survey the State every year to check our cost and everything, and they never got a penny for it. They gave us

beautiful reports. They surveyed our business methods in operating the treasury. They sent their top people to make the survey as a result of which we installed some computers and things of that type. I sit here as we talk of Bellcomm and I feel like you can have a hundred doctors around, but if one of them had gall bladder trouble, he always knows a better doctor he wants to go to. When you want to meet the better men in communications, you have to go to the people from where Dr. John Hornbeck came from. They really know what they are doing. It is really thrilling. They are the best citizens we have, and I have every faith that NASA acted wisely in using their know-how and their facilities.

This contract strikes me as very logical and in the long run NASA is going to get a lot of know-how that it couldn't get any other place.

I'd like to say that for the record.

Mr. FULTON of Pennsylvania. Would the gentleman from New Jersey yield?

Mr. TEAGUE. I was going to tell him he sounded like someone from Texas talking over there.

Mr. YEAGER. If it's all right with you, Mr. Chairman, I have a few questions which I would like to submit to Dr. Shea.

(The information referred to is as follows:)

QUESTIONS REGARDING THE GENERAL ELECTRIC CONTRACT

Question 1. Relative to the "Integration and checkout" budget request for fiscal year 1964, how much of the direct research and development cost represents the General Electric contract?

Answer. The "Integration and checkout" budget request for fiscal year 1964 is estimated at $153 million. At this time, the GE portion of this program is estimated to be approximately $100–$125 million.

Question 2. If there is a balance of direct R. & D. money, what will this money be used for?

Answer. The balance of the direct R. & D. money will be used to fund work performed by other contractors or by the NASA centers. The exact amount of funds required for this effort will be determined as the program progresses and decisions are made regarding whether GE makes or buys certain parts of the program or whether these items are furnished to General Electric by NASA through its field centers or other prime contractors.

Question 3. Are the personnel listed for this part of the budget concretely identifiable or is this a proration of the total operating budget?

Answer. The personnel figures listed were arrived at through a proration of the total operating budget.

Question 4. If the personnel can be identified, exactly what will they be doing?

Answer. Not applicable, see answer to question 3.

Question 5. Is the figure of $2.6 million given for the operation of installations a prorated figure as NASA officials have explained regarding some other portions of the 1963 fiscal year budget?

Answer. Yes; it is a prorated figure.

Mr. TEAGUE. We can do that.

Lots of good luck, and we will hope for the best of success between now and next Thursday.

The committee will stand adjourned.

(Whereupon at 11:40 a.m. the committee was adjourned to meet at the call of the Chair.)

1964 NASA AUTHORIZATION

TUESDAY, MAY 21, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
JOINT MEETING OF THE SUBCOMMITTEE ON MANNED SPACE FLIGHT, AND THE SUBCOMMITTEE ON SPACE SCIENCES AND ADVANCED RESEARCH AND TECHNOLOGY,
Washington, D.C.

EXECUTIVE SESSION

(The following testimony was taken in executive session because of the possible classified nature of the material presented. The testimony as shown below is unclassified.)

The subcommittees met in joint session at 10 a.m., the Hon. Olin E. Teague presiding.

Mr. TEAGUE. The committee will come to order.

This morning the committee will hear Maj. Gen. Theodore C. Bedwell, Jr., commander of the Aeromedical Division of the Air Force Systems Command, Brooks Air Force Base, and Capt. Clifford P. Phoebus, commanding officer, Naval School of Aviation Medicine at the Naval Aviation Medical Center, Pensacola, Fla.

General Bedwell, will you introduce the colonel with you?

General BEDWELL. I have Col. John E. Pickering, Deputy Chief of Staff for Research and Development.

(The biographical sketches of General Bedwell and Col. John E. Pickering are as follows:)

MAJ. GEN. THEODORE C. BEDWELL, JR., U.S. AIR FORCE, MEDICAL CORPS

Maj. Gen. Theodore C. Bedwell, Jr., son of Mr. T. C. Bedwell, Sr., Greenville, Tex., was born March 31, 1909, and now calls Dallas, Tex, his home. He graduated from Southern Methodist University with a bachelor of science degree, and from Baylor University Medical College, in June 1933, where he received a doctor of medicine degree.

He practiced medicine and surgery at a clinic hospital in Longview, Tex., prior to entering active duty in 1935. His first assignment was with Fitzsimons General Hospital, Denver, where he served until November 1939.

He attended a postgraduate course in industrial medicine at Harvard School of Public Health in 1941. During the following 18 months he was Chief of Industrial Medicine in the Preventive Medicine Division in the Office of the Army Surgeon General.

His first Air Force duty was as a student in the flight surgeon's course at Randolph Field, Tex. Upon graduation, he was assigned to McClellan Field, Calif., in December 1942, for duty as base surgeon and hospital commanding officer.

During World War II General Bedwell served as hospital commander, base surgeon, and command surgeon for the Air Materiel Command, Hill Field, Utah; and as commanding officer of the regional hospital and area surgeon for the Warner Robins air materiel area. During this time he also served on temporary

duty to organize the 6th Central Medical Establishment assigned to 8th Air Force on Okinawa.

From February 1946 until March 1948 he was assigned to Headquarters, Air Materiel Command, Wright Field, Ohio, where he served first as deputy surgeon and chief of industrial medicine and later as command surgeon.

In April 1948 he was assigned to Far East Air Forces as staff surgeon for 5th Air Force at Nagoya, Japan.

In June 1951, he was awarded the master of public health degree upon completion of postgraduate course at the Johns Hopkins School of Hygiene and Public Health, Baltimore, Md.

In October 1951, he received certification from the American Board of Preventive Medicine and Public Health. From July 1951 and 1952 he attended the Air War College, Maxwell Air Force Base, Ala. He was certified as a specialist in aviation medicine in 1953 and in occupational medicine in 1956.

Following graduation from Air War College, he was assigned as a staff member to the assistant for health and medicine in the Office of the Secretary of Defense. Later he served as Chief of Preventive Medicine, Office of the Surgeon General, Headquarters, USAF.

On August 1, 1956, he was assigned as deputy surgeon for the Strategic Air Command with headquarters at Offutt Air Force Base, Nebr. He was named command surgeon September 1, 1959. On February 1, 1961, he was named commander of the USAF Aerospace Medical Center (ATC), Brooks Air Force Base, Tex. The Aerospace Medical Center was reorganized into the Aerospace Medical Division of AFSC on November 1, 1961. At that time the Aeromedical Research Laboratory of Holloman Air Force Base, N. Mex., and the Aerospace Medical Research Laboratory of Wright-Patterson Air Force Base, Ohio, came under jurisdiction of the Aerospace Medical Division.

He holds the rating of chief flight surgeon. His decorations include the Air Force Commendation Ribbon with Oak Leaf Cluster, World War II Victory Medal, Republic of Korea Presidential Unit Citation Emblem, and Occupation Medal (Japan).

He is a fellow of the Aerospace Medical Association, the American College of Preventive Medicine, and the Royal Society of Health. He holds membership in the Association of Military Surgeons, Industrial Medical Association, American Medical Association, and the American Public Health Association.

From 1957 to 1959, he was a member of the Executive Council of the Aerospace Medicine Association and in 1960 he served on the executive committee of that organization and now is president-elect of the association. Also, in 1960 he was vice president for Aviation Medicine of the American College of Preventive Medicine.

He married the former Blanche Elizabeth Harper on June 1, 1935, in Dallas, Tex. They have a daughter, Geverly Anne, who is a graduate of Bucknell University.

He was promoted to first lieutenant, November 17, 1935; captain, June 1, 1937; major (temporary), February 1, 1942; lieutenant colonel (temporary), June 23, 1944; brigadier general (temporary), June 5, 1956, permanent, March 23, 1960; major general (permanent), February 28, 1963.

The most recent papers published by General Bedwell are "Medical and Public Health Aspects of Nuclear Weapons Incidents in Peacetime," Armed Forces Medical Journal, September 1960; "Medical Service in the Strategic Air Command," Medical Service Digest, January 1961; "Medical Support of ICBM Operations," in press, Aerospace Medicine.

COL. JOHN E. PICKERING, DEPUTY CHIEF OF STAFF FOR RESEARCH AND DEVELOPMENT

Born April 27, 1918, Bisbee, Ariz. Universities attended and degrees received: University of Arizona, 1936–40, B.S.; University of Arizona, 1940–41, M.S.; 1945, M.S., meteorology, University of Chicago; 1947–48, Pre-Ph. D., University of Chicago. Postgraduate training: University of Chicago Institute of Nuclear Studies, 13 months; nuclear weapons course, Los Alamos, N. Mex.; nuclear weapons course, Sandia Base, N. Mex.; USAF Radiation Laboratory, University of Chicago—meteorology. Major assignments: 1942–45, navigation, navigation instructor, flight commander, and squadron commander; 1945–46, meteorology training; 1946–47, weather research; 1947–48 nuclear chemistry and nuclear physics, University of Chicago; 1948 to present, School of Aviation Medicine, Randolph Air Force Base and Brooks Air Force Base, Tex. Professional societies: director, Health Physics Society, Phi Lambda Upsilon (chem-

istry honorary), and Aerospace Medical Association. Civilian occupations: mining engineer and chemist. Teaching appointments: chemistry and metallurgy, University of Arizona 1938, 1940, 1941 (student and graduate assistant); 1958–61, Director of Research, USAF School of Aviation Medicine, Brooks AFB, Tex.; 1961, DCS/R. & D., Aerospace Medical Division, recipient of the University of Arizona 75th anniversary Medallion of Merit for distinguished service in research, February 1958. Military awards: Legion of Merit (for nuclear radiation theory on incapacitation). Certified by American Board of Health Physicians.

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Mr. TEAGUE. And Captain, who do you have with you?

Captain PHOEBUS. Capt. Walton Jones, Aviation Medicine Technical Division, Bureau of Medicine and Surgery.

(The biographical sketches of Captain Phoebus and Captain Jones are as follows:)

CAPT. CLIFFORD P. PHOEBUS, MEDICAL CORPS, U.S. NAVY

Clifford Preston Phoebus was born in Baltimore, Md., on May 11, 1910, son of Charles P. and Bessie D. (Wilson) Phoebus. He resided in Baltimore for only a few weeks, moved to Bloomfield, N.J., where he remained until age 9, then moved to the Brooklyn-Queens area of New York City. He completed high school at the James Madison High School, Brooklyn, N.Y., graduated cum laude in 1928. During these years he was active in swimming on high school teams, and in scouting where he achieved the status of an Eagle Scout.

He entered Lafayette College, Easton, Pa., in the fall of 1928. There he majored in chemistry and biology, pursuing a premedical course, and received a bachelor of science degree in June 1932. While in college he was a member of Delta Tau Delta, Alpha Chi Sigma honorary chemical fraternity, junior manager of the football team, captain of the swimming team, and active in other campus societies and organizations. Entering Jefferson Medical College, Philadelphia, Pa., in the fall of 1932, he was graduated with the degree of doctor of medicine in June 1936. There he became a member of the Alpha Kappa Kappa medical fraternity, and was active in various local scholastic medical societies.

After serving his internship at the George F. Geisinger Memorial Hospital, Danville, Pa., July 1936 to August 1937, he entered the U.S. Navy Medical Corps in the rank of lieutenant (junior grade) on August 19, 1937. Through subsequent promotions he attained the rank of captain, his date of rank June 1, 1953.

Reporting for active duty at the U.S. Naval Medical School, Washington, D.C., on August 21, 1937, he completed the basic course at the U.S. Navy Medical School (including the field medical school course at the Marine Corps School, Quantico, Va.) in April 1938. He attended the U.S. Army Chemical Warfare School, Edgewood Arsenal, Md., in May–June 1938, and the U.S. Army Air Force School of Aviation Medicine, Randolph Field, Tex., July to November 1938. Designated U.S. naval flight examiner upon completion of that course, he reported to the U.S. Naval Air Station, Pensacola, Fla., for the flight phases, completing this training in May 1939, with designation as U.S. naval flight surgeon.

In June 1939 he reported to the U.S.S. *Enterprise* (CV–6) for duty as flight surgeon to that ship's air group. The *Enterprise* cruised during that period between the west coast of the United States and Hawaii, and he served as junior medical officer of that aircraft carrier during the latter 8 months of this tour of sea duty which terminated in April 1941.

He was next attached to the Marine Corps Air Station, Quantico, Va. This tour of shore duty was marked by his leadership in the installation and initial operation of the first of the Navy's small, low-pressure chambers. During this same period he played the leading role in the design and construction of the present aviation dispensary at Quantico. He was detached on December 7, 1942, for duty with Fleet Air Wing 15.

Fleet Air Wing 15 was formed at Norfolk, Va., in December 1942 and immediately embarked for duty in antisubmarine warfare at Port Lyautey, French Morocco. Dr. Phoebus served as wing flight surgeon in this area until March of 1944. He was instrumental in the development of this base and led the major effort which was necessary from an epidemiological viewpoint for the survival of the wing personnel in this area of highly endemic diseases such as malaria, typhus, smallpox, the dysenteries, etc. In April 1944 he returned to the United States for duty on the staff of commander, Air Force, Atlantic Fleet, as assistant staff medical officer.

In October 1944 he was ordered to the Naval Air Station, Ottumwa, Iowa, for flight training. He completed the preliminary training in March 1945 and reported to the Naval Air Station, Pensacola, Fla., for the basic and advanced phases of flight training. He was designated naval aviator on September 20, 1945, and was detached a few days later. He joined the U.S.S. *Shangri-La* (CV–38) in October 1945, for duty as senior medical officer until February 1947. The ship operated in the Pacific off the coast of California, and in the Hawaiian area, with the exception of the period April through August 1946, when the ship's VX–1 (Air Development Squadron) participated in the Crossroads operation at Bikini.

Assigned to the Naval Air Auxiliary Station, Cecil Field, Jacksonville, Fla., in March 1947, he served there for 4 months as senior medical officer. This tour

of duty with the training command at a field where advanced operational fighter instruction was given, was brief and marked principally by his efforts in instruction and training of students in the physiological problems of flight.

He next had duty at the dispensary of the Naval Air Station, Norfolk, Va., as medical executive officer. During this tour of duty he played an active role in the many administrative and clinical problems confronting such an activity. As a naval aviator he was frequently called upon to fly various types of transport aircraft engaged in the evacuation of naval sick and injured personnel from outlying area hospitals, both naval and civilian to the Naval Hospital, Portsmouth, Va., and to fly an appreciable number of patients from that hospital to other specialty naval and civilian medical institutions. The combination of medical officer and naval aviator in the one man was most useful in this type of air evacuation mission.

In August 1950 he reported aboard the U.S.S. *Coral Sea* (CVB–43) for duty as senior medical officer. During this tour of duty ending in October 1951 the ship was employed principally as a unit of the 6th Fleet in Mediterranean waters. This assignment provided ample opportunity for experience not only with a modern air group which included jet fighters, but the operation of a large ship independent of any other medical facility. In this respect, the *Coral Sea*, to a large degree, acted as the hospital ship for the 6th Fleet. The contacts established with foreign medical personnel and institutions in the Mediterranean area were most valuable. He became interested in research as it related to venereal disease among naval personnel and submitted a report on the utilization of hexachlorophene soap for prophylaxis. He also organized a safety board for shipboard safety aboard the *Coral Sea* with excellent results insofar as accident reduction was concerned.

He reported in November 1951 to the Bureau of Medicine and Surgery as the head of the Aviation Medicine Branch of the Research Division. In that capacity he visited numerous service and civilian research activities in the field of aviation medicine and was deputy member of the Committee on Medical Sciences, RDB; member of the Human Engineering Panel of the Committee on Human Resources, RDB; the Armed Forces Vision Committee of the National Research Council; and the Armed Forces-NRC Committee on Hearing and Bio-acoustics. He also had additional duty with the Air Branch of the Office of Naval Research as aeromedical officer from May 1952.

In June 1953 Captain Phoebus was made Special Assistant for Bio-Sciences in the Office of Naval Research. In this duty he was adviser to the Assistant Chief for Research and the Science Director concerning the programs in the medical, biological, and psychological sciences and was responsible for the external relations of ONR in these areas. He had responsibility for all ONR sponsorship of research in these fields, particularly as to the adequacy of support given to Navy requirements through the contract programs of these two divisions in medical and personnel fields.

Captain Phoebus served in a close liaison capacity between ONR and the Bureau of Medicine and Surgery, and maintained the relationship of ONR with the Bureau of Naval Personnel as well as coordination with other agencies engaged in medical research. He was a member of the Committee on Medical Sciences, RDB, and a deputy member of the Committee on Human Resources, RDB. He was appointed the Navy member of the Division of Medical Sciences of the National Research Council and continued in his capacity as Navy member of both the Armed Forces-NRC Vision Committee and the Armed Forces-NRC Committee on Hearing and Bio-Acoustics.

He was a student at the Naval War College, Newport, R.I., from September 1958 to June 1959, then reported to the Bureau of Medicine and Surgery, where he currently serves as Director of the Astronautical Division.

Captain Phoebus has the American Defense Service Medal; the American Campaign Medal; the European-African-Middle Eastern Campaign Medal; the World War II Victory Medal; and the Navy Occupation Service Medal, Europe Clasp.

His present home address is 210 Hazelton Street, Falls Church, Va. On March 12, 1938, he married Miss Bernadine Shultz, of Millville, Pa., a former nurse at the Geisinger Memorial Hospital.

CAPT. WALTON L. JONES, JR., MEDICAL CORPS, U.S. NAVY

Walton Linton Jones, Jr., was born in McCaysville, Ga., on December 4, 1918, son of William L. and Pearl (Gilliam) Jones. He attended Emory University, Atlanta, Ga., from which he received the degrees of bachelor of science in 1939 and doctor of medicine in 1942. On June 22, 1942, he was commissioned lieutenant (junior grade) in the Medical Corps of the U.S. Navy and subsequently advanced in rank, attaining that of captain, to date from July 1, 1956.

After receiving his appointment in the Medical Corps of the Navy in 1942, he served his internship at the U.S. Naval Hospital, Charleston, S.C. In August 1943 he reported as medical officer at the Navy Construction Training Center, Williamsburg, Va., and in November of that year was assigned as junior medical officer at the Navy Construction Training Center, Camp Lejune, N.C. He remained there until February 1944, after which he was a student in aviation medicine at the School of Aviation Medicine, Pensacola, Fla. He was designated aviation medical examiner in April 1944.

Attached to the 9th Marine Air Wing at the Marine Corps Air Station, Cherry Point, N.C., and outlying fields, he served as squadron medical officer with Marine Fighter Squadron 522, and with Headquarters, 9th Marine Air Wing from May 1944 to June 1947. During the last year and a half in that assignment he conducted research on bailouts. He was designated flight surgeon in October 1944. He was next assigned to the Bureau of Medicine and Surgery, Navy Department, Washington, D.C., for duty as liaison medical officer to the Chief of Naval Operations and also served in the Aviation Safety and Aviation Training Sections of the Bureau of Medicine and Surgery.

In June 1953 he joined the U.S.S. *Randolph* as senior medical officer. That attack aircraft carrier was deployed with the 6th Fleet in the Mediterranean for two tours. While there he also served as staff medical officer on the staff of Commander Cruiser Division 4. In October 1955 he returned to the Bureau of Medicine and Surgery, where he currently serves as head of the Aviation Medical Equipment Branch, with additional duty as aeromedical assistant in the Airborne Equipment Division, Bureau of Naval Weapons, Navy Department.

Captain Jones has the American Campaign Medal; World War II Victory Medal; Navy Occupation Service Medal, Europe Clasp; and the National Defense Service Medal.

He is married to the former Caroline Schachte of Charleston, S.C., and they have three children, Walton Linton Jones, III, Francis Stephen Jones, and Kathleen Caroline Jones. Their usual home address is 131 South Battery, Charleston, S.C., but they presently reside at 1309 Beech Tree Lane, Falls Church, Va.

Dr. Jones was certified by the American Board of Aviation Medicine in 1954. He is a member of the American Medical Association, the Aero Medical Association, and the Space Medicine Association.

Mr. TEAGUE. As I am sure you are aware, this is a rather informal meeting this morning. Did either of you come with a prepared statement?

Captain PHOEBUS. I did not, sir.

General BEDWELL. No, sir.

Mr. TEAGUE. All right. What the committee is interested in is the work going on to coordinate the biosciences effort between the Navy, the Air Force, and NASA. We are interested in what is happening in San Antonio and what is happening in Florida.

Some of us have been to San Antonio and some to Florida, and we discussed the work going on within the services. The person that has taken the greatest interest in this problem has been Congressman Daddario of Connecticut.

Mr. Daddario, do you have any questions or comments? We are glad to recognize you.

Mr. DADDARIO. Thank you, Mr. Chairman.

Could we have a statement from each of you gentlemen concerning the growth problems at your respective institutions and how they have

been affected, either in a positive or a negative way, through the cooperative activities that you have with NASA?

What was, for example, your program for the future when the NASA program began? Has that growth potential been affected by the life sciences activities as it has developed within NASA? Has it grown along with it? Has it been affected either in a positive or negative way?

General BEDWELL. Shall I start first?

Mr. FULTON of Pennsylvania. One more thing. Would you also indicate any possible duplication of facilities of the Armed Services and NASA?

Mr. DADDARIO. I think if we start with a general statement from each of you, we could then get into more specific questions.

TESTIMONY OF MAJ. GEN. THEODORE C. BEDWELL, JR., COMMANDER OF THE AEROSPACE MEDICAL DIVISION, AIR FORCE SYSTEMS COMMAND, BROOKS AIR FORCE BASE, SAN ANTONIO, TEX.; ACCOMPANIED BY COL. JOHN E. PICKERING, DEPUTY CHIEF OF STAFF FOR RESEARCH AND DEVELOPMENT

General BEDWELL. I do not have a prepared statement to present to the committee, but would like to make some introductory remarks concerning the overall subject in order to place the committee into a better perspective. In so doing, I would ask the privilege of referring to my notes.

When we consider the problems that arise from the effort to establish man in space—particularly those problems relating to the magnitude of the effort, its urgency, and its cost—I believe it is useful to begin with a brief review of the knowledge and facilities which had been accumulated before the present space program was adopted.

We tend to think of the current drive toward space as if it were a totally new kind of human activity—one that came into existence after the launching of the first orbital satellite in 1957, without any previous background of study or experience.

If that were so, nothing whatever would be known about the ability of man to survive in space. We would surely not have risked the life of a single astronaut, until every circumstance connected with the safety of the flyer had been made the subject of exhaustive research by medical science.

Instead, we have already seen a total of eight astronauts lifted into orbit around the Earth and recovered safely, four by the United States and four by the Soviet Union. At the same time, elaborate research programs are still being formulated, to examine the physiological factors on which their lives depend.

The fact is that this operational effort, which is now so well advanced, has evolved out of medical concepts and experiments that go back several decades, to World War I or earlier. Otherwise, it hardly could have come so far so fast.

Essentially, as General Schriever told the subcommittee several weeks ago, space flight is an extension of the normal flight environment above and beyond the lower levels of the atmosphere. With very few exceptions, the problems involved in medical support for the astronaut differ only in degree from those affecting a high-alti-

tude balloonist or a jet-aircraft pilot. Before orbital flights became practical, many of the problems were studied intensively in such earthbound vehicles, as well as in laboratory devices.

The U.S. Air Force launched a systematic investigation of these problems as long ago as 1918, when the School of Aerospace Medicine was founded. Over the past 45 years, many hundreds of detailed studies have been made on the reactions of the flyer to decreasing amounts of atmospheric oxygen, to reduced air pressures, radiation exposure at great altitudes, rapid acceleration or deceleration, and the various other difficulties which an astronaut may encounter in their full severity.

In 1934, the Aerospace Medical Research Laboratories were opened at Wright-Patterson Air Force Base, Ohio. Their aim was to develop equipment which would enable the flyer to overcome these environmental difficulties.

The laboratories in Dayton have provided basic research which contributed to the development of the space suits worn by astronauts today. They have contributed systems which are still used to supply oxygen; ejection seats that led to the complex mechanisms for escape from a damaged spacecraft, and a wide range of protective devices which have been adapted to the requirements of space flight.

The first biological experiments with small animals in rocket vehicles were conducted by the Aeromedical Research Laboratory at Holloman Air Force Base in 1948.

In 1949 the first Department of Space Medicine was organized at the School of Aerospace Medicine in Texas. During the decade before sputnik, the Department not only made the first comprehensive survey of conditions that affect a human flyer in space, it also conducted practical experiments in the first laboratory prototype of a space capsule, with its life-support systems and communication equipment.

The Air Force at that time had no mission to prepare for the possibility of military operations in space. Yet if all this prelminary research and development had not been done, I wonder how much progress would have been made by our national space effort up to now?

The work was done because the Air Force had these medical research facilities, already staffed by talented scientists, and because the advanced ideas which they were pursuing grew naturally out of the routine studies they had been carrying forward in support of military aviation.

The same facilities exist today. In fact, they have grown substantially with the progress of the space effort. The three outstanding laboratories that I have mentioned are now consolidated into the Aerospace Medical Division of the Air Force Systems Command. The Division also includes the large Wilford Hall Hospital, at Lackland Air Force Base, and several smaller laboratories offering specialized services in the human sectors of aerospace research.

The School of Aerospace Medicine occupies a modern plant at Brooks Air Force Base, completed within the past 4 years. Since the last visit of the committee five new professional buildings are now ready for occupancy at Brooks, and ground has been broken for one more. Together, these facilities more than double the school's laboratory area.

During this past fiscal year, the Aerospace Medical Division has assumed a major portion of the bioastronautics research responsibility

within the Department of Defense. We are now a singular part of the Air Force Systems Command and, as a consequence, are bringing our programs into a sharper focus, identifying laboratories more specifically with their capability in terms of personnel, talent, and unique facilities.

If you will, we are endeavoring to develop along the line of the "lead laboratory" concept; that is to say, each laboratory is becoming the focal point for an area of responsibility. In this way we feel we can more closely control programs and avoid unwarranted duplication. Similarly, if other agencies of Government recognize these laboratories for their specific capabilities, an immediate contact and localization of responsibility can accrue.

To more appropriately support the National Aeronautics and Space Administration in the area of bioastronautics, I and members of my staff have on several occasions visited the Manned Spacecraft Center to effect a mutual exchange of ideas, to discuss problem areas, and to ascertain wherein we may reorient specific of our programs to the basic support of Mercury, Gemini, and/or Apollo.

Looking to future programs, we have had exchange visits with members of the Office of Advanced Research and Technology, and only recently accomplished an onsite visit to the Ames Laboratory. Since much of our work is geared to the possibility of military man in space and of necessity points to the future, portions of our research will parallel the requirements within the Office of Advanced Research and Technology and in the Ames Laboratory. Working closely with these organizations permits the development of programs that have continuity as well as breadth and depth.

It is my feeling, following the outline of work developed in the NASA-DOD Planning Committee, which parenthetically was made up from the DOD point of view by members of my staff, that we must very carefully derive the proper "mix" of DOD work and NASA work. Particularly if we are to retain our capable people over an extended period of time, they must find application to their scientific pursuits. Yet at the same time, they cannot become so engrossed with NASA requirements that responsiveness to the Air Force is lost.

As you know, our responsibilities are not limited to the space program. We are supporting the aeronautics program of the Air Force, B/C operations, counterinsurgency efforts, weapons effects, toxicology, and must similarly be alert to any gaps in our program for future applications such as biomagnetics and geophysical warfare.

Perhaps the clearest limiting factor in all of our work is that man is the focal point, and because of this it is only of limited significance whether he be a man assigned to a NASA program or to a military program. By and large his requirements are identical and only the things he is asked to do are variables.

The SAM buildings, designed against Air Force requirements, fortuitously enhance a capability for NASA problems, particularly in the area of hazards—be they space radiation, nuclear propulsion, biological and/or toxicological. Similarly, they enhance our Air Force capability in B/C operations, microbiology, counterinsurgency, and medical selection. As I stated previously, the full utilization of these facilities and personnel must come from a careful yet proper

"mixing" of both NASA and DOD programs in support of the national interest and objective.

At the present time, about 15 percent of our inhouse tasks are formal agreements directly responsive to NASA, while over 50 percent of our tasks support both DOD requirements and those of NASA. They are aimed at an orbital space station, medical selection and monitoring, rendezvous docking and transfer problems, long-term radiation effects, protection, visual problems, and others. This percentage in support of NASA could be significantly increased if the DOD were brought in on a coordinating basis before the NASA program is firm.

The remainder of the work shades to Air Force requirements: B/C operations, weapons effects, occupational and clinical medicine, personnel selection and classification, systems support and integration.

I have with me today Col. John E. Pickering, my Director of Research and one of my leading scientists. We are anxious to answer any questions that you may have concerning the bioastronautics programs now in being and planned for the future.

Mr. GURNEY. May I interject a question now?

Mr. TEAGUE. Mr. Gurney?

Mr. GURNEY. Does the Air Force, today, have a military mission in space?

General BEDWELL. We have a mission in aerospace medicine. It is not a military mission in space, as such, no.

Mr. GURNEY. What is your mission in medicine?

General BEDWELL. Our mission in medicine is to support the air crews at whatever mission they have been given.

Mr. GURNEY. If we have no program in space for the air crews, how can you have a mission?

General BEDWELL. We have a medical mission to support the pilots in the X–15 aircraft, for example, that are flying at extreme altitudes.

Mr. GURNEY. But, as such, you have no definite military mission except to back up the X–15 program?

General BEDWELL. I am supporting the medical requirements of the Air Force only, sir.

Mr. TEAGUE. Mr. Roudebush?

Mr. ROUDEBUSH. General, one statement you made there interested me very much. You mentioned the studies you made on the prototype of the space capsule in 1949.

General BEDWELL. Yes, sir.

Mr. ROUDEBUSH. Was your study turned over to NASA when they developed their space capsule?

General BEDWELL. I might say, sir, all the work that has been done in the facilities of the Air Force has been reported in technical reports available to the scientific community throughout the world.

Mr. ROUDEBUSH. Now they are available, I know.

General BEDWELL. Yes, sir.

Mr. ROUDEBUSH. Were they turned over to NASA? Do you know if NASA requested them?

General BEDWELL. I am not aware of them making any specific request for any particular item.

Mr. TEAGUE. General, in answer to Mr. Gurney's question, isn't it true that you have been given a medical mission in space to support NASA because of the very capabilities you have in this field?

General BEDWELL. Yes, sir.

Mr. TEAGUE. The mission does not necessarily support the Air Force alone, but rather it is a medical mission as far as astronauts are concerned.

General BEDWELL. Colonel Pickering has something on this.

Colonel PICKERING. May I, sir?

Mr. TEAGUE. Yes, sir.

Colonel PICKERING. I think the Air Force has been used, sir, in going along with the selection of the seven original astronauts as we presently know them.

Subsequently, there have been selected and medically screened, 32 that are to be the potential astronauts.

Each of the medical monitors around the world were trained at the School of Medicine. I think the reason for this was to take advantage of the research data that has been available over the past 20-some odd years, particularly in terms of the physiological and cardiovascular responses.

This data is on flying personnel and the individuals concerned are also flying personnel.

So, I think in that regard, the medical aspect of the mission is one which was used.

Mr. GURNEY. Did the Air Force work with the last Mercury flight this past week?

Colonel PICKERING. Well, sir, we had medical——

Mr. GURNEY. I am thinking only insofar as medicine is concerned.

Colonel PICKERING. All right, sir. From our own institution, now first, we had medical monitors at Canton Island, Port Arguello, in Australia, debriefing team at Cape Canaveral, psychiatrists and technical people, and a surgical component to the team if it be necessary.

About half the Aerospace Medicine Branch at the Cape are military medical officers on duty with the Space Agency.

I think the total is about 47 medical officers from the Air Force and Captain Phoebus, I know, has some.

Captain PHOEBUS. Yes.

Mr. GURNEY. Would it be fair to say that the Air Force obtained as much knowledge medically from the flight this week as NASA?

Colonel PICKERING. From the displays on the scope, I would assume. I was not there to see the type data that was returned. I think that answer is, "Yes."

Mr. TEAGUE. Colonel, is it true that all the information that came in is available to all, the Navy, Air Force, Public Health Service, or anyone else that wants it?

Colonel PICKERING. Right.

Mr. TEAGUE. Mr. Karth?

Mr. KARTH. Mr. Chairman, I have a question to ask the General. On June 16, 1960, General Flickinger testified before a Special Subcommittee of the Committee on Science and Astronautics that it was the understanding of the armed services that the bulk of NASA's biomedical requirements for manned spaceflight would be done by the armed services. Has that understanding changed?

Have you been notified by NASA their requirements for the Air Force no longer exist in this field of cooperation?

General BEDWELL. Sir, I can state, about 15 percent of our work today is in direct support of NASA.

Mr. KARTH. How much, sir?

General BEDWELL. About 15 percent of our total effort.

Mr. KARTH. At that time, General, the bulk of NASA's biomedical requirements for manned spaceflight were done by the armed services. I question whether or not that is true today inasmuch as the NASA's request for "Aerospace medicine," for example, since that time, has grown from a $7 million budget to $16.5 million. In bioscience the budget has grown from $3 million to $35 million. In the human factor systems it has grown from $2.5 million to more than $18 million.

Have NASA's requirements quadrupled and quintupled, or whatever these figures indicate they have done; so that the Air Force is no longer capable of supplying NASA with the requirement it has?

General BEDWELL. I'd like to state that over 50 percent of our tasks, support both DOD and NASA. These tasks are aimed at the orbital space stations, medical selection, rendezvous, docking, tracking, and transfer problems. This work, in support of the Air Force, in my opinion, could be significantly increased within the Aerospace Medical Division and the Air Force if the DOD were brought in on a cooperating and coordinating basis before NASA has a firm program.

In other words, we have an added capability within the expanded School of Aerospace Medicine, Brooks Air Force Base which many of you have visited.

We have five new buildings that will be open within the next month and we will have the capability of supporting NASA to a much larger degree if we are afforded the opportunity; but I do feel it is necessary the DOD agencies be brought in at an early time in the planning phase so that we can determine the type of research that is necessary.

Mr. KARTH. General, when you talk about "opportunity," you indicate that NASA has not requested the type of assistance that the military services, in 1960, understood they would request in this field of biomedical research. Isn't that correct?

General BEDWELL. That is essentially true. However, I might add one statement to that. About 6 months ago we were asked by NASA to submit research tasks, certain areas that they spelled out and we did submit research tasks to NASA; some of which they approved and will fund for us to pursue, some of which they turned down.

Others are still in study.

Mr. KARTH. Just one more question. I understand a Senate report issued some years back, perhaps in 1960 or so; stated that the biomedical research projects as of that time numbered some 30,000. Wouldn't you feel that some place along the line these 30,000 projects should take care of most of NASA's requirements along with the Air Force's and the Navy's requirements?

How many projects do we need to take care of whatever requirements we have?

General BEDWELL. I think a careful review of the projects would lead you to believe you may have 30,000 or 40,000 or maybe 20,000 might be essential—enough.

On the other hand, I think the successful flight of Major Cooper, recently, indicates a lot of these tasks may not need to be developed because the basic groundwork has been laid by the work that's been done in the Air Force and Navy over the years.

Answers to many of these potential problems are already known. I mean, the potential problems are already known and it's conceivable 20,000 research tasks are not necessary.

Mr. KARTH. So, what you are saying is that because we are further down the road, our requirements should be more focalized?

General BEDWELL. Yes.

Mr. KARTH. This can be more easily done today, probably, than 3 or 4 years ago when you didn't know what the requirement was going to be?

General BEDWELL. This is true.

Mr. DADDARIO. Mr. Chairman, I think we are getting to the problem that should concern us, and that is how the cooperative effort can be put together.

As I understand some of your answers to Mr. Karth's questions, General, NASA has asked you to submit your qualifications or capability to undertake certain of their tasks for them. This would be almost on a contractor basis, rather than as a full cooperative partner; isn't that what it boils down to?

General BEDWELL. Yes, sir.

Mr. DADDARIO. So, in those areas where NASA has requested assistance you have had an opportunity to participate, but in other areas where you have a capability you have not had the opportunity to either set out a plan or to enter into a cooperative venture.

General BEDWELL. This is so; yes, sir.

Mr. DADDARIO. Mr. Karth touched upon a very important point. Taking into consideration the enlargement of NASA in the field of life sciences and the development of Air Force capabilities at San Antonio, where you say there are five new buildings now being opened, do we have the manpower in this country to staff all of these facilities and to keep them all going at full speed and in the most efficient manner unless we have a full cooperative venture?

Mr. TEAGUE. May I make one comment there.

Mr. DADDARIO. Certainly.

Mr. TEAGUE. General, I would like you and Captain Phoebus to understand that we know how you are in your assignments. If the committee asks questions which should be answered at an echelon above you, and you do not wish to comment on it; just say so.

General BEDWELL. Yes, sir.

Mr. TEAGUE. Perhaps some of the questions you would rather have answered by somebody higher up.

General BEDWELL. Yes, sir.

Mr. TEAGUE. The understanding was that when you came before this committee the questions would pertain to your assignment.

General BEDWELL. We have approximately 2,100 experienced people within aerospace medicine and life sciences.

We have 815 highly trained professionals that constitute the Nation's most valuable asset in the race for space.

Now, these people have been with the Air Force for some time, in the main—of course, some of them are new, but are trained and experienced research people. Among them, 279 scientists, military and civilian personnel, hold a doctorate degree in one or another of the numerous scientific specialties; about 142 hold master's degrees and 394 with bachelor's degrees, fall in the same category.

These people occupy and use the physical plant in existence; with that under construction, and counting the equipment that is in the buildings at Brooks, the property evaluation approximates $30 million.

In my opinion, if we do not use these people effectively in the long run we are liable to lose them to some other agency. Though I haven't been concerned about it up to now, I am concerned about the future impact there may be on our scientific staff if we are not able to use them completely in the support of the national goal.

Mr. DADDARIO. What plan do you have to use these research people?

General BEDWELL. We have a certain capability in the aviation sciences we can expand on in cooperation with NASA.

We have, for example microbiology, cellular, physiology, classified as "basic research." Of course, we can expand this in support of NASA's program if given an opportunity.

Radiobiology—we have new buildings in radiobiology that will have an extensive capability and, in my opinion, we can increase our work in support of the NASA's objective if we are given appropriate opportunity.

We have now, I'd like also to say, we have visited—several of my staff and I, have visited the Manned Spacecraft Center in Houston, and we at the working level have been cooperating and coordinating our efforts.

We have trained several of their people in the operation of pressure chambers. We have run many experiments with them.

We visited the laboratory at Ames last week, and went over the program with them and there is a great deal of work there if we were allowed to cooperate and coordinate with them, we could, I think, use our one facility at Brooks in complete support of some of the work that's planned for Ames.

Mr. KARTH. Mr. Daddario, will you yield?

Mr. DADDARIO. Yes, Mr. Karth.

Mr. KARTH. General, are you saying that the Air Force at this point could almost meet NASA's total requirement without NASA duplicating existing facilities that the Air Force already has in this biomedicine field?

General BEDWELL. I don't believe I could say we could duplicate it—support it completely, without knowing some of their specific program requirements.

I do think that——

Mr. KARTH. If NASA submitted its specific, overall requirements to you, how long would it take you to evaluate those requirements, and then make a determination as to whether or not the Air Force could fulfill all of them, most of them, some of them, or perhaps just a few of them?

General BEDWELL. I think if we were given an opportunity to review the file within 2 months' time—2 to 3 months—we could make a determination of how much of it we could do.

Mr. KARTH. This is indicative, Mr. Chairman, that the Air Force has not been allowed to make this determination.

Mr. RIEHLMAN. Would the gentleman ask the same question of the representatives from the Navy?

Mr. DADDARIO. Yes, we intend to do that, Mr. Riehlman. I have one further question, General Bedwell. At the present time, even though the Air Force has this capability, the only way in which it could be of help to NASA would be under those instances when NASA specifically requests the Air Force to set forth a program for NASA to initiate. Beyond that, there is no further opportunity?

General BEDWELL. Yes, sir.

Mr. FULTON of Pennsylvania. Would the gentleman yield at that point?

Mr. DADDARIO. Yes.

Mr. FULTON of Pennsylvania. One agency in the Government must have the responsibility for particular research programs. In this instance, NASA has the jurisdiction and the responsibility for the Mercury program. That means that NASA has had to set the parameters of the programs and the requirements.

When NASA called upon you to fulfill requirements for them, I believe the Air Force, as well as the Navy, have been cooperative, haven't you?

General BEDWELL. Yes, sir

Mr. FULTON of Pennsylvania. So that the question you should be answering here is whether there is a duplication of facilities, scientific and research personnel, or of research programs, or is there a lack of correlation and cooperation between the Air Force, the Navy, and NASA, that causes a loss of efficiency in an overall U.S. aeromedical or space medical programs?

Mr. DADDARIO. Mr. Chairman?

Mr. TEAGUE. Mr. Daddario.

Mr. DADDARIO. Mr. Fulton, if we could develop the question a bit further, we could come to certain conclusions respecting that. In a way, your question is heading in the same direction as some of the questions which I have asked.

Mr. FULTON of Pennsylvania. That's why I'm following it up. I think he should answer whether there is duplication or not.

Mr. TEAGUE. General Bedwell, would you care to comment?

General BEDWELL. In my opinion, I am forced to say, I feel there is duplication.

Mr. FULTON of Pennsylvania. Is there a lack of cooperation or correlation between the programs of the Air Force, the Navy, and NASA?

General BEDWELL. I think this is true to a degree.

Now, we have at the working level—we have been trying to cooperate and coordinate our programs.

Mr. FULTON of Pennsylvania. On these basic biomedical research programs, such as you were speaking of on cellular structure, are you correlating with the National Institutes of Health on their programs as well?

Are all the agencies such as National Science Foundation and the National Institutes of Health working together on one program in aerospace medicine?

General BEDWELL. There is continual communication in the scientific community; yes, sir.

When you compare scientific programs, specifically investigating research programs, we are not directly checking our program against the one that is developed at the National Institutes of Health, as such.

Mr. FULTON of Pennsylvania. At a later time, I would like to ask you to comment further on your statement regarding duplication, where it might be, and what remedies you might suggest. I don't want to take the committee's time now unless the chairman would care to go into it.

Mr. TEAGUE. I wish you would elaborate a little bit further, General Bedwell, on where you think there is duplication.

Mr. GURNEY. Mr. Chairman, I wonder if we could, perhaps, consider a specific example by taking the Mercury program?

Mr. FULTON of Pennsylvania. I would rather cover it just generally.

Mr. TEAGUE. Answer the general question first, General Bedwell, and we will go into the specifics.

General BEDWELL. Well, sir, if I may refer to Ames, we visited there last week, Colonel Pickering and several other members of my staff.

Mr. TEAGUE. Would you speak a little louder, please?

General BEDWELL. We found evidence—I shouldn't say "evidence." We found work going on there we have had in being at the School of Aerospace Medicine for some time. I specifically refer to one area; that is, in the field of audiology. We have a specially designed room at the School of Aerospace Medicine at San Antonio and also Wright Field, for checking on hearing.

We have been studying hearing loss of aircrew members for many years in the Air Force and have developed a rather extensive program of audiograms on our aircrew members for protection against hearing loss and we have this capability within the Air Force and yet I saw evidence of a program of basic audiology program at Ames.

In the field of microbiology and cellular physiology, the same is true and I understand also they are planning on developing a department of cardiology for basic studies in regard to circulation and cardiology.

We have had this going on for some time.

I know the Navy has had a similar program on their aircrew members.

These are evidences I consider in my personal opinion that are a duplication. Furthermore, I'd like to say, we have had experienced people in these areas and we would like to take advantage—I think the Nation should take advantage of their research capabilities and experience.

Mr. DADDARIO. Captain Phoebus, could you give us a breakdown about the same way General Bedwell has? Would you tell us the number of people you have, their background, the estimated cost of your physical plant, and its capabilities?

STATEMENT OF CAPT. C. P. PHOEBUS, COMMANDING OFFICER, SCHOOL OF AVIATION MEDICINE, PENSACOLA, FLA.; ACCOMPANIED BY CAPT. WALTON JONES, AVIATION MEDICINE TECHNICAL DIVISION, BUREAU OF MEDICINE AND SURGERY

Captain PHOEBUS. If I may, Mr. Daddario, I would prefer to make a general statement about the Navy's relationship with NASA in our biomedical program, first.

As far as we are concerned, our relationships with NASA have been very, very happy. NASA has enabled us in the Navy to pursue programs which we wanted to pursue for aviation medical reasons within the Navy itself, that without NASA's support we would never have been able to move ahead as fast and as far and as adequately as we are now doing.

At my own institution, the Navy School of Aviation Medicine, in Pensacola, I think we have an outstanding example of this in that within the last few years since NASA started its program in this area we have had a great deal of support from them, moneywise—something over $2 million at this stage of the game.

We have submitted a number of proposals to NASA for work in our mutual interests and it's gone along very beautifully. We have similar cooperative efforts going on in a number of our other Navy laboratories, notably at our Air Crew Equipment Laboratory, Philadelphia; at Johnsville, the Human Centrifuge Lab; the Navy Medical Research Institute at Bethesda; at the facility at El Centro, and possibly other places.

I am not quite up to date on it any longer, because I'm now at Pensacola, rather than at the Washington level here.

On this question of duplication, if I may comment, I don't believe that there is any serious or unjustified or undesirable duplication of effort going on in the biomedical area; specifically the aerospace area, in any of the agencies of Government.

To use General Bedwell's example of audiology—sure, we are all working on this; but from different angles and this is the very nature of research, "different investigators take different approaches" to things.

The problems are broad and they need to be attacked on a broad front.

We are doing audiology work in Pensacola in the interests of the Navy and in the interests of a broad program of research.

I think NASA is almost compelled to get into this area as well; to, if you will, bring it all together and focus it in areas of their own peculiar interest.

As far as we are concerned, we feel that this sort of nationwide effort going on with many people getting in the act, is producing more scientists, more skills and enhancing our knowledge all the way up and down the line whether it is applicable to space or aviation medicine or just medicine.

Now as to the question of the people that we have, compared to the Air Force, we are relatively small. I don't know precisely what kind of figures the general was using here, but I can only talk about our in-house effort rather than any contractor effort.

At Pensacola, I have a total staff of approximately 200 people. Perhaps, 50 of these are of the scientific type with another 50 of the technical type.

We are pursuing a number of programs of our interests which we have been interested in for a long time and we intend to continue doing so.

Notably, our largest program in support of NASA is in the area of disorientation, and I think it is utilizing facilities which we have, as well as "savvy" and know-how, which I'm sure are not duplicated any place else and I think unmatched any place. When NASA recognized the potential, and the serious nature of this problem a few years ago, we were in the best position with the tools and people and so forth to pursue this research area; and this is why they have poured quite a bit of money into us.

Dr. Shaffer at our place, working in the area of radiation effects, I think is recognized as one of the outstanding authorities in this area. He started working in it 17 years ago, not when sputnik went up.

Dr. Beicher that we have there has been working in another area now of very great interest to NASA; namely, the efforts of magnetism, rather high intensity of magnetism, or the lack of it, on man. I think he is probably unique in working in this area, and the leader at this point. He has been invited by NASA to expand his program here.

We have worked in close cooperation with the Air Force, for example, in the cardiology area. We have had a large program going here for many, many years; and now it has been linked to some degree at least with the NASA program—notably and recently, again Doctor Beicher, has for the first time been able to get what we call a baseline ballistocardiograph. Scientists who have been interested in this area for years have always wanted to have one in the absence of gravity, a true baseline against which you can measure everything else. At Wright-Patterson, where they can fly planes through a weightless trajectory for a few seconds, we were able to put a man in the weightless state and measure his ballistocardiograph, and now they do have something to measure against. It may prove to be one of the more important ways to measure a man's heart function in space in the future.

I think that covers it, but if you care to ask any more questions, I can go on.

Mr. DADDARIO. Captain, what you say is extremely important and it's not my intention, and I'm sure it is not the intention of any other member of this committee, to do anything other than that which must be done. But there is some question as to how much we can do since these programs are extremely costly.

Captain PHOEBUS. Yes, sir.

Mr. DADDARIO. Inasmuch as we would like to have basic research going on in as many areas as possible, people shooting at different targets; the question nevertheless does come down to what this country can afford.

Captain PHOEBUS. I understand.

Mr. DADDARIO. It is to this point that the committee is directing its effort. We must ascertain how we can most efficiently contain the cost

of a program which, in the civilian area alone, this year is approaching $5.7 billion.

Captain PHOEBUS. Yes, sir.

Mr. DADDARIO. I would like you to take that into consideration when you consider this subject. For example, you have mentioned the auditory experimentation. I think that it is fine. The Navy has it; NASA has it; the Air Force has it; and other agencies have it. The question is, however, can the country afford all of this and still afford all of the other experiments but not affect our national goals.

Do we have enough scientists? Do we have sufficient capability in this field to expand these programs without in some way affecting the mission of the Navy, NASA, or the Air Force, and maintain our scientific competence in private industry? We must look at this from an overall point of view.

What is your observation as to the availability of manpower in the biomedical field?

Captain PHOEBUS. My own feeling is it is only through a program of rapid expansion such as we are undergoing now in this whole biomedical area that we are ever going to get adequate manpower to support the effort necessary for our space goals.

Sure, we are having trouble recruiting the topnotch people we would like to have; but we are recruiting, we are expanding and they are doing a capable job.

This is true all over the country, I'm very certain; but if you don't give people the opportunity, and something to attract them into this area, you are never going to train them and we will never achieve our goals.

Mr. DADDARIO. The opportunity is certainly available. We have programs in military as well as in some of the civilian agencies. It is disturbing to me that you do have trouble recruiting. This committee is not trying to inhibit the program by refusing to give the support that it needs, but rather we are trying to force the program into a pattern of efficient cooperation. How can we do the job better than we are doing it?

I would like to give you some figures.

On August 11, 1960, Senator Hubert Humphrey's committee, the Committee on Government Operations, published a report stating that at that time there were 10 agencies with biomedical research programs.

The total number of Federal personnel, including scientific, professional, and technical, engaged in full-time or part-time biomedical research was estimated at 5,900 people. This was in 1960.

At that time the largest agencies were: the Department of Health, Education, and Welfare, $291 million; Atomic Energy Commission, $53.2 million; Department of Defense, $48.6 million; National Science Foundation, $24.4 million; Veterans' Administration, $17.3 million; Department of Agriculture $16.1 million.

Then NASA and the smaller agencies at that time with $1.8 million.

Mr. Karth has already indicated that NASA has grown to the point where the total sum of money has gone from $1.8 million to the $21 million, $41 million, and $23 million, or some $80-plus million requested for fiscal year 1964.

Now, Colonel Pickering, who happens to be here this morning, put it into perspective. This is, again, back in 1960 and I quote him:

> We have seen over the past 2 years a tremendous growth in our national biomedical space effort. Nearly every institution and industrial organization has some facet of a space medicine research effort. Additionally, practically everyone in this audience has a personal interest in space research or is a member of one or more space committees. Yet, with all of this we are still without a central coordinated space biology research team.
>
> Programs are being pursued on a near individual basis without benefit, many instances without advice of interested and knowledgeable people. As a consequence we are, in fact, diluting our national talent to such an extent the future may not hold much more hope for real success and understanding than the past and the record of the past is not one of sound and rigorous scientific achievement.

This is what we are trying to accomplish, and what we have been concerned about in the past 4 or 5 years. How do we bind this effort together and how may it best be coordinated so that the full talents, and abilities of all these organizations can be concentrated? We are concerned when NASA starts off with a life sciences section, which was expected to consist of a team of 60 people and now within a matter of just a few years' time it has grown to almost a thousand people. This is a growth which would indicate there is somewhat of a strain in this area where an expert such as Colonel Pickering 3 years ago was concerned about the dilution of effort.

Has this country created a greater capacity in the past 3 years so that we should not be concerned about diluting our effort?

Captain PHOEBUS. In my opinion, sir, NASA has done a very fine job of stimulating attention, training, effort, in this area by the mere fact of their existance and the fact of the problems which they have brought forward; perhaps, not independently of the military forces, but certainly they have provided a great deal of incentive for this.

People, biomedically trained people, who were working in many other areas in the past have been attracted to the national space program and there are more of them coming all the time.

I see this for example, in my students coming to the School of Aviation Medicine (and I interview them all) I ask them, "Why are you here?" and one of the more common answers I get is because they have been stimulated by this program; and I know there are a great many men in the human factors area in industry and the Armed Forces, who a few years ago would never have contemplated coming into this if it weren't for the challenge of space.

Mr. KARTH. Captain, may I interrupt you at this point?

You are not saying that because of NASA's interest in this, everyone else is becoming interested, are you?

Captain PHOEBUS. No, it is not just NASA's interest. It's the Nation's interest.

Mr. KARTH. I understood you to say that because of the stimulation that has been added——

Captain PHOEBUS. The monetary stimulation NASA has provided has helped a great deal.

We certainly have many more people working in this area, due to the assistance we have had from NASA, than we'd ever have been able to do if we'd been dependent on Navy resources alone.

Mr. KARTH. Captain, the military and other agencies of the Government, whether it be NASA or the National Institutes of Health,

have got to take into consideration one thing, and that is the general public. We happen to be facing a shortage of medical and technically trained people. It seems to me that an overly ambitious effort on the part of the Government agencies caused this problem to become increasingly acute.

Captain PHOEBUS. Sir, the more one looks at this overall space problem and our national goals as stated by the President; the greater these problems become and the more work is required to be done upon them.

Now if the policy of the country is to go ahead in this area and put men in space and put them on the Moon, then there's a certain amount of work that must be done and people must be attracted to do it.

If this is not the policy——

Mr. KARTH. Captain, do you think that this national goal that has been set forth by the President of landing a man on the Moon and returning him safely to the Earth, requires 10,000 or so people working specifically in the biosciences area? Is that what you are saying?

Captain PHOEBUS. Yes, sir.

Mr. KARTH. The biosciences area?

Captain PHOEBUS. I think there are many problems that can attract amply at least that many people.

Mr. KARTH. If it takes that many people to work out the answers to our biomedical problems in getting a man to the Moon and back; I want to tell you that we can't afford the Moon program.

Mr. FULTON of Pennsylvania. There is a difference of opinion.

Mr. DADDARIO. Captain Phoebus, let us pursue that a moment. You are not saying, are you, that we shouldn't do this as efficiently as possible?

Captain PHOEBUS. Not at all.

Mr. DADDARIO. Take the auditory experiments, for example, that you were talking about. Is it your opinion that we have within the Department of Defense, either in the Navy, the Air Force, or the Army, the capability to accomplish NASA's requirements without NASA building up an auditory capability of its own, even though it might be nice for NASA to have it?

Captain PHOEBUS. This is a very difficult question to answer unless I know, specifically, what NASA is building up their auditory capability for. This, I don't happen to know at the moment.

Mr. WAGGONNER. Would the gentleman yield?

Mr. DADDARIO. If you don't know that, how can you answer Mr. Karth's question and say we should build up to 10,000 people?

Captain PHOEBUS. I am not thinking entirely of the auditory area, but many others.

Mr. DADDARIO. Of anything. If you don't have the full and complete knowledge to be able to come to a conclusion in any of these areas unless you know every particular facet of the program, how can you say it ought to be so expanded?

Captain PHOEBUS. May I put it this way?——

Mr. DADDARIO. Isn't this one of the failings with this program? It is not tied together so that the existing capabilities, knowledge, and overall experience have not been keyed into the operation, and you have not been able to offer your best abilities, personnel, and equipment to satisfy this effort?

Captain PHOEBUS. Sir, I think we have been keyed into it to this degree. We know what the NASA requirements are. They promul-

gated them to us and when we find an area of interest to us and one which we feel we are capable of working in and we need some support, we go to NASA and see if we can work out something together.

Mr. WAGGONNER. Would the gentleman yield?

Mr. DADDARIO. Yes, I yield.

Mr. WAGGONNER. Captain Phoebus, are you saying that when NASA promulgated their requirements to you, you have participated to the fullest extent of your capability in every instance and that you do not have capabilities in those areas in which other people are working?

Captain PHOEBUS. I wouldn't say we participate to the full extent of our capability in every instance; no, sir. But we are trying to participate—I am speaking of my own organization now, to the utmost of our capabilities.

Mr. WAGGONNER. Speaking of your own organization, has NASA been to you to see what the Navy is doing or to see whether or not NASA is duplicating anything that you are doing?

Captain PHOEBUS. Yes, sir; they very specifically have been down there, not once, but on a number of occasions, and have had very complete briefings on what we are doing and they have encouraged us to join with them in pursuing programs of joint interest.

Mr. WAGGONNER. General, could I ask you the same question?

General BEDWELL. I'll answer that this way, sir.

Dr. Dryden and members of his staff visited Brooks Air Force Base in April of 1962, I believe it was; and we gave him a briefing on our capabilities and what we have. We showed him our buildings and told him of our capabilities. From then on, we have coordinated some efforts with them and in every instance we have been asked to do things for them we have supported them to our greatest capability. There are areas in which we are capable of doing things they have not asked us to do.

Mr. WAGGONNER. Areas in which you now believe that NASA is doing in-house research with their own capabilities?

General BEDWELL. I'll answer that this way: They are planning to do these things with new construction and also some of them are under contract. For example, in the radiobiology field.

Mr. GURNEY. Would the gentleman yield?

Mr. WAGGONNER. I think the gentleman's statement there, illustrates a very pointed duplication.

Mr. GURNEY. Would the gentleman yield?

Mr. TEAGUE. Mr. Daddario has the floor.

Mr. DADDARIO. I'll yield.

Mr. GURNEY. Captain, can you tell us in what respect NASA has sought your services?

Captain PHOEBUS. Yes, sir. Specifically, they have sought our services in three major areas. The one I mentioned before in disorientation, in radiation, and in the studies of magnetism. These are the three big ones we have been working in.

There have been several other smaller efforts which we have generally participated in as well.

Mr. GURNEY. Now, I would ask you, General, are you capable of supporting NASA in these areas?

General BEDWELL. We are doing radiation studies in support of NASA now; yes, sir.

Mr. GURNEY. Then, do you feel that you are capable of supporting NASA in the same areas that NASA is asking the Navy to do work for them? Here, again, we are not trying, General, to pit one service against the other but actually to find out what capabilities do exist.

General BEDWELL. I would like Colonel Pickering to answer.

Colonel PICKERING. Gentlemen, I think just using the word "radiation" is too broad. Dr. Shaffer of the Navy is very confident in heavy primaries, in looking at "hits" in nuclear emulsions. He has done this work with the Mercury project. This is one aspect in which radiation is involved.

One of the unique facilities that exists in the Air Force is the large monkey colony which has been used for the study of long term biological-radiation effects. There are about 1,000 animals in a long term study that exists essentially nowhere else in the free world.

This is of interest to the entire Nation, and that is the contribution which the School of Medicine is making.

Similarly, there are shielding studies and specific accelerator studies we do around the country in conjunction with the Atomic Energy Commission.

Having said this, I'd like to dwell on a word—when you take a word, it is difficult—and I think this is the problem we face in the word "duplication."

We have to look at programs, the actual task that an individual wishes to pursue.

Very frequently the research task titles as you gentlemen, and we would review it, are dissimilar. When you look at what the men propose to specifically do, the tasks are essentially the same.

I can assure you as a "for instance," of having canceled seven contracts, in four of these instances they were programs with the same contractor who was doing work for two agencies.

I would assume it natural he would choose the larger financial grant which was not ours, for doing the same kind of research; there is an obligation somewhere to stop this; and at least in our small way, we did.

Secondly, if you look at programs again, it's not a question of titles, but rather when you are talking about doing a broad program of research, you need people; you need buildings; you need support.

It takes 2 or 3 years to get this—maybe 5 years, but if that capability already exists, in part, perhaps, even not at the hundred-percent level, you are 2 or 3 years ahead.

Secondly, if it takes 150 people at a laboratory you are going to build and you have the ingredients of that capability in an existent laboratory, you may save as many as 75 people.

These people are precious in America. The people that have 10, 15 years' experience in research, be they university, military, industrial, civil employees—they are precious. They are hard to come by.

They only got these 10 years' experiences because they worked for 10 years, so the man you train today is not necessarily the most qualified to go into this new building. I think in our visits, there has been an attempt to honestly say, "What do you specifically want to do"; not the broad title of algae, for example, or space genetics, or space radiation.

What specifically are you doing to do?

Are you going to use the same kinds of subjects, the same kinds of endpoints that we are using—or that someone else is using, and if so, should you do this or be about doing something else?

Mr. DADDARIO. Colonel Pickering, following that line of thought, this committee has asked time and time again whether under these circumstances we should develop our capability in this area on the foundation which already exists, or whether we should start from scratch. It has been constantly reiterated that the intention of all concerned was to work close together, and that facilities would not be built in such a way that manpower shortages would occur or so that manpower would be used in an inefficient way.

This is the point to which we have now arrived because NASA is building up a capacity in manpower which already is reaching a thousand or so, and will most likely keep increasing. If I understand your last statement correctly, this means that since NASA is starting from scratch in this area, it will be using much more manpower than it would if it utilized them in existing facilities.

Colonel PICKERING. That is my personal opinion, yes, sir; that——

Mr. DADDARIO. Now, while NASA is spending this amount of money, the School of Aerospace Medicine at Brooks is also just finishing up more than $6 million of construction to increase a capability which already exists in accordance with, I presume, a pre-thought-out plan. This would appear, following your theory again, that the programs are in conflict with each other from that point of view alone.

Colonel PICKERING. It appears to me that there are several points of conflict. Yes, sir.

Mr. TEAGUE. May I ask one question, then I must leave for a moment?

Mr. DADDARIO. Yes, sir.

Mr. TEAGUE. General, last year we visited San Antonio and Pensacola and after our discussion with you, I left with the impression that there was a planned program of cooperation on different problems between the DOD and NASA where teams would be working on different phases of radiation, and so forth.

Recently, Dr. Roadman testified before this committee that he, in conjunction with someone from DOD, who I assume was an Air Force officer, sat down and listed about 89 different problem areas in this field. They decided how, within their capabilities, they would try to solve these problems and he intimated satisfaction as to how it has worked out.

Now, are you saying that this didn't work out and that there is not enough coordination and that there is enough duplication so that this committee should be concerned about the money we are asked to authorize for the NASA medical program?

General BEDWELL. Sir, I'd like Colonel Pickering to answer that, if I may.

He was the member of that Panel working with Dr. Roadman.

Mr. TEAGUE. First, Colonel, would you mention our discussion there as to how you were going to form teams to deal with the different problem areas.

Colonel PICKERING. Yes, sir.

Mr. TEAGUE. Was I correct in my assumption when I left there that this was going to happen?

Colonel PICKERING. You were correct, sir.

The space agency and the Department of Defense, as you mentioned, under General Roadman and Col. John Talbot who is in the audience this morning, were representatives of a working group.

The major objective which we had at the time, was to develop a DOD–NASA 10-year program in bioastronautics. We were charged with reviewing all of the existing programs, the existing facilities, the capital investment of equipment, our contract programs, our man-years of in-house research.

The initial outline was developed in about January and February. Subsequently and in several instances, simultaneously, all three services met, and developed their specific programs.

In the area of radiation, which during this time period the individuals were called team leaders, I was the radiation team leader; Dr. Shaffer of Pensacola joined me also.

Dr. Alpen, of the Naval Radiological Defense Laboratory, later substituted by Mr. Tochlin and Colonel Brennan, from the Army.

We went through the total of programs and tried to arrive at a course of action which would be most beneficial to the total program. A document was prepared. As General Roadman testified, it was signed off by him and Colonel Talbot. I think on May 8. Certain programs grew as a result of this in the DOD–NASA relationship.

Now, as General Roadman indicated in his testimony, what happened to the document and the subsequent working relationships are not in my purview to answer. This is not at our level. Many of the programs, however, have been used, not in the context of this cooperative coordinated program. They have, in fact, been used at various institutions and laboratories. The work still needs to be done.

Again, I personally contend that a great deal of this work could, in fact, be done by the services. After all, they proposed it as on-going programs which they, in fact, did have, and we gave to you that outline of program and gave it to you in the way of forecasting buildings and personnel accumulation. To some degree, this has obtained—but has not in its entirety.

Mr. KARTH. What you are saying, Colonel, is that it is not working in practice like it worked on paper. Is that right?

Colonel PICKERING. In my opinion, in my area, it is not working in practice as it worked on paper.

Mr. TEAGUE. It probably would not work that way to the satisfaction of any person involved.

Colonel PICKERING. No, sir.

Mr. TEAGUE. But it is not working to the degree that we should not be concerned about it?

Colonel PICKERING. There again, Mr. Teague, I think there are specific areas wherein it is working so you should not have a concern.

In other areas, I personally do have a concern.

It just is difficult to hire people when they have five different choices of places for employment and you are the lowest bidder.

Mr. TEAGUE. In other words, the government is competing with itself for this capability.

Is there duplication to the degree the Government ought to try to cut some money out to stop some of the duplication going on? Is the duplication that serious?

General BEDWELL. Well, I think an answer to that would be contingent upon a review of the research tasks and programs that NASA would propose, for example.

In my opinion in looking over some of the work—and this is just my personal opinion, there are many basic research tasks that are being conducted that are not in direct support of the space program.

For example, the fact that we did orbit Major Cooper successfully without the basic research being done on many areas, there are some areas that need to be concentrated on, but I do not feel many of the research tasks that are proposed are necessary to this specific purpose. I don't mean to infer that research isn't necessary but for that program.

(Whereupon Hon. Joseph E. Karth assumed the chair.)

Mr. KARTH. General, would you list these areas you feel rather strongly about and submit it to the committee for the record?

General BEDWELL. I think I could, in general terms, yes. In general terms.

Mr. KARTH. I don't mean right now, but later on, in the workpapers.

(The information requested is as follows:)

Notwithstanding the jurisdictional responsibility retained by NASA in the National Space Act of 1958 for the conduct of basic research, there appears to be a rightful concern that certain of the work seemingly unrelated to the space program is the heritage of universities and the National Science Foundation—for instance, studying the effect of X-radiation on the web-building activities of spiders. Though of itself perhaps interesting, results obtained could, only with extended imagination, enhance a space program already in the manned orbital stage. In a similar vein, though not to list extensively but rather to illustrate, there is concern among scientists for such tasks as: Inclosure control of fibrinolysis, electron microscopic studies on squirrel monkeys, molecular biology of nitrogen-fixing nodules in common legumes, effects of ionizing radiation on the canine ovary, localized effects of ionizing radiation, etc. The point being, though these studies in themselves contribute to science on a national basis, other organizations have for many years evinced this kind of interest and capability with existing facilities and ongoing programs.

I further stated a concern for certain research projects and tasks as they apply to the manned program, and more specifically to the manned lunar program. Here, though more difficult to differentiate, questions can still appropriately be asked pending program review and understanding. For instance, "Auditory perception during space mission" is a mix of highly applied and fundamental investigations. Basic parts of it include studies of basic anditory processes and extension of knowledge of man's auditory capabilities and limitations during influences by space flight. A factor to consider is that facilities already exist for this type of work to the extent that it is significant to the manned program and/or other programs. As a consequence, establishment of separate additional Government facilities and procurement of additional investigators does not appear essential to the national interest. As another example, "Visual perception during space mission" in its task description suggests that it is in a category similar to the auditory perception task mentioned above. Visual problems have been of longstandng interest in DOD research, as significant, in fact, as auditory functions. As a consequence, an enormous amount of baseline information data under operational, including even combat situations, is available and would appear to be highly relevant and extremely important in analyzing experimental projects for new and future work. Closer coordination and understanding at the task level may eliminate the need for additional facilities and personnel in such areas. As final example, there are programs in pituitary chemistry—research to determine the nature of chemical and physiological mechanisms for biosynthesis, storage, and secretion of pit hormone, with special reference to effects and stresses such as may be encountered during manned space flight. Again, pituitary chemistry hormonal studies as related to stress are programs that have been conducted in DOD laboratories, medical schools and physiological laboratories

for many years. Stress reaction and its implications to flight with high-performance aircraft under combat conditions and/or X-15 research have been and will continue to be extensively investigated. To establish this as an additional in-house capability does not appear essential in my judgment.

General BEDWELL. Yes, sir. May I make one further comment.

The Air Force and the Air Force Systems Command, General Schriever, was concerned about duplication within the Air Force of the medical research program and on the first of November 1961, the Aerospace Medical Division was formed, which I head, for the purpose of trying to prevent unwarranted duplication within the medical research laboratories of the Air Force.

As you know, you visited Brooks and our Wright-Patterson Lab and the Lab in New Mexico and in our formative stages we have visited our laboratories and we have tried to determine the capability of each laboratory and to prevent unwarranted—I admit, defining "unwarranted duplication" is a little difficult; but we are trying to conserve our limited, qualified research people and give the various laboratories the specific task that is in consonance with their training and we have, by direction, changed some research tasks and research areas from one laboratory to another to take advantage of the facilities that we have in being and the research people.

In other words, we are preventing what we call unwarranted duplication within our own command.

Mr. KARTH. Thank you, sir. You yield to Mr. Fulton?

Mr. DADDARIO. Yes, I yield to Mr. Fulton.

Mr. FULTON of Pennsylvania. The problem comes up as to the jurisdiction of the various Government agencies such as the Air Force, the Navy, the Army, and NASA as well as the National Science Foundation and the National Institutes of Health.

The purposes of the various agencies are different and, of course, their requirements are different.

Therefore, I think that it is unwise for the Air Force to comment on the requirements of NASA in its own programs, or whether the programs should necessarily be within NASA. If that is done, then NASA should be given the opportunity to reply to the Air Force and say what Air Force programs NASA feels could well be done without the Air Force, and without the money in the coming budget. That puts us into a problem of competition between agencies for jurisdiction.

I feel that this committee should not get into such an area. Where the Space Act specifically gives NASA jurisdiction of research on a broad base as well as the man-in-space programs such as Mercury, Gemini, and Apollo. We should look to see that there is a proper correlation between the agencies rather than trying to say which agency should be doing a specific program. Under that concept, we are not jousting and disputing between agencies, but we are, rather, trying to get a correlation and make sure there is no duplication.

Dr. Roadman is an Air Force general. He is now with NASA. He said that he had the 89 various projects at the working level, which were looked at by NASA and the Air Force and that correlation is going along well. Of course you always find these agreements but I took that to be a very authoritative statement.

My questions are: Don't you think that NASA should have a broad basic research and development program as well as the programs for

Mercury and Gemini and Apollo? Secondly, don't you think NASA should set the requirements for its own program and call on other Government agencies to help satisfy these requirements? Thirdly, do you disagree with General Roadman's previous statement before this committee?

General BEDWELL. Well, sir, in reply to your question: I think there's no question in my mind but what the Air Force, in the medical field, is attempting to coordinate and coordinate fully with NASA. We want our facilities to be utilized in the interest of the national objective and I certainly would not quibble with the requirement of NASA to have their own research program.

It was my personal opinion when I stated many of these research tasks are not essential to orbiting a man safely and I don't mean to downgrade research at all.

Mr. FULTON of Pennsylvania. But, of course, that is not the limit of NASA's jurisdiction. It is the exploration of space and research in respect to space, basic applied research, as well as technical development in aviation. NASA is different from the military in that the military must have a military mission possibly ending up in an operational weaponry system.

Don't you think there is that difference?

General BEDWELL. I agree, there is a difference. Yes, sir; no question.

Mr. FULTON of Pennsylvania. Do you disagree with General Roadman?

Gen. BEDWELL. I am not in a position to say that we have 89 research tasks that are completely coordinated.

Mr. FULTON of Pennsylvania. Rather than take the committee's time, at this point, would you and Colonel Pickering each please put a statement in the record as to your position on General Roadman's testimony?

(The information requested is as follows:)

COMMENTS ON GENERAL ROADMAN'S TESTIMONY BY MAJ. GEN. THEODORE C. BEDWELL

There is no question that NASA is uniquely experienced in selected areas associated with launch, flight, and recovery phases of Project Mercury. However, from General Roadman's testimony, the mistaken impression could be gained that all aerospace medicine competence for space flight is to be found within NASA. I don't believe General Roadman intended this implication. That he did not is borne out by his later elaboration. However, I would like to point out the following.

Continuing medical evaluation of the Mercury crewmen is performed at the SAM (School of Aviation Medicine) and Wilford Hall USAF Hospital. The medical monitors for the Project Mercury tracking stations were trained at the SAM. Over the entire period of the various Mercury flights the Air Force, Navy, and the Army supplied medical monitors for tracking stations throughout the world. The DOD supplied highly skilled medical support personnel for the Mercury recovery teams. After each Mercury flight, the astronaut was medically evaluated and debriefed by flight surgeons of the schools of aerospace medicine of the Air Force and Navy. In addition, the Air Force and Navy have been an important source of scientific manpower to staff key positions in the NASA organization as, for example, General Roadman and many others.

In any program as large and complex as that of aerospace medicine, in support of DOD activities and in NASA, it is obvious that it will be difficult, if not impossible, to get uniform and complete agreements on the solutions. It is, however, the desire of the Aerospace Medical Division laboratories to cooperate fully and completely with NASA. It is believed, in order to take full advantage

of the capabilities existing within our Division, that early coordination should be effected before a program is finalized. This would afford an opportunity to prevent any unwarranted duplication either in the in-house type of research or that done by contract. Since there is a relative shortage of qualified personnel to conduct research in the overall field of aerospace medicine, this would afford an opportunity to properly utilize the capabilities of existing laboratories and personnel.

COMMENTS ON GENERAL ROADMAN'S TESTIMONY, BY COL. JOHN E. PICKERING

A careful review of the comments of Gen. Charles H. Roadman in testimony before the Teague and Karth committees prompts the following comments:

1. The description of the DOD–NASA bioastronautics working group, its organization and its objectives are quite factual, and in my opinion this was a logical scientific approach to program coordination with the possibility of mutual implementation.

2. In this respect, I do not completely agree with the statement "As the two groups developed a better understanding of the interests of one another, the list of things requiring reduction to a formal agreement dwindled." The projects identified by the working group considered critical to the Gemini, Apollo, and Dyna-Soar programs still remain. They will dwindle only as solutions to these programs are attained, proven satisfactory, and applied to the systems involved. It is my firm conviction that continuing coordination, discussion of the research projects underway, by the working level scientists involved, must continue if the total program is to be pursued in the most efficient and responsive manner consistent with a national program, particularly if one accepts as an objective conservation of scientific manpower, funding, and additional facilities. Otherwise, total cognizance is not maintained and duplication in one form or another will accrue. To not use facilities, personnel, and programs already in being, eventuates the need to duplicate if the problem is to be solved.

3. The early attempts at coordination, programing, and implementation unequivocally demonstrate existing facilities and peoples within the Department of Defense could effectively pursue certain of the NASA objectives while simultaneously contributing to DOD objectives. Thus several requirements could be simultaneously answered. This conservation in itself enhances our national space capability, insures utilization of scientists of longstanding experience and satisfies essentially identical research of closely related programs.

4. Without this formal agreement, coordination is at best only superficial and even then in the rather large program areas. Specific details that pertain to a given task: what is to be done, what is already known, what need not be done, where it is to be done, and who has the responsibility for the answers, is the way to insure a sound, scientifically, well-coordinated program.

5. In terms of the organization which the NASA now has in life sciences, it is my opinion again that this is basically sound and represents (1) systems research in the Manned Spacecraft Center, (2) exploratory research in the Office of Advanced Research and Technology and (3) fundamental research in biosciences of the Office of Space Sciences. This flexibility permits differentiation of problem areas of immediate importance, of long-range importance, and research in the interplanetary environment for the enhancement of the sciences.

Mr. WAGGONNER. I think General Bedwell would be interested in seeing what General Roadman's testimony is after General Roadman goes back to the Air Force, too.

Mr. KARTH. I would like to follow the question Mr. Fulton started a few moments ago. Whether a man is manning a weapons system in space or whether he is flying in a peaceful-type capsule really does not make much difference insofar as aerospace medicine is concerned, does it?

General BEDWELL. None whatsoever.

Mr. KARTH. The problems of keeping the man alive are identical?

General BEDWELL. Yes.

Mr. KARTH. If you are working on problems to keep a man alive in space while he is, in fact, manning a weapon system, that is pretty

much identical with what NASA might be doing insofar as answering problems to keep a man alive in a peaceful capsule. Isn't that correct?

General BEDWELL. That is true.

Actually, our problems are to support the man and his mission regardless of what his mission is.

Mr. KARTH. I agree with Mr. Fulton. I think we are doing exactly as he said we should be doing. I am not, for example, saying that the Air Force should be doing all of the aerospace medical research work.

General BEDWELL. No, sir.

Mr. KARTH. All I am saying is that where the physical buildings now exist, and where the professional expertise now exists, and where the technicians now exist, and where the facilities now exist, that if NASA decides it must do research in the aerospace medical field—and I am one of those who feel it must—the only point I make is that NASA should contact those agencies of Government who now have the physical facilities and the professional staff for doing the research.

Is this what you are saying, gentlemen? Are we on the same wavelength?

General BEDWELL. I think so.

Mr. KARTH. I don't particularly care whether it is the Air Force, the Navy, the National Institutes of Health, or some other agency of Government where the capability exists, my point is that we should use it instead of duplicating.

Mr. FULTON of Pennsylvania. I thoroughly agree with that.

General BEDWELL. This is my point.

Mr. KARTH. This is the effort the committee is making to find out whether or not this situation does exist, where it exists, and if we should attempt to utilize it.

General BEDWELL. I believe we have a great capability within the Air Force and Navy both and where it exists it should be utilized, fully.

Mr. DADDARIO. I think we ought to remember too, in line with the questions which Mr. Fulton has opened up, that although NASA does have the responsibility by law, it also has the responsibility to use facilities in scientific and technical areas wherever they are located, and it is incumbent upon them to use these rather than build up their own. This is the area within which the problem has developed.

Mr. FULTON of Pennsylvania. Would you yield?

Mr. DADDARIO. Yes; I do.

Mr. FULTON of Pennsylvania. This is a remarkable position where a member of the opposition is defending NASA, and, I think, also defending the correlation and cooperation.

Mr. DADDARIO. It's not a question of defending NASA or defending the Air Force or anyone else.

Mr. Karth has put it, I think, in the most concise terms; that is, that it shouldn't make any difference where this work is done so long as it is done in the most efficient manner. We have seen a tremendous buildup in NASA. A buildup which, in the first instance was justified, not because this could not have been handed over to existing agencies, but because NASA had to develop a competence in this field. This competence was spelled out to be one by which NASA would build up to not over 60 professional people in the next 4 or 5 years.

This has now grown to the point where NASA has over a thousand people and the end not in sight. This should cause us all concern, and Mr. Karth, again, has pointed out a very important point.

We don't have enough medical schools and technical schools to graduate the kind of people we need to take care of the civilian problems, let alone some of the military ones. This can put a great stress and strain on the country in its other goals, and if we establish a breaking point in one place, it can affect us in a harmful way in many others. This is what causes me concern, and I think it is important we spell it out as closely as we can.

Captain Phoebus, you have talked about the necessity of duplication. You touched on centrifuges, for example, and you have a great competence at Johnsville.

We went into this at some length last year, and what we were trying to do was get the moneys diverted from within NASA. Instead of building centrifuges all over the country, we thought it might be better to develop a further competence in a place where there already was a core of skilled personnel upon which further capabilities could be developed.

Now, wouldn't that have been a cheaper and more efficient way to develop a national centrifuge capability?

Captain PHOEBUS. It may very well have been, sir.

I don't know the extent and nature of the program that was proposed to you at that time. Certainly it makes sense to build around an existing capability and that we certainly have at Johnsville; and NASA has utilized that capability to some degree, at least. We have enjoyed quite nice relationships.

The question of whether NASA should have utilized that capability and expanded it even further is not for me to say. This is NASA's business.

Mr. DADDARIO. Well, it probably is NASA's business, but it is also our business since we authorize the funds. If it can be done cheaper and more efficiently, we would like to find out how.

You say NASA has used this to some extent.

Captain PHOEBUS. Yes, sir.

Mr. DADDARIO. NASA is presently constructing centrifuges of their own. Can we then conclude that when these centrifuges are developed, NASA will be using Johnsville even to a lesser extent than it now is?

Captain PHOEBUS. I am not at all certain that the statement is necessarily true, sir, because centrifuges have different capability and different kinds of equipment to do different jobs.

I feel rather certain newer and modern equipment can do certain jobs our centrifuges cannot.

It happens at the moment, I think I am correct when I say, Johnsville is the one having the greatest capability in the country and it has been used extensively by NASA——

Mr. DADDARIO. It is recognized that centrifuges have various functions and can be used for various purposes, but the people who are trained in the use of centrifuges can be used to work various kinds of centrifuges.

Captain PHOEBUS. Yes, sir.

Mr. DADDARIO. Because of this, it seemed that it would make some sense to develop this capability at Johnsville.

Captain PHOEBUS. We certainly would have no objection to this.

Mr. DADDARIO. So, somewhere along the line this committee must come to a determination whether or not to support the new centrifuges and thereby cut the personnel available to those which already exist.

Colonel Pickering has spoken of the monkey colony that is so important. Last year, despite the fact that this existed and even though it had been called to the attention of NASA, they attemped to put in a similar operation which would have cost some $2.5 million and which we were able to show was a duplication and therefore cut.

But many of these are not as apparent as that, and Colonel Pickering causes me further concern when he says that even though you have different titles, many of these programs go in the same direction. That must apply in many, many places throughout this whole program.

Isn't that so, Colonel Pickering?

Colonel PICKERING. Ones I have looked at sir, it does. Yes, sir.

Mr. KARTH. I wonder if I could interrupt the proceedings at this point to announce to the joint subcommittee that we would like to continue this discussion this afternoon if the witnesses could make themselves available.

Mr. DADDARIO. Yes. Mr. Teague said it is all right.

Mr. KARTH. The reason I make the announcement at this time, and I hope the witnesses will understand, is that a number of the members of the committee have to be somewhere at noon. It might be necessary to recess at 11:30 a.m., if this is entirely acceptable to the witnesses.

I would then advise the committee members to proceed until 11:30 a.m.

Mr. DADDARIO. I had touched, gentlemen, upon the number of personnel involved in programs of this kind. Taking into consideration that in 1960 the estimated number was 5,900 involved in this program, and the fact that it has grown since that time, the number is now probably somewhere in the vicinity of 7,500 people. Have we reached the point where all of these programs ought to be bound together in some kind of a national facility so that it, as a national facility, could be called upon by all of the agencies of Government to perform experimentation?

Captain PHOEBUS. I am not at all sure that I understand your question, sir.

When you say "national facility" you don't mean in any one place, but a total capability of the country?

Mr. DADDARIO. Total capability, yes.

Captain PHOEBUS. To be coordinated to do a task together?

Mr. DADDARIO. Total capability under one head to which all the agencies of Government could go.

Captain PHOEBUS. I don't personally think this would work.

Mr. DADDARIO. Then we get to the next point. Does there need to be a better cooperative effort worked out so that all of these people, and all of these facilities, and all of these capabilities can be used. Take into consideration the extreme cost of this program and the possibility we will dilute our effort not only in space, but in other areas as well, as a result of the growth of the program and the number of people who are now being called to participate in it?

Captain PHOEBUS. Obviously, this would help matters, if it were possible to work it out this way.

Mr. DADDARIO. Why isn't it possible, Captain?

Captain PHOEBUS. I don't know that it isn't, sir.

Mr. DADDARIO. You have said earlier that even though there is duplication, that we ought not be concerned about it because in a basic area there should be duplication.

How do you justify a program as extensive and as large as this one?

Captain PHOEBUS. Sir, I make no attempt to justify it in every area; but I do know of many areas wherein different investigators taking different approaches to problems come up, shall we say, with different answers—all of which are valid.

Mr. DADDARIO. I can recall talking to one of the top British scientists a few years ago about our scientific program. One of the things that amazed him was that we were running off in so many directions at the same time. He said, "Of course, a lot of it is unnecessary, but you are so affluent a nation you can stand the cost."

But, cost does become important and don't you think we ought to avoid as much unnecessary duplication as we possibly can. If you could perform a function for NASA with a buildup of existing facilities and personnel, isn't this the best way to do it?

Captain PHOEBUS. I can't quarrel with that, sir.

General BEDWELL. May I comment on that, sir?

I think this would be a good approach and thinking, as an individual and not my official position, because this has not been cleared with the Air Force or DOD; but it would seem reasonable to me, the question of joint staffing within our facilities might be of value and, for example, in our new buildings at Brooks we could take on a segment of NASA and assign them space and have a joint program and a joint solution of a program within our existing capability with the addition of a few scientists. This would cut down on duplication of effort.

Mr. DADDARIO. You would have sufficient space and equipment for NASA to come in and develop certain of these programs together with the Air Force?

General BEDWELL. I would not want to say I would give them so many square feet of space. I think it would be based on the integration of the tasks or the research programs and with the coordinated effort on the research program this could be worked out, rather than just say, "We will give them one or two or three buildings."

Mr. WAGGONNER. General, are you not saying at the same time you have facilities that you don't need and which are in excess of your requirements?

General BEDWELL. No, sir; this is the reason I say we wouldn't give them so many square feet of space but I think a program in the research field——

Mr. WAGGONNER. You are saying you could tighten your belt and make room for somebody else?

General BEDWELL. No, sir; I am going to say we will double up on the assignment of space per man.

Mr. KARTH. If there are no objections, we will recess at this point until this afternoon.

(Whereupon at 11:30 a.m. the subcommittee recessed.)

AFTERNOON EXECUTIVE SESSION

Mr. DADDARIO (presiding). This meeting will come to order.

Colonel Pickering, this morning I read a quote of yours from a speech you gave back in 1960, I think.

I wonder if you might, taking that into consideration, comment on how we might better approach a method of procedure through which there could be stronger coordination in this field of biosciences.

Colonel PICKERING. Yes, sir. The comments I made were at that time about an effort which was not well coordinated. The time was 1960–61.

This morning at the questioning of Mr. Teague, I made reference to a NASA–DOD working book, also referenced, I believe, in General Roadman's testimony.

Mr. Daddario, in the development of that book, the programs, the tasks of interest in a national space program in aerospace medicine were discussed and developed by the three services and representatives of the then Life Sciences Office of the National Aeronautics and Space Administration.

The leaders of this group met and I would like to refer to them as task scientists, people at the working level. They discussed the programs, the facilities that were available, the kinds of work that NASA had programed and proposed, the kinds of work that DOD had programed and proposed, the individuals who were responsible for this work. This was then related to the three programs of interest, Gemini, Apollo, and Dyna-Soar. The tasks were referred to them in a context of those which we consider to be most vital in the pursuit of these programs, those which are of less significance and perhaps could have a lower priority, and those which perhaps one could defer in the interest of manpower, facilities and so forth.

I further stated that approximately May 8, after this type of coordination had taken place and the program appeared to be underway, there was no further face-to-face working level coordination on this total program.

In answer now to your question as an individual who was a part of that and, as my opinion, that this kind of coordination that discusses the task, what is to be done, what need not be done, where it is to be done, and who has that responsibility, is the way to assure a better coordinated program.

I would not like to imply that nothing has come since my 1960 statement. I think certain progress has been made. This brown book represents—this NASA–DOD book represents progress, an attempt at coordination.

Furthermore, I think it served at least as a reference, if you will, a baseline reference, for many programs, and, as I stated this morning, some of them have been implemented perhaps with less than the desired amount of coordination, but nevertheless used as a baseline.

Mr. DADDARIO. Then we were getting off on the right foot?

Colonel PICKERING. In my judgment we were; yes.

Mr. DADDARIO. When these task scientists met, as you put it, how can we get back on that track?

Colonel PICKERING. Well, we were directed to do this at one point in time and I think in the minds of the scientists this was the right thing to do.

I don't mean one has to direct that it now be done. It should be done. There needs to be this kind of a coordination arrangement by working-level people.

You can only effect it as an individual to a very limited degree, but when you have representatives of the services and the agency meet at a common time, which was done, both here in the Washington area and subsequently at the Manned Spacecraft Center in Houston, the specific problems are more readily discussed.

I haven't answered as to how. I am certain, by mutual agreement of the parties, this is the way to do it.

Mr. DADDARIO. Mutual agreement of the parties, the opportunity for them to get together at the working level to discuss the programs?

Colonel PICKERING. Yes, sir.

Mr. DADDARIO. The kind of coordination that you need to put this type of program together in the way that you hoped, as I understand it, would have developed from the time the task scientists set this program out.

Colonel PICKERING. Yes. I think too, it is the kind of program that had to be done against a deadline. Renewed coordination serves now as a better review for the validity of that program. By doing it again it should be improved upon.

Mr. GURNEY. Will the gentleman yield?

Mr. DADDARIO. Yes.

Mr. GURNEY. How did you leave that, Colonel, when you finished this task force report, if that is what it was. Were you ready to take another step and go further than that?

Colonel PICKERING. Yes, Mr. Gurney. I think the intent was that those programs which could be implemented at that point in time would be undertaken by the respective agencies. Additional work, as facilities came along—at that time there were facilities in the report that were under construction at various sites—would give an additional opportunity to implement more of the program, and I would be wrong to imply that certain of these programs were not implemented. They, in fact, were.

The total implementation in my judgment did not occur and, as a consequence, I have the personal feeling in looking at our research program that there has been a suffering by not continuing this.

Mr. GURNEY. Was there a continuing committee set up? Was that contemplated?

Colonel PICKERING. I would have assumed it was contemplated.

Mr. GURNEY. But it actually was not carried out?

Colonel PICKERING. No, sir. If I may make the assumption—I was a standing member of that committee—we have not been asked to reconvene. It is conceivable we were looked upon simply as an ad hoc committee and after the report was signed off, dismissed.

Mr. DADDARIO. Colonel Pickering, when you say there has not been total implementation, you still lend an encouraging note by stating that there has been some progress.

Colonel PICKERING. Yes, sir.

Mr. DADDARIO. I would hope that you feel that we should strive for total implementation?

Colonel PICKERING. Yes, I do. I think this——

Mr. DADDARIO. Now——

Colonel PICKERING. Excuse me.

Mr. DADDARIO. Go ahead, please.

Colonel PICKERING. I think this represents, if I may, at that point in time, the best judgment that could be simulated over this period of preparatory time to develop a program.

Now, as time goes on and more and more people become an integral part of this, it should obviously improve. I am not saying that book should be the finality, but it is certainly a good wiring diagram, if I may use that, as the beginnings of a program.

Mr. ROUDEBUSH. Mr. Chairman.

Mr. DADDARIO. Yes, Mr. Roudebush.

Mr. ROUDEBUSH. Before we get away from this, when did the ad hoc committee last meet? When did you last get together? Do you recall, just roughly?

Colonel PICKERING. June, if you will give me that roughness.

Mr. ROUDEBUSH. Yes. June this year?

Colonel PICKERING. No, sir, June of last year; 1962.

Mr. ROUDEBUSH. I meant the past year.

Colonel PICKERING. On approximately May 8 I would say the scientific efforts of the book were satisfactory in their development. We then went, after NASA and DOD review, to the Manned Spacecraft Center, and it is here I think where this number 89 comes up; there were certain programs that were perhaps not of immediate interest to NASA, and perhaps properly so, in the context of Gemini and Apollo. I am going to use another rough number.

There were about 123 specific tasks in this book. Eighty-nine, however, did seemingly satisfy the totality of this objective, and maybe there were 59 or 60 that could get underway right away. My encouragement, Mr. Daddario, is there are some 25 tasks that were an integral part of this that to my knowledge have been implemented. Maybe we are talking about 11 percent.

Mr. ROUDEBUSH. That would be 25 out of a total of 89.

Colonel PICKERING. Out of the total of 89.

Mr. ROUDEBUSH. I see.

Colonel PICKERING. These are the ones for which I would have an Air Force awareness.

Mr. ROUDEBUSH. One other question if I might, Mr. Chairman. You speak of mutual agreement and I can see the necessity of this. However, who makes the decision when you don't have this, as the lawyers say, "meeting of the minds"? Who would resolve the differences? For example, here is a facility to construct for a certain type of testing. The Air Force says, "We need this badly." Then NASA says, "We need it badly." Perhaps the Navy says the same thing. Who makes the decision as to which agency gets the facility under this arrangement, or who is supposed to make the decision?

Colonel PICKERING. It wasn't made at my level.

Mr. ROUDEBUSH. It was not?

Colonel PICKERING. No, sir, this was not a part of our charge.

Mr. ROUDEBUSH. Were there many cases where you were unable to resolve a question that came before your committee when it was operating?

Colonel PICKERING. I don't think so.

Mr. ROUDEBUSH. In most cases you were able to work it out?

Colonel PICKERING. I think we were.

Mr. ROUDEBUSH. In other words, this committee was working very well?

Colonel PICKERING. Well, it was beginning in the right direction. We weren't meeting often enough, in my judgment, to say it was working real well.

Mr. ROUDEBUSH. Was the Navy represented on the committee?

Colonel PICKERING. Yes, sir.

Mr. ROUDEBUSH. Were all the departments of the DOD represented?

Colonel PICKERING. Yes, sir, one of the team captains was Captain Graybiel and I had two naval representatives on the Radiation Committee. Captain Graybiel had other services represented on his committee and conversely on down the line.

Mr. ROUDEBUSH. I think, Mr. Chairman, that satisfies me.

Captain PHOEBUS. Mr. Chairman.

Mr. DADDARIO. Yes.

Captain PHOEBUS. If I may express an opinion here, I will say that I agree with the colonel completely in his account, the reasoning and the events that occurred. I would just like to point out that there was one thing missing in this get-together of the minds.

As he pointed out, this program was directed specifically toward Gemini, Apollo and Dyna-Soar. One must not forget in the planning of a long-range program to go beyond that.

Mr. ROUDEBUSH. Broaden it?

Captain PHOEBUS. Broaden it, yes. This is the one point I would make, that such a coordinating effort should be broadened beyond those programs which are currently funded or contemplated.

Mr. ROUDEBUSH. Would it be fair to ask you to express an opinion, or if you don't care to answer, I will understand, as to why this agreement failed to function further?

It was successful according to each of your testimonies; a lot of good was coming from it, apparently money was being saved, and duplication was being done away with. Why did it fail to function further? What stopped it?

Captain PHOEBUS. I am afraid I don't know the answer to this, or even that it was, shall we say, stopped, perhaps it just died because no one was pushing it. I don't know any better answer to it than that.

I know the men who met were working scientists who had a common agreement on what was important or unimportant and there were virtually no conflicts that I am aware of.

It is just the sort of thing that you would expect out of a group of this sort, but then someone—and I would imagine this would take higher level people in both the Department of Defense and NASA to make a decision to proceed in this direction or in the other direction, and I don't know what happened any more than does Colonel Pickering.

Mr. DADDARIO. The agreement, Mr. Roudebush, is neither dead nor is it incapable of being brought to life. It is hibernating somewhere.

Mr. ROUDEBUSH. I would say it is withering at least.

Colonel Pickering, do you have any opinion on that, as to why the state it is now in occurred?

Colonel PICKERING. No, sir; I truly don't.

Mr. ROUDEBUSH. Thank you very much, Mr. Chairman.

Mr. DADDARIO. I think Mr. Roudebush's questions are important and I am happy they are on the record. This committee has had Dr. Dryden of NASA and Mr. Rubel of the Department of Defense before us, and it was our understanding that they would come to an agreement which was based on the preliminary work being done by this group of scientists. It was this activity that was so apparent at the time Congressman Riehlman, Chairman Teague and I, as well as others, visited the School of Aviation Medicine.

Now, Mr. Gurney has pushed this a little bit closer to a point which we would discuss further.

Captain Phoebus, you pointed out the fact that this program that Colonel Pickering has talked about ought to be broadened somewhat.

Captain PHOEBUS. Yes, sir.

Mr. DADDARIO. I think we all agree that it has to be broadened since there has been so much difficulty in getting a method through which this coordination can be satisfied. Is the answer to the problem reactivating the committees and seeing if we can stimulate that same kind of thinking, taking into consideration that we have advanced the program somewhat and considering present-day circumstances, should we see if we can get that same kind of activity going again?

Captain PHOEBUS. Mr. Daddario, I think possibly one thing of which I am reasonably sure—you can check the dates with me, some of you know better than I—that may have changed this picture somewhat is a change in the organization of the life sciences group in NASA itself.

You have the one group under General Roadman, who are responsible for manned space flight; another group under Dr. Konecci for the biotechnology, and a third group under Orr Reynolds, who are interested in the biosciences in space, if you will.

I think their program planning, although I am very certain it took into consideration some of the recommendations of that committee, may be going in, shall we say, further directions?

I think that this is a factor in the thing, a reorganization within NASA itself.

Mr. DADDARIO. This, of cource, is not the first time that NASA has shifted gears in the life sciences programs and this may be one of the problems. We are concerned because of what the Kety report recommended as a life sciences section. Although we have gone over this ground before, it might be well for us just to refer to this again. Dr. Randt indicated that what NASA needed in this program was 60 professionals and a facility requirement of 90,000 square feet at an approximate cost of $3 million.

When Mr. Moeller, who was then on this committee, asked whether or not the 60 would be increased, Dr. Randt said that it would not be, and in fact it wouldn't be getting to the 60 until 5 or 6 years had passed. It was also spelled out that what they wanted was internal confidence to provide leadership. Now, NASA has gone far beyond that.

Mr. RIEHLMAN. Would the chairman yield for a comment?

Mr. DADDARIO. Yes, sir.

Mr. RIEHLMAN. I think you are getting right to it, but I want to be sure it is on the record. The witnesses told this committee at that time, and I want to verify this by you, Mr. Chairman, if you will, that they wanted the competence within NASA to judge the needs for this type of program. They wanted to coordinate the program with the other activities carried on by the Navy and by the Air Force, and that there would not be the buildup; we were assured of that.

Today we find we are now faced with a proposition of authorizing this great expansion, not alone for facilities, but permission to procure up to a thousand people. This is where I think that we, before we do anything else, Mr. Chairman, must take another look at this with the NASA people.

Mr. DADDARIO. Mr. Riehlman has pointed out some of the background of this very well.

Colonel Pickering, this morning when you referred to the development of programs of this kind, you said that you could save people by using them in existing facilities, and that by so doing you could accomplish a greater job. As time goes on and as this program broadens out, we can expect that even more people will be brought into it than are in it today, is that not so?

Colonel PICKERING. Yes, sir.

Mr. DADDARIO. If that is so, the question of coordination becomes a critical one.

Colonel PICKERING. I think you have to have this point in mind: If I have a laboratory and a senior scientist, I must support him with technical help, with logistics and all that goes with keeping business as usual. If I build two labs, I essentially double that.

If, however, I take my existing facility and its logistics and its support and move in a few more scientists, I certainly don't double this requirement. I am not even certain that I increase it by a factor of 33 percent, so there has to be a saving.

Mr. DADDARIO. This being the case——

Colonel PICKERING. That is my judgment.

Mr. DADDARIO. This being the case, Colonel, as this program enlarges and if coordination is not brought about, because of the strain that will be on facilities and manpower, could it have some effect on the Air Force's capability to handle its security mission?

Colonel PICKERING. This obviously has to be a personal opinion.

Mr. DADDARIO. Yes.

Colonel PICKERING. It is my concern that as Director of Research, General Bedwell knows this—we have talked about it—as programs grow, as facilities grow, each organization needs its best competence. I know General Schriever has testified the attrition to date is not one of great alarm. Yet there is some attrition. As more and more facilities come into being, there will be a greater attrition, and the competence is disappearing, could disappear, I will correct that to say, it could disappear.

I think that a scientist wants to be associated with a program in which his work is used. There is no benefit if he just writes papers. His benefit is being an integral part of an ongoing program so that he can feel "What I have done has made a significant contribution."

This is real and people are going to go wherein there is an ongoing program. If they leave for lack of a program or a participa-

tion in a program, then yes---we lose people on whose competence we rely, to answer your question.

Mr. WAGGONNER. I think that is the fundamental reason that NASA has had the success they have had in recruiting personnel in all areas. They have a program that is doing something.

Mr. GURNEY. On just that point, is there any vast difference between the NASA program and that of the Air Force?

When Mercury began, who was doing the aerospace medicine and bioscience part of the first Mercury program? Was it the Air Force or was it NASA, or both?

Colonel PICKERING. Are you asking me?

Mr. GURNEY. Yes.

Colonel PICKERING. Sir, I think in the beginning of Mercury--and I think most people would agree with this—it was done by the Department of Defense personnel. This is the way in which they got their start.

Mr. GURNEY. Now, are we talking about 1959, 1960, 1961?

Colonel PICKERING. Well, you can go back to 1949, you can go back to when ballistic probes, if you will, started using animals, and was accomplished by the DOD. This was before NASA came into existence.

Mr. GURNEY. But when NASA came into existence, and particularly with regard to the Mercury program, who was doing the biosciences work then, the Air Force or NASA?

Colonel PICKERING. The services were.

Mr. GURNEY. This was in 1960?

Colonel PICKERING. The services were still doing a part of it, yes, sir.

Mr. GURNEY. When did the change occur and how did it come about? We are talking about ongoing programs. This would appear to me to be an ongoing program, the Mercury program of NASA, a place where you could support it.

Where did the break come?

Captain PHOEBUS. Sir, may I speak to this point?

Mr. GURNEY. Anybody that can shed light on it.

Captain PHOEBUS. I don't really believe that any real break ever occurred. We in the Navy certainly have been working in this area with increasing intensity with NASA. I am very certain that the Air Force, and I can't speak for them, haven't slowed down their efforts.

I am quite certain they have increased them.

Mr. GURNEY. When did the Navy start to work on the Mercury program?

Captain PHOEBUS. Right at the very beginning of it.

Mr. GURNEY. What year?

Captain PHOEBUS. 1959 or 1960, around that period.

Mr. GURNEY. What were you doing then? What was the Navy's role in the Mercury program?

Captain PHOEBUS. I think probably one of the earliest efforts in the Mercury program was getting life support equipment assembled and checked out to see whether it was feasible to use the existing pieces of hardware in the Mercury program. For example, the suit which our astronauts have worn was developed by the Navy primarily as an operational suit and modified for Mercury.

Similarly, other pieces of equipment which had been developed by the Armed Forces were modified to suit the peculiar requirements of Mercury.

Mr. GURNEY. Now, Colonel, would you like to answer that same question?

Colonel PICKERING. Sir, in my opinion again, I think what Captain Phoebus has said, the Department of Defense furnished the aerospace medicine support on the centrifuges, both at Wright-Patterson and Johnsville, used at that time if you will, to man-rate or missile-rate various components of not only life support, but the restraint, the seat, the configuration of the seat, various instruments, sensors which had been used, if you will, as in the X–1, X–2 aircraft for making sensing measurements at higher speed and higher altitude continued in their development; they were being miniaturized. The need to develop equipment, that is miniaturized, equipment for, blood pressure, respiration, for keeping track of heart measurements on the astronauts, the best way in which this could be done, the newer methods were continued, and they as a matter of fact are still continuing.

The sampling of atmospheres, the development of an atmosphere in which the astronaut might properly be supported, these, too, are continuing.

Mercury, I think, is still dependent upon the Department of Defense personnel. Perhaps the word "break" is not the choice of word I would use, but when Gemini and Apollo, as programs, more clearly evolved, there, in my judgment and my limited experience in one of the areas, there was then less of an interplay of the services' contribution.

Mr. GURNEY. Would you say that as the program got larger, that the Air Force continued to do many of the same things, but as possible new functions or larger functions were taken on, then the Air Force was not called upon to do the job, but rather NASA did it itself? Is that generally the idea?

Colonel PICKERING. Well, it is more than this, I believe, because of the industrial interplay; other aspects of life sciences, if one wants to describe it that way, did evolve and develop out of necessity—so that as more and more individuals became a part of this total program, and I think your statement and question, as it grew and grew, yes, there is less, to me, of a direct affiliation in the aspects of this program which I sincerely believe represent a competence within the Department of Defense.

Mr. GURNEY. Is it your feeling, though, that had you been called upon, you could have continued to support the program completely?

Colonel PICKERING. In the areas for which I have a responsibility, yes, sir.

Mr. GURNEY. Thank you.

Mr. RIEHLMAN. I notice the captain is eager to make a statement, or at least he appears to be. In respect to the Navy, what has happened as far as you are concerned, Captain Phoebus?

Captain PHOEBUS. As far as we are concerned, the stimulus that we have received in our ongoing programs from NASA has been very, very welcome. Our programs have grown in size; we have hired additional people and put in additional facilities to work specifically in problems of our mutual interest. We don't feel that we have been

neglected by NASA in any way, manner, shape or form, at the activity I am speaking for, the School of Aviation Medicine.

I happen to know that in a number of other naval medical activities they also have benefited considerably from NASA assistance, and are working also in problems of our competence and of NASA interest.

Also I might say that NASA—and I think rightfully so—has not bought every proposal that the Navy has sent in to them. They have to fit them into their program.

Mr. RIEHLMAN. The Navy has sent in proposals pertaining to the Gemini program and to the Apollo program?

Captain PHOEBUS. No, sir. It happens that at the School of Aviation Medicine our work is on a much more broad and fundamental basis, and is only occasionally directly related to an ongoing, practical, hardware-type program.

Mr. GURNEY. Will the gentleman yield?

Mr. RIEHLMAN. Yes.

Mr. GURNEY. Captain, were you in this aerospace or bioscience field, as it pertains to space program, actually before NASA called upon you?

Captain PHOEBUS. I would put it this way: That there is a continuum between aviation medicine and space medicine, and the areas in which we had over the years built up competences primarily for our aviation medical interests were quickened, shall we say, by the space program. They have been enlarged, we are doing more work on them, and it is working out quite nicely from our viewpoint.

Mr. GURNEY. That is to say, where the Navy had a specialty that NASA could draw upon and did so, this naturally augmented what you were doing?

Captain PHOEBUS. Exactly.

Mr. GURNEY. Going back to what I stated before, as far as the Air Force is concerned, it was really in the aerospace medicine field, and the Navy really was not, is that a fair statement? I am speaking of the beginning of the program, and not when NASA came on the scene.

Captain PHOEBUS. No, sir; I don't believe that is a fair statement.

Mr. GURNEY. Then I ask you again, in what way was the Navy interested in space medicine?

Captain PHOEBUS. Well, I guess probably I could describe it as being a fundamental program looking forward to the future for aviation and space medicine in several rather important areas; in the radiation area, in the disorientation area; at other organizations, in acceleration, in vibration, in heat studies, in oxygen and support equipment-type things. All of these are a continuing process of developing the state of the art, as we go ever higher and faster, whether in a plane or spacecraft.

Mr. GURNEY. True, but most of those were in connection with aircraft, weren't they?

Captain PHOEBUS. Yes, sir.

Mr. GURNEY. Rather than space?

Captain PHOEBUS. The Navy has never had any specific program in space, space medicine.

Mr. GURNEY. That is what I was getting at, whereas the Air Force, I think, had a little different picture because it was in the space business at the beginning.

Mr. DADDARIO. Mr. Waggonner.

Mr. WAGGONNER. Captain, you stated that as far as the Mercury program was concerned, there was never any real breaking point in the knowledge of life sciences that you could identify as such?

Captain PHOEBUS. Yes, sir.

Mr. WAGGONNER. Isn't it a fact that we don't need any breakthrough in the life sciences field for either the Gemini or the Apollo program?

Captain PHOEBUS. I don't believe anyone knows the answer to it as yet. Our experience up until now is limited to a man in space for a few days and, incidentally, at relatively low altitudes. I think we are all anticipating problems that we just don't know the extent and nature of, but which we are working toward being in a position to be able to handle.

Mr. WAGGONNER. Are you aware, Captain, of the fact that NASA has on repeated occasions made the statement that we need no great breakthroughs for the Apollo program?

Captain PHOEBUS. I would think, myself, speaking as a medical man, that they are referring largely to the state of hardware that need be assembled for those vehicles. Whether the man, himself, is going to be able to carry out his functions, with the present state of the art, against radiation, for example, and weightlessness and a number of others—long periods of time are involved here now, and I don't think one can talk about the extent and nature of any of these problems without looking at the time factor.

There is a world of difference between exposure to stresses of lasting a few hours, or days, or weeks, and so forth; and they change the whole ball park of the problem you are studying when you add these increments of time. We don't know, for example, right now for how long a man can stand the weightless state. So far the results are very gratifying, but is there a breakoff point? We just don't know. No one knows.

Mr. WAGGONNER. No further questions, Mr. Chairman.

Mr. TEAGUE. Mr. Roudebush.

Mr. ROUDEBUSH. This question is for either Colonel Pickering or Captain Phoebus. Are you aware of any case where NASA enters into contracts with either private companies, private laboratories or universities to carry on basic research, that either the Navy or the Air Force have the capability of carrying it out?

Captain PHOEBUS. I can talk to one point of this. I don't know the entire picture of NASA, but I do know that in a number of instances we have suggested and recommended to NASA that the competence of certain industrial organizations and universities be utilized in coordination with the programs which we have, and which we do not feel we should develop a competency for when it already exists elsewhere.

So we have recommended, in fact, had NASA withdrawn funds already allocated to us, in order to effect contracts with various universities and industrial organizations.

Mr. ROUDEBUSH. Does the Air Force have any capabilities where you feel, Colonel, that certain research could have been carried out

by the Air Force instead of NASA entering into contracts with universities or private laboratories?

Colonel PICKERING. In my opinion, Mr. Roudebush, the answer is yes; there are certain areas that were being done in balloon fly[illegible], in certain of the tissue culture areas aboard satellite vehicles, where the work was ongoing in the laboratory that could just as easily have been continued.

I don't say this is the ultimate answer. As Captain Phoebus said, certain checks—what I prefer to call checks rather than just outright duplicative endeavors—are the only way to validate scientific information. But when individuals have the identical program this need not exist. And as a consequence, as I stated this morning, there were programs we felt required to terminate, since they were identical.

Mr. ROUDEBUSH. Now getting back to this NASA–DOD Committee that we discussed a few minutes ago, in any case was the National Science Foundation brought into this since they handle grants for studies and so forth in quite large numbers?

My question specifically is: Was there ever a case that you know of where NASA or the Air Force asked the National Science Foundation to make an award of a certain type to carry out certain basic research?

Colonel PICKERING. During this NASA–DOD Committee programming, to my knowledge the answer is, "no." There were no National Science Foundation grants.

Mr. ROUDEBUSH. Do you feel that would be wise for our committee to consider the possibility of utilizing the facilities of National Science Foundation for some basic research; that is, through their grants and fellowships program?

Colonel PICKERING. Well, I think the National Science Foundation, in part, is set up to do just that.

Mr. ROUDEBUSH. But you do not feel, then, Colonel, it has been doing that?

Colonel PICKERING. Yes, sir; I think it has, but I am not aware of the NASA-National Science Foundation relationship on these grants.

Mr. ROUDEBUSH. I see.

Colonel PICKERING. I wouldn't say they do or they don't, I don't know.

Mr. TEAGUE. Do any of you have any serious doubts that medically speaking, the man will be ready to go to the Moon by the time the hardware is, according to the schedule that has been published.

General BEDWELL. I think I can answer that, sir. I discussed that at quite some length with Dr. Strugold whom all of you know.

In fact just the other day I wanted to get an up-to-date opinion and appraisal from him.

He has the opinion that the medical aspects are reasonably well under control and that when the hardware is fabricated that the medical aspects will be such that he can travel safely and then return.

Mr. TEAGUE. Captain Phoebus, do you have any comments?

Captain PHOEBUS. I would make this comment, sir, and in support of the general to this degree: If anybody, I think, had told us 5 years ago that we would have achieved the feat which we did last week with Cooper, many of us no matter how optimistic we were at that time, would have had serious doubts; and particularly that we should have been able to run through the Mercury program as we have now without any failures and really nasty accidents.

I don't think many of us believed that this was impossible within the state of the art. I have the same high hopes for our Moon program. While at the same time I am not quite so sure in my own mind that all of the medical problems have, by any means, been satisfactorily solved already. I think those that we know about have been thought about, and work is progressing on them, that gives promise of solving them, so that we will attain this objective.

Whether this will come about on any kind of a timetable or not, I don't think anyone can say. But the scale of effort is constantly going up and the results are starting to fit together, and so as I say, I am optimistic.

Mr. TEAGUE. General Bedwell.

General BEDWELL. I didn't mean to give the impression that all the medical problems had been solved, as Captain Phoebus stated.

My inference is that by the time the hardware is developed, I think it is far enough downstream that the medical problems will be reasonably solved. However, it is going to be necessary to do some further work to make sure of this.

Mr. TEAGUE. There is discussion going on right now about a future Mercury flight. There are capsules available, a booster is available, and the man is available. Would there be, as far as you know, a lot to be gained, medically, by another flight?

Is it possible another Mercury flight could contribute considerable medical knowledge?

General BEDWELL. Sir, I would like to evaluate the data before I answer that. However, I might give an opinion, that the medical data, if it is as good as has been reported, and all I have seen so far is what I have seen on the television and in the papers, I don't believe it would be significantly enlightening to extend the flight from a medical point of view.

I am not talking about the hardware, just the medical point of view. I don't believe an extended flight would add greatly to our knowledge.

Mr. GURNEY. You mean extended for several days, or longer than the 22 hours.

General BEDWELL. Yes.

Mr. TEAGUE. Along that same line, I have a little daughter that has just started driving a car, and I notice that she is much more comfortable driving to town the second time than she was the first time. How much do we get from a man having this additional experience of having made a flight?

Does our country gain something from such a flight, not necessarily medically, but it is still a human factor?

General BEDWELL. Well, if you are thinking of having the man gain confidence in his ability to do this, I think there is no question but what he would; yes.

Mr. TEAGUE. That is what I was speaking of; yes.

Captain PHOEBUS. May I make one point here?

Mr. TEAGUE. Yes.

Captain PHOEBUS. Even though the data that we know of so far from these flights has all been quite encouraging, may I point out that from the scientific viewpoint one can never get too many cross checks and enough data.

A few samples of the performance on one occasion, under a given set of circumstances, and perhaps even with a given individual, may

not stand up over the long run, and from that viewpoint alone I think, personally, that it would be a good idea to have another Mercury flight.

There are many other reasons for doing it, too; but the more data we have, the more statistics, and the more validity we have.

It is just that simple.

Mr. RIEHLMAN. May I make this comment, Mr. Chairman?

Mr. TEAGUE. Mr. Riehlman.

Mr. RIEHLMAN. We would all like to continue these operations, if we possibly could, to get more data and more information. But somewhere along the line we have to cut off some of these experiments and some of these expenditures so that we will have money enough to go on to another program. They are all desirable, Captain, and we all agree with you, but unless we can get significant information there is the question of whether it is worth the cost involved.

Captain PHOEBUS. I thoroughly appreciate this.

Mr. TEAGUE. My wife came home and said we can save half the price if we can get it up. We still have the capsule, we have the capability. We can save some money.

Mr. RIEHLMAN. I am perfectly willing to consider saving some money, but just because we have the capsule and the capability, I am not sure that what we will gain in the field of advanced medicine and other accomplishments is going to offset the cost.

Mr. DADDARIO. It is not even a bargain at half the cost.

Mr. RIEHLMAN. No, I am not looking for bargains, either. If you can't use them to some great advantage, they are not bargains as far as I am concerned.

Mr. TEAGUE. Any other questions.

Mr. GURNEY. Yes, Mr. Chairman. In trying to find out if there is duplication in this effort, particularly in NASA and the Air Force, could anything be gained by your submitting for the record what programs you are going to have in the next year in this field?

Could you state for the record those projects you have underway with a brief descriptive sentence or two about each one?

Then we could get the same information from NASA and come up with a picture of possible duplication that we could understand? Would this be possible?

General BEDWELL. Yes, sir, we have quite a bit of the information on this and if I may I would like to submit this for the record, and which I can very briefly refer to it.

We have tasks that we have offered to NASA, ones that they have accepted and ones they have rejected and ones that are still under study.

These are outlined by subject matter.

Mr. TEAGUE. Without objection, we will put that information in the record.

You can revise and extend your remarks, you don't have to do that now.

General BEDWELL. Yes, sir.

(The information requested is shown in appendix G.)

Mr. GURNEY. I wonder if we could get the same information through our Committee Chairman from NASA.

Mr. TEAGUE. Yes, sir.

Mr. GURNEY. Maybe we could get some kind of a comparison on them.

Mr. FULTON of Pennsylvania. Mr. Chairman?

Mr. TEAGUE. Mr. Fulton.

Mr. FULTON of Pennsylvania. There has been the comment of the list of 89 items of various elements or programs which have been under discussion and which are being, shall we say, worked on between NASA and the Air Force. Would you give us for the record, with the chairman's permission, your point of view on the 89 items and the standing of them?

General BEDWELL. Sir, if I may, that was covered previously by Colonel Pickering in quite some detail.

Mr. TEAGUE. Well, read it to him.

General BEDWELL. Would it be all right for Colonel Pickering to give a résumé of it?

Mr. FULTON of Pennsylvania. Please do it for the record and in a considered manner.

Mr. TEAGUE. I think this work was done at a different level than yours. Wasn't it done by a DOD representative?

Mr. FULTON of Pennsylvania. If you put the 89 items in some detail in the record——

General BEDWELL. No sir, they were not itemized.

Mr. FULTON of Pennsylvania. I would like you to go through them. General Roadman said they are working satisfactorily on 89 different items. I think we should have the answer for the record.

Mr. TEAGUE. Before you leave that, is it not true that the 89 items are at a different level than yours?

General BEDWELL. Yes, sir.

Mr. TEAGUE. It should come from a different source.

Mr. FULTON of Pennsylvania. I see.

Mr. TEAGUE. The Colonel is here, is he not, who worked with General Roadman?

General BEDWELL. Colonel Pickering worked with him and also Colonel Talbot of DOD at that time.

Mr. FULTON of Pennsylvania. Whoever it is I would like to have it in the record. It should be cleared up.

Colonel PICKERING. I was under the impression that General Roadman made this a matter of record according to his testimony.

Mr. TEAGUE. He gave us the list, but there was no discussion of it. It was just a list of the different items they had worked on. I think if there is disagreement we would like to know it.

Mr. FULTON of Pennsylvania. On these Mercury flights at this particular stage of development of both hardware, boosters, and checkout, the question, of course, comes up of the safety of the person in the capsule. My feeling has been that we should wait for automatic checkout before we have another manned space flight. To me, that would not only be on the basis of economy but also on the ground of safety.

Would you comment on that?

General BEDWELL. Sir, if I understand you correctly, you mean automatic checkout of the capsule prior to flight?

Mr. FULTON of Pennsylvania. That is right, an automatic checkout through flight, probably for 150 miles.

General BEDWELL. No question but what we are all interested in safety, naturally.

Mr. FULTON of Pennsylvania. Say that again.

General BEDWELL. No question but what we are all interested in safety of the man.

However, I think Major Cooper demonstrated that if the automatic equipment does not work and a man on board can return the craft without the benefit of automatic pilot, now as far as automatic checkout on the ground is concerned I think this would be—is, I am sure, a factor that we all would rely upon.

Mr. FULTON of Pennsylvania. That is a real advance in safety for the astronaut when we have automatic checkout.

General BEDWELL. Yes, sir. However I think——

Mr. FULTON of Pennsylvania. So we had better wait for that before we subject another astronaut to the risk of flight without automatic checkout?

General BEDWELL. I would like to defer answering this to NASA because we have not been in the direct chain of events here and I am not in a position to answer this one.

Mr. FULTON of Pennsylvania. That is all, thank you.

Mr. TEAGUE. General Bedwell, Captain Phoebus, the committee certainly appreciates you gentlemen coming up here.

General BEDWELL. Sir, may I extend an invitation to you and all the members of both committees to visit us at your convenience.

Mr. TEAGUE. Yes, we have been working on that, but we just haven't been able to find the time. We almost worked it out a week ago. I would certainly like to have the members visit Pensacola also. We will keep working on it.

Captain PHOEBUS. Thank you.

Mr. GURNEY. May I have one more question?

Mr. TEAGUE. Mr. Gurney.

Mr. GURNEY. I suppose your division has given some thought to manned space platforms orbiting the earth?

General BEDWELL. Yes, sir.

Mr. GURNEY. The medical aspects of this, I would suspect, would be pretty important, wouldn't they?

General BEDWELL. Yes, sir.

Mr. GURNEY. What work have you done on this?

General BEDWELL. We have done a lot of preliminary planning and discussion so far, Mr. Gurney. We have not been given a specific research task, as such. We have, within Colonel Pickering's research directorate, been trying to lay some groundwork in which we could pursue some tasks if we are given this mission.

Mr. GURNEY. Do you think this is a pretty important mission for you to increase the state of the art and the knowledge of this field?

General BEDWELL. I think in the interest of the national objective it is, yes; if this is the mission that is going to be given either to NASA or to the Air Force, I think it is an area that needs extensive work.

Captain PHOEBUS. If I may comment, Mr. Gurney?

Mr. GURNEY. Yes.

Captain PHOEBUS. In one of our programs at Pensacola we have been working specifically in this area. As you know, one of the suggestions, more than a suggestion, a proposal, for restoring weight,

gravity to a man in space, is to spin the space stations. The spinning, itself, can have very deleterious effects upon a man, physiologically, and we have been working in this area in conjunction with our other disorientation work.

To give you an idea as to some of the practical importance of this, we have discovered with our slow rotation room that there is a world of difference in the affects on a man from the different rates of speed at which you spin him. And this, in turn, can dictate the size of the space station. If you can only spin a man, we will say, at 3 r.p.m., then the radius of your space station must be considerably larger than if you are going to spin him at 10 r.p.m. So this has a direct bearing on the overall magnitude of the task of putting a space station up there, how large it is going to be and what the engineering problems are, to know whether the man can take it or not. We have the answers to this problem, incidentally.

Mr. GURNEY. Is there exchange of information between you and the Air Force in that field?

Captain PHOEBUS. The information is contained in our publications which they receive; yes, sir.

Mr. GURNEY. No further questions.

Mr. TEAGUE. Thank you, gentlemen.

The committee will meet tomorrow morning at 10 o'clock in room 354 in executive session.

Mr. RIEHLMAN. Will the chairman be there?

Mr. TEAGUE. He will be there at that time.

(Whereupon, at 5:04 p.m., the subcommittee adjourned.)

1964 NASA AUTHORIZATION

THURSDAY, JUNE 6, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON MANNED SPACE FLIGHT,
Washington, D.C.

EXECUTIVE SESSION

The subcommittee met, pursuant to adjournment, in room 354, Cannon Building, at 10 a.m., Hon. Olin E. Teague presiding.

Mr. TEAGUE. I would like to say to the committee members that Mr. Holmes and his people have been told the major areas where there may be cuts or postponements, whatever you want to call it. We will ask them to start with the M–1 engine, and then we will cover the construction of facilities and the research and development.

I would hope that the committee will give them a chance to say what they want to say. I see no reason for a lot of questions. We will finish this aspect of the hearings and this afternoon mark up the bill and get it finalized for the full committee.

Mr. ROUDEBUSH. When do you intend to go into an executive subcommittee meeting?

Mr. TEAGUE. As soon as they have finished.

Mr. ROUDEBUSH. Thank you, sir.

Mr. TEAGUE. Now, Mr. Holmes, we have argued for hours about the M–1 engine and have considered cutting the whole thing out, facilities and everything. We also have considered a reasonable continuance of the engine at some level that keeps it going, and doesn't destroy the program.

I think that is the feeling of the majority of the committee at the moment. What figure would continue the program without harming it too much?

I think the point is that after NASA discontinued Nova, or delayed it, there have been improvements in the vehicle. Perhaps if you went a little slower with the M–1 engine, there might be new improvements you would want to make. It would still not stop the program.

Would you take it from there?

TESTIMONY OF D. BRAINERD HOLMES, DEPUTY ASSOCIATE ADMINISTRATOR AND DIRECTOR, OFFICE OF MANNED SPACE FLIGHT, NASA; ACCOMPANIED BY GEORGE M. LOW, DEPUTY DIRECTOR, (PROGRAMS) OFFICE OF MANNED SPACE FLIGHT; DR. JOSEPH F. SHEA, DEPUTY DIRECTOR FOR SYSTEMS; WILLIAM E. LILLY, DIRECTOR, PROGRAM REVIEW AND RESOURCES MANAGEMENT; AND DONALD J. KEUCH, OFFICE OF MANNED SPACE FLIGHT, PROGRAM REVIEW AND RESOURCES MANAGEMENT

Mr. HOLMES. Yes, I will comment in general on it. I would like to have both Mr. Low and Dr. Shea comment also.

As you know, we considered carefully what level of effort should go into the M–1 engine on the very basis on which it is being requested; that is, on the basis that would be developed for use in future launch vehicles of the post-Saturn class. The engine would be used in a high efficiency manner in upper stages to be consistent and compatible with developments which we are presently carrying on for solid boosters in the first stage. It is our considered belief that the current budget request represents the proper level of funding for carrying on this work in the most efficient manner.

These matters are all a matter of seasoned judgment. It is our judgment and belief that any reduction at all in the M–1 budget request would not be in the best interest of the national space program. I think deleting it entirely, which, you say, the committee is not suggesting would have very serious consequences. In my opinion, it would be inconsistent with our carrying on future developments, for instance, for very large solid boosters. It would be inconsistent with our saying that we are going deeper into space.

Therefore when one has to reach a judgment between the funding requested and lesser funding, I think my position is one that we carefully consider all of these implications before making the request and we think that the funds we requested would provide the proper level to continue this technology.

Mr. Low, would you like to comment?

Mr. TEAGUE. Would you comment on "facilities" versus "R. & D."?

Mr. LOW. Yes, Mr. Teague.

It is my understanding that there is a tentatively proposed cut of $40 million in R. & D. and a complete cut of facilities.

We had requested $45 million in R. & D. We will have obligated by the end of this fiscal year; that is, the end of this month, all of the 1963 funds available in the M–1 project.

This means then that a cut of $40 million would leave us $5 million for 1964 and this, we believe, would be tantamount to killing the project completely.

We are spending right now at Aerojet General Corp. between $3 and $3½ million per month——

Mr. HOLMES. In R. & D.

Mr. LOW. In R. & D. We plan to maintain the spending rate, maintain the same level of engineering and production level throughout 1964. We had not planned on an increase, 1964.

The additional funds beyond that for 1964 were for propellants and some special test equipment in the plant.

We have examined the facilities also and have come to the firm conclusion that the facilities are the longest leadtime items, the most critical path in the M–1 program, so that if any cut must be taken, our first recommendation would be to reduce the R. & D. and leave the facilities completely alone.

Mr. TEAGUE. What is the status of facilities now?

Mr. LOW. With 1962 and 1963 funding, we have under construction, all of the component test facilities and, well underway, the first major test stand for full engine testing. This test stand called, K–1, I believe, is for short duration, 15-second tests of a complete engine.

We have also started with fiscal 1963 funds, a second test stand which is for the altitude testing of the engine.

We are requesting funds in fiscal year 1964 for the completion of the second test stand and the beginning of a third test stand.

Dr. SHEA. The altitude test stand is not for full-duration run, whereas the third test stand is.

Mr. TEAGUE. Any more questions before we leave?

Mr. DADDARIO. What is the third test stand used for?

Dr. SHEA. The third test stand is required for full-duration ground tests of the engine, Mr. Daddario. Full duration on the M–1 engine is about 530 seconds. The K–2 test stand can be used for runs of approximately 300 seconds.

Mr. HOLMES. I'd like, Mr. Chairman, if Dr. Shea might say a few words about the system aspects of the M–1 engine.

Dr. SHEA. We discussed this area in previous testimony. I think that the M–1 engine is part of our investment in the next generation of launch vehicles. Most of the studies which we have done on advanced vehicle concepts still tell us that if we are to have a new vehicle in the 1970 time frame—this would be particularly the first half of the 1970's—the vehicle will undoubtedly require an engine of the M–1 type.

We don't think that nuclear propulsion is going to come along fast enough, nor would we want to use nuclear propulsion in the lower stages of the booster. The M–1 engine can be used both in base booster and will undoubtedly be used in the second stage of the next large vehicles over and above the Saturn V.

Unless we maintain a reasonable pace on the program we will be in a position where we really can't start a new booster because we won't have a suitable man-rated engine available.

I think you are all familiar with the length of time it takes to develop an engine into maturity. This is going to take as long as or longer than the F–1 because of the difficulty of the task. It is a tougher engine job.

Mr. TEAGUE. Then, to summarize, Mr. Holmes, you think that it is most important to continue the engine.

You are spending $3 to $3½ million a month. If there is to be any postponement or cut, you would prefer that it is made in R. & D. portion of the program and not in the construction of facilities.

Does that summarize it correctly?

Mr. HOLMES. I think that's a good summary. We feel it should go to about this level.

Mr. DADDARIO. Mr. Chairman, we have had some evidence that would lead us to believe that the C–5 stage can do for the next period

of time until other engines are developed. Everything that NASA could do or needs to do to carry out its program, including deep probes into space, could be accomplished using the Saturn C–5 stage. Is this not so?

Mr. HOLMES. I think it's a question that really can't be answered specifically "yes" or "no" until we know what difficulties we will get into with rendezvous. I believe we all think that it is feasible. On the other hand, there will be certain deficiencies particularly with meteorites or very large masses. I assume this is what you mean.

We will use the Saturn V to go deeper into space. However, it will be far more economical and efficient to use a larger booster for increasingly deeper penetrations into space. I think here we feel as time goes by we are going to need a more powerful booster than the Saturn V. Therefore, we are doing these large solid developments. We feel that this engine development and technology—not having a hurry-up program to produce the engine in the minimum time and learning how to produce it—is consistent with our approach. Dr. Shea may wish to comment further.

Dr. SHEA. I think the true situation, as Mr. Holmes said, is that we don't honestly know at this point in time what payloads are going to be required to do more advanced missions beyond the manned lunar program. We also don't know the time period in which the country is going to want to do such missions. I am sure the payloads are going to be large and if they require more than three or four rendezvous in Earth orbit, it will be a situation where the operational problems will be quite complex. My personal feeling—and I started to put a quantitative argument on this—but, my personal feeling is that we probably will never rendezvous more than four or five payloads for one operational kind of mission. As a matter of fact the economies, in terms of booster cost—not just operational problems—begin to break over at the point of four or five Saturn V kinds of payload, something that might be done more efficiently and economically with a larger booster. Now, the pure and simple fact is that if engines are not available, we either won't be able to do the missions if the country wants to do them or we will be constrained to do them on a very complex operation. In a sense, what we are saying to you is that the M–1 engine and several other elements of advanced technology are really an investment that we require in this country not for the space program in the 1960's but really for the space program in the 1970's. We are not able to identify exactly what the missions are going to be and exactly how we are going to put them together, but we do know, essentially, by historical analogy that these types of engines and these types of systems have to be brought along if we are going to do more complex operations. The history of our business so far has been one of continuous assignments of more and more complex operations. I think all you can do is what we've done—go back and look again at the historical analogy. If we had not initiated the F–1 engine program back in the 1950's we literally wouldn't be doing the manned lunar program today, in my view.

Mr. DADDARIO. If I can review that. The C–5 stage will do everything we have on the board at the moment but the M–1 engine will do some of the things you expect will be necessary sometime after the first phase of our space program, as we now understand it, comes to an end.

Dr. SHEA. I think that's right and presumes that there are no requirements on us now—and this is literally the case—to go beyond either Earth orbit or the Moon and there is no requirement on us to do an extensive lunar base program.

Mr. TEAGUE. Mr. Fulton.

Mr. FULTON of Pennsylvania. There is listed $15 million for the proposed facilities for the M–1 engine in fiscal year 1964. The question is: Do you need all three test stands in this fiscal year, or could we fund some of them in the next fiscal year?

Mr. LOW. Mr. Fulton, we have looked into this as carefully as possible. Matter of fact, yesterday we had Dr. Silverstein and his people into Washington to discuss this, since the M–1 engine is being developed by the Lewis facility, and Dr. Silverstein stated that he knows that the facilities are the long leadtime items he must have as early as possible in order to develop the engine at all.

Mr. FULTON of Pennsylvania. Then on the rate of expenditure for R. & D.; that, of course, is dependent on the number of firings and how fast you set up the engine test stands.

At what rate of firing is the $3½ million a month and why do you set this particular flow of research and development?

Mr. LOW. It is a level of effort that was started during the current year. It's a leveling year, during the next year. We would have to continue at this level, or decrease the people involved—the program that is currently in existence. If we went to a lower level, it would lead to great inefficiencies immediately. It would, of course, stretch out the program.

Mr. FULTON of Pennsylvania. On the $13.6 million still available in fiscal year 1963 as of May 1, 1963, what do you intend to spend that for? What are you going to obligate it for by the end of June 30? Is it facilities or is it R. & D.?

Mr. LOW. This is R. & D.

Mr. Lilly can address himself to that.

Mr. LILLY. Out of the $35 million available R. & D. funds, we had obligated $21.2 million as of May 1, 1963. The current funding for Aerojet will run to $30 million at the end of this fiscal year. As you know, we have not definitized the contract with Aerojet. In other words, the company is working on a letter contract, which we are funding on a month-to-month basis to stay ahead of their accrued costs. We are just staying ahead of their billings.

Mr. FULTON of Pennsylvania. When you add the $7, or $3.5 million per month, to the $21 million you have already obligated in fiscal year 1963 for research and development on the M–1 engine; you get $29 million out of the $35 million which had been authorized for R. & D. in fiscal year 1963.

My question is: You have a balance of $6 million left over; is this going to be used for facilities?

Mr. LILLY. I was just coming to that. The $30 million figure I was talking about was R. & D. funding for Aerojet. In addition, we buy propellants. We don't buy propellants from Aerojet. The propellant bill is an additional $2 million, in addition to this. We have also set aside the anticipated fee for definitization of the contract. When the contractor is working on a letter contract, he is, of course, paid no fee. That is help up until the contract is definitized; however, we must anticipate a fee and earmark funds for this purpose.

Mr. FULTON of Pennsylvania. What percentage would that be of the total contract?

Mr. LILLY. Of the amount that we have set aside for the potential fee——

Mr. HOLMES. Has that been negotiated yet?

Mr. LILLY. The fee has been negotiated, up to the point of definitization—the signing off at NASA Headquarters.

Mr. FULTON of Pennsylvania. My final question is this: Suppose you had to have a cut somewhere. Would you rather have a cut on the M–1 engine, with a possible delay but, as the chairman says, still have a reasonable continuance of the program; or would you rather have a cut in either the Gemini or the Apollo program?

Mr. HOLMES. I will answer that. We'd rather have it out of the M–1 engine, although we believe that the M–1 engine is justified for future requirements that we discussed.

We have actual, established schedule requirements in Apollo and Gemini to do which we cannot meet if those funds for these two programs are cut.

I would have to say clearly that if it had to be one or the other if that is the question, it would have to be the M–1 engine.

Mr. FULTON of Pennsylvania. It is a balance of judgment.

When you are saying $5 million for a vehicle of a Nova type, and $5 million for the M–1 engine, and you are spending the remainder of the R. & D. money up to the first of the fiscal year; that would only give you $10 million for your M–1 engine program, including the vehicle.

Is that clearly not enough so that it would cripple the development of the engine?

Mr. HOLMES. Yes, sir; it would cripple the development of that engine.

Mr. FULTON of Pennsylvania. So you could not possibly get along on $10 million plus the additional $16 million for the facility?

Mr. HOLMES. We could not run a reasonable development program for the M–1 under those conditions.

Mr. FULTON of Pennsylvania. That is all, Mr. Chairman.

Dr. SHEA. There is a difference in what we do with the Nova money and the M–1 money, recognizing that the Nova money I talked about when I testified before, is really advanced design money. Paper design can be adequately done in the low millions of dollars. You get good feasibility studies. You can do trade-off study. As long as you stay in the "paper" or study stage, $3, $4, or $5 million is adequate to do very good, definitive studies on the advanced vehicles. Nova, incidentally, is a misnomer here—we are really talking about the advanced vehicle study program. The advanced vehicles, beyond the Saturn V, are only in the study stage. In contrast, the M–1 engine is in the preliminary stage of hardware development. As soon as you start to cut hardware, because of the detailed hardware design—running up tests and so on—your costs obviously go up. Remembering again that the engines have to precede the vehicle, you can't really start a vehicle, just as we couldn't ever start an airplane, without a good existing engine, a well-tested engine, an engine in advanced development. In fact, most of the specifications for an airplane start out saying, "These are the engines you should consider."

Mr. FULTON of Pennsylvania. On that point, one thing that has caused this committee some concern has been the complete change in the requirements and specifications for the M–1 engine within the last year, and also the change in the time schedule by about 2 or 3 years.

Are you sure that this program is now headed in the direction, and that you have the proper specifications and requirements? Should we put the money into it now or should we wait?

Mr. HOLMES. I think that's a very good point, Mr. Fulton, and I think that we changed for the very reason that this committee is concerned, and properly so. We had to assess the M–1 engine funding in terms of the rate at which one should proceed.

If we continued at the highest rate to support development of an early Nova vehicle, I think we would have been wrong; therefore, we cut back from that level of effort and stretched the development time. We felt that it was vitally important to continue at the proper level of funding necessary to develop this engine, but not to proceed at the rate of funding that we had previously planned when we thought we had to have this on-coming Nova vehicle immediately.

Dr. Shea?

Dr. SHEA. That's right, and the second point is that, in our thinking on advanced vehicles—I still think we keep tripping over the term "Nova"—we have, in effect, said that the capability originally planned for Nova, which was in the order of twice the Saturn V vehicle capability, really, is not a large enough step forward. The capability originally planned could be justified, just as it was justified a year and a half ago, because it was really trying to aim for the manned lunar mission in parallel with the Earth orbital rendezvous technique. When we decided that we could accomplish the mission with the Saturn V, using the lunar orbital rendezvous technique, we essentially agreed on the advanced vehicle design. If you look at it from a national view, it is quite clear that the next generation of launch vehicles should be a larger step than 2 to 1 over the vehicles we presently have or would have in the national inventory at that time.

Mr. FULTON of Pennsylvania. That is all.

Mr. TEAGUE. Mr. Gurney.

Mr. GURNEY. I also was going to ask about the $60 million. It has been partially answered. Since the feeling of the committee is that the program ought to be stretched out, I don't understand why you need four test stands instead of two. I realize you can do a much better job with four, but can't you do some job with two?

The next question is along the same line. You have a large amount budgeted for instrumentation and testing equipment. Is leadtime needed for this equipment, or are these items you can readily procure when you need them later on?

I am speaking about the facilities now.

Mr. HOLMES. I think Mr. Low is probably best qualified to answer that.

Mr. LOW. To answer your questions on the facilities, each one of the four facilities has a different function, of course, as Dr. Shea pointed out. Now, the first test stand, the K–1 stand, will be activated late in calendar year 1964 and it is well under construction now. Its purpose is, essentially, starting tests of the complete engine. It can

only support engine operations for about 15 seconds. The second test stand which will come into operation about half a year later——

Mr. FULTON of Pennsylvania. When is that?

Mr. LOW. In 1965.

Mr. GURNEY. You are now committing the money for this from your last year's budget. Is that right?

Mr. LOW. I believe that's right.

Mr. LILLY. That is correct.

Mr. GURNEY. Have you signed contracts on it?

Mr. LILLY. There is a letter contract, Mr. Gurney.

Mr. LOW. For simulated altitude testing, and testing up to 300 seconds running time.

The third test, the KP–2 test, will test the engine for full duration time. It is scheduled for late in 1965. The last test stand, which is another test stand for full duration testing, will probably not come until 1967.

We are not requesting any funds for the last test stand now; so it is a phased program to go along with the 10-year development program Dr. Shea mentioned before.

Mr. GURNEY. Can't you use one test stand for all three missions, or two of the missions?

Mr. LOW. Well, you cannot use a short duration test stand for the long duration test because it does not have the propellant capability, handling capabilities, the tankage, and so on.

Mr. GURNEY. Dr. Shea?

Mr. LOW. You want to add to that?

Dr. SHEA. I might comment on that. The stands are designed for specialized types of testing. Recognize that the main cost of these stands relates to both the flame deflector, and how you want to protect this kind of thing, and the tankage required to hold the fuel. The short-duration stand is the least expensive of the stands because it has small tanks and essentially requires a minimal type flame deflector. It has a total running time of about 16 seconds.

This is a relatively inexpensive facility and is one we use a great deal to get over the extensive "start-stop" testing necessary to qualify the engines.

The intermediate length facility and the one that works with the vacuum or altitude simulation has tanks that are sized for roughly half the total load of propellant needed for the fuel system. This stand lets us test another element of the overall program without having to build the final full-sized facility required for true qualification of the engine and full-duration testing. There really are economies in the design of the facilities and essentially we use the three different types in order to maximize the utilization of a particular type of test and at the same time not duplicate or triplicate the total facility.

Mr. GURNEY. What about the instrumentation and test equipment?

Dr. SHEA. You can't develop this type of program without making detailed measurements of what's going on.

Mr. GURNEY. No; I realize that. I am talking about the leadtime involved.

In other words, if you can buy an instrument off the shelf, no leadtime is required. You have $2 million in the budget request for test

equipment, and almost $2 million for instrumentation. My question is: Do you need that, or could you get that quickly next year?

What we are trying to do is to keep the program going, and at the same time, we are trying to get this budget where people will accept it.

Mr. Low. I believe that the instrumentation that we are requesting this year is for the first test stand and that in future years' budgets we will be requesting instrumentation for the later years' test stand, so this is phased with the test stand schedule.

Mr. Holmes. Why don't we get a statement for the record that spells out the requirement? I don't think we have it right here, and that's a very reasonable question.

(The information requested is as follows:)

Instrumentation equipment is one of the pacing activities in the acquisition of a test stand because of the aggregate timespan required for procurement, installation, and checkout of the instrumentation system. The majority of instruments used in the operation of rocket test stands are designed for specific applications. They are not available for immediate delivery because of the need to meet requirements on range, capacity, accuracy, and response dictated by the test article. Instrumentation is one of the earlier actions to be initiated and one of the last to be completed. Therefore, a delay in funding would have an adverse effect on the schedule.

Mr. Gurney. That is all.

Mr. Teague. Mr. Roudebush.

Mr. Roudebush. I want to ask something in line with Mr. Gurney's question.

Why can't NASA build a test stand, the more expensive type, admittedly, that will handle the full duration test, and also use it for the short duration tests by using less fuel tanks and so forth?

Why is it necessary to build three or four or five different types of test stands to test the different lengths of time or different functions of the engine? Why can't you use one test stand and, let's say, partially fill the tanks with fuel and so forth?

Mr. Low. In order to qualify one of these engines to get it through its preflight rating tests, one must go through a schedule of hundreds of tests and to do all of these, one needs more than one test stand by the time one completes it.

Now we are talking about completing this qualification in the very late sixties and we are phasing in the various test stands to go along with this qualification date.

To complete the point then, one could build by that time, four test stands to do the whole job, but this would be far more expensive than four test stands, each one of which only does part of the job.

Mr. Holmes. I think I could say the same thing.

Mr. Roudebush. I do not get your point, Mr. Low. How you can build four test stands cheaper than you can build one.

Mr. Low. No——

Dr. Shea. The point is that one test stand isn't adequate. In order to conduct the required number of tests, we will wind up in the 1965 to 1968, 1969 time frame doing testing on all three stands simultaneously.

Mr. Roudebush. Admittedly true, Dr. Shea. I agree with you there, but we are not in any tremendous race, I don't think, to develop the M–1. We don't even have a mission for this engine.

Mr. Holmes. I agree that we don't consider the M–1 development a race. However, another point to consider, along with what Mr. Low

and Dr. Shea have said (and we can get the people working on hardware to come and talk in more detail) is that our experience has proved that this number of facilities goes along with this type of development and comprises a smooth program. It is still rather leisurely compared to any true crash program.

If you have a development of this kind actually in production of test hardware, with engineering people tied up, but you don't have enough test facilities supporting that activity, you operate in a more restricted manner than if those facilities are available.

Although we are so vitally concerned about funds here, and our primary emphasis is on the Apollo program, we think that this M–1 development is necessary; we have carefully scrutinized it with our people at the Lewis Research Center.

Lewis Research Center has as much experience in propulsion as any research laboratory in the world. It is their very best and considered opinion, including that of the director, Dr. Silverstein, that these are the minimum facilities requirements to carry out an efficient program.

Mr. TEAGUE. How many actual M–1 engines are we talking about?

Mr. HOLMES. Only the M–1, as far as types, pieces, and parts, and so forth are concerned, and this kind of thing. I don't have the actual number. Perhaps Mr. Low does.

Mr. LOW. I don't know the number of engines. In this 10-to-12-year development program. We are planning now about a hundred engine tests for calendar year 1965. About 220 engine tests are planned for calendar year 1966—and so on. To do this amount of testing requires a considerable number of engines, more than 10 I'm sure, but I don't have the precise figure here.

Mr. HOLMES. We can get that for the record, Mr. Chairman.

(The information referred to is as follows:)

From the present until June 1964 only engine components (subassemblies) will be undergoing tests. For example, by June 1964 11 thrust chamber assemblies, 31 gas generator assemblies, 10 liquid oxygen turbopumps, and 8 fuel turbopumps will be undergoing tests. These numbers will increase as the program continues.

The delivery of the first engine assembly is scheduled for the third quarter of calendar year 1964. By the fourth quarter of calendar year 1964 there will be 3; the total will increase to 6 engines in the first quarter of calendar year 1965, 10 in the second quarter of calendar year 1965, 14 in the third quarter, and 19 in the fourth quarter of that year. The total will build in this fashion until 36 engines in the R. & D. program are obtained by the end of the present PFRT plan.

Mr. TEAGUE. The point is, there are a number of M–1 engines being tested on test stands as they go through different stages of completion. Is that correct?

Mr. LOW. Yes.

Dr. SHEA. Yes.

Mr. ROUDEBUSH. I think the judge had a question.

Mr. CASEY. That is what I wanted to know. Is NASA going to have just one engine in existence and move it from stand to stand, or is it going to test four engines at once, or four different phases at one time?

Mr. HOLMES. In order to do that number of tests we have to have multiple engine tests going on, yes, without taking the time to pull a given engine off the stand, move it, and so on.

We will furnish the planned number of engines, parts, et cetera, for you.

Mr. TEAGUE. Mr. Waggonner has not asked a question.

Mr. WAGGONNER. To further extend the questioning of the chairman, Mr. Holmes, when he speaks of the number of engines we can identify.

What other engines can we identify that are under development and which will utilize the test stands?

Mr. HOLMES. No others, sir.

Mr. WAGGONNER. No others?

Mr. HOLMES. No, sir.

Mr. TEAGUE. There are a number of M–1 engines.

Mr. HOLMES. A number of M–1 engines will be involved, but no other type of engine is presently planned for these test stands.

Mr. WAGGONNER. Are there other engines under consideration, now, other than the M–1 engines?

Mr. HOLMES. No, sir. No other engines are under consideration for these test stands.

Mr. WAGGONNER. Other than for these test stands.

Mr. HOLMES. There is the solid engine which the Defense Department is developing in a separate program. There is the nuclear engine, called the NERVA engine, and the Rover program. The first reactor-in-flight vehicle combination will be called the RIFT. Of course, we have engines under development for the ongoing Apollo program, including the F–1, H–1, J–2, and A–3. These are the only engines that we have currently in development and test.

Mr. TEAGUE. Mr. Daddario has a question.

Mr. DADDARIO. You said that if we have a lunar base program we couldn't do without the M–1 engine. We had testimony before us which indicates that the Saturn V would be capable of establishing a lunar base of about six people on the moon and keeping it supplied.

Is this a conflict of technical and scientific opinion?

Dr. SHEA. I think I said that I am confident the Saturn V can handle all the early phases of the lunar program and all the Earth-orbiting missions we envision.

We don't yet know about the lunar base. I don't think we have done enough sizing work on it yet to say whether the Saturn V can or can't fulfill this requirement.

Mr. DADDARIO. Is there the possibility that the Saturn V could establish, as has been testified to before this committee, a lunar base colony of about six people and maintain them?

Dr. SHEA. The Saturn V can "direct land" approximately 30,000 pounds of payload on the lunar surface.

Mr. HOLMES. Or two people.

Dr. SHEA. Or two people in our present mode of operation. You can work out a logistic operation where those 30,000 pounds, or increments of that payload, and two people at a time, can be built up to a base colony of about six people.

Mr. DADDARIO. Your answer is "Yes"?

Dr. SHEA. The answer is, "Yes—that size—that size vehicle."

Mr. DADDARIO. Mr. Holmes, one other problem bothers me in this matter of financing.

Last year we authorized money for the M–1 engine, out of which $15 million was reprogramed into another program. This is, frankly, one of the problems that faces the committee in its attitude toward this program.

What assurance do we have it is not going to happen again? Actually, all we are doing this year is reauthorizing the money we authorized last year, and which you spent for other purposes.

Mr. HOLMES. Yes, sir.

Mr. DADDARIO. It is a very embarrassing position for the committee.

Mr. HOLMES. Yes; I think that's certainly a very good question. Once again, however, I think the reason for our reprograming is exactly the reason the committee is concerned about the M–1 engine and, quite properly, looking at it very carefully, we felt we should not go ahead on the M–1 engine at a faster rate than was necessary to assure us of this capability in the future.

When we asked for the M–1 authorization, we had planned the M–1 engine for an early Nova vehicle, and it was funded at that rate. As soon as we knew we were not going to use the Nova vehicle to go to the Moon, and that we should have a more advanced vehicle, to come along later, we cut down the expenditure on the M–1 and, consistent with our request this year, we minimized M–1 expenses at a rate we think will develop the technology of this engine toward the end of the decade.

Had it been a different decision, a decision to go via direct flight, we would not have reprogramed these funds. We would probably have programed money into it, and we would have an ongoing Nova program today.

I think it is all consistent and fits into the present mode for going to the moon using a satellite Apollo vehicle and the lunar orbital rendezvous technique.

Mr. LOW. I might add that we would have requested $70 million instead of $75 million in fiscal 1964, had there been an ongoing program.

Mr. DADDARIO. I understand the explanation. It is a good one from your point of view. It is a very poor one from a legislative point of view.

It poses other problems to us, serious problems.

Mr. TEAGUE. Shall we leave the M–1 engine?

Mr. FULTON of Pennsylvania. Mr. Teague, just one more point.

You have spoken of a 10- to 12-year development program on the M–1 engine. Now that, to me, shows a 2-year leeway in your thinking and if there is that 2-year leeway, it brings up the question of a stretchout even of your own figures by one-sixth, or 16 percent. The question then is: Why can't there be a similar variation within the fiscal year? Why do you need all the money in a particular fiscal year?

Mr. HOLMES. I think the answer to that is that we are requesting this year what we think is a minimum but efficient funding rate in order to have an engine for a longer period of time. The only reason there is any flexibility is dependent on how much one intends to speed up development in later years.

Mr. FULTON of Pennsylvania. Actually, if you clustered the J–2 engines at this time, you could probably get along with a second stage that would do everything the M–1 would do?

Mr. HOLMES. If you could make the J–2 engine reliable enough, you might do that. When you consider using 8 J–2 engines instead of a single M–1 engine, the statistical probability of having a reliable vehicle decreases, particularly when you say you are going to have 4 M–1's and 32 J–2's. I wanted to draw a comparison. It is unlikely that you would get a statistical probability that the vehicle would work very well, and have sufficient reliability.

Mr. FULTON of Pennsylvania. There is a comparable result by clustering a J–2 engine.

As a matter of fact, you are now moving ahead with the J–3 engine, improving the J–2. So, don't you think you should be doing that as well?

Mr. HOLMES. I am not aware of the J–3 engine, Mr. Fulton.

Mr. FULTON of Pennsylvania. Aren't you improving the J–2 engine so that it gives above a 200,000-pound thrust?

Mr. HOLMES. Not today.

Mr. WAGGONNER. 188, isn't it?

Mr. HOLMES. I think that you are referring to the H–1 kerosene-oxygen engine, which is used in the first stage of the Saturn I and IB, and has a thrust of 165,000 pounds, which will be increased to 188,000. The J–2 liquid oxygen-liquid hydrogen engine has a thrust of 200,000 pounds. I do not know of any current program to increase that level of thrust.

Mr. WAGGONNER. Hasn't clustering proved practical in upper stages?

Mr. HOLMES. It has, but when you consider more than the five J–2 engines which we are using in the second stage of the Saturn V, the reliability bocomes questionable.

Mr. FULTON of Pennsylvania. NASA has no alternative on clustering the J–2 engine, as it now is; nor are you in a development program to increase the 200,000-pound thrust of the J–2 engine.

Mr. HOLMES. That is correct.

Mr. TEAGUE. Let's go to RDO 1–5, Gemini.

Mr. Low, were you told what the cut would be here, and where it would be?

Mr. LOW. I was told there was a proposed cut of 16.9 million. I don't know, specifically, where it was.

Mr. TEAGUE. Mr. Fulton, can you tell them what the cut will be on RDO 1–5, volume 2.

While he is finding that, can you tell us a little bit about Gemini? Are there some problems we don't know about? Is the "patient sick"?

Mr. HOLMES. I don't think the "patient" is sick, Mr. Chairman. It is my opinion that we have now, with this reestablishment of the Gemini schedule for two unmanned qualification flights before the first manned flight a plan allowing us to proceed in development and to come to grips with the real problems. It is a different type of problem, but one that can be met.

Mr. TEAGUE. Are you considering a third unmanned Gemini flight?

Mr. HOLMES. Pardon?

Mr. TEAGUE. Are you considering a third unmanned Gemini flight?

Mr. HOLMES. No; not in the sense, I am sure, you are asking the question. If we had difficulty with the Titan II booster—and we

don't anticipate any—we might consider an additional unmanned flight; but there is no present scheduling for three unmanned flights in that sense. There are vehicle problems, and you might want to check these out structurally with a boilerplate Gemini sitting on the Titan II. All in all, I think the program is firming up. The equipment is so impressive that I would welcome a visit by the committee to the McDonnell Aircraft plant.

Mr. TEAGUE. We are trying to go, but we have not been able to find the time.

Mr. HOLMES. Gemini is an entirely different concept from Mercury; I think you will agree when you look at it. In that sense I think we can see, for the first time in this country, an operational-type spacecraft, one built like an operational aircraft. Just looking at it makes you proud. It is true that I preferred we meet our initial schedules, but I think they were somewhat optimistic; I think if we had to do it again, we would still take the present route to make Gemini much more than a big, overgrown Mercury. It is a wise decision, and we will have developed a much better spacecraft for the country.

Mr. FULTON of Pennsylvania. On RDO 1-5 in volume 2, if you look at the $306,300,000 figure, we have discussed having 12 Gemini flights instead of 15. That was the first thing. Then there was a prorated cut, down to $16,900,000.

Mr. ROUDEBUSH. Three of the flights are backups.

Mr. FULTON of Pennsylvania. Yes. Actually, there are 12 flights, so what we are doing is cutting off the equivalent of your 3 backup flights.

Mr. LOW. Mr. Chairman, if we——

Mr. FUQUA. That is, we are postponing it until next year.

Mr. FULTON of Pennsylvania. "Postponing it," would be better.

Mr. LOW. If we propose to cut the launch vehicles, we'd have to cut the last three; if we cut the launch vehicles now, it would delay the program by, at least, a year. These last three launch vehicles will not be delivered until calendar year 1966, and there are no fiscal year 1965 funds requested for those last three launch vehicles.

Mr. FULTON of Pennsylvania. Yes, but you have only seven Gemini shots scheduled in calendar year 1965, therefore you have eight Gemini shots that come after calendar year 1965. What this committee is saying that on this overall figure of $306,300,000, that we are asking you to postpone, or back up on your procurement. With adequate leadtime, you could procure the vehicles without putting it into this year's budget.

As Mr. Fuqua said, it is a postponement rather than a cut.

Mr. DADDARIO. Would you yield, Mr. Fulton?

Mr. FULTON of Pennsylvania. Gladly.

Mr. DADDARIO. As I understand your point of view, the last three vehicles will not be delivered until 1966, and you are not going to request the funds for them until next year. Is that correct?

Mr. LOW. That is right.

Mr. DADDARIO. If we cut out 3, we are not going from 15 to 12, but from 12 to 9?

Mr. Low. Or more than that, because of the leadtime necessary—I don't have the exact leadtime with me.

Mr. Daddario. Would you spell out what effect this would have?

Mr. Low. If we eliminated three launch vehicles at this point in time, we would be cutting launch vehicles which would fly, at the latest, in calendar year 1965, because there is about a 16-month leadtime on the launch vehicles.

Mr. Fuqua. How many launches do you plan in this coming fiscal year?

Mr. Low. In the fiscal year itself?

Mr. Fuqua. Right.

Mr. Low. Three.

Mr. Fulton of Pennsylvania. Is my figure correct, you are only planning seven shots through calendar year 1965?

Mr. Low. That is correct.

Mr. Waggonner. There would be four launches then in 1965.

Mr. Teague. Mr. Low, why do you plan to reuse three of the spacecraft?

Why don't you reuse all of them, or none of them?

Mr. Low. Currently, we are programing 12 spacecraft and 15 launch vehicles. The thought is this: if we have an early abort on any of the flights, we would not accomplish our mission. We would, however, be able to reuse the space craft because it will not have been in orbit; it will not have reentered at very high speeds. But a launch vehicle would have been expended.

Our best estimate, based on projected reliability members, is that there might be 3 failures during the launching of the 12 vehicles, so we have backup boosters for this. We would reuse these spacecraft. Any spacecraft that has completed a mission, we feel we could not reuse, because of the much harder use it will have had going into orbit and rentering the Earth's atmosphere.

Mr. Holmes. I think that I should make a statement here, Mr. Chairman. It's only in fairness to the committee; you ought to know the facts. If you look at our overall program that we have scheduled for fiscal 1964, and you look at our present funding problems, you will note that we are struggling with a deficit of well over a hundred million dollars. What we are trying to do, desperately, is to take a look at this problem and attempt to alleviate it. I'm not sure if there's any help available from Gemini; I think, probably not, because part of the overall shortage is in Gemini. We are desperately trying to hold the schedule with the funds that we have. I tell you this with complete honesty, because the committee must know these facts. Any cut in the Apollo R. & D. funds is going to result in schedule slippages. There is absolutely no part of those funds that can be cut because of redundant items. We are so hard pressed now, and short, that it's going to take all our skill and ingenuity—with small amounts of reprograming here and there—to keep this program going on schedule.

We have already been through a very stringent exercise with the Bureau of the Budget and the President, because, as you know, they are very much concerned about whether we should ask for these large sums of money. I can assure you that it's just about as tight as we know how to make it.

Mr. TEAGUE. Suppose you were resubmitting this budget today; would it be the same?

Mr. HOLMES. If we were resubmitting this budget today, it would be higher—provided my superiors would agree to it. As I say, there has been tremendous pressure from the Bureau of the Budget. Quite properly the Bureau of the Budget's attitude is: Run the program, yes. But don't be wasting money.

Mr. TEAGUE. Any other question on the Gemini program? Mr. Waggonner?

Mr. WAGGONNER. This $100 million deficit you spoke of is in the Gemini program?

Mr. HOLMES. No, sir; the deficit refers to R. & D. funds for the total manned program.

Mr. WAGGONNER. The total manned research and development program, it is not in the construction facilities?

Mr. HOLMES. I was addressing myself to the research and development; the deficit is over a hundred million dollars. Though "deficit" is usually the proper word, I haven't faced up to that term yet because I'm sure we are going to find some way to shift small amounts around to hold the fort. I certainly hope so.

Mr. WAGGONNER. This deficit exists as a result of underestimated costs in the manned space flight program?

Mr. HOLMES. Yes, I think that certainly is accurate. Another way to say it, the way it appears to me, is that if one looks at the funding requirements—and, certainly, there have been some underestimates—and one sees what we have available for our present scheduled rate, but one talks about $3 billion which is our R. & D. request for a manned program—then the problem of a hundred million deficit takes a different perspective. I couldn't be worth my salt as a program manager if I had given up on that one. Part of the responsibilities of a program manager is to balance these requirements somehow.

Mr. FUQUA. Mr. Holmes, on the change of flights from 15 to 12, we are not cutting out 3 and asking you to operate with 12 instead of 15. You can still operate on 15, but postpone funding 3 of them until fiscal year 1965.

Mr. LOW. But if we do that— -

Mr. TEAGUE. The last flights are not in this year's budget.

Mr. LOW. The flights—the last three flights—are not in the fiscal year 1964 budget.

Mr. TEAGUE. They will be in next year's budget.

Mr. HOLMES. Not only that; it looks at the present time as if that Gemini funds are tight. But if we could identify any funds, we need them in other areas. We have to balance this whole program so that it goes forward together.

Mr. FULTON of Pennsylvania. Have you reprogramed any money from fiscal year 1963 out of the Gemini program?

Mr. LOW. No, sir.

Mr. HOLMES No, sir; we haven't.

Mr. FULTON of Pennsylvania. Will you have any unobligated funds as of June 30, 1963?

Mr. HOLMES. In the last few months, I, and all key members of my staff and the key members of the Manned Spacecraft Center have been involved in identifying additional funds for Gemini.

Mr. FULTON of Pennsylvania. Do you have any money in the Mercury program that you could use for Gemini?

Mr. HOLMES. No, sir.

Mr. FULTON of Pennsylvania. Where would you get the money for an extra Mercury flight then?

Mr. HOLMES. If we have an extra Mercury flight, it is going to mean from $10 to $15 million, depending on how one approaches it, "out of our hide." Certainly that amount will hurt the rest of the program. That's one of the reasons why I have some feeling of opposition about the flight.

Mr. FULTON of Pennsylvania. You are virtually stating that no money can come out of the Gemini program?

Mr. HOLMES. I can state that no money can come out of Gemini, Saturn, or Apollo without delaying the respective programs.

Mr. TEAGUE. Mr. Roudebush.

Mr. ROUDEBUSH. You mentioned the number of vehicles is 15. Is it true you are buying 15, but isn't it also true that you are buying 8 Atlas and 8 Agenas? Those are for your——

Mr. HOLMES. The Atlas/Agenas are required for rendezvous.

Mr. ROUDEBUSH. Rendezvous techniques only?

Mr. MOLMES. Yes.

Mr. ROUDEBUSH. Am I mistaken in my assumption that you have a total of 23 launch vehicles, rather than 15?

Mr. HOLMES. You need the Titan II to launch the Gemini spacecraft and the Atlas for the Agena target vehicle. Two launch vehicles are required.

Mr. ROUDEBUSH. I see. That answers it.

Mr. TEAGUE. Mr. Waggonner?

Mr. WAGGONNER. Did I understand you to say this $10, $12, or $15 million to make an additional Mercury flight is money that would come "out of your hide," and is one of the reasons why you oppose the Mercury flight?

Mr. HOLMES. Yes, sir.

Mr. WAGGONNER. Is that the primary reason?

Mr. HOLMES. It is one of two key reasons. The primary reason is that I would like to see the present Mercury people, such as Preston at the cape, and Kleinknecht at MSC put on Gemini. Now, to be fair, if there were sufficient doubts from a space-knowledge standpoint, it would be worth the price of another Mercury mission; but indications are very strong against it.

Mr. TEAGUE. Let's go to RDO 1–10, Apollo.

Mr. Holmes, you heard the story before. We went out and talked to North American. If they would have been before the committee to ask for money, I don't think they would have received enough to buy a cup of coffee. I think the postponement cut there, whatever you call it, was just an arbitrary figure of 10 percent.

You already answered the question, any cut in the Apollo program delays the program.

Mr. HOLMES. I know of no other choice.

Mr. TEAGUE. This budget process started 18 months ago; if you were resubmitting it today, what would the figure be?

Mr. HOLMES. I'm sorry. I didn't hear you.

Mr. TEAGUE. If you were resubmitting this budget today, instead of $1.287 billion, what would the figure be?

Mr. HOLMES. I think that the total budget of $3 billion is a reasonable, good, sum. As a program manager, I would say that we could have used between $100 and $150 million above the total budget request.

Mr. TEAGUE. Take North American, for example. They say that they are negotiating with NASA, and you say that you are negotiating with North American. Where did this $661 million come from? There must have been some consultation back and forth to arrive at this figure.

Mr. HOLMES. Let me comment first, and then I think Mr. Low may want to comment on it. We only have a few routes to follow in order to save money.

One is a schedule "stretchout"; another is cutting out hardware; and as I say, there is no redundant hardware to cut out. The third is to operate more efficiently. We are trying desperately to do that. As I mentioned in earlier testimony, we have a set of detailed program schedules, which list all the key milestones for the effort down through the sub-sub-system level. In addition, the scheduling system shows the estimated and actual contractor costs and manpower related to the effort.

Here is a stack of these schedules—quite a great clerical job, but the scheduling system does tell us where we are and where we are going. [Indicating documents.]

To answer your question directly, the requirements come from an integration of these separate estimates of what funds are needed to accomplish the job in a certain amount of time with so many engineers.

The requirements are plotted for each contractor; the entire program is finally plotted so that the requirements are established.

This detailed scheduling system is one reason why we feel we can speak with a great deal more confidence than a year ago about our present and future costs.

I want to have Mr. Low address himself to this.

Mr. Low. I want to speak particularly regarding North American. We received in October of last year—before the budget book was finally put to bed—a firm cost proposal from North American, which formed a basis for the negotiations with North American. These negotiations have now been completed.

This cost proposal was analyzed in detail by our people in Houston. There were some places where we cut them, and other places where we found we had to increase. This analysis was then used by our people in the negotiations, and this is the way the negotiations finally came out—just a few weeks ago.

We did, therefore, base the number in this book on a firm estimate of North American, as analyzed and adjusted by our people; it was so good an estimate and analysis that this number was agreed to when we finally shook hands with North American on the contract.

I would like to make another point. I brought along a number of charts that give a number of breakdowns on this as to divisions of contracts, divisions of effort in-house, and so on.

I would be happy to discuss these with the members, now or later.

Mr. TEAGUE. What is the wish of the committee?

Mr. WAGGONNER. If we are going to discuss it, we might as well do it now.

(The information referred to is proprietary and may be found in the committee files.)

Mr. FULTON of Pennsylvania. Why is it North American could not come within a certain specific amount on what their requirements would be for their operations in fiscal year 1964?

Mr. HOLMES. I think they could have. However, two problems did exist. First, and I think that I'll have to take the responsibility for this difficulty. I don't think that the people involved were properly informed and experienced enough to handle themselves before a congressional subcommittee. The second point was that they were in the middle of negotiating the definitive contract. As a result, the people were probably in a difficult position with regard to what information they could and could not talk about. I am very sorry that the trip turned out that way and I hope we can arrange for another visit by the committee; I would like to be there personally. That would be much more satisfactory.

Mr. FULTON of Pennsylvania. How can one company get this sum of money?

Mr. HOLMES. I think the answer to that question concerns the extremely large number of companies involved. As you know, if you consider the subcontractors involved and if you estimate the manpower, purchase material, and various other equipment for each program element and add them together, this is the level of effort required.

Mr. FULTON of Pennsylvania. Would a $50 or $100 million cut cripple this particular portion of the Apollo program?

Mr. WAGGONNER. Mr. Holmes already testified to that.

Mr. HOLMES. It would delay the schedule.

Mr. FULTON of Pennsylvania. Which cut would delay the schedule?

Mr. HOLMES. Either $50 or $100 million cut would endanger the schedule.

Mr. FULTON of Pennsylvania. How much would each delay the schedule?

Mr. HOLMES. I can't answer that, precisely; if, for instance, the committee saw fit to cut out of Apollo any sum of money—say a hypothetical $50 million—then the responsibility would rest with me to put the program in balance. We would have to say: "Is it coming out at the same time as the Saturn booster?" and you probably would delay this a little and that a little, and take a part from each to keep the total program in balance.

Mr. FULTON of Pennsylvania. Have you reprogramed any money out of Apollo program during fiscal year 1963?

Mr. HOLMES. No, sir, not to my knowledge. Do you know of any, George?

Mr. LOW. I believe we have recently reprogramed——

Mr. HOLMES. Mr. Low knows the details more than I do.

Mr. FULTON of Pennsylvania. Have you programed any construction of facilities money out of the Apollo program?

Mr. HOLMES. No. We have, as I mentioned earlier; scraped every place we could to help Gemini in the last few months, and we may have taken some Apollo research and development funds to assist Gemini. Is this what you are referring to, Mr. Low?

Mr. Low. Yes, sir.

Mr. Holmes. But it would be a relatively small amount.

Mr. Fulton of Pennsylvania. If North American is so uncertain as to their plans, why is this figure so specific when North American obviously, regardless of their experience in dealing with a congressional subcommittee, was not specific in their own mind as to their industrial programing either as a prime contractor or in dealing with a subcontractor?

Mr. Holmes. There were books of extremely detailed data during the negotiation of the contract, which we recently definitized. I just think that they inadvertently gave the wrong impression.

Mr. Fulton of Pennsylvania. How do you account for the impression given to several members of the subcommittee that were there?

Mr. Holmes. As I mentioned, I can account for it only two ways. The individuals involved probably didn't recognize what their position was and what their responsibilities were to the committee, versus their own management. Also, they were in the midst of negotiating a major contract and did not make that position clear; thus they did not discuss in a full and open way with you the extent to which they actually had programed the funds they needed.

Mr. Teague. Mr. Fulton, we have covered that. That is the second time Mr. Holmes has answered that question.

We have a long way to go. Any other questions?

Next is Aerospace Medicine on RDO 3–1. We ought to have Mr. Daddario here for this.

Suppose we move on to RDO 4–1, Integration and Checkout.

Mr. Holmes. Dr. Shea's program.

Mr. Teague. Dr. Shea, we were considering cutting $28 or $30 million out of the $153 million.

What if you were resubmitting this budget today? Surely you have come a long way on integration checkout.

Dr. Shea. Yes, sir, we have, and again I think that just as in the spacecraft area the final development of these figures turned out to be very close to what the present program is. The way I understood the discussion of the $28 million figure was that it would come out of the "Non-GE" part of the overall effort, and I think there is a little bit of confusion on this particular point. If you look at the way the fiscal year 1964 budget request for the integration and checkout area is broken down, there's about $101 million worth of checkout——

Mr. Teague. That is hardware.

Dr. Shea. The $101 million are in the checkout area. It's not all hardware. Some $47 million are for hardware; some $54 million are for engineering services; and, in addition, there are approximately $26 million for the overall integration effort, which GE explained to t committee. The remaining $26 million are for the reliability assessment area.

Now, when I testified the last time, a comment was made that the total GE requirement would probably be between $100 and $125 million, and this related to the fact that in the hardware checkout area itself we don't intend to buy all of the hardware from GE. The reason is that some of the hardware is what you might call common equipment. It's been developed in some instances by stage contractors, but more particularly it's general-purpose equipment, such as the

RC 10–1 digital computer, developed independently of the contractor. It's our intention to take those types of equipment—as we identify them—and buy them through the Centers rather than through the General Electric Co. The equipment will be Government-furnished equipment to GE.

There is really no identifiable "non-G.E." chunk of this program that is not specified. As a matter of fact, we are in the process right now of identifying the equipment that the centers are going to buy, determining what we are going to procure and furnish to G.E., and what hardware we are going to buy directly through G.E.

I can give you detailed breakdowns on the equipment racks, the kind of gear we will be buying that constitutes the total of $101 million in the checkout area; my summary comment is that I can't identify any large chunk of money here which is not specifically committed either to the management tasks that we are asking G.E. to do either in the integration and reliability areas or in checkout hardware procurement. If we don't procure the hardware equipment in parallel with the development of the stages, it's going to be a little embarrassing when we get to the cape and can't fire.

Mr. TEAGUE. Yes, sir.

Mr. WAGGONNER. What is the funding on the G.E. contract for fiscal year 1964?

Dr. SHEA. It has not yet been definitized.

Mr. WAGGONNER. What are the expenditures for fiscal year 1963?

Dr. SHEA. You have——

Mr. KEUCH. $21 million has already been put in to the contract. In addition, some funds have gone to the field centers for obligation into the contract.

Dr. SHEA. A total of $21 million has been obligated already, and we are expecting to obligate approximately $10 million more into the contract prior to the end of this fiscal year.

Mr. FUQUA. This year?

Dr. SHEA. It is incremental funding.

Mr. LILLY. The G.E. contract is being funded incrementally.

Mr. HOLMES. Something over $20 million actually, has gone to G.E. for their operations, isn't that correct?

Mr. LILLY. That is correct

Dr. SHEA. We are in the last stages of checking overall systems. Once the checkout specification is completed, we can ask for actual detail hardware. We are in a position where we are working on our own internal estimates, in terms of total number of equipment racks, and so on. We laid these requirements out and know about what these types of racks cost. This is the basis of our figures.

Mr. TEAGUE. Mr. Roudebush?

Mr. ROUDEBUSH. Dr. Shea, your particular portion of the NASA budget represents the most rapid increase. In fiscal year 1962 you had just $1.25 million.

In fiscal year 1963 we authorized $38.5 million, and next year you are asking for $153 million.

Now, is that all due to the Apollo and Gemini programs, or principally the Apollo program?

Dr. SHEA. It is due principally to the Apollo program, sir; the reason that it looks like such rapid buildup is due essentially to the

organizational structure within NASA. There was a deliberate choice made at the beginning of the program that in the checkout area, in particular, and in the overall management area associated with Office of Manned Space Flight, certain functions would be centralized; it's that centralization of this function that you are seeing here.

Checkout hardware is going to cost the same, and would have cost the same whether we procured it through the field centers or whether we procured it in a centralized fashion through the Office of Manned Space Flight.

This $47 million portion of the $153 million integration and checkout budget request for fiscal year 1964, is that hardware procurement. It's almost a budgetary breakdown, rather than any buildup of a particular element of the organization.

Mr. ROUDEBUSH. You feel that integration and checkout—the task involved—is four times as much as it was last year?

Dr. SHEA. Yes, sir, and the reason for this again is the fact that the task is a combined hardware and management task. I think that in both the systems engineering area and in the integration area, we have been in a process of building a competent organization; we just couldn't bring it into being overnight. We frequently say to ourselves that we wish we had been in existence 2 years before we actually were, and completely staffed to accept all the responsibilities that have subsequently been thrust upon us. There is a question as to how fast you can build the organization, set the standards, and get to doing the job we are supposed to do.

Mr. ROUDEBUSH. That is my question, exactly. Can you build an organization that fast?

Can you spend money that fast, four times the rate you spent last year?

Dr. SHEA. Yes, I think we can, because of the particular way in which we chose to do it. We are not starting organizations completely from scratch; rather, we are relying on the competence of industrial firms to give us teams of people who are used to working together and who can provide us with the strength, if you will, to get the job done. These are very important jobs. Both the systems job and the integration job, we believe are keys to the overall effective operation of the program. These vital areas represent a small percentage of the total program, but they are, in effect, the management check and balance that Mr. Holmes, Mr. Low, and myself feel are essential, if we are to maintain control of the program and to assure both ourselves and the committee that the program is being run efficiently and that all facets of the program are going together properly.

Mr. ROUDEBUSH. You are asking for a total of $77 million in engineering under integration and checkout. That is a tremendous jump.

How much of this $77 million will be in contract, we will say, to GE? I think Bellcomm is under this also, are they not?

Dr. SHEA. No, Bellcomm is supporting us in the systems engineering area, not in the integration area, sir.

Mr. ROUDEBUSH. They are not.

What companies or universities and so forth are involved here?

Dr. SHEA. Essentially all the funds requested for engineering services in the integration budget is G.E. money. There are a couple of

very small subcontracts; but they are down in the hundred-thousand-dollar bracket. The bulk of all that is G.E.

Mr. ROUDEBUSH. The bulk is G.E.

Mr. HOLMES. I think I'd say just what Dr. Shea said, that is, how fast the program is going—and I still maintain that it is very tight. If one considers that this is one of the elements, as we explained last year, that we were just getting started, the fact that it has gone up about four times is not inconsistent.

The whole program has doubled; we have developed our strength and have an on-going program. This is a program which was creeping and there is no doubt in my mind that we will need to spend this kind of money for this critical work.

Mr. FULTON of Pennsylvania. You feel that to get highly reliable integration and checkout, we should not cut this particular item?

Mr. HOLMES. Yes, sir, I feel that we must have these funds to conduct an efficient and reliable program.

Mr. FULTON of Pennsylvania. It is important.

Mr. HOLMES. Very important.

Mr. TEAGUE. Could you take a particular problem and trace it through, explaining how integration, checkout, and reliability, are all tied together?

Dr. SHEA. Right now?

Mr. TEAGUE. Right now.

Mr. WAGGONNER. Mr. Chairman, do you mean utilizing the machinery set up through the G.E. contract?

Mr. TEAGUE. Yes.

Dr. SHEA. I think I can, sir.

In effect, there are three things we are planning to do with the General Electric contract.

One of these is to provide integrated checkout systems. We realized very early in the program that the vehicle that we intended to launch with Saturn V, the Apollo Spacecraft, was by far the most complex system that the country had been faced with in terms of being able to assess its state of readiness to do the mission.

We concluded that we could not continue to use purely manual methods, as we have been doing at the cape up to the present time. We evolved the concept of taking all the normally monitored sensors and handling them in a digital, automated fashion.

This system turns out to be, in effect, a very intricate, complex, special-purpose computing system, which will provide us with the capability in a faster time than we could do with manual countdown techniques.

Mr. HOLMES. Mr. Chairman, would you excuse me a moment?

Mr. TEAGUE. Yes.

Dr. SHEA. It's all part of the use of the vertical assembly building at the cape, and the short time down on the pad. We felt, frankly, that the in house competence in electronics and digital systems of this kind needed to be augmented by industrial contractors who had experience in this field. This conclusion then led to the first impetus toward the General Electric operation. They have the experience and capability to do it for us. We also had requirements for two other things: One, as an overall monitoring of the reliability of the program and an ability to assess at any instant in time, that, indeed, the state of

the program was proper. Now, what do we mean by this? We mean two things, really. First, an ability to analyze problem areas, to analyze designs to counter potential problem areas and to pick out problems before they exist. Secondly, an ability to watch in great detail all through the system—for any failure that occurs, no matter where it occurs. Any such failure is spotted, properly recorded, and the proper action taken to fix the failure. Although we talk about statistical failures, random failures, and so on in our systems, the only reason we do that is because there are frequently so many failures that you can't think about them individually.

As we go back and do a "post mortem" any particular problem, I have never seen one that didn't have an assignable cause, which could not be corrected by quick, logical action. Sometimes it means changing a design. Sometimes it means changing the manufacturing procedure. Sometimes it means tightening up certain procedures or tightening up on the manufacturer.

The key to Apollo was developing the management disciplines so that every one of those failures is studied and analyzed to determine the cause and the necessary corrective action. We have established the management system to assure that these actions are done. In addition, because all this test data has been carefully recorded, we have a means of measuring how well we are doing at any particular instant in time.

Mr. ROUDEBUSH. May I interrupt you there, Doctor?

Dr. SHEA. Yes, sir.

Mr. ROUDEBUSH. In 1962, as I pointed out, you had a million and a quarter dollars for integration and checkout. We were going forward with the Mercury program, and we were in a field of the unknown. We were trying to manage a program of a new and tremendous scope.

Why does it cost so much money, $153 million to be exact, to manage the Apollo integration and checkout when it only cost $1.25 million to manage the Mercury program or weren't we managing it carefully, gentlemen?

Dr. SHEA. No, sir. The situation in Mercury was quite different, and it might help to talk about how I believe we achieved reliability in the Mercury program. Reliability was not pulled out in as special a way in Mercury as we pulled it out here, and a million and a quarter in 1962 did not really relate to the Mercury program at all; it was, really, related to the buildup of our reliability effort for Apollo.

The way we have gotten reliability for Mercury is through the team of people at the cape, Walt Williams and his Checkout and Pre-Flight Operations Division. We have literally bought those people and the people at Houston, who combed both the spacecraft and the launch vehicle to completely wring them out at the cape and to put them through as rigorous or more rigorous a test at the cape than they have at the factory.

The people down there are sufficiently well-trained so that no deficiency goes unexplained prior to a launch. This is the reason why the launch sometimes is postponed.

During the last shot, MA–9, they noticed an anomaly in the gyro package; in digging into this, found out there was, in effect, a process deficiency which allowed solder balls to float potentially around in the gyro can.

This type of situation has cropped up during the Mercury/Atlas program. Here was something that the rigorous check of these people at the cape turned up.

Mr. FULTON of Pennsylvania. That is a recurring trouble because it was the cause of the Vanguard failure.

Dr. SHEA. It may well have been, sir; I am not familiar with that program. It slowed down the MA-9 launch, however, to get it fixed. If we hadn't fixed it we might have had an abort on that flight.

Let me make another point. I am saying that somewhere in the operations prior to getting that Atlas down to the cape there had been some anomolies in the test keys; and, perhaps, some failures elsewhere. Perhaps, at one of the other Atlas launches someone said: "Okay, that failure is a random affair. It hasn't happened very often, and this particular part is meeting its reliability goal."

The error got through because in effect nobody in the overall organization went back and had the rigor, essentially, to examine the system and find the fault.

Now, what we are saying is that we can't afford, in the Apollo program, to find out these problems at the cape. The vehicle will be too big. The system will be too big. We are not going to have enough people at the cape to be able to take enough time to iron out these problems there, as we have been doing for Mercury/Atlas.

As a result, we *must* get back to the Centers; and through the Centers, back to the contractors, in order to apply these rigors all the way down the program. Thus, we are taking preventive action in the early phases of design and test, at the factory, rather than watching for these things at the cape.

We will still have a rigorous examination at the cape, but if we had, for Appollo, the percentage of failures at the cape that we have discovered on the Mercury program, we'd sit down there for a year and a half before we ever got a shot off.

This is the whole point: It's a much bigger and more complex management effort, and it's a firm requirement to have rigorous examinations at the contractor level and not to have Government people, in effect, do it all down at the cape. It turns out that such a massive amount of data has to be analyzed, that it just costs a good deal of money.

Mr. HOLMES. I couldn't agree with Doctor Shea more. I would just like to add something from the very practical standpoints of prestige and economics. Assume that it is 1968, and a Saturn V and Apollo spacecraft are sitting on the launch pad—just moved out—and the three crewmen are on board. We have there—not counting the development—three lives and probably a $150 million investment.

Now one says, "How much effort should we put into this area?" "How much effort should be put in this or that element to assure everything is going to function as planned?

You can see that from the vantage point of human safety, economics, and the pride of the Nation that we certainly can afford to spend quite a good deal. We think what we are estimating is about the right amount.

Mr. TEAGUE. That amount for this next year?

Mr. HOLMES. Yes, sir.

Mr. TEAGUE. Any questions?

(No response.)

Mr. TEAGUE. Let's go back to RDO 3–1, Aerospace Medicine. Mr. Daddario.

Mr. DADDARIO. I personally have enough evidence on it. If Holmes or anyone else has something to say about this section, over and beyond and above what has already been said, I would be happy to hear it.

Mr. TEAGUE. Anybody want to ask any questions on aerospace medicine?

Mr. FULTON of Pennsylvania. What would a $10 million cut do to you?

Mr. HOLMES. Mr. Low?

Mr. LOW. A hypothetical reduction of $10 million would cut our R. & D. direct down to $6.7 million, since we are requesting $16.7.

The $21,840,000 includes personnel and institutional costs, pointed out before, that are prorated through the entire programs. A cut in space medicine to a specific amount would be against the R. & D. direct cost. In this case, a $10 million reduction would leave only $6.7 million.

Mr. FULTON of Pennsylvania. That would be the equivalent of the same amount you had in fiscal year 1963—$10.8 million?

Mr. LOW. Including institutional support and operations—including personnel costs and operations of installation.

Mr. FULTON of Pennsylvania. That is correct.

What would it do to you if you had the same figure for fiscal year 1964 that you had in fiscal year 1963?

Mr. LOW. The space medicine program, as with the rest of our program, is an expanding program. In this program we are developing and manufacturing the space suits, for example, for Gemini and Apollo. These developments are coming into the hardware phase, if you will, in 1964. In addition to that, the experimental studies of the reactions of man to impact and landing accelerations and so on are proceeding, for Apollo and Gemini, from the paper phase into test phases. All of these things are going to cost us more in 1964 than they did in 1963. I think, in line with what Mr. Holmes said before, that if we were faced with a cut of $10 million in space medicine, we would have to reprogram funds from the rest of the program to balance it again to bring these developments along with the rest of them.

Mr. HOLMES. At least to balance some of the developments—you wouldn't balance the whole effort.

Mr. DADDARIO. What did you say?

Mr. HOLMES. I'm not saying that a cut of $10 million could be balanced. If you take away funds from any element, unless we determined that we didn't need it, you have to put something in to equalize the effect on the overall effort.

We do have space medicine problems resulting from the last Mercury flight. We have a great deal to do in the development of suits and the transfer of body wastes so that the astronaut can carry out the flight assignments for extended periods. It was quite obvious from this last flight, MA–9. The committee might be interested in having Dr. Charles Berry discuss these aspects sometime.

Mr. TEAGUE. Is Dr. Berry in Houston?

Mr. HOLMES. Yes, sir, he is in Houston. We have a long way to go in developing plumbing, space suits, and so forth.

Mr. TEAGUE. Does that pertain to this, or does Ames do it?

Mr. HOLMES. This is the money that pertains to these problems.

Mr. TEAGUE. This money is for that kind of work?

Mr. HOLMES. Yes, and for the development of space suits.

Mr. DADDARIO. This has been a long struggle and one in which I wonder how much progress we have made. When we first began to look into this, Dr. Glenn said:

> This is not a large buildup, although I realize the fear, and the fear I share with you; once you start something, it begins to grow.

At that time NASA was talking about building up a professional staff of 60 people, divided into 3 sections of 20 each. You would support another 120 or 180 people. This was not supposed to be developed until 1964 or 1965, and the cost was to be about $1.8 million a year.

NASA would be developing this to build up a leadership competence. As of the moment, the three sections involved in the life sciences which have developed from that point have a budget request of almost $90 million and employ about a thousand people.

Taking into consideration that the program has grown, there are other aspects of it which cause me concern. We have had testimony that the aerospace medicine aspect, which is what we are talking about here for the manned spacecraft, is a bioengineering problem.

In the first instance, NASA was allowed to go into this because of the fact that there was evidence in the record that the only capacity the Department of Defense had was a bioengineering field. Much more than that was necessary, and therefore NASA had to build up its own capability. I just wonder where this is all going to end.

I have no question to ask because we have gone into this in some detail. But I am concerned about the fact that NASA keeps growing and growing in an area where there was no intention that it would in the first instance, and where, admittedly, we are dealing with personnel whose talents are in short supply.

Senator Hubert Humphrey had a study made in 1960 which shows that there are over 5,000 people involved in the life sciences area, some $81 million in facilities, and thousands of contracts.

We just keep adding to it, and it seems to me that this is an area in which we have done very poor integration of activity.

Mr. HOLMES. Mr. Daddario, I would like to comment, in broad terms, only on the part I am qualified to comment on; and that is our fiscal year 1964 budget request. It seems to me that it's not unreasonable to expect to expend this percentage of R. & D. funds for the manned flight program on the man himself, on his suit, his instrumentation. If we do look at it in this way: the whole focus is on man, trying to get man into space. However, the whole R. & D. budget for manned space flight does not deal with the man himself, or with the spacesuit, et cetera. That doesn't direct itself to your question or the broader issue. It directs itself to the only part I am qualified to talk about.

Mr. DADDARIO. If we take it away from other two life sciences areas and get it within the jurisdiction of this subcommittee, it is not much, but it is very difficult for us to close our mind to the testimony we have had in the past, and which still remains our responsibility to the full committee.

Mr. HOLMES. I can understand that. I do feel, within the manned space flight program, that we have very close and direct coordination with the Air Force, particularly, and with the Departmentof Defense in general.

No specific criticisms of lack of coordination, either in the astronaut selection program or pertaining to medical examinations, has been brought to my attention over the past many months. In this program, unfortunately, I am not qualified to deal with the broader issue which, I agree, you should be concerned with. When I say that, I don't imply that there's anything wrong with it; I don't have that much personal knowledge. But I agree, you certainly have a broad interest.

Mr. DADDARIO. Well, it is impossible for us to come to any conclusions about it, and I really did not want to ask you any questions about it, but it is an observation.

Mr. TEAGUE. Any other questions?

(No response.)

Mr. TEAGUE. Mr. Holmes, suppose we talk about the construction of facilities this afternoon at 1:30 o'clock.

Mr. HOLMES. Yes, sir. I have a 2:30 appointment that will be very hard for me to break, because people are coming from out of town. If it would be permissible, I'd personally like to be excused and have my people here. I'll be here at 1:30.

Mr. TEAGUE. That will be satisfactory. The subcommittee will be recessed until 1:30 p.m.

(Whereupon at 12 noon the subcommittee was recessed until 1:30 p.m.)

AFTERNOON SESSION

Mr. TEAGUE. The committee will come to order.

We will start with the support facilities; that is, the cafeteria and the number of parking areas at the Manned Spacecraft Center.

Mr. HOLMES. Yes.

Mr. TEAGUE. You have $5,162,000?

Mr. HOLMES. Yes. Mr. Low will testify on that, with your permission.

Mr. LOW. It is my understanding, Mr. Chairman, that there is a proposed cut here in the cafeteria. Insofar as the cafeteria is concerned, I have reaxamined over the past several weeks the number of people who will be at the Center in Houston on a normal daytime shift in fiscal year 1966, which is about the time this additional cafeteria would come into being. We come up with an average number of 5,910 people. There is a peak of 6,100. This includes the Manned Spacecraft Center permanent personnel, temporary personnel, contractor employees, and visitor traffic.

Based on this number being there on an average day, I think it is essential that we add to the existing cafeteria with this second cafeteria.

Insofar as the parking space, ditches, roads, and so forth, I would like to have Mr. Lilly answer that.

Mr. LILLY. There are 800 additional parking spaces included in this fiscal year 1964 project. These additional spaces will increase the existing capacity to 3,300. We had calculated on the basis of handling about 6,000 people, including visitor traffic. This is about

one parking space for two people, which we think is a minimum requirement with the traffic at the Manned Spacecraft Center.

Mr. Low. If I can add one other point, we are examining at all centers, the proposed personnel complement for the fiscal years 1964, 1965, and 1966 against our projections made several months ago. We find in general in the manned spaceflight centers, Marshall, Houston, and the launch operation centers, that we have a much smaller number of people per program or per dollar spent than in any of the other NASA centers, and that probably will not be able to carry on the program of the scope that we have facing us without requesting additional spots, more people, and will probably have considerably more people, at each of those centers than used in the projection for the 1964 budget.

Mr. TEAGUE. Mr. Fulton?

Mr. FULTON of Pennsylvania. They have answered my question.

Mr. TEAGUE. The backup book mentions serving about 3,500 people in the cafeteria based on a half hour eating time.

Mr. LILLY. At present, we feed about 500 people in 30 minutes. On this basis, within 2½ hours you could feed 2,500 people in a 500-seat cafeterial. I don't think that you can cut it any closer than that.

Mr. TEAGUE. Let's go to the project engineering facility at Houston, $2,761,000.

Mr. LOW. This is an office building to take care of the people in the Gemini and Apollo offices. The only point I would like to make here is that today our Houston operation, the Manned Spacecraft Center operation, is the most inefficient operation of all of our centers. People are scattered around town in 13 different locations. It cuts into their work, makes it inefficient. I think that all of us want to be able to get them all down at Clear Lake at the earliest possible time.

Mr. TEAGUE. The leased space will be released when the building is completed?

Mr. LOW. Yes, sir.

Mr. TEAGUE. In NASA we frequently find that even though we build additional buildings, your leased property will still be needed.

Here at Houston, it will be released?

Mr. LILLY. As a result of this 1964 bulding program it will be released.

Mr. HOLMES. This leased space will be released, unless of course, we increase the ceilings for personnel.

Mr. LILLY. Our experience to date in converting space at Ellington has run between $5½ to $6½ per square foot for renovating that area.

Mr. TEAGUE. Any questions?

Colonel GOULD. The cost of annual leasing at the present time is $1,117,084.

Mr. LILLY. That is correct.

Colonel GOULD. How much of that will be released as the result of 1962 and 1963 projects?

Mr. LOW. One specific number I can give is, the 1964 project management facility would take the place of about a third of a million dollars worth of leased space per year.

Mr. LILLY. I don't have the exact number on the 1962 and 1963.

Colonel GOULD. Based on the construction authorized in 1962 and 1963, and on the space which you have already modified, could you

accommodate all of your personnel at Ellington and at the Center?

Mr. LILLY. The figure as I recall it, Colonel Gould, is that through the fiscal year 1963 building program and our forecast of number of people aboard at that time, we would have to continue to keep the space at Ellington, which is 316,671 square feet.

Colonel GOULD. The figures given us before were at Ellington. You have now 316,671, square feet of space modified and in use, and you have an agreement with the Air Force for an additional 98,576 square feet, and if this is not modified the 1962 and 1963 items will provide for 348,800 square feet at the Center.

On an arithmetical basis there is enough square footage.

Mr. LILLY. There is approximately 364,000 square feet of leased space, plus the 316,000 square feet at Ellington and the additional 99,000 square feet if required in the future at Ellington.

Colonel GOULD. It would take a major shift in personnel and organization to accommodate them.

Mr. LOW. For the 1963 complement. I am not sure of the 1964 and 1965 complement.

Mr. LILLY. The space at Ellington Air Force Base is not adequate to provide any kind of laboratory area. It is strictly office space.

Colonel GOULD. These are primarily World War II barracks?

Mr. LILLY. Yes.

Mr. TEAGUE. Mr. Casey, any questions on Houston?

Mr. Low, do you care to comment on this advanced design money?

Mr. LOW. One question first, Mr. Chairman.

I understood last night that the Mission Simulation and Training Facility was included. Shall I comment on that?

Mr. TEAGUE. Yes.

Mr. LOW. This facility will house the Gemini and Apollo flight simulators. Initially these simulators that we discussed before will be built under our R. & D. contracts. They will be located initially in other facilities. We plan in early 1965 to move them into the Mission Simulation and Training Facility. I have examined whether or not we could delay this another year and while I was making this examination I found Houston had accelerated the schedule for this facility by 5 months because to them it is one of the more critical facilities.

The reason for it being critical is that in the temporary facility we will not have two of the important elements of the mission simulators. The first of these is the so-called out-of-the-window displays. It is a wing of the facility, which will be constructed so that the Moon, Earth, and star background can be projected into the walls of this almost planetarium-like wing. This is an essential part of simulations in preparing for the lunar mission. We don't need it, of course, for the Gemini or the orbital Apollo flights. But to get this part of the training early enough the people in Houston are accelerating the schedule for this facility and have urgently requested that we do the paper work as quickly as possible after the 1964 funds become available for this particular facility. The tie-in with Mission Control Center will not be complete and that has to be for a complete simulation. So rather than getting an answer that "Yes, we can slow it down without hurting the program," I found that plans had already been made to accelerate it, if possible.

Mr. TEAGUE. Any questions?

Mr. HOLMES. Mr. Chairman, if one looks at the office facilities and, to some extent, the simulation facilities at Houston, the Manned Spacecraft Center will be monitoring quite a bit over a million dollars in R. & D. funds for fiscal year 1964. If the Manned Spacecraft Center staff is one-tenth of 1 percent more efficient because they are provided with the necessary tools, we will save a million dollars in that year. To my mind you will find no better place to achieve greater efficiency than to bring these people together in reasonable office space, I think that it is just plain economy.

Mr. CASEY. I am convinced we should go ahead with this project. I hope everyone else has all the information they want.

Mr. FULTON of Pennsylvania. I would agree with you, Mr. Casey.

Mr. TEAGUE. Do you want to talk about advance design now?

Mr. LILLY. Yes. We have discussed all the way through our hearings the importance of advanced design funds.

Our facilities requirements and tight time schedules make advanced design funds a critical item. I think that they are the most important money that can be spent on a project in order to carry it out in an efficient and timely way. Not only does it allow us to save 6 to 8 months of time getting started but it also allows us to provide much better estimates and construction costs when we come before the committee.

Mr. TEAGUE. This is advance design money?

Mr. LILLY. It has been borrowed. It is not all spent.

Mr. DADDARIO. You have the money?

Mr. LILLY. Yes.

Mr. DADDARIO. You have been able to accomplish what you say is so important, that is, to spend the money at the right time to get the design for the planned construction?

Mr. LILLY. Yes.

Mr. HOLMES. We had to rob Peter to pay Paul.

Mr. DADDARIO. But for the subject we are talking about, this has been accomplished?

Mr. HOLMES. Yes. However, we could only respond to the need for advanced design funds by borrowing funds from other projects, in accordance with our reprograming authority. In other words, we deferred obligations in other projects to prevent schedule slippage, we must return the borrowed funds.

Mr. LILLY. At the time we appeared before, we had obtained some advance design funds out of the relatively small amount that was appropriated in NASA's fiscal year 1963 budget. We had released some at Houston in January. When we appeared before you we had notified the Bureau of the Budget and the Congress that we had reprograming actions. I believe that part of this amount went out in the latter part of April.

I can give an example of this process. We borrowed $2 million from the Mississippi Test Facility in order to fund part of the advanced design requirements. Our planning had been on the basis of having that $2 million to pay back the borrowed funds.

Mr. DADDARIO. I think this committee was aware of the importance of providing funds for the facility planning and design. Last year we put in $10 million for facility planning and design not otherwise provided for.

Mr. LILLY. I believe that NASA as a whole requested $10 million in advanced design funds for fiscal year 1963. However, the House cut the request to $5 million. The Senate restored $3 million, bringing the total advanced design funds for NASA to $8 million.

Mr. FULTON of Pennsylvania. That is correct.

Mr. DADDARIO. The fact that there was $8 million for——

Mr. LILLY. $8 million in advanced design funds were available for the total agency. That is correct.

Mr. HOLMES. But the advanced design funds that we were discussing came out of our hide, didn't they?

Mr. LILLY. Yes.

Mr. TEAGUE. As far as advance design is concerned, what you are saying applies to every other facility?

Mr. LILLY. Yes.

Mr. DADDARIO. The pressure may be on Mr. Holmes and his group, but the fact is that over and above the rest of the funds for construction of facilities last year, there was another $8 million for planning. I imagine we will have some this year.

Mr. YEAGER. Yes.

Mr. DADDARIO. Last year we had $8 million, now we are talking about $10 million.

Mr. TEAGUE. Any other questions concerning Houston?

Mr. ROUDEBUSH. Mr. Holmes, I think you mentioned laboratory space. It was my understanding that the Project Engineering Facility was mostly office space. I was not aware you were going to put any laboratories in down there.

Mr. HOLMES. I think that you misunderstood. I meant that one has to consider the laboratories, in addition to the Project Engineering Facility. It was not related directly to my point of efficiency in management.

Mr. ROUDEBUSH. Thank you.

Mr. FULTON of Pennsylvania. There was something about a warehouse which Colonel Gould had mentioned, the necessity of constructing a warehouse.

Mr. TEAGUE. Yes. Let's move on to White Sands and talk about the Lunar Test Facility there.

Mr. LOW. Of all the special purpose Apollo facilities I consider this the most important. The reason is that at White Sands, particularly with the funds requested in 1964, we will be testing the engines for the lunar excursion module. One of these engines, namely, the takeoff engine, is the one single component in the Apollo mission that must work. Everything else has been and can be backed up. Even if the lunar landing engine fails one could still abort with a takeoff engine. If the lunar takeoff engines fail to light off, or fails while burning, there is no way for the men to get back from the moon.

The engine test program then for this engine——

Mr. TEAGUE. Why is this so?

Aren't you considering alternatives in this area?

Mr. LOW. We have studied it, we have looked at different ways of doing it, and we felt that the best way of doing this was to build an engine with the highest possible reliability. But this means testing and retesting, qualification testing, that will be done at White Sands. For this reason, as I stated, this is one of our more important facili-

ties. Any delay in this facility will delay the engine test program and will in turn delay the Apollo program.

Mr. TEAGUE. There has been a delay, hasn't there? Didn't somebody have a contract and it was taken away?

Mr. LOW. I don't believe that this caused a delay in the program. There were to be two separate facilities. We have a design engineering contract with the Parsons Co. for designing the North American portion of this. After we selected Grumman, we felt it would be better if we could give Parsons the total job of designing both facilities and integrating them into a single facility, and because this meant two contractors, we decided to let the Corps of Engineers manage this. We transferred an existing contract from North American to the Corps of Engineers. The same people went on with the work. I don't think there was a delay.

Mr. LILLY. There was no delay.

Mr. LOW. We thought it was a better way of doing business, to combine these two and do it with the corps rather than with the two separate companies.

Mr. TEAGUE. Any questions?

Colonel GOULD. Taking into account the $9.5 million that was in the North American contract originally plus this $15 million, what is your schedule of obligations, please, Mr. Lilly?

Mr. LILLY. I don't believe I have the complete obligation schedule with me. I will furnish that information. The amount available in fiscal year 1963 was $9.084 million, which will be fully obligated in early fiscal year, 1964. In terms of phasing the lunar excursion module test facility, it is due to go to construction contract in September 1963. On this basis, I expect to have those funds fully obligated in early calendar year 1964.

Colonel GOULD. That is all.

(The information requested is as follows:)

Of the $9,084,000 available for the service propulsion system test facility at the White Sands Missile Range, a total of $7,418,000 has been obligated to date. The remaining $1,666,000 is scheduled to be obligated in the first quarter of fiscal year 1964.

The schedule of obligations for the Lunar Excursion Module Test Facility is:

October 1963	$10,000,000
November 1963	2,000,000
December 1963	2,000,000
January 1964	1,000,000
Total	15,000,000

Mr. TEAGUE. Where did I get the idea that a cut of $5 million might delay our first LEM flights by a year?

Mr. LOW. A delay of something like $5 million for this facility would push completion a year later. The engine development program for the LEM is now tied to the Saturn I–B flights so that a $5 million delay would delay the flight test program on the Saturn I–B, and therefore would delay the manned landing.

Mr. TEAGUE. Any other questions?

Mr. YEAGER. May I ask one question?

Mr. TEAGUE. Yes.

Mr. YEAGER. Mr. Holmes, we read a lot lately about the possibility of a lunar reconnaissance module. Is there a decision pending in this

regard and is it something that is apt to have an impact on the fiscal year 1964 budget?

Mr. HOLMES. Not an impact. We are studying the possibility. Studies will probably be conducted during the next fiscal year and would involve perhaps a few million dollars. Most of that would be in the systems engineering area, where we already have requested funds. Advance planning has enormous value. We proceed very carefully and work very closely with DOD, which has had a great deal of experience in that area.

Mr. TEAGUE. Are there any other aspects of this that we do not know about, any possible big changes in the budget for the coming year?

Mr. HOLMES. No, sir; not to my knowledge. Mr. Webb has not authorized a lunar reconnaissance vehicle. There is no indication that we will do any development work on it during fiscal year 1964.

The work would be limited to a study effort.

Mr. TEAGUE. Are there any other questions before Mr. Holmes leaves?

Mr. ROUDEBUSH. Mr. Holmes, I want to ask about the hangar for vehicle components and also the modification of the vertical assembly building at the Marshall Spacecraft Center. It is my understanding that you would do some rethinking on this and might combine the two. It that correct? What is your present thinking on it?

Mr. HOLMES. Mr. Lilly would be glad to dicuss that question.

Mr. LILLY. When we proposed this project in the fiscal year 1964 budget request, it was based upon our manufacturing plans at that time. These plans indicated that it would be more desirable to go ahead and raise the roof of the building and that it would not interfere with manufacturing.

Schedule. Since that time the circumstances have changed. The manufacturing plans are such at this point that the previous approach would interfere. The cost, in terms of the time involved in sealing off other parts of the building, and raising the roof, runs to a comparatively high price.

We have considered several alternatives; one was extending the building. The major disadvantage of this approach was the very limited space available to extend the building. It would entail moving many utilities and roads, et cetera.

As a result, we turned to other alternatives, such as the hangar. We have examined this approach very carefully. A decision has not been made. I have a feeling that it will be our judgment of where it would fit best. Now the trade-offs in our studies are that we would require, as I recollect the figures of the space we were providing on this building, about 14,700 square feet. We would have to provide a hangar for additional support facilities that would have been available for the other building. Our cost estimates on this, at least without design, have indicated that it is within $150,000 of the original cost estimate for the two separate projects. In other words, combining the two estimates, $2.8 million plus $1.8 million, there is a possibility, according to our estimates, of saving in the order of $150,000.

Mr. ROUDEBUSH. Instead of having two items, the budget will have one and it will be called hangar for vehicle components and vertical assembly building?

Mr. LILLY. I wish that I could give you a final determination on it. I have talked to Colonel Gould about this subject. I think that we both agreed that it was not advisable to force us into making a premature engineering judgment on it. We really are not in a position to make an engineering judgment at this point in time.

Mr. TEAGUE. There is presently $2.8 million and $1.8 million in the budget for this.

You don't have an answer to it now?

Mr. LILLY. In terms of specifics, I feel, and the recommendation of the staff is, that it will be combined. My estimate is that combining the two projects would require an estimated $4.5 million, give or take a little, instead of the total $4.6 million estimated for the two separate proposed projects. I can't give you a precise figure.

Mr. TEAGUE. Are there any questions?

Mr. FULTON of Pennsylvania. At Michoud you have about 43 acres of buildings which you are going to fill with personnel and equipment. This vehicle component supply building supplies 200,000 square feet of storage space.

The feeling of some of us was that you ought to have some available space in the building as you gradually fill it up. So why couldn't you postpone the vehicle component supply building at this time? Likewise, the other question is whether you actually need an airstrip there,or could you just rebuild the road that runs along the airstrip. Of course, then you have the cafeteria.

Mr. HOLMES. I can discuss the airstrip rehabilitation, having driven from the Michoud plant to the airstrip. It is all the way across New Orleans. We have a great deal of traffic between the Marshall Space Flight Center at Huntsville and the Michoud plant. It is our feeling that rehabilitation of the airstrip would be a worthwhile expenditure from an economy standpoint, since these people's talents can be fully applied with the minimum expenditure of time.

Mr. FULTON of Pennsylvania. Could you prop up some of the slabs and repair it instead of resurfacing the airstrip?

Mr. LOW. Colonel Gould might be able to answer that.

Colonel GOULD. I think it could be done for a temporary thing; yes, sir.

Mr. ROUDEBUSH. This is more than adequate for an air command. We land those in cornfields at home.

Mr. HOLMES. We don't have that courage, sir.

Colonel GOULD. Because of the foundation conditions, some of the slabs have buckled. On a temporary basis, you could mud-jack these slabs back up and use it as is without heavy aircraft load.

Mr. HOLMES. My feeling is that we have recommended the most economical way to make the airstrip safe for an aircraft to land.

Mr. LILLY. That space has been fully analyzed in terms of any available space for storage and there just is not any there. We are talking about some huge components here.

Mr. FULTON of Pennsylvania. You are going to build a full 43 acres of the plant right away? Don't you have some extra room in there?

We are trying to make some cuts that are not directly related to slowing down the Moon program.

Mr. HOLMES. That is a good question. Perhaps Mr. Lilly can add to his statements. I know that Marshall is very careful in conducting its studies.

Mr. LILLY. I would be glad to. In terms of the phasing, what you say is correct; in terms of buildup there would be some now. But in terms of phasing, by the time this storage building comes into being, our manufacturing will be at its peak.

Mr. HOLMES. Excuse me, I must go.

Mr. TEAGUE. All right.

Mr. LILLY. I will supply you a trend on that, Mr. Fulton.

Mr. FULTON of Pennsylvania. Give it to Colonel Gould.

Mr. LILLY. Yes.

Mr. FULTON of Pennsylvania. There is $300,000 for the cafeteria construction and $40,000 for equipment.

Could you comment on that?

Mr. LILLY. At Michoud? Yes, sir.

Mr. FULTON of Pennsylvania. There is a $6 million figure.

Mr. LILLY. There is underway a 740-seat cafeteria, which will serve 2,000 people. In the new engineering building that we are building, there is a cafeteria which will take care of 1,800 people. The proposed mezzanine cafeteria is based upon serving 3,200 people. This comes out to 7,000 spaces available.

I should point out that the engineering building, about a half mile away from the manufacturing plant, can not take any overflow. For safety reasons persons carrying their lunches cannot eat in the manufacturing plant. They have to eat in the cafeteria. I definitely think that the cafeteria space is fully needed, Mr. Fulton.

Mr. FULTON of Pennsylvania. That is all.

Mr. TEAGUE. That covers Michoud; let's go back to the Marshall Space Flight Center.

Mr. Roudebush, do you have any questions about the hangar for vehicle components?

Mr. ROUDEBUSH. No. I think that has been answered.

Mr. TEAGUE. We had some questions about the acceleration test and calibration facility. I believe we were told that the names were similar but that they were different type facilities. Is there any possibility of using the same one for all the operations?

Mr. LOW. Lewis is requesting a bigger one in the 1964 budget. But they are essentially different kinds of facilities. The Lewis facility is, I believe, a 400-foot drop tower. It is a big pipe which can be evacuated and in this pipe the people at Lewis will drop samples of fluid equipment valves and tanks, to get the effects of weightlessness on fluid flow.

The Marshall facility has two major pieces of equipment in it. One is a constant linear acceleration facility. This is also a vertical tower like the one at Lewis. But it will have a hydraulic jack in it and will be able to move different kinds of equipment, the kind of equipment used for guidance systems, and have well prescribed the loss of these accelerations up and down this facility.

Why is this necessary?

The heart of all of our guidance systems, the brains, if you want to call it that, are the gyroscopes. These, as you know, maintain a stable attitude. If you turn the launch vehicle around, the gyroscope will keep the same frame of reference, it won't move with the vehicle.

From this, one can calculate exactly what the flight path of the vehicle is.

These gyroscopes have one major failing, or fault. When they are subjected to sharp motions of a launch vehicle, they tend to drift off a little bit. One has to determine precisely on the ground just how unstable they become, how easily they are subjected to this kind of drift.

The Marshall facility is being designed to determine these drift rates under weightlessness in this vertical tower, under small accelerations, accelerations of less than 1-G and under accelerations of 1-G or more. There will be also a very special kind of centrifuge, a so-called centrifuge where the gondola at the end of the arm swings around with the arm, but it will stay in one orientation like the cab does on the Ferris wheel, so that it will always be oriented in the same direction relative to the fixed axis. This again is used in testing gyroscopes and determining their drift rates under every kind of acceleration.

Mr. TEAGUE. Any questions?

Mr. FULTON of Pennsylvania. Could you build this acceleration test and calibration facility for ninety or a hundred thousand dollars less?

Colonel GOULD. That $90,000 is advance design.

Mr. LOW. I think we have covered the advance design question, Mr. Chairman.

Mr. FULTON of Pennsylvania. It is already in there.

Mr. LOW. Specifically, I think we have to state that, if the $90,000 were not in design but in construction, until the design is completed, we don't really know the numbers that closely.

Mr. FULTON of Pennsylvania. The question is: Can you then build the building for maybe a hundred thousand dollars less?

Mr. TEAGUE. May they can not. They say their best guess is this amount. They will tell you a definite figure when the design is completed.

Mr. FULTON of Pennsylvania. This is not now a firm figure?

Mr. TEAGUE. No.

Mr. FULTON of Pennsylvania. All right.

Mr. LOW. Our experience has been in the past year that the bids for some facilities have come in up to 5 percent less and some 5 percent more than we initially estimated and it pretty well averages out.

Mr. TEAGUE. How close was your estimate in Houston? There was a loud hue and cry about labor prices in Houston about a year ago.

Mr. LILLY. What happened was that the design criteria that first came in, after it was priced out, were considerably in excess of what we could build, and we had to fit it in. The original estimate was around $60 million to start a facility and not even a location had been selected at that point in time.

Mr. TEAGUE. The next item is the "High Pressure Gas Propellant System."

Mr. LOW. I have some interesting numbers on that, Mr. Chairman.

Mr. TEAGUE. Could you get along on $2 million next year?

Mr. LOW. I could only give a general answer. We did recently examine, in connection with a hydrogen production facility for Mississippi, whether we should build a larger size facility immediately or phase it into a smaller size and expand it later on. The preliminary answer was that if you build the smallest size to make it ex-

pandable into the larger size, it would cost you almost as much as the larger size, because you need all the facilities for the larger size immediately. So generally this is the kind of facility that cannot be built to a certain size and expanded later on. Perhaps Mr. Lilly would like to add to that.

Mr. LILLY. This has been phased, Mr. Teague, to meet the peak testing of the big engines and boosters there. It is also interesting to note the differences between present requirements and requirements for the larger vehicles. For instance, present requirements for gaseous helium are now 3 million cubic feet. It goes to 12 million cubic feet. The quantities used in the larger boosters are about five times as much.

Now we are using mostly mobile equipment there. It is a safety problem now and it is a safety problem I don't think we would want to live with, considering these magnitudes.

Mr. LOW. We are talking about going from 3 million cubic feet to 12 million cubic feet in helium, 1½ to 5 million cubic feet in nitrogen, and so forth. Major increases are required for a major booster.

Mr. HOLCOMB. We expect to have it ready in early calendar 1965, which will about hit the peak of our testing.

Mr. ROUDEBUSH. You are speaking of the actual storage capacity, but not any of the handling facilities?

Mr. LOW. That would be the case.

Mr. TEAGUE. The next item is the "Expansion of Computation Facilities."

Colonel Gould?

Colonel GOULD. This is an expansion to an existing facility for this purpose. It is primarily to combine all of your activities now being carried on in leased space and in some scattered locations on the property. Is that correct?

Mr. LILLY. The project growth is also considered. There is a total personnel complement of 417. By July 1965 the personnel planning is for 518. The current computation building, as you know, is approximately 44,000 net square feet; 22,000 of this space is for the computers. The number of people in that building is 232 in the main facility—about 55 percent are in the main facility.

The requested addition is based upon 33,000 plus 9,000, or 42,000 square feet; 33,000 square feet of this space is for equipment, and 9,000 square feet is for the personnel requirement, which will take care of approximately 90 people.

Mr. TEAGUE. Any questions.

The next item is the "Extension of the Propulsion of Vehicle Engineering Laboratory" for $1,900,000.

Mr. LOW. This is a facility to allow us to consolidate the people working in a single facility rather than having a large number of them in leased space in Huntsville.

Mr. HOLCOMB. I have a recent chart which plots the space needed versus what they actually have available. This lower line below your colored portion is what is available. This is their need. Here on your fiscal years 1964, 1965, and 1966. The bar across the bottom is leased space where we have now about 1,650 people, and we have just about run out of available leased space.

Funds for this and another facility which was questioned here at Marshall will go to provide new facilities because we have run out of

leased space. This will not release any of the leased space we have. We don't anticipate getting any relief on that until fiscal 1965.

Mr. TEAGUE. Are there any questions?

Mr. LOW. I think the same comments apply also, Mr. Chairman, to the "Project Engineering Office" on page 2 of Colonel Gould's list.

Colonel GOULD. What is the annual leasing cost?

Mr. LILLY. We have 264,000 gross square feet leased, and the cost is $764,200 per year.

Mr. TEAGUE. Are there any other questions?

That completes the Marshall Spaceflight Center.

Mr. HOLCOMB. There is one item having to do with the barge dock and loading facility and deletion of one pier, that I think was questioned. The reason for having two piers is because our Corps of Engineers records indicate that we have a spread between our high water and low water of about 7 feet.

With our barges our ballast is about 4 feet. To have year-round capability, with the roll-on roll-off capability, we have to have the two piers, or we run into a dead spot, where we can't move the vehicle.

Colonel GOULD. I think we have that.

Mr. TEAGUE. We will cover the Mississippi Test Facility next.

What is the question there, Colonel Gould?

Colonel GOULD. This is reduction, sir, for shorter leadtime items that could be slipped into fiscal year 1965.

Mr. TEAGUE. How much of the $35.7 million could be deferred until next year?

Mr. HOLCOMB. In looking at that we felt we had budgeted what we need to take care of the facility this year. We are putting in the foundation and putting in one test position. Next year we plan to complete the second test position. These efforts are scheduled so we will have the facility at the time to meet our test program. I have the schedule here.

This provides for the first test stand having a readiness date of the end of August 1965, but during that time we are installing equipment beginning back in 1964. Meanwhile we have a leadtime on procurement of this equipment, with anticipated availability of money in October. We have practically no leadtime for the procurement of the equipment to be installed unless we buy it with 1964 money.

Colonel GOULD. What is the leadtime on the high pressure water pumps costing $22,600,000?

Mr. LILLY. On the high pressure water pumps item, let me give the leadtime in two phases, tying in both the S–IC facility and S–II. For phase 1, we had criteria developed in February of this year; we started drawing specifications in March, and completed them at the end of May. We go out for invitations to bid on the first phase in June 1963 and complete the manufacture in April 1964. Going back, the leadtime is about a year, slightly over a year.

Colonel GOULD. Will these propellent storage barges be manufactured new or will they be converted?

Mr. HOLCOMB. That is conversion.

Colonel GOULD. What is the leadtime on those conversions?

Mr. HOLCOMB. That is a misprint.

Colonel GOULD. Twenty.

Mr. HOLCOMB. It should be two.

Mr. LILLY. The figure of 20 is incorrect. It should be 2. They cost $550,000 apiece.

Colonel GOULD. What is the leadtime on the conversion?

Mr. LILLY. On the barges, from the start in the drawings and specifications, to the completion, it is almost 21 months.

Colonel GOULD. Do you have the barges now?

Mr. HOLCOMB. The barges have been reserved. They are available.

Mr. GURNEY. Can't you get the water pumps immediately?

Mr. HOLCOMB. These are high-capacity pumps which are essential for our test operation. They require special design. They are not an off-the-shelf item.

Mr. GURNEY. They are not immediately available?

Mr. HOLCOMB. Not to the criteria that we have to have.

Mr. TEAGUE. That explanation, I assume, would apply to the next item, "Advanced Saturn Second Stage?" Is there any part of that $19 million that you could defer until the next fiscal year?

Mr. LOW. No. That is our most critical facility.

Mr. HOLCOMB. This is true. We have a very urgent test schedule requirement to meet the Saturn launch schedule. Our facilities at Santa Susana will be loaded with our early all-systems tests. It looks like our first S–II test stand at MTO may have to accept some later tests because of not being able to get relief on some hazard criteria at Santa Susana. This means this test stand at MTO will be an absolute necessity to meet our planned program.

Colonel GOULD. In a recent report it was indicated that $2,925,000 from fiscal year 1963 money was committed for advanced design. In your project estimate, does that amount show up in the fiscal year 1963 column on CF 1–21, Mr. Lilly?

Mr. LILLY. Yes. When you add the $17,800-plus to the $2,925,000, you come to the figure in the book.

Mr. TEAGUE. Are there any other questions? The next item is the "Engine Test Stand." What was the question there?

Mr. FULTON of Pennsylvania. Whether they should have that done at Marshall.

Mr. HOLCOMB. It is going to be fully occupied in doing the all-systems tests. The other tests at Edwards are involved in the engine development and acceptance test schedule.

This particular test stage is tied in with the acceptance test of the stage itself. In the course of our stage testing, if we encounter problems where one engine is high and one low, they have to pull the engine, work out their problems and get it back into the stage. They can't afford the time necessary to send the engine back somewhere else for test particularly if the problem is associated with valves and piping which are a part of the attachments to it rather than the engine itself.

Mr. TEAGUE. Questions?

Mr. GURNEY. How often does this happen?

Mr. HOLCOMB. It is something that can happen at any time.

Mr. GURNEY. But how often does it happen?

Mr. HOLCOMB. It is not a thing you can predict.

Mr. GURNEY. Have you had any experience on it?

Mr. LOW. We have in the first stage of the Saturn I at Huntsville.

Mr. GURNEY. How many times does it happen then?

Mr. LOW. Especially every static firing. You have to pull the engines and test them separately.

Mr. GURNEY. That doesn't tell me anything. How many times will you use this facility? We ought to be able to get some information instead of just the shoveoff that it can happen any time.

Mr. TEAGUE. Are you talking about the whole test stand?

Mr. GURNEY. I am talking about how many times you have to use this thing. We are talking about $9 million that we may be able to take out of the program.

Mr. HOLCOMB. In your early development phases, you run engine tests further apart because you find more problems that must be solved. Initially you may have 3 months between firings. Later you may be running your test firings as often as two or three times a month, and it takes a great deal of preparation. You then have to have the data you collect reduced, analyzed to determine what your problems are, and in the case of one of your engines which is not working, you have to pull it and wring your problems out of that engine before you can run your next stage test. So these things are dependent upon each other.

Together they have a very direct effect on the delivery capability for your stage.

Mr. FULTON of Pennsylvania. There is another point that I would like to mention when you are finished.

Mr. TEAGUE. Yes.

Mr. FULTON of Pennsylvania. On the first two items, "Advance Saturn First Stage," and "Static Test Facilities," I understand that there is a 2-year leadtime, and that this is only to be used if something goes wrong. Aren't you getting it too soon? Couldn't that $9 million be postponed? Why does it have to be in this particular budget?

Mr. HOLCOMB. First test stand for the S–1C has a readiness date at the end of August 1965.

Mr. FULTON of Pennsylvania. As of what date?

Mr. HOLCOMB. End of August 1965.

Mr. FULTON of Pennsylvania. What is that date?

Mr. HOLCOMB. That is the date on which we are ready to accept the facility checkout vehicle on the stand itself, the point at which we have installed our checkout equipment, we have checked the equipment, we bring in the dynamic test vehicle, set it up, and at this point we are ready to run through a complete simulated operation.

Mr. FULTON of Pennsylvania. So you do have a 2-year leadtime because it is to be used in August 1965 and this is June 1963.

Mr. HOLCOMB. That is right. On the F–1 engine test stand we have a date of the first of July 1965.

Mr. FULTON of Pennsylvania. Why do you need the F–1 test stand if you are only going to use it if something goes wrong on the S–IC stage vehicle.

Mr. HOLCOMB. They need to be ready at the same time. When you run into problems on the testing of the stage, you need the F–1 engine test stand available.

Mr. TEAGUE. The S–1C stage is powered with the F–1 engine.

Mr. HOLCOMB. They are timed so they both wind up at the same time.

Mr. FULTON of Pennsylvania. We are trying to get your timing.

Mr. HOLCOMB. There is only 30 days' difference between them. We run into a problem on one stand and we work out our problems on the other.

Mr. FULTON of Pennsylvania. You couldn't do that at Marshall?

Mr. HOLCOMB. Marshall facilities will be saturated at the time supporting our all-systems tests.

Mr. FULTON of Pennsylvania. All right.

Mr. TEAGUE. Any questions?

Mr. FULTON of Pennsylvania. Does that satisfy Colonel Gould?

Colonel GOULD. I have one other question that probably should be answered. The test stand at Marshall costs, I think, $7.6 million. Why is there a difference in this one at the Mississippi Test Facility, other than soil conditions?

Mr. TEAGUE. Is it that Marshall tests the single engine and the one at Mississippi tests the whole S–1C stage?

Mr. HOLCOMB. No.

Mr. ROUDEBUSH. They should be comparable.

Mr. LOW. Could we get to that afterward?

(The information referred to is as follows:)

The F–1 test stand at the Mississippi Test Facility is more costly than the F–1 test stand at the Marshall Space Flight Center for the following reasons:

The foundation for the MTF stand will require more funds because of the difference in subsurface conditions at the two locations. At Marshall bedrock was encountered at approximately 40 feet below the surface. At MTF no bedrock was encountered at a reasonable depth. Therefore, it is necessary to build an extensive system of piling and piling cap to support the test stand and superstructure. In addition, the water table was close to the ground surface at MTF which necessitated dewatering and incurred additional cost.

MTF is a virgin territory and thus requires extensive systems to support the test stands. Examples are the water supply and the electrical systems. At Marshall only extensions or additions to existing systems were required.

Mr. TEAGUE. Yes. The next item is Maintenance Facilities costing $5 million. Could that be deferred for a year?

Mr. HOLCOMB. These are maintenance facilities. They need to be timed to be complete at the same time as your other facilities. There is also in this same budget line item vehicle maintenance facilities. We have no other facilities available in the area for a number of miles where any kind of maintenance could be done on vehicles.

Mr. LILLY. As to the timing of the facilities we have, the test maintenance shop is tied specifically to the beneficial occupancy date of the S–II test stand, which is November 1964. The test maintenance shop is scheduled to be completed in the last of December 1964; the automotive maintenance shop is tied in to be ready in the last of October 1964, again tied in to the activity on the S–II test stand. The marine terminal facilities are scheduled to be ready in the last of December 1964 to meet the first stage delivery of the S–II ground test stage in April of 1965.

Mr. TEAGUE. Are there any questions?

Mr. CASEY. How many vehicles will you have to maintain down there?

Mr. TEAGUE. We have a figure from somewhere, Captain, of 600.

Mr. LOW. That is the number I have.

Colonel GOULD. When do you reach that number of vehicles in your buildup?

Mr. HOLCOMB. I would have to provide that.

(The information requested is as follows:)

The buildup of vehicles at the Mississippi Test Facility is planned as follows:

Date	Total number of vehicles
December 1963	25
March 1964	85
June 1964	250
September 1964	485
December 1964	545
March 1965	600

Mr. TEAGUE. The next item is "Security Control Facilities" costing $675,000.

Mr. FULTON of Pennsylvania. $675,000. North and south gatehouses.

Mr. HOLCOMB. These facilities are scheduled to be completed about mid-1964. About this time our testing facilities will be well along. We will have a lot of money that will be invested in the Mississippi facility. Some of our office buildings will be near to completion.

We need provision for controlling entry into the area. We need some way to provide security.

Mr. FULTON of Pennsylvania. Four guard shacks at $16,000, aren't they pretty plush guard shacks?

Mr. FUQUA. You could build a nice home for that.

Colonel GOULD. I think you estimated four of these.

Mr. LOW. Four of them, $16,000.

Mr. FULTON of Pennsylvania. $16,000 for four guards shacks. Go ahead. If that is the price, I just wanted to hear it.

Mr. HOLCOMB. $13,000 is what is listed here in the budget.

Mr. FULTON of Pennsylvania. That is all.

Mr. TEAGUE. Gentlemen, we have to travel fast.

Mr. FULTON of Pennsylvania. Don't you have an existing temporary facility?

Mr. HOLCOMB. Yes. But the existing temporary facility is for research in this area only. It is finding out in advance an indication of what kind of meteorological conditions we have there which will affect the propagation of acoustic noise in the local populated area.

Mr. FULTON of Pennsylvania. You say you cannot use the present facilities, and that it might be dangerous to the local area if you do not have the sonar test facility?

Mr. HOLCOMB. Yes. On every test you must have this information available. If you get a temperature inversion leading to acoustic hazard in some place, it would have a very dangerous result.

Mr. LILLY. It is not just a matter of whether you could or could not use it. It is also the location. It is located in a farmhouse, in the middle of which the construction is going. All this would have to be picked up and moved some way. I don't know how you would move it.

Mr. TEAGUE. What was the question on the Transportation Department facilities?

Colonel GOULD. The project provides for 70 miles of road, 5 miles of paved road, 2,800 parking spaces, and relocation of Mississippi State Highway 43. Based upon our review, it looked as though the Mississippi highway should be relocated and the balance of the roadway should be programed over a 2-year period.

Mr. TEAGUE. Can you do that?

Mr. LILLY. I don't really know how to answer this specifically. I can't relate it readily to the schedule, as I can the test stands.

All I can say is that these facilities were laid out in accordance with the total master plan and their need to take care of the area. The patrol roads just can't be put off. Parking space is necessary. I just can't say how it would affect the program if you tried to phase it.

Mr. FULTON of Pennsylvania. Next?

Mr. CASEY. Is that a divided highway?

Mr. LILLY. Two-lane.

Mr. CASEY. Do you have to have a four-lane road there?

Mr. LILLY. Yes, sir. These requirements were substantiated by traffic studies. All the studies we have had on it come up with this conclusion.

Mr. CASEY. This is on the site?

Mr. LILLY. Yes.

Mr. TEAGUE. The next item is "Warehouse and Storage Facilities."

Mr. FULTON of Pennsylvania. In 1963 you were authorized a building of 66,000 feet, I believe. This is three new buildings.

Can you delay it a year or do you have to have it in this budget?

Suppose we cut $1,382,000, what would happen then?

Mr. HOLCOMB. These are the facilities in which we will not only store some of our consumables and final material, but also in which we will store some of the stage components during the time that we are between tests or taking them down from the stand.

Mr. FULTON of Pennsylvania. Do you actually need just this extra storage facility in addition to the 66,000 feet you got in the fiscal year 1963 authorization for storage?

Mr. HOLCOMB. Yes. This facility will be completed probably in late summer of calendar year 1964. By the time that you could provide similar facilities in fiscal year 1965 you will be at the point where we will be operating our first S–II stand there, beginning in April 1965.

Mr. FULTON of Pennsylvania. That is all.

Mr. TEAGUE. The next item is Various Locations, $14 million. This is in California.

Did someone have a question there?

Mr. ROUDEBUSH. I think the question was should we invest more money in an area that was so highly populated, and in a facility we could not adequately use because of the danger of explosions.

Mr. LILLY. I think there is some confusion here. The Santa Susana facility is for the F–1 engines—strictly for battleship or components testing. The sound levels are not the same. This is where we are currently doing component testing.

Mr. LOW. We will certainly continue to use Santa Susana. There is no plan to phase it out. We cannot do full stage testing with hydrogen and flight weight hardware there.

Mr. HOLCOMB. There is no problem at Santa Susana in battleship or in component test.

Mr. TEAGUE. Any questions?

Let's go to Cape Canaveral and the Advance Saturn Complex.

Mr. FULTON of Pennsylvania. There is a $10 million slippage factor in the first figure of $217,219,000. That is an unidentified slippage factor. It is not for any particular purpose other than as an insurance, is it?

Mr. LOW. I don't follow the question.

Mr. TEAGUE. Could I ask the question this way:

Suppose you got a total of $300,663,000. What would a $32 or $33 million cut do to the whole Launch Operation Center?

Mr. LOW. If we had a single line item for the Launch Operation Centers, one single facility and complete freedom of putting the money where it ever was needed, without having it assigned to various buildings, various pockets, various departments, something like a 10 percent reduction would probably be OK, but——

Mr. FULTON of Pennsylvania. I am ready to fall over.

Mr. LOW. I would like to emphasize this point though: If you look at the total Launch Operation Center's dollars, it will not be all obligated at the end of the fiscal year. On the other hand, having to fund this program, for individual facilities, really individual pieces of facilities, I don't know how many separate projects are represented here, we know also that we will on a large majority of these obligate all of the funds. Without complete flexibility of being able to put the money every place and any place, I think we need all the money requested.

Mr. FULTON of Pennsylvania. Don't you have that under the statute, because it is all facilities?

Mr. LILLY. Mr. Fulton, I have to compare this to the Department of Defense type of authorization in which complete facilities are authorized for the total cost.

They obtain authorization for the total scope of the facility. The appropriation is not tied in a specific year to the given authorization. This procedure allows them to come in with a budget based on their phasing of total obligations in these areas.

Our appropriation bill is tied specifically to the authorization by budget line item and location. If your report indicated that the basis of a reduction was to cut back certain of these facilities, I would not be allowed to use reprograming authority to move any money from one facility to the other.

Mr. FULTON of Pennsylvania. That is not the authorization act. That is the appropriation act.

Mr. LILLY. No. Previous authorization bills state no funds may be used for any facility budget line item for which the Congress has previously denied authorization.

Mr. FULTON of Pennsylvania. "Denied." But we are authorizing it in whole, which would give you the right to reprogram because we have not previously denied any of the items you asked for.

Mr. LILLY. If I had X facility, estimated at $5 million and you decide that in your judgment $3 million is all that is needed at this point in time, then the report states that in your judgment $3 million is adequate and limits the scope to $3 million.

Mr. FULTON of Pennsylvania. What the chairman said is much different.

Mr. Teague said that suppose we give you an overall figure minus 10 percent reduction, and in the report we give you the opportunity

to put it where you want it, then it would take an appropriation bill to limit your actions.

Mr. LILLY. That is correct. If your report and the authorization bill are in the terms which you described.

That ties in with what Mr. Low said. My obligation plans right now for this total area of launch operations are laid out on the basis of having the funds obligated. I believe less than $10 million would not be obligated by July 1. Statistically it will be more than that. The figure that George used, somewhere around 10 percent, is a good figure. If I had the flexibility to shift between facilities, I think I can make my cash flow follow the patterns and the bid packages of the obligation.

Mr. FULTON of Pennsylvania. Mr. Yeager could handle that for us.

Mr. TEAGUE. I think this is the best place for us to stop for the afternoon.

(Whereupon, at 3 p.m., the subcommittee adjourned.)

APPENDIXES

APPENDIX A

CONSTRUCTION COST ESTIMATES

Section I. Derivation of construction cost estimates.
Section II. Construction cost index.
Section III. A comparison of building unit costs.
Section IV. Basis of cost estimate for fiscal year 1964 facilities.

SECTION I. DERIVATION OF CONSTRUCTION COST ESTIMATES

Cost estimates are usually prepared by engineers in the field in conjunction with the planning of a facility project and are based on preliminary design (when available), design criteria, or engineering estimates relating the planned facility to similar previous facilities or construction standards developed by other Government agencies.

TYPES OF ESTIMATES

In general we use two types of estimates, preliminary and final. Preliminary estimates are usually prepared before construction drawings and specifications are initiated. They are based on available project information, such as design criteria, schematic drawings, or descriptions of the scope of the work and the basic material to be used. Final estimates are firm estimates based on construction drawings and specifications. In the preparation of final estimates many factors affecting the ultimate cost of the project are considered. These include the construction methods to be used, access to the site, prevailing climatic conditions, and the availability of materials and labor.

UNIT COSTS

Basic construction estimates are normally based on units of cost, such as cubic yards of concrete, squares of roofing, square feet of floor area, or cubic feet of enclosed space. A unit of cost, then, would be the installed cost of a cubic yard of concrete. Each unit represents the sum of four elements: material, labor, overhead, and profit.

To establish the units of cost initially, quantity surveys are made to determine a material and labor base to which unit cost can be applied. Material unit costs are determined from current cost data or by contact with suppliers and manufacturers. Labor unit costs applicable to material items are ascertained from current usage and cost data, or from the estimator's experience. Overhead is treated by adding a percentage of the material and labor cost, the percentage varying with the type and extent of the construction, location, and other factors. Profit, like overhead is provided by adding a percentage of the total of the other elements.

Unit costs are also obtained by reference to known costs of comparable structures and facilities and used in preparing estimates but are constantly checked and adjustments made for variables such as price of materials and wages. Additional modification to unit costs are necessary to adjust differences in time and geographical locations. These adjustments are accomplished by applying index factors to the unit costs.

Standard construction costs to provide utility services are available from industry sources, other Government agencies and from NASA's own records of previous utility installations.

The cost of a utility service is determined by—

1. The capacity of the service required,
2. The distance of supply runs from the service source,
3. The size of the transmission lines, and
4. Any unusual construction features such as: overhead suspended systems versus underground installation.

SECTION II. CONSTRUCTION COST INDEX

The Office of Assistant Secretary of Defense for Installations and Logistics and the Bureau of Yards and Docks publish an "Index of Construction Area Costs" for each State as well as most foreign countries. The index is a cost analysis of the various contracts issued by these agencies and take into consideration such factors as: wage rates, cost of living index, material, and distribution costs.

BASE CITIES

The Office of the Assistant Secretary of Defense for Installations and Logistics selected Washington, D.C., as the base city while the Bureau of Yards and Docks selected Philadelphia, Pa. Each city is assigned an index value of 1 and construction costs in American cities, the States and foreign countries are compared to these index cities.

SECTION III. A COMPARISON OF BUILDING UNIT COSTS

There is no basis which will allow a reasonable comparison of construction costs of the specialized facilities requested in the fiscal year 1964 construction of facilities budget. Facilities, such as test stands, are unique to the particular system being tested and bear no common base for comparing the cost of one to another. A complete rundown of each individual facility has been listed in section IV and the basis of the cost estimate has been indicated for each line item.

Other facilities, whose estimated costs can be logically compared within categories are shown below. This section categorizes the buildings into seven general classification and explains the reasons why the estimated costs for similar structures vary.

Summary comparison of building costs, fiscal year 1964 construction of facilities

Category	Number of buildings	Total cost	Area in square feet
		Thousands	
1. Cafeteria building	2	$725	30,400
2. Laboratory building	14	10,846	277,627
3. Instrumentation building	5	5,435	112,250
4. Operation and checkout building	5	3,207	90,025
5. Administration building	6	9,959	451,000
6. Utility building	1	209	8,200
7. Storage building	12	11,673	637,210

CATEGORY 1.—*Cafeteria buildings*

Center	Page	Project	Total cost	Area in square feet	Cost per square foot
LOC	CF6-45	Cafeteria	$370,000	15,000	$24.70
MSC	CF8-18	do	354,500	15,400	23.02

It should be noted that the cafeteria at MSC does not provide a central kitchen. It will service food prepared from the cafeteria included in the fiscal year 1962 construction of facilities budget. Therefore, the higher unit cost for the cafeteria at LOC is attributed to the inclusion of a central kitchen. The Office of Assistant Secretary of Defense for Installations and Logistics indicates an average unit cost of $24.50 for messhalls which are similar in size to the cafeterias being constructed at MSC and LOC.

CATEGORY 2.—*Laboratory buildings*

Center	Page	Project	Total cost	Area in square feet	Cost per square foot
LOC	CF6-28	Ordnance Laboratory	$700,000	10,000	$70.00
LOC	CF6-50	Calibration and Standards Laboratory.	700,000	15,000	46.65
LOC	CF6-74	Ordnance Field Test Laboratory	39,800	1,324	30.00
MSC	CF8-26	Launch environmental facility	3,067,000	47,600	64.43
MSC	CF8-40	Spacecraft Control Technology Laboratory.	1,702,000	45,400	37.49
MSC	CF8-44	Ultrahigh vacuum space chamber	240,000	3,200	75.00
MSFC	CF9-5	Laboratory building	470,000	13,300	35.33
MSFC	CF9-5	Linear acceleration tower	330,000	7,300	45.20
MSFC	CF9-11	Control and acoustic instrumentation building.	66,000	2,000	33.00
MSFC	CF9-30	Extension to load test annex building	1,404,000	44,000	31.95
MSFC	CF9-36	Extension to Propulsion and Vehicle Engineering Laboratory.	1,470,000	70,000	21.00
MSFC	CF9-42	Hazardous Operations Laboratory	192,000	6,400	30.00
MTF	CF11-55	Acoustic Laboratory	365,000	7,990	38.00
MTF	CF11-55	Meteorology building	160,000	4,113	39.00

There are 14 laboratories in the fiscal year 1964 manned space flight construction of facilities program at the several centers. The lowest cost per square foot is $21 for the extension to the Propulsion and Vehicle Engineering Laboratory at MSFC and the highest cost per square foot is $75 for the ultrahigh vacuum space chamber laboratory at MSC.

The variance in cost for laboratories is determined by—

(*a*) Specific functions to be housed.

(*b*) Type of construction required (architectural requirements: structure, material, etc.).

(*c*) Degree of safety required and the degree of hazards in the functions to be performed.

(*d*) "Clear" work area required.

AN EXAMPLE OF HOW COSTS VARY FOR LABORATORY BUILDINGS

The extension to the propulsion and vehicle laboratory is a normally sized structure and is estimated to cost $21 per square foot. The basic building is already in existence. Utility installations need only be expanded to handle the additional load. The unit cost is thus significantly lower.

The launch environment facility is estimated to cost $64.43 a square foot. This structure will be approximately 140 feet wide, 272 feet long and 120 feet high to house a vibration laboratory, an acoustic laboratory, and anechoic chamber. The high unit cost is due to the fact that the facility must meet special features for testing the Apollo Spacecraft such as an extreme clear ceiling height and reinforced concrete walls approximately 18 inches thick.

CATEGORY 3.—*Instrument buildings*

Center	Page	Project	Total cost	Area in square feet	Cost per square foot
LOC	CF6-28	Instrumentation facility	$120,000	4,000	$30.00
LOC	CF6-28	Data link terminal and repeater buildings.	90,000	2,800	32.15
LOC	CF6-57	Central instrumentation facility primary buildings	4,700,000	94,000	50.00
LOC	CF6-57	Central instrumentation facility auxiliary building.	390,000	7,800	50.00
LOC	CF6-98	Air surveillance radar building	135,000	3,650	37.00

There are five facilities, proposed for construction in the fiscal year 1964 construction of facilities program, which fall into this category. These facilities are all located at LOC. The unit cost varies from $30 per square foot to $50 per square foot. The variance is attributed to several design and construction factors peculiar to each facility. For example, the instrumentation facility on CF6–28 is a one-story structure whereas that on CF6–57 is a two-story structure with special features. The latter facility will have a dropped acoustic ceiling, special flooring in certain areas for extensive cabling, and a high order of humidity control and air-conditioning. This facility will require special foundation for certain equipment and special power requirements.

CATEGORY 4.—*Operations and checkout buildings*

Center	Page	Project	Total cost	Area in square feet	Cost per square foot
LOC	CF6–28	Operations support buildings	$750,000	20,000	$12.50
LOC	CF6–43	Operations building	48,000	2,400	20.00
LOC	CF6–74	Addition to spacecraft operation and checkout building.	948,000	31,625	30.00
MTF	CF11–11	Test control center	1,065,000	30,000	35.50
Various (WSMR)	CF13–41	Control center	396,000	6,000	66.00

The five operations and checkout buildings contained in the fiscal year 1964 construction of facility program vary from a low of $12.50 to a high of $66.

The higher unit cost for the MTF facility in contrast to the LOC operations support building is attributed to the structural differences between the two facilities. The test control center will be of reinforced concrete, flat slab floor construction on a raft foundation. It will contain a basement and will furnish special power and electrical and instrumentation cables to and from the installed equipment. In addition, instrumentation tunnels requiring "blast walls" will connect to his building from the test positions. In contrast, the LOC operations support buildings are single-story, prefabricated-type buildings without special foundations, power, or electrical requirements.

CATEGORY 5.—*Administration buildings*

Center	Page	Project	Total cost	Area in square feet	Cost per square foot
LOC	CF6–40	Addition to LOC headquarters	$4,334,000	197,000	$22.00
LOC	CF6–41	Security headquarters	50,000	2,500	20.00
LOC	CF6–91	Range Engineering and Administration building.	440,000	20,000	22.00
MSC	CF8–35	Project engineering facility building	2,050,000	84,500	24.25
MSFC	CF9–52	Project engineer office building	2,210,000	112,000	19.75
Various (WSMR)	CF13–41	Additions to administration building	875,000	35,000	25.00

There are six administration buildings requested in the fiscal year 1964 construction of facility budget. These unit prices compare favorably with the construction cost of a similar type Air Force administration building, as shown in AF88–008–1, where cost standards are listed as $25.50.

The rate for the proposed buildings ranges from $19.75 a square foot at MSFC to $25 a square foot at the White Sands Missile Range. Costs vary between locations due to—

(*a*) Siting comparisons.
(*b*) Vertical elevation comparisons.
(*c*) Materials utilized dictated by existing architectural patterns.
(*d*) Special purpose areas such as conference, reception, display areas, and computer rooms.
(*e*) Ability to utilize existing services and utilities.

CATEGORY 6. UTILITY BUILDING

The central heating plant addition requested in the program at the Manned Spacecraft Center will provide an 8,200-square-foot addition to the central plant existing and/or under construction. The unit cost reflected for this addition is $25.50 per square foot. As such, this is an extrapolation of the unit costs experienced from the contract costs of the basic facility approved in the fiscal year 1962 program and the additional increment approved in the fiscal year 1963 program.

CATEGORY 7.—*Storage buildings*

Center	Page	Project	Total cost	Area in square feet	Cost per square foot
LOC	CF6-40	Addition to central supply facility	$360,000	40,000	$9.00
LOC	CF6-40	Additions to warehouse	800,000	80,000	10.00
MSFC	CF9-20	Storage building	6,400	400	16.00
MSFC	CF9-38	Hangar for vehicle components	1,660,000	50,000	33.20
Michoud	CF10-23	Vehicle component support building	2,200,000	200,000	11.00
MTF	CF11-11	Stage storage building	1,415,000	53,450	26.50
MTF	CF11-20	Stage service and storage building	2,500,000	68,900	36.00
MTF	CF11-73	Warehouse	1,260,000	1,086,000	11.60
MTF	CF11-73	Flammable materials storage building	285,000	18,500	15.35
MTF	CF11-73	Compressed gas cylinder storage building	35,000	5,460	6.56
	CF11-73	Salvage materials storage	35,000	4,100	8.60
Various	CF13-42	Addition to warehouse	117,000	7,800	15.00

The cost of a storage building varies with the function to be housed and special requirements such as: Overhead bridge systems, environmental control, lateral span required, clear overhead height specified, and other functions that are to be performed in the building in addition to storage.

There are 12 storage buildings requested in the fiscal year 1964 construction of facility budget, with a range from $9 to $36 a square foot.

The $36 a square foot building is the proposed stage service and storage building at the Mississippi test facility. The building will provide storage and servicing capabilities for stages before and after test firings. It will have a 68-foot clearance providing three high bay areas each equipped with a 150 ton bridge crane. The building will be heated throughout and have some areas that are air conditioned. It will be protected with a wet pipe sprinkler system and will provide the various services required to service the stages.

The $9 a square foot building at the Launch Operations Center is an addition to a basic building approved in the fiscal year 1963 construction of facility budget. It will be a simple storage building and some of its basic utility requirements will have been provided in the basic warehouse. This unit cost compares favorably with standards published by the USAF Office of Civil Engineering.

VOLUME IV

Launch Operations Center

Page No. (vol. IV, pt. 1)	Project	Basis of cost estimate
C6-28 to 30	Advanced Saturn Launch Complex No. 39.	1. There was an overall study of the entire complex made by the architect-engineer firms of Urhahn, Roberts, Sealye & Moran; and Reynolds, Smith & Hills. Criteria was developed and served as the basis for their estimate. 2. The Corps of Engineers assisted in developing budgetary estimates based on their experience with similar type facilities. 3. The NASA engineers coordinated the overall development of the estimates and contributed estimates, as well, based on their own experience with similar type facilities.
C6-40-41	Advanced Saturn supporting facilities.	Estimate was based on similar type facilities already constructed at LOC.
CF6-43	Barge lock and channel	1. Estimate prepared by Chief of Engineers Office, based on engineering studies.

Launch Operations Center—Continued

Page No. (vol. IV, pt. 1)	Project	Basis of cost estimate
CF6-45-47	Cafeteria	Estimate based on similar facilities cost as developed by the Air Force Civil Engineering Office and the Office of the Assistant Secretary of Defense for Installations and Logistics.
CF6-50	Calibrations and Standards Laboratory.	Estimate was derived by first establishing basic costs for a similar structure using Corps of Engineers construction standards. This basic estimate was then revised to reflect unique requirements of special foundations, additional air conditioning, and exceptional cleanliness.
CF6-57-58	Central instrumentation facility.	This estimate was developed on the basis of similar facilities already constructed at LOC and refined to reflect the estimated cost of its unique requirement.
CF6-63	Launch equipment shop	Based on actual unit cost of constructing similar industrial-type facilities at AMR.
CF6-73-74-75	Manned spacecraft facilities	Design and cost studies developed by architect-engineer firms: Hardeman, Morrison & Knudsen; and the Tampa Bay Engineering Co.
CF6-79-80	Modifications to Saturn Launch Complex No. 34.	This type of modification has been accomplished under the supervision of the corps many times within the past several years. The figures on previous similar construction were revised to allow for the particular requirements of Complex 34.
CF6-84-85	Modifications to Saturn Launch Complex No. 37.	This type of modification has been accomplished under the supervision of the corps many times within the past several years. The figures on previous similar construction were revised to allow for the particular requirements of Complex 37.
CF6-88	Optical and electronic component servicing facility.	Based on unit cost of Air Force definitive construction of this type of facility at AMR.
CF6-89-91	Range engineering and administration building.	Based on unit cost of Air Force definitive construction of this type of facility at AMR. This is a standard building and there are many professional references readily available.
CF6-98	Range instrumentation sites.	Based on unit cost of Air Force construction of similar type radar structures and towers built at AMR.
CF6-111-112-113	Utility installations—new area.	Based on actual bid price and completed construction costs for roads and utilities already under construction at AMR. Estimate was adjusted to reflect any variations in the planned construction with that of similar work previously completed.
CF6-118-119	Vehicle maintenance and service facilities.	Based on unit cost of prefabricated buildings constructed at AMR.

Manned Spacecraft Center

Page No. (vol. IV., pt. 2)	Project	Basis of cost estimates
CF8-6-7-8	Additions to the Mission Control Center.	Only cost of equipment is included in this project. Estimate derived from preliminary bids based on equipment specifications developed for this facility.
CF8-11	Atmospheric reentry materials and structures evaluation facility.	Major cost is for equipment. Estimate is based on manufacturer's list prices.
CF8-18-19	Center support facilities	Estimate based on previous experience with the same type of facility now under construction at MSC.
CF8-26-27	Launch environment and antenna test facility.	Basic estimate for this facility was derived from standards developed by DOD. Estimate was modified to reflect the following special features: 1. 120-foot-high structure which requires pilings for the foundation. 2. Special electrical power for the equipment. 3. Precise humidity control. 4. Large air-conditioning requirements. 5. Special acoustic treatment for sound control. 6. Vibration control design features.
CF8-31	Mission simulation and training facility.	Basic estimate was derived from standards developed by DOD. Estimate was modified to reflect the following special features: 1. 60 feet of clear ceiling height. 2. Special heating, electrical, air-conditioning requirements.
CF8-32-35	Project engineering facility	Estimate based on experience with the project management office building now under construction at MSC.

Manned Spacecraft Center—Continued

Page No. (vol. IV, pt. 2)	Project	Basis of cost estimates
CF8-40-41	Spacecraft Control Technology Laboratory.	Basic estimate was derived from standards developed by DOD. Estimate was modified to reflect the following special features: 1. 45 feet and 30 feet ceiling height requirements. 2. Temperature, humidity, noise, and vibration control design features.
CF8-44	Ultra-high-vacuum space chamber facility.	Basic estimate was derived from standards developed by DOD. Estimate was modified to reflect the following special features: 1. Semiclean (sterile-type facility) design with special requirements such as positive pressure system and dust control. 2. 60 feet clear ceiling height.

Marshall Space Flight Center

Page No. (vol. IV., pt. 2)	Project	Basis of cost estimate
CF9-5	Acceleration test and calibration facility.	Estimate was based on completed design criteria and reflected experience on similar type facilities previously constructed at MSFC.
CF9-11	Acoustic model test facility	Estimate was based on costs for similar type structures erected at MSFC and other installations throughout the country. These costs were adjusted to reflect changes in the Construction Cost Index and local conditions in the Huntsville area.
CF9-14	Additions to the components test facility.	Estimate for this addition was based on costs of the previously constructed basic facility with adjustments made for unique requirements of the addition and also to reflect changes in the index.
CF9-15-17	Addition to test support shop.	Estimate for this addition was based on costs of the previously constructed basic facility with adjustments made for unique requirements of the addition and also to reflect changes in the index.
CF9-20	Barge dock and loading facilities.	Estimate was developed by the Corps of Engineers representative based on previous extensive experience for similar type facilities in the general geographic area of the Mobile district.
CF9-23	Expansion and modernization of the high-pressure gas and propellant systems.	Based on costs of construction of existing systems at the Huntsville installation with adjustments to reflect the current index.
CF9-26	Expansion of computation facilities.	The estimated costs of this addition were based on the actual construction costs of the basic facility with adjustments made to reflect the unique requirements of the addition and changes in the current index.
CF9-27	Extension to load test annex.	The estimate was based on the bid prices and the actual cost of completed construction of the base building which was underway at the time the estimate was prepared. There is a direct correlation between the basic building and the proposed extension.
CF9-34	Extension to the Propulsion and Vehicle Engineering Laboratory.	The actual construction costs of the basic building were adjusted to reflect the unique requirements of the extension and adjustments to correlate current index costs.

Michoud plant

Page No. (vol. IV., pt. 2)	Project	Basis of cost estimate
CF10-13-14	Additions to production facilities.	Based on experience with similar type of work at MSFC. Equipment cost estimates are based on current manufacturer's list prices.
CF10-17	Parking and security improvements.	Based on experience with similar work at this location.
CF10-18-20	Road and airstrip rehabilitation.	Estimate based on experience of other Government agencies and adjusted to conditions in the New Orleans area.
CF10-23	Vehicle component supply building.	Based on experience with similar construction in the New Orleans area. Criteria and standards available from DOD were adjusted for local conditions in estimating this construction.

Mississippi Test Facility

Page No. (vol. IV., pt. 2)	Project	Basis of cost estimates
CF11-10 to 13	Advance Saturn first-stage (S-IC) static test facilities.	Completed design criteria servied as the basis of the architect-engineer cost estimates. The Corps of Engineers assisted in developing budgetary estimates based on their experience with similar type facilities.
CF11-19 to 21	Saturn V second-stage (S-II) static test facilities.	1. Completed design criteria served as the basis of the construction and equipment cost estimates prepared by the architect-engineer firm of Sverdrup and Parcel. 2. The Corps of Engineers assisted in developing budgetary estimates based on their experience with similar-type facilities. 3. The NASA engineers coordinated the overall development of the estimates and contributed estimates, based on their own experience with similar-type facilities.
CF11-24	Bridge for U.S. Interstate Highway No. 10.	Based on cost estimates prepared by the Bureau of Public Roads.
CF11-26-27	Control center and data acquisition and handling facilities.	Estimate developed on the basis of somewhat similar facilities at LOC and MSFC and refined to meet unique requirements reflected in completed design criteria.
CF11-29	Electronics, Instrumentation, and Materials Laboratory.	Construction and equipment cost estimates prepared by architect-engineer based on completed design criteria.
CF11-35-36	F-1 engine systems test stand.	Estimates based upon the construction of a similar stand at Huntsville, Ala.; these plans were adjusted to suit the conditions at Mississippi test facility and to reflect current construction costs in the region.
CF11-42-43	Maintenance facilities	Based on experience with similar-type facilities at MSFC and LOC and adjusted to reflect requirements contained in the completed design criteria.
CF11-46	Navigation lock	Completed design criteria served as the basis of the architect-engineer cost estimates. The Corps of Engineers assisted in developing budgetary estimates based on their extensive experience with similar-type facilities.
CF11-50-51	Security control facilities	Based on similar construction at other NASA locations and on completed design criteria.
CF11-55-56	Sonic measuring facilities	Construction and equipment cost estimates prepared by A-E based on completed design criteria.
CF11-59-60	Transportation and parking facilities.	Based on similar construction at other NASA locations and on completed design criteria.
CF11-66 to 68	Utility additions and extensions.	Based on similar construction at LOC and MSFC.
CF11-73	Warehouse additions and storage facilities.	Warehouse additions and storage facilities based on similar construction at LOC and MSFC, and on completed design criteria.
CF11-78	Waterways and docking facilities.	Estimates were based on Corps of Engineers extensive experience with similar facilities and on completed design criteria.

Various locations

Page No. (vol. IV., pt. 2)	Project	Basis of cost estimates
CF13-8 to 11	Facilities for F-1 engine program.	Edwards test facilities: Estimated costs were based on bid experience for similar work under construction. Canoga Park and Santa Susana development and production facilities: Estimated costs for the manufacturing quality control and test equipment are based on vendors' catalog prices and quotations for equipment including installation costs.
CF13-12-13	Facilities for H-1 engine production.	Estimated cost is based on completed construction costs of similar facilities at MSFC Huntsville, Ala. These actual costs were adjusted to reflect the particular characteristics of this program and consideration was given to the current index.
CF13-20	Facilities for J-2 engine program.	Canoga Park development and production equipment: The estimated costs for the development, production and test equipment which made up the major portion of this facility are based on the purchase and installation costs for the equipment derived from vendors' catalog prices and quotations.
CF13-25-26	Facilities for M-1 engine program.	Construction estimates based on extrapolation of costs of comparable existing test facilities at Edwards AFB and Huntsville. These actual costs were adjusted to reflect the unique requirements of this facility and also to reflect the current Index.
CF12-27 to 29	Facilities for S-IVB stage program.	Estimated costs for machinery and equipment were based on Catalog listings and quotations from manufacturers for delivery and installation thereo
CF13-30-31	Improvements to the RL-10 A-3 engine test facility.	The estimated costs of the improvements for this facility at West Palm Beach were developed by the contractor, Pratt-Whitney, and reviewed by engineers from the Huntsville Center with prior experience in this type of work both at MSFC and AMR.
CF12-41-42	Lunar excursion module test facility.	Estimated costs based on: (*a*) Construction costs of similar facilities under construction at the White Sands location. (*b*) Blast protection construction. (*c*) Special air lock and dust free requirements. (*d*) Specialized mechanical filtering system. (*e*) Current Index costs.

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APPENDIX B

EXECUTIVE SESSION

STAFF CONFERENCE, MANNED SPACE FLIGHT PROGRAM—CONSTRUCTION OF FACILITIES

The conference met pursuant to notice, in room 214–B, Longworth Building, at 1:30 p.m., May 6, 1963.

Presiding: Lt. Col. Harold A. Gould, Technical Consultant, Committee on Science and Astronautics, U.S. House of Representatives.

Representing the National Aeronautics and Space Administration: William E. Lilly, Director, Program Review and Resources Management, Office of Manned Space Flight; Rodolfo A. Diaz, Assistant Director for facilities, Office of Program Review and Resources Management; S. M. Smolensky, Deputy Director Launch Vehicles and Propulsion, Office of Manned Space Flight; A. O. Tischler, Assistant Director for Propulsion, Office of Manned Space Flight; John R. Wilhelm, Launch Operations, Office of Manned Space Flight; G. A. D'Onofrio, Launch Operations, Office of Manned Space Flight; John A. Graham, Launch Operations, Office of Manned Space Flight; M. Joseph Simoes, Facilities Engineer, Office of Manned Space Flight; I. Jerry Hlass, Facilities Engineer, Office of Manned Space Flight; Harry Mitchel, Facilities Engineer, Office of Manned Space Flight; N. A. Crone, Launch Vehicle Facilities, Planning and Requirements, Manager; W. T. Ashley, Executive Assistant, Launch Vehicle and Propulsion, Office of Manned Space Flight; Captain J. K. Holcomb, U.S. Navy, Assistant Director for Launch Operations; Theodore S. Toppen, Chief, Launch Operations and Spacecraft Branch.

Colonel GOULD. In accordance with the instructions of the chairman, Subcommittee on Manned Space Flight, this conference is convened for the purpose of further discussions regarding the requirements for facilities in support of manned space flight as requested by NASA in the fiscal year 1964 authorization request.

MARSHALL SPACE FLIGHT CENTER

The legislative history of this Center indicates a total of $68,678,500 has been authorized in fiscal years 1962 and 1963.

Of this $68.7 million, which includes reprograming, how much has been obligated to date?

Mr. LILLY. Of the amount authorized in fiscal year 1962, obligations as of March 31 were $25,872,000.

Of the authorized program in fiscal year 1963, the obligations as of March 31 totaled $24,324,000.

Colonel GOULD. When will the balance be obligated?

Mr. DIAZ. It will be completed by September of this calendar year.

Colonel GOULD. What is the value of the existing plant at this site?

Mr. LILLY. Building and structures, $45 million. Equipment and instrumentation, $50 million. Total, $95 million.

Colonel GOULD. The NASA construction status report of February 28, 1963, indicates $325,000 in fiscal year 1963 advance design funds have been committed to a project known as "Grounds Support Equipment Test Facilities." To which fiscal year 1964 project does this relate?

Mr. DIAZ. That is a complete project in itself.

Colonel GOULD. Is it a 1964 item or is this a reprograming action?

Mr. DIAZ. It is a 1963 reprograming.

Colonel GOULD. What is the total amount of construction included in this facility?

Mr. DIAZ. The total project is $5,528,000.

Colonel GOULD. What is the scope of the work involved in this project?

Mr. DIAZ. This facility is required to develop and test swing arm elements which will be used in providing structural support and mobility for servicing

lines linking the Advance Saturn Vehicle (C–5) with appropriate ground support equipment during launch period. Each swing arm must be subjected to full-scale functional test at Marshall before shipment to the cape.

ACCELERATION TEST AND CALIBRATION FACILITY

Colonel GOULD. Where are the personnel to occupy the laboratory building now being housed?

Mr. SMOLENSKY. The people that are to occupy this are presently in various facilities on the center itself, in other buildings.

Colonel GOULD. Are any of these personnel in leased space off the site?

Mr. DIAZ. Not the people who will occupy this facility.

Colonel GOULD. The justification states that the capability does not exist for some types of environmental tests. What types of environmental tests are we talking about?

Mr. CRONE. Zeroing capability does not exist here or in any of the other places. The ultra-linear acceleration capability does not exist anywhere in the country that we are after.

Colonel GOULD. It is noted that the laboratory building will cost $35.33 per square foot, and the linear accelerator tower cost $45.20 a square foot. What structural characteristics causes the cost of these buildings to be so high?

Mr. DIAZ. In the building we require special electrical power, cranes, heating, ventilating and air conditioning to support severe environmental conditioning.

The basic structure itself runs about $17 per square foot, and is based on the going price of similar projects in Marshall Center.

Colonel GOULD. The justification states that environmental test equipment will be relocated. When this occurs, will this vacate existing space that can be used for other purposes?

Mr. CRONE. The answer is very small areas will be vacated from various spots. It will be a relocation and reassignment facility.

THE ACOUSTIC MODEL TEST FACILITY

Colonel GOULD. Why can't other model test facilities at Marshall be modified or expanded to meet this requirement, rather than build a new facility?

Mr. CRONE. The location for the acoustic test facility was selected because of the freedom from reflected sound waves that interfere with our instrumented data.

There is no facility currently being used that does not have these reflection problems.

Mr. DIAZ. You will also have a problem here of doing hot firings. These tests cannot be done in existing facilities without major modifications.

Mr. CRONE. Yes.

THE ADDITIONS TO THE COMPONENTS TEST FACILITY

Colonel GOULD. Those projects which have been previously authorized in fiscal years 1962 and 1963 in the amount of $6 million, have all of the funds previously authorized been obligated for this project?

Mr. DIAZ. Yes.

Colonel GOULD. Has the construction been started?

Mr. DIAZ. Most of the construction has started.

Colonel GOULD. What are the scheduled completion dates?

Mr. DIAZ. The status of completion for the fiscal year 1962 and fiscal year 1963 increments are:

Support facilities, complete; turbopump test stand to be completed January 1964; test position and control center modifications, under design; construction to be completed November 1964; instrumentation controls, under design; to be completed November 1964.

Colonel GOULD. Has the design for these additions been initiated?

Mr. LILLY. The criteria has been developed. We have identified a requirement of approximately $200,000 to start design in this fiscal year. It has not been started at this point in time.

Colonel GOULD. Is this another project where the possibility exists that you may start design from fiscal year 1963 funds, if you can find sufficient money?

Mr. LILLY. That is correct.

Colonel GOULD. I notice that you have $450,000 included for design and engineering services. Could you tell me what the basis for this estimate is, please?

Mr. LILLY. The design and engineering services cost is approximately 11½ percent of the total cost to the project. Although the facility construction and modification portion of the project is a relatively small amount, design and engineering is required on the equipment, instrumentation and the support systems.

Colonel GOULD. So that the basis for the design engineering service is predicated on the total costs involved in items (b), (c), and (d) of this project? Is this correct?

Mr. LILLY. That is correct.

Colonel GOULD. The reason that it comes out to $450,000 is because of the $2.5 million requirement in equipment and instrumentation and support systems, all of which has to be designed?

Mr. LILLY. All of which either has to be designed or incorporated into the design of a complete system.

ADDITION TO THE TEST SUPPORT SHOP

Colonel GOULD. The justification indicates that an increase in work capacity is required. Why is this necessary, please?

Mr. SMOLENSKY. Is this the test support shop?

Colonel GOULD. Yes.

Mr. SMOLENSKY. This is for the S–IC ground test program. That is the increase that this is to be supporting and must support the west test area.

Colonel GOULD. I understand that, Mr. Smolensky, but do you have any figures to indicate the volume of testing that will occur that cannot be accommodated in the existing facilities and therefore requires an addition to the support shop?

Mr. CRONE. The total test work growth that is coming up now and will at this time when this facility is ready, approximately 70 percent of the total will be new. Some of the old work will be no longer needed, but the remaining amount added to the new increase will just about absorb or will absorb the full size of this plant with this addition.

This is difficult to tell you in numbers other than maybe 70 percent of the total will be all new.

Mr. SMOLENSKY. The existing shop facilities are fully utilized now. We need the addition to support the new work.

Colonel GOULD. Are you saying there will be a 70-percent increase in testing requirements that necessitates this addition to the shop?

Mr. CRONE. No, because that means then—I am reading it backward. Let me see if I can rephrase this.

There should be about 150 percent over what we are doing today, total. The resultant increase is about 50 percent.

Colonel GOULD. In other words, the rate of testing, the testing load will increase by 50 percent? This is what I was trying to get, is some term of measurement here.

Mr. CRONE. This is about it.

Colonel GOULD. Since this is an addition to an existing facility, the cost of utility connections appear to be rather high—$120,000—including $50,000 for utility connections. Would you explain the reason for this apparent high cost?

Mr. DIAZ. One of the main things, of course, is the relocation of roads and parking areas. There is also the distance from the proposed structure to the main utility systems.

Colonel GOULD. But you are just adding on an extension to an existing building. Won't the mains now serving the existing building satisfy the connected load that you anticipate in this new facility? Would you like to provide something for the record on that, please?

Mr. DIAZ. The existing electrical substation is being used to capacity and must be enlarged. Additional water must also be provided.

Colonel GOULD. To follow up on Mr. Fuqua's question; it is noted that the project includes $400,000 for machine tools, $100,000 for welding equipment, and another $100,000 for shop equipment. Since this is an addition to an existing shop, completely equipped with these tools at the present time, it would appear that further justification is required to substantiate the requirement for $600,000 for new shop equipment. Would you care to comment on that, please?

Mr. CRONE. The additional tools and equipment are to make the addition to this building usable. In other words, if a machine shop is to be expanded, I add more tools also, to do the increased workload.

Colonel GOULD. The reason I am asking this question is that I visited the test support shop not too long ago and they have a very elaborate machine shop in existence already.

Mr. CRONE. Correct.

Colonel GOULD. It would appear that you are just about doubling the capacity.

Mr. CRONE. Earlier when we mentioned the 50-percent increase, I would like to correct that right now—it is actually doubled. What I mean to say is the new area covers 50 percent of the load. It is doubling the capacity and we are doubling the capacity of this shop.

Colonel GOULD. So then the workload will increase by 100 percent instead of 50 percent.

Mr. CRONE. We expect it to.

Colonel GOULD. Therefore you need to double your shop capacity?

Mr. CRONE. Right.

Colonel GOULD. How many shifts do the crews work at the present time in this support activity?

Mr. SMOLENSKY. At the present time one shift is being used.

Colonel GOULD. I would like to ask you to supply it for the record, and at the same time supply an indication as to why a multiple-shift operation might not be employed to meet these schedules without the requirement for an added facility.

Mr. SMOLENSKY. Use of a multishift operation will not help since the existing structure does not meet the requirements imposed by the Saturn V. The structure does not have sufficient area, clear height or the equipment necessary to handle the larger elements of hardware.

Colonel GOULD. What is the actual date that this facility is needed to meet this 100-percent increase in test activities?

Mr. LILLY. Our current schedule for required operational date is December 1964.

Colonel GOULD. Does that coincide with the 100-percent increase in test activities?

Mr. LILLY. Yes, it does.

BARGE AND LOADING FACILITIES

Colonel GOULD. How much dredging is included in this project for an estimated cost of $41,200?

Mr. DIAZ. Approximately 50,000 cubic yards of dredging are included.

Colonel GOULD. Also, do you happen to know how much sheet piling is involved for $277,600?

Mr. DIAZ. Approximately 500 tons of sheet piling are involved.

Colonel GOULD. There is an indication that two docks are required to support the anticipated barge traffic. Do you have with you any indication of this volume in tons of goods shipped or numbers of barges per week or anything of that nature against which we can evaluate this project?

Mr. CRONE. The two dock piers are required to insure continuous utilization of the dock under all conditions of river stage (high or low water).

Anticipated Saturn booster traffic from 1963 to 1967 is as follows:

	Stages
Calendar year 1963	5
Calendar year 1964	8
Calendar year 1965	15
Calendar year 1966	13
Calendar year 1967	10

These stages vary in weight from approximately 70 to 200 tons each depending upon the vehicle being transported.

In addition, 15 to 20 trips annually will be required in transporting various items of equipment. Barge loadings for these trips will vary considerably up to a maximum of approximately 400 tons each.

EXPANSION AND MODERNIZATION OF THE HIGH-PRESSURE GAS AND PROPELLANT SYSTEMS

Colonel GOULD. Certain modifications have been accomplished during recent years to the existing system. How much has been spent for these modifications to date? I am taking this statement out of your justification.

Mr. DIAZ. Are you referring to this project?

Colonel GOULD. Expansion and modernization of the high-pressure gas system, yes.

Mr. LILLY. The statement to which you refer in our justification, Colonel Gould, that is that portions of these systems have been upgraded and modified in support of the Saturn program in previous years refers to a number of different projects and parts of projects. I would have to provide for you a consolidation of these amounts.

Colonel GOULD. Would you provide that for the record, please?

Mr. LILLY. Modifications accomplished during recent years include the provision of gaseous nitrogen (GN2) vaporizers, gaseous nitrogen (LN2) storage tanks, liquid oxygen storage tanks and associated piping. These modifications were provided by the Army (prior to being turned over to NASA) and subsequently by NASA. The cost was approximately three-quarters of a million dollars. The facilities were acquired in connection with the Redstone, Jupiter, and Saturn I programs.

Colonel GOULD. The justification indicates that existing facilities having their own storage and transfer systems are being serviced by mobile equipment at the present time. Why can't this procedure be continued in effect?

Mr. SMOLENSKY. The increased test schedule that we have projected here and the increased quantities of the propellants that are to be used make the present mobile facilities inadequate. In addition to that, we have the problem of upgrading the existing facilities to provide for the safe transfer of what we consider to be hazardous materials.

Colonel GOULD. You do consider the present system to be hazardous and inefficient; is this correct?

Mr. SMOLENSKY. Yes.

Colonel GOULD. We talk about increased demands placed upon the systems. Do we have any method of measurement that we could apply to this project? What are the increased demands and what are the present capacities?

Mr. SMOLENSKY. The increased demands that we are faced with is the forthcoming S–IC stage development program testing that will be reaching a peak, of course, this is our largest booster stage that will be coming into increased development and test schedules.

Colonel GOULD. But do we have any measure of the number of gallons of propellants or pounds of air or something that we can use to justify the requirement for an expansion to the system?

Mr. CRONE. The exact figures I do not have. It is a ratio of approximately 5 to 1 in many of the tests that we are now doing.

Colonel GOULD. Five to one?

Mr. CRONE. About 5 to 1.

Colonel GOULD. Could you provide without too many statistical gyrations, a comparison of the present capacity and demands versus the future capacity and demands?

Mr. SMOLENSKY. A comparison of present and future requirements is as follows:

Product	Present requirements	Estimated future requirements
Gaseous helium	3,000,000 square cubic feet per year	12,000,000 square cubic feet per year.
Gaseous nitrogen	1,500,000 square cubic feet per day	5,000,000 square cubic feet per day.
Liquid nitrogen	245,000,000 square cubic feet per year.	1,540,000,000 square cubic feet per year.
Liquid oxygen	300,000,000 square cubic feet per year.	1,000,000,000 square cubic feet per year.
Liquid hydrogen	110,000 pounds per year	350,000 pounds per year.
RP-1 fuel	345,000 gallons per year	1,000,000 gallons per year.

Facilities available are not adequate to meet present requirements. The requirements are being met in many instances by use of temporary tankage and "jerry-rig" installations.

Colonel GOULD. Since there are no sketches provided for the buildings to be constructed as part of this project, it is not clear as to the type of facilities that will be built. Could you define, please, the types of structures that will be erected to provide the addition to the air compressor building, the addition to the gaseous nitrogen and helium compressor building, and a propellant facility maintenance building?

Mr. DIAZ. The buildings will require heavy foundations, with clearance for moving large pieces of equipment in and out. The construction will be prefabricated metal.

Colonel GOULD. The cost of these facilities, since they are prefabricated structures, appears to be pretty high. The air compressor building is estimated at $20 a square foot as well as the gaseous nitrogen and helium building, and the propellant facility maintenance building is estimated at $25 per square foot.

Prefabricated-type structures usually run about $15 a square foot; that is, for a structural steel building with metal siding, which I assume these will be. Would you look into these individual cost estimates, please, and provide for the record a statement as to what makes the costs so high?

Mr. LILLY. The unit cost of these buildings is based on experience in construction of buildings of this type at Huntsville. It should be noted that estimated contingencies and overhead costs are included in the unit cost figures. The $25 per square foot cost of the propellant facility maintenance building includes an overhead crane, pressure checking equipment, a deionized water system and air conditioning which accounts for the higher unit cost of this facility.

Colonel GOULD. I notice that $130,000 is requested for clearing and grubbing for the three buildings. This area, the total area for the three buildings only totals 12,000 square feet and assuming normal clearance of 20 to 25 feet around the outside of these buildings, this also appears to be a very high cost. Do you have any reasons for this, please?

Mr. DIAZ. You are referring to clearing, grubbing, that we have shown for three buildings. This is an error. The figure refers to the complete project which is widely scattered over a large area. That is the reason for the high cost.

Colonel GOULD. That satisfies the requirement. I notice that you have asked for $400,000 for design and engineering services. I assume the majority of these design costs are going into equipment, since these buildings probably will require very little design.

Mr. LILLY. That is correct.

EXPANSION OF COMPUTATION FACILITIES

Colonel GOULD. Of the 42,000 square feet involved in this expansion, how much space is being designated for equipment and how much for personnel?

Mr. LILLY. The personnel space will accommodate approximately 90 people. Approximately 11,000 square feet will be provided for this purpose.

Colonel GOULD. How much space in the existing building is devoted to computer activities?

Mr. LILLY. Approximately 50 percent of the space or about 22,000 square feet is devoted to computer activities.

Colonel GOULD. To what extent is real time computation effected at this center?

Mr. SMOLENSKY. Our whole concept in developing the computation facilities here is to provide real time computation capabilities for this development center. With the increased amount of testing that we expect and the multitudes of tests that we expect, we have decided that we have a requirement and must have real computation capabilities at both Marshall and at our other centers to be able to react to the test program and to be able to effect appropriate modification of the test programs.

Colonel GOULD. Your objective then at Marshall at least is to develop a 100-percent capability for real time computation; is that correct?

Mr. SMOLENSKY. Yes.

Colonel GOULD. I note in the project that there is to be provided 8,250 square yards of additional parking. How much parking space was included in the original project for the computation center?

Mr. LILLY. The original computation center was built by the Army and was provided to NASA in the transfer agreement. This project provides for 6,250 square yards rather than 8,250. A total of 7,280 square yards had been provided with the original building. Approximately 8,500 square yards are being provided under fiscal year 1963 bringing the total to 21,830 square yards.

Colonel GOULD. What criteria were used in developing the requirement for additional parking?

Mr. LILLY. The ratio that was used is the same as we have used in the other projects at Marshall which is approximately 1 to 2.

Colonel GOULD. One parking space for every two persons assigned?

Mr. LILLY. That is correct.

Colonel GOULD. Do not personnel at the Marshall Center participate in car pools?

Mr. LILLY. I am certain that many of them do participate in car pools. However, the extent of car pooling has been taken into consideration in the development of this ratio and this requirement.

Colonel GOULD. Is there adequate public transportation available to service this center?

Mr. DIAZ. No, sir, there is not.

Colonel GOULD. Have your requirements been made known to the local transportation company in the city of Huntsville?

Mr. LILLY. Yes. Requirements have been made known to local transportation companies. However a plan to use public transportation companies appears economically unsound from the standpoint of diversification in locations of people employed at the arsenal and from the standpoint of load peaks. Transportation would be heavy during peak hours and equipment comparatively idle during the balance of the working day.

Colonel GOULD. But you state that the availability of public transportation is inadequate to meet your needs?

Mr. LILLY. That is correct.

EXTENSION TO LOAD TEST ANNEX

Colonel GOULD. Are there any facilities available at other NASA installations or at any Department of Defense installation that could be used to meet this need? I am referring specifically to the heavy-duty universal testing machines.

Mr. SMOLENSKY. To our knowledge there are no existing facilities that fit our requirements for the testing, the structural testing of these large vehicles.

Colonel GOULD. The reason I ask this question is that I have been informed that the Titan components were tested at the U.S. Naval Air Materiel Command at Philadelphia, Pa., where a 5-million-pound universal testing machine exists.

The Air Force seemed to be satisfied with the results of component testing at this site. My question is, why couldn't the Naval Air Materiel Command facilities be used to meet your needs also?

Mr. SMOLENSKY. We have found in projecting our schedule tests here that it would be uneconomical and inefficient to be transferring these components during a very critical test period to different localities for specific tests.

Colonel GOULD. Has any study of the economics of such a procedure been made within NASA?

Mr. SMOLENSKY. We have made this type of study on other projects. I would assume that in this case the Center has, too.

Colonel GOULD. Are there no commercial facilities that could meet this need in the vicinity of Marshall?

Mr. SMOLENSKY. There are none, sir.

Colonel GOULD. I notice that the cost of the 2-million-pound universal hydraulic testing machine is estimated at $500,000. Is this purely an estimate on your part or do you have some figures to substantiate this estimate?

Mr. DIAZ. Colonel Gould, this figure was based on actual preliminary quotes from manufacturers.

Colonel GOULD. You do have a quote from a manufacturer?

Mr. DIAZ. Yes, sir.

Mr. LILLY. A preliminary estimate was obtained from the Baldwin Co. on a machine of this capacity. Its estimated cost was $500,000 to $600,000 at that time. No other quotations have been obtained from the potential manufacturers.

Colonel GOULD. Since this extension is immediately adjacent to the existing test load facilities, why are the utilities extensions in the amount of $47,000 so high?

Mr. DIAZ. The fiscal year 1962 project did not provide extensions of utilities to the area of proposed facility. Although connections points are near, there is a requirement to tie into and extend utilities within the limits of the project. Further unforeseen increased demands have necessitated larger sizing of the utilities ties.

Colonel GOULD. Could you explain the relationship between the load ballast system for $360,000 and the two testing machines, please?

Mr. CRONE. The load ballast system will be used consisting of lead shot which will distribute itself when loaded inside of a section of a tank for testing the inflight G loadings that will be experienced near cutoff, which seems to be the critical point.

Colonel GOULD. What does the special power supply which is categorized as "elevated temperature testing" consist of, please?

Mr. DIAZ. The $70,000 line item involves the relocation of a 3,000-kilovolt-ampere transformer and associated controls and equipment to power an infrared heating facility used to simulate aerodynamic and solar heating conditions. Structures are load tested under heat conditions.

Colonel GOULD. The reason I am concerned is that we are talking about relocation of special power supply. However, the justification does not state what type of power supply this is. Is this a generator or transformer block, or what type of method are you going to use, and specifically what does it do?

What is the basis of your $365,000 estimate for design and engineering? The reason I ask this question is that it would appear that a great deal of the equipment will be purchased which will probably need no design, and consequently the $365,000 is predicated only on the construction part of this project which works out to about 23 percent. Can you comment on that, please?

Mr. LILLY. The $365,000 estimated for design and engineering is for more than the facility construction and modification. It also provides for design and engineering required on the load ballast system, the high force, low-frequency vibration systems, and the signal circuits and digital data acquisition systems.

The total design required is estimated at less than 10 percent of the total project.

Colonel GOULD. That is for design, supervision, and inspection, or just design?

Mr. LILLY. Design, supervision, inspection and engineering required.

Colonel GOULD. The building is estimated at $31.90 per square foot. I imagine this high cost is attributable to heavy-duty foundations; is that correct?

Mr. DIAZ. That is correct.

EXTENSION TO THE PROPULSION AND VEHICLE ENGINEERING LABORATORY

Colonel GOULD. The project description mentions a cafeteria and the sketch indicates a lunchroom. Which is it, a cafeteria or lunchroom?

Mr. DIAZ. It is a cafeteria.

Colonel GOULD. In other words, it will be completely equipped with kitchen and serving equipment; is that correct?

Mr. LILLY. That is correct.

Colonel GOULD. What is the size and the cost of the cafeteria?

Mr. LILLY. The cafeteria is 7,000 square feet.

Colonel GOULD. And the cost?

Mr. LILLY. Using the same factor of $21 a square foot, the cost of the cafeteria would be approximately $250,000.

Colonel GOULD. Then the size of the cafeteria and the cost of the cafeteria is included in the 70,000 square feet you show for the building proper?

Mr. LILLY. That is correct.

Colonel GOULD. Despite the fact that it is a separate building?

What is the penthouse required for on this building?

Mr. DIAZ. The penthouse is required to house the mechanical equipment to be used in connection with this building.

Colonel GOULD. By "mechanical equipment" I assume you mean the cooling towers for the air-conditioning system?

Mr. DIAZ. That is right.

Colonel GOULD. Going back to the cafeteria again, how much cafeteria capacity exists at the present time at this Center?

Mr. DIAZ. Through July 1963, we will have 5 cafeterias, with a total serving capacity of 740 spaces. To July 1964 we will have 8 cafeterias with a seating capacity of 1,260. By July 1965 we will end up with 9 cafeterias with a total seating capacity of 1,700, which will serve approximately 8,600 people. That is in the entire complex.

Colonel GOULD. This is by the end of——

Mr. DIAZ. July 1965.

Colonel GOULD. Fiscal year 1964, is that correct?

Mr. DIAZ. That is right.

Colonel GOULD. What criteria did you use in arriving at the seating capacity for the cafeteria?

Mr. DIAZ. We use a criteria of feeding period of 2 hours with a turnover two and a half times per hour.

Colonel GOULD. A turnover of two and a half times per hour?

Mr. DIAZ. That is correct.

Colonel GOULD. So that would be a turnover rate of five for the 2-hour period?

Mr. DIAZ. Right.

Colonel GOULD. You state that you are going to buy cafeteria equipment in the amount of $80,000, which seems a little reasonable as compared to other cafeterias included in the program. Could you give me the basis for this estimate, please?

Mr. DIAZ. We will use existing equipment to furnish a part of this cafeteria.

Colonel GOULD. Does this mean you are going to close down an existing cafeteria?

Mr. DIAZ. We will close down one existing cafeteria; yes, sir.

Colonel GOULD. But you will still be providing a total of 8 cafeterias with a capacity of 8,600 persons by the end of fiscal year 1964?

Mr. DIAZ. With a capacity of 1,700 to support 8,600.

Colonel GOULD. The justification for this facility indicates an R. & D. mission for launch and space vehicles. To what extent is Marshall involved in research on space vehicles?

Mr. SMOLENSKY. The Marshall Space Flight Center is responsible for the research and the development and the technical management of the launch vehicle programs that come under its mission. It has a very extensive research mission and capability. This project is aimed at extending its laboratory capabilities in support of the present programs being developed.

Colonel GOULD. Is this extension primarily for work in the research area, or is it both for research and development activities?

Mr. SMOLENSKY. It is mostly for development, but it is for both applications, research and development.

Colonel GOULD. Is this a duplication of a like capability being developed at Houston?

Mr. SMOLENSKY. No, sir.

Colonel GOULD. The justification indicates that you are presently occupying leased space for the personnel that will occupy the extension to this facility at some subsequent date. What is the annual leasing cost, and will the lease space be released when this addition is completed?

Mr. DIAZ. The lease space amounts to 264,000 square feet, at a cost of $755,200 a year.

Colonel GOULD. This is the total space now being leased to meet all requirements at Marshall; is that correct?

Mr. SMOLENSKY. Yes, sir. However, no leased space will be released as a result of the construction of this facility.

Colonel GOULD. In other words, even after we build this extension you will release no leased space for this facility?

Mr. SMOLENSKY. That is correct.

Colonel GOULD. Why is that?

Mr. MITCHELL. Our total requirement for space, administrative space, that is, will not have been satisfied through the fiscal year 1964 program. We are contemplating additional projects in future programs primarily through the 1965 program which will at that time enable us to give up much of our leased space.

Colonel GOULD. You are telling us there will be no leased space released as a result of any project in the fiscal year 1964 program?

Mr. DIAZ. Yes, sir.

Colonel GOULD. Since this addition is immediately adjacent to the existing facility, can you give further justification for the $90,000 requested to extend utilities?

Mr. LILLY. No provision was made in the fiscal year 1961 project for extension of utilities to the area of the proposed project. A requirement therefore exists for tying in and extending necessary utilities to service the fiscal year 1964 projects.

A forced main sewer is needed to service the facility and necessary pumping equipment must be provided for this purpose.

HANGAR FOR VEHICLE COMPONENTS

Colonel GOULD. The fiscal year 1963 components and subassembly acceptance building was authorized at an estimated cost of $950,000. Has this facility been completed?

Mr. LILLY. That project has not been completed.

Colonel GOULD. What will the fiscal year 1963 item be used for?

Mr. CRONE. The 1963 item will be used to receive most of the components coming in for the S–IC stage and other S–IB work that is being done there. This was to bring together a central receiving point for all of these components. Today we have no such place. It was designed at that time to cover a good number of the larger components. The new facility in 1964 goes into much larger components, and actually houses a completely assembled stage.

Colonel GOULD. You say will house a completely assembled stage?

Mr. CRONE. That is right.

Colonel GOULD. I thought that the completely assembled stages were going to be housed in your test shop?

Mr. CRONE. Sir, the test shop is for the assembly of a stage. We will have five ground test vehicles on the base; we will have the dynamic test vehicle, which is one which will be serviced, tested and used in the dynamic test facilities; the static firing vehicle will also be serviced here. We will have to refurbish those vehicles arriving from Michoud before and after testing.

One high bay area will take care of the assembly portion—I believe it is building 4705—and this will house the major large components such as tail assemblies, et cetera, while they are awaiting assembly, and will house the extra portions of these ground test vehicles.

Colonel GOULD. Of all of the facilities that are being built and proposed to be built, how many completely assembled vehicles could you accommodate at any one time?

Mr. RAFEL. There will be five of the S–IC stages that we can envision being at one time in a fully assembled condition. In addition to this, there will be the S–II stage and S–IVB, an instrument unit for the dynamics vehicle, which will all be there at the same time.

Colonel GOULD. So you have a capacity in existing buildings of accommodating five vehicles at one time, is that correct?

Mr. RAFEL. This is not five of the complete vehicle components. It is the S–IC stages only. We will not have five complete vehicles at one time.

Colonel GOULD. This facility, including the cost of bridge cranes, was estimated at $25 per square foot. I am referring here now to the fiscal 1963 item. The fiscal year 1964 hangar is estimated at $33.20 per square foot, excluding bridge cranes.

Could you please explain the difference in these costs?

Mr. LILLY. The fiscal year 1963 project, "Components and subassembly acceptance building," cost at $25 per square foot, was based on an average price for a high bay area (10,000 square feet) and an office and low bay area (10,000 square feet). The fiscal year 1964 hangar for vehicle components project provides for a high bay area throughout with a hook height clearance of 70 feet. On a cubic foot basis the unit costs of the two buildings are approximately the same.

Colonel GOULD. Has the design been started on this proposed hangar yet?

Mr. LILLY. No; it has not.

Colonel GOULD. What are the construction and design leadtimes, please?

Mr. LILLY. The design leadtime is approximately 4 months, construction leadtime approximately 13 months.

Colonel GOULD. When do you anticipate design will be initiated?

Mr. LILLY. This project falls into the same category as the others that we have discussed. We have identified a requirement to start design on this facility in the amount of approximately $150,000, and will be undertaken in this fiscal year if the funds can be identified for the project.

HAZARDOUS OPERATIONS LABORATORY

Colonel GOULD. How is this requirement being met now?

Mr. CRONE. The requirement has not reached its peak at this time. We are doing some of this testing under hazardous conditions, unsafe conditions, and

the major purpose here is to meet the increased workload and to solve the hazard problem.

Colonel GOULD. The reason I ask this question is because most of the equipment required for this facility is already available at the Center and apparently in use. Why can't the present facilities be continued in use?

Mr. CRONE. Proximity to inhabited areas where other work is going on, which has to be vacated when we do this. It is a result of a safety survey.

MODERNIZATION OF INSTRUMENTATION AND CONTROL SYSTEMS IN THE EASTERN AREA

Colonel GOULD. When was the present equipment installed?

Mr. LILLY. The present equipment was installed 1956–57 and in 1958. The cost of the in-place requirement is approximately $3.5 million. Practically all of this equipment will be modernized or replaced. Approximately 60 percent of the displaced equipment will be utilized on less critical projects at the center. The balance will be salvaged.

When we speak of "inherent delays" in the evaluation of test runs, occasioned by the necessity of manual readings, how much delay are we actually talking about, Mr. Smolensky?

Mr. SMOLENSKY. The present manual readout of data requires in many cases weeks of evaluation to properly determine what our test results are and be able to incorporate them into new designs.

With the increased workload and the test load that we have, and the necessity of speedy and accelerated analysis of data and feedback into the development program, it necessitates the updating and automatic data analysis equipment to support our test programs.

Colonel GOULD. The weeks of work now experienced in readouts by the manual method will then be reduced to what period of time, with automated equipment?

Mr. SMOLENSKY. Hours, possibly days at the most.

Colonel GOULD. The present instrumentation, could it be continued in effect without seriously jeopardizing the Advanced Saturn program?

Mr SMOLENSKY. No, sir.

MODIFICATIONS TO THE VEHICLE ASSEMBLY BUILDING

Colonel GOULD. You state that the static testing of vehicles from the Michoud plant will be effected at Marshall. Please define the extent of testing of vehicles from Michoud to be done at Marshall and what will be accomplished at MTF.

Mr. RAFEL. The static testing of the S–IC stages will be accomplished up through vehicle 502 of the Saturn V. All subsequent stages will be static tested at the Mississippi Test Facility.

Colonel GOULD. When you say "vehicle 502," what do you mean?

Mr. RAFEL. This is the second flight vehicle.

Colonel GOULD. You speak of the "next generation of vehicles" in the justification. Are we far enough along in our studies to know what the configuration of the next generation of vehicles will be beyond the Advanced Saturn, and are we relatively certain that the large diameters planned for the Advanced Saturn will prevail in the future booster vehicles?

Mr. SMOLENSKY. Studies to date indicate that the first stage of future vehicles may well be larger than that of the Advanced Saturn, unless a major breakthrough occurs for propulsion systems. However, this building may readily accommodate upper stages of such a vehicle.

Colonel GOULD. On page CF 9–48, a requirement for early approval of this project is indicated.

What time frame are we talking about?

Mr. LILLY. The planned operational requirement date for this facility is October 1964.

Colonel GOULD. Have advanced design funds been committed or earmarked for this project?

Mr. LILLY. We have identified a requirement for approximately $86,000 to start design in this fiscal year. If we locate the funds for this requirement, the design will be started.

Colonel GOULD. In view of the limited number of Advance Saturn vehicles to be manufactured at Marshall—four, I believe—could existing facilities be used in lieu of this modification if a certain amount of inconvenience were accepted?

Mr. CRONE. The head clearance in the existing building for assembly of this vehicle S–IC stage, is not adequate to allow a crane to pass over the vehicle.

This means that we have hazardous operations in lifting and assembling and lining these tanks to this stage. There is no other place on the station where this can be done at the present time.

Colonel GOULD. Instead of raising the elevation of this building, would it not be possible to modify the carrier or the carriage that is used to wheel the vehicle in on tracks?

Mr. RAFEL. The carriage which is proposed for the S–IC will provide a minimum ground clearance. There is no way to lower it.

Colonel GOULD. Not even by lowering the trackage?

Mr. RAFEL. I can't see how you could lower anything and still be able to maintain an adequate—I think that they are planning something of about 6 inches to 1 foot clearance between the bottom of the stage and the ground.

Colonel GOULD. Again, back to the cost per square foot of raising the roof on this building, it might be that more economical modifications could be made.

Mr. LILLY. As we indicated to you the other day, Colonel Gould, this problem is under study and you will so be notified as to the results.

Colonel GOULD. How much pavement is going to be placed for $23,600, and how many motor vehicle parking spaces will be provided?

Mr. DIAZ. The parking area, as shown in this case, is access roads around the structure and a parking area for the vehicle itself. It is not automobile parking, as such.

PROJECT ENGINEER OFFICE

Colonel GOULD. The project description states that the design of this facility will be adapted from the design of the fiscal year 1963 facility.

How much of the $160,000 requested for design and engineering services is for site adaptation?

Mr. LILLY. Although the project description states that design of this facility will be adapted from the design of the fiscal year 1963 facility, design will not be an adaptation in the strict sense since the layout of the proposed project includes the layout and design of a cafeteria. It is estimated that approximately $70,000 of the $160,000 requested for design and engineering services will be required for design of this project.

Colonel GOULD. This is a very favorable estimate and I wanted to bring into the record that wherever possible NASA is trying to use existing design that they have, to lower the cost of engineering.

Mr. LILLY. That is correct.

Colonel GOULD. I note that this project also includes a 300-seat cafeteria.

What provisions for cafeteria service are being made to accommodate the 850 personnel that will occupy the engineering and administrative building which is now under construction?

Mr. DIAZ. That is part of the complete study that I mentioned a while ago.

Mr. LILLY. As you are aware, Colonel Gould, in our description of the project in 1963, we did not include provision at that time for a cafeteria.

Upon definitization of criteria and design, it was determined that a cafeteria was required in it, and was provided in the final design for the building.

This building will be equipped with a snack bar and small serving counter to be served from the central cafeteria. It will primarily serve the light lunch group and lunch carriers, and thus relieve the load on existing facilities.

Colonel GOULD. Would you provide also the size and capacity of the cafeteria being incorporated into the fiscal year 1963 item?

Mr. LILLY. Yes; we will.

(The information, when submitted, may be found in the committee files.)

Colonel GOULD. This project includes parking spaces for 400 vehicles. The fiscal year 1963 project also included parking facilities to accommodate an unknown number of vehicles.

How many vehicles will the combined parking lots accommodate, sir?

Mr. LILLY. The fiscal year 1963 engineering and administration building will include a 400-vehicle parking lot for a total population of 850 persons.

The fiscal year 1964 project engineer office will include a 400-vehicle parking lot for a total population of 700 people.

Thus the combined total will provide parking facilities for 800 cars to accommodate a total population of 1,550 persons.

Colonel GOULD. You indicated before that no leased space will be released as a result of any of the 1964 items.

I note in the justification for this project that leased space is now being used to meet the needs that will be provided as a result of this project.

Is this another instance where you will not release any leased space?

Mr. LILLY. Our present plans do not allow us to release any total lease space in fiscal year 1964, or as a result of fiscal year 1964 building programs.

However, there will be a realinement of personnel assigned to the leased space.

Colonel GOULD. I notice that you are only asking for $100,000 for office and cafeteria furniture.

There is no provision being made in this estimate for cafeteria equipment of any great magnitude.

Are you planning to relocate existing kitchen equipment into this facility, and what is the breakdown of the $100,000 between office and cafeteria furniture?

Mr. DIAZ. The breakdown on that $100,000 is for the cafeteria, such things as tables and chairs, is $35,000. The balance of $65,000 is office equipment for the building.

Colonel GOULD. Do not the personnel that are going to occupy this building already have office furniture?

Mr. DIAZ. The office equipment that we are talking about, Colonel Gould, is such things as conference room equipment and special purpose type of office equipment.

Colonel GOULD. Such as what?

Mr. DIAZ. Conference tables, lobby furniture and this type of thing, and a certain amount of desks and chairs.

Colonel GOULD. Is this new engineer office going to provide another foyer or lobby similar to the one that is going into the building now under construction?

Mr. DIAZ. Not as such, no, sir.

Colonel GOULD. You just mentioned lobby equipment. I was wondering whether another lobby was going to be provided similar to the fiscal year 1963 project.

Mr. LILLY. There will be a small reception area, Colonel Gould, that will in no way compare to the lobby which is being provided in the central office building.

Colonel GOULD. Would the deferral of this project for one year cause the Advanced Saturn program to slip?

Mr. SMOLENSKY. Yes, sir. The answer to your question, Colonel Gould, is "Yes," it would cause a slippage in that we would not be able to have timely and on schedule operation of all of the engineering personnel involved in this development effort. It would be difficult to estimate days, but it is obvious that if they couldn't work at their top efficiency, there would very definitely be delays in the program.

SUPPORT OPERATIONS BUILDING

Colonel GOULD. What is being used now to meet this need?

Mr. CRONE. The answer, Colonel, is that most of this work has not yet begun regarding the Saturn S–IC stage.

The small amount that is underway is not fully turned over to contractors yet.

Colonel GOULD. The justification indicates that 80 contractor personnel to support Government operations are necessary in fiscal year 1963 and that this requirement will increase in fiscal year 1964.

Now, you tell me that the contractors are not fully entrenched at the present time in this mission, is this correct?

Mr. CRONE. That is correct.

Colonel GOULD. Fiscal year 1963 is going to expire in just 60 days.

Mr. CRONE. The 80 personnel approximately, are on board.

Colonel GOULD. How much of an increase is anticipated in the contractor personnel between fiscal year 1963 and 1964? The reason I ask this, you say in your justification that the requirement for contractor personnel will increase in 1964.

Mr. SMOLENSKY. The number of contractor personnel planned for fiscal year 1964 is approximately 200, representing an increase of about 120 over fiscal year 1963 figures.

Colonel GOULD. What is the nature of the work that these contractors will perform?

Mr. CRONE. The contractors will be operating the S–IC testing in conjunction with Marshall. They will be operating the S–I stand, the Chrysler Corp., in acceptance testing of the S–I stages at Marshall. They will be participating in considerably varied other tests that will be conducted there.

Colonel GOULD. How many different contracting firms are involved in this activity-required facility?

Mr. CRONE. I can list the two major, which I just did, Boeing and Chrysler. There will be others. I cannot give you a total or how many.

Colonel GOULD. The description indicates that shop space is required for the maintenance of mobile equipment. Is this equipment Government or contractor owned?

Mr. CRONE. This is Government-owned equipment.

Colonel GOULD. On mobile equipment, has the possibility of a cross-servicing agreement with the Army been considered? As I understand it, the Army has a considerable amount of shop space available at Redstone. Have they been queried as to availability of shop space to meet this need?

Mr. SMOLENSKY. Maintenance and servicing of mobile equipment, as planned for the support operations building involves such things as maintenance and repair of high pressure bottles, instrumentation of mobile GSE, and so forth. This is not an automotive shop.

This type of support is not available within the Army shop capability.

Mr. LILLY. This requirement was discussed with the Army prior to the preparation of this project.

UTILITY INSTALLATIONS

Colonel GOULD. $420,000 was authorized in fiscal year 1962 for the extension of primary utilities. In fiscal year 1963, another $2,517,000 was authorized for utility extensions at this site.

What was accomplished with the $3 million previously authorized at Marshall?

Mr. LILLY. Items provided in fiscal year 1962 and fiscal year 1963 for utilities projects are as follows:

(*a*) 10,000 kilovolt-ampere substation and 4,160-volt transmission lines for additional electrical demands in the vehicle assembly and quality inspection areas	$200,000
(*b*) Secondary roads for the increased traffic at MSFC	180,000
(*c*) Additional potable water filter capacity at water treatment plant 3 to meet increased demands	133,000
(*d*) Additional steam lines in the western part of MSFC to support new facilities and increased loads	204,000
(*e*) Construction of Saturn V Road for movement of the Saturn V through from fabrication and assembly areas, test areas, and to the dock at the Tennessee River. This road is 60 feet wide for component transporter and 48 feet wide over the remaining length of 7.5 miles	1,700,000
(*f*) New sewerline and force main pumping station	15,000
(*g*) Additional secondary substation capacity to provide for new electrical demands in new and modified buildings	62,000
(*h*) New waterlines both potable and industrial to new areas of construction including an additional 30-inch waterline to support vehicle tests in components test area	193,000
(*i*) New telephone cables, communication ducts, and multipurpose communication cable	250,000
Total	2,937,000

Colonel GOULD. The costs shown in this estimate appear to be rather high.

As Mr. Fulton has previously pointed out, the cost estimates for facilities seem to be well rounded. This project, for example, is a "round" $5 million. Would you define for the committee, please, the basis for this estimate? It is based upon definitive-type plans, rule of thumb costs, or just generalized estimating?

Mr. LILLY. As you are aware, Colonel Gould, we did not have detailed designs or preliminary designs for this project. Therefore, it was based upon the best engineering judgment of the facilities engineers at Marshall.

Colonel GOULD. I would like to know a little bit more about these requirements for the record, please, and a little more than is shown in the budget data presented.

The following questions which are technical in nature, if you do not have the answers, please provide them for the record as we go along.

First of all, the steamplant; What are the average peak demands?

Mr. DIAZ. At present the average peak demand amounts to 182,000 pounds per hour. This reduces to a demand of 100,000 pounds per hour for the summer months when processed steam requirements are the only loads.

Colonel GOULD. In addition there to the 249,000-pound-per-hour existing steam-plant, what is the total combined capacity of all standby equipment tied into the main system?

Mr. DIAZ. The total combined capacity of the system, including the main plant, is 331,000 pounds per hour.

Colonel GOULD. At what percent overload do you consider maximum efficiency can be achieved with the present system?

Mr. DIAZ. It is 150 percent overload.

Colonel GOULD. What percent of overload is being used as criteria for the design of the new plant?

Mr. DIAZ. 150 percent over, Colonel Gould.

Colonel GOULD. As far as the electrical distribution is concerned, do you buy power directly from the local electric power concern, or is it allocated and prorated from the power blocks purchased by the Army at Redstone?

Mr. LILLY. Power is supplied to Redstone Arsenal from the Guntersville and Wheeler Dams, part of the TVA system. Marshall Center purchases power from the Army Missile Support Command at Redstone Arsenal at a cost of $0.0625 per kilowatt-hour.

Colonel GOULD. I note that the Redstone Arsenal is going to add 25,000 kilovolt-amperes to the primary substation, bringing the total capacity to 80,000 kilovolt-amperes. How much demand is placed on this primary substation by the Marshall Center?

Mr. DIAZ. Our total demand is 13,000 kilowatts.

Colonel GOULD. What secondary substation capacity exists at the present time at Marshall?

Mr. LILLY. At the present time, the secondary substation capacity at Marshall is 40,000 kilovolt-amperes.

Colonel GOULD. What is the estimated connected load through 1964 including facilities planned in this year's budget?

Mr. DIAZ. The estimated connection load is approximately 18,000 kilowatts.

Colonel GOULD. The justification indicates that the present pumping is inadequate. Is this correct, speaking of the water system now?

Mr. LILLY. That is correct.

Colonel GOULD. The fiscal year 1963 program included a water filtration plant for $50,000, a water reservoir for $65,000, and water mains in the amount of $85,000, or a total of $200,000. Have these additions and improvements been accomplished, and, if not, have the funds been obligated, or when will they be obligated?

Mr. LILLY. As of the 31st of March, $1,792,000 has been obligated, the balance of funds are expected to be obligated in May of this year.

Colonel GOULD. Are you possibly speaking of the overall utilities extension that was previously authorized? How much of that pertains to the water supply system authorized in fiscal year 1963 in the amount of $200,000?

Mr. LILLY. I don't have those details with me, Colonel Gould. I have only the total project obligations. I will supply the amount for the specific item to you.

Colonel GOULD. What was the capacity of the reservoir which was authorized in fiscal year 1963?

Mr. LILLY. The water reservoir in fiscal year 1963 was programed for $65,000; however, that reservoir was in support of the special vehicle tests, not for the general water distribution. Detailed criteria indicated that an additional 30-inch waterline was required in lieu of the reservoir in support of test facilities: consequently, the reservoir was never constructed.

Colonel GOULD. Would you also provide with that figure the amount of capacity, reservoir capacity, that is, that was existing prior to the fiscal year 1963 item, coming up with a total reservoir capacity, including the project in fiscal year 1963?

The pump outage which occurred in July 1962, according to your justification, was of how long a duration?

Mr. LILLY. Reservoir capacity existing prior to fiscal year 1963 included:

	Gallons
Domestic	1,950,000
Industrial	8,500,000
Test area	1,000,000
Total	11,450,000

The pumps were out for 10 hours.

Colonel GOULD. What is the minimum capacity required at this station to meet the fire reserve level?

Mr. LILLY. To meet firefighting requirements except for special systems on static test stands, approximately 3,000 gallons per minute are required for a 4-hour duration at any one location.

Colonel GOULD. I notice that the cost of widening of existing roads and constructing a new one are both priced at $100,000 per mile. This is a little unusual. Would you please explain this budgetary phenomenon, please?

Mr. DIAZ. Colonel Gould, these roads must actually be rebuilt as well as widened.

Colonel GOULD. But isn't the existing base adequate to meet the loading requirements planned?

Mr. DIAZ. No, sir; it is not. It will have to be ripped up.

Colonel GOULD. Would you describe, please, the overpass to be constructed for $240,000?

Mr. DIAZ. The overpass we are talking about is at the main entrance to the Marshall Center. The overpass will be approximately 80 feet long with earth embankment approaches to pass over Rideout Road.

Colonel GOULD. Is it on the post?

Mr. DIAZ. It is within the installation; yes, sir.

Colonel GOULD. Does it tie into a public highway?

Mr. DIAZ. It does.

Colonel GOULD. If so, is the Bureau of Public Roads, or has the Bureau of Public Roads been contacted and will they contribute any toward the total cost of this project? Would you provide for the record the agreements reached with the Bureau of Public Roads with regard to this project, and provide also the agency who will be responsible for the construction?

Mr. DIAZ. The Bureau of Public Roads was advised of the road requirement and current Redstone Arsenal requirement by letter in October 1962. As a result of past agreements the Bureau has been active in improving access to the arsenal installation. However, either the Army or Marshall has improved the internal road net through their own construction programs. The Mobile District Corps of Engineers will be responsible for construction on the arsenal.

Colonel GOULD. Turning to communications; your cost estimate calls for a data transmission system, a utilities monitoring system, an anti-intrusion system, and a coded fire alarm system. In each of these instances would you define what is being used to meet the need now and state why the present systems cannot be continued in effect.

Mr. LILLY. Data transmission system: There is presently none in effect. The existing telephone systems are not designed to transmit data.

Utilities monitoring system: There is presently none in existence.

Anti-instrusion system: There is presently none in existence.

Coded fire alarm system: Only manual alarms are in the buildings with no tie in to a central fire alarm system.

MICHOUD PLANT

Colonel GOULD. How much has been spent to date in renovations to the Michoud plant since NASA took it over?

Mr. LILLY. We have provided authorization in fiscal year 1962 and in 1963, approximately $18 million. As of March 31, 1963, $6,386,000 of fiscal year 1962 funds have been obligated against rehabilitations and modifications to the Michoud plant. There remains $1,876,000 of fiscal year 1962 rehabilitation and modifications fund to be obligated. These funds will be obligated before the end of June 1963.

Of the fiscal year 1963 funds, $14,171,000, for rehabilitation and modification, $5,653,000 has been obligated as of March 31, 1963. The schedule for the remaining obligations is as follows: April, $6,201,000; June $400,000; August, $400,000; October, $400,000; December, $417,000.

Colonel GOULD. The authorization and appropriation history of this plant, as I reconstruct the past legislation, indicates that in fiscal year 1962 basically as a result of reprograming actions, $9,763,000 were authorized. In addition to this, fiscal year 1962 advance design funds in the amount of $960,000 were made available for a total of $10.7 million from fiscal year 1962.

In fiscal year 1963 there were authorized $18.4 million for new facilities. There were reprogramed $6.6 million for plant modifications. These funds came

from within the construction of facilities program, and $10.2 million for an engineering building, the funds for which came from the R. & D. appropriation. In addition to this, advance design funds in fiscal year 1963 in the amount of $350,000 were made available for the engineering building. This brings the fiscal year 1963 total to $35.5 million, or a total for 2 fiscal years of $46.2 million.

Could you tell me, please, what the status of obligations are for these facilities that have been previously authorized and when all work will be completed?

Mr. LILLY. I believe that we have a slight difference in the total amounts of money which have been made available at the Michoud plant. I believe our discrepancy comes primarily between the split of funding on these projects between the 2 years. The total amount of funds that we have actually authorized for the Michoud plant between the 2 years is slightly over $39 million. The basic difference is in the fiscal year 1963 amount, into which apparently we did not fund all of the authority that was given to us. The status of the obligations as of March 31 were, against the fiscal year 1962 funds, $7,748,000, and the obligations against the authorized amount in fiscal year 1963 were $8,685,000.

Colonel GOULD. Mr. Lilly, I will provide you with a breakdown of the authorizing legislation and construction status data that have been provided by NASA, and apparent differences between the figures which you have presented and the ones that we have reconstructed here, I think should be compared and explained in the record.

Of the fiscal year 1963 money, you indicate that $8.7 million only has been obligated. When will the balance of these funds be obligated?

Mr. LILLY. The balance of these funds will be obligated prior to the end of this calendar year. The total fiscal year 1962 and fiscal year 1963 program at Michoud amounts to $39,517,000. The breakdown of the total program is as follows:

Fiscal year 1962:	
Funds allocated	$9,763,000
Advanced design	960,000
Total fiscal year 1962	10,723,000
Fiscal year 1963:	
Funds allocated	28,444,000
Advanced design	350,000
Total fiscal year 1963	28,794,000
Total funds allocated fiscal year 1962 and fiscal year 1963	39,517,000

Total funds obligated against the fiscal year 1962 program amount to $7,748,000 and $8,685,000 against the fiscal year 1963 program as of March 31, 1963. The remaining $2,975,000 of the fiscal year 1962 program will be obligated by the end of June 1963. The schedule of obligations for the remaining $21,525,000 against the fiscal year 1963 program is as follows:

April	$7,051,000	September	$300,000
May	1,294,000	October	550,000
June	10,620,000	November	300,000
July	300,000	December	560,000
August	550,000		

Colonel GOULD. What is the estimated cost of all known requirements for this plant beyond fiscal year 1964?

Mr. LILLY. We do not have a definitive layout of requirements as yet. However, we can anticipate that there will be in future years requirements for additions to production equipment and facilities. I would estimate this to run somewhere between $7 million and $12 million a year.

Colonel GOULD. For how many years?

Mr. LILLY. For the number of years that the plant is in production.

Colonel GOULD. You mean the new construction and modification costs are going to run $7 million to $12 million per year, indefinitely?

Mr. LILLY. No; I didn't mean to imply that. I meant that there will be a continuing cost associated with the production in the plant, a requirement for

new production equipment and modifications that are always associated with the operation of a production facility.

Colonel GOULD. Has a firm master plan for this site been developed?

Mr. LILLY. Yes; it has.

Colonel GOULD. The one that I saw recently only projected requirements through fiscal year 1964. Have there been any projections beyond fiscal year 1964 for construction requirements?

Mr. LILLY. As I indicated previously, of known requirement, Colonel Gould, we do not at this time foresee new facilities or new construction requirements, as such. The indicated requirements that I spoke of relate to the normal production equipment and modification costs.

Colonel GOULD. How are the design and construction accomplished at this activity?

Mr. LILLY. The design of the facilities at Michoud have been and are accomplished by the facilities engineering organization at Marshall; the supervision of the construction at the plant is accomplished under the contract with Mason-Rust.

Colonel GOULD. Is this contract with Mason-Rust a CPFF type of contract?

Mr. LILLY. The current contract with Mason-Rust Co. to support services at Michoud facility is a cost-plus-fixed-fee contract, currently running through June 30, 1963.

Colonel GOULD. When you say that this contract is a CPFF contract, is the construction accomplished on a CPFF basis?

Mr. LILLY. No, sir, it is not. It is accomplished, like all other construction projects we have, on a fixed-price contract.

Colonel GOULD. In other words, the management of the construction is on a CPFF basis, but the actual construction is put out on a competitive bid basis?

Mr. LILLY. That is correct.

Colonel GOULD. Are the contractor management modifications included in the CPFF program, that is to say, R. & D. facilities projects or repairs and alteration projects?

Mr. LILLY. Yes, it does.

Colonel GOULD. What is the volume of R. & A. funded work at this facility?

Mr. LILLY. Essentially all of our work at Michoud today has been under the projects previously mentioned as construction facilities projects, modifications to the Michoud plant. The one exception to this to my knowledge is the roof repair at Michoud which was around $1 million.

Colonel GOULD. The reason I ask this question, Mr. Lilly, is that many of the construction requirements indicated in the fiscal year 1964 program, particularly as regards the additions to production facilities, are of a minor modification nature and it would appear that with the 2- to 2½-year programing cycle for a C. of R. project that many of these modificatitons would lend themselves to being financed out of your operating money as R. & A. items.

Would you care to comment on that, please?

Mr. LILLY. I would agree with you, Colonel Gould, that the type of modifications that are done at Michoud would be in normal contractor-owned plants be considered as repairs and alterations. In many respects such determination would make the job easier for us to administer.

However, the NASA policy has been, in presenting requirements for such a facility, to make full disclosure of all of our anticipated or known requirements at a given location.

Therefore, all of our known requirements in this area have been included in these facilities projects for modification.

Colonel GOULD. Does the Mason-Rust contract include plant maintenance for this activity?

Mr. LILLY. Yes, it provides those services which are common to both contractors.

Colonel GOULD. Mr. Lilly, do you have available with you a fee schedule for this contract?

Mr. LILLY. The original contract with Mason-Rust provides for those "housekeeping" and managerial functions which are required for the common use of the Michoud facility by Boeing and Chrysler (for example, food service, custodial service, fire protection, et cetera) and to keep such premises in good usable condition by performing all minor plant repairs, alterations and maintenance in such common-use areas. In addition, Mason-Rust is responsible for reviewing on-site installation and construction work conducted by the tenant stage contractors and is charged with coordinating the performance of such work to avoid

conflict between the respective operations of the tenants. Mason-Rust's fee for these services has been established at 3.6 percent.

A supplement was later awarded to Mason-Rust as an add-on to the basis contract on a CPFF basis to provide construction managerial services. For these services Mason-Rust is to receive a fee of .8 percent.

Colonel GOULD. Does the Mason-Rust contract also include the Slidell facility?

Mr. LILLY. Yes, the Mason-Rust contract does include the Slidell facility.

(Whereupon, at 4 p.m., the investigation was recessed, to reconvene at 1:30 p.m., Tuesday, May 7, 1963.)

EXECUTIVE SESSION

STAFF CONFERENCE, MANNED SPACE FLIGHT PROGRAM—CONSTRUCTION OF FACILITIES

The conference continued, pursuant to notice, in room 214–B, Longworth Building, at 1:35 p.m., May 7, 1963.

ADDITIONS TO PRODUCTION FACILITIES (MICHOUD)

Colonel GOULD. Mr. Diaz, you stated that certain personnel at Michoud are now occupying leased facilities offsite. I believe you said that these were Boeing and Chrysler personnel. How much space are they occupying offsite and where?

Mr. LILLY. Colonel Gould, the leased space that is being occupied by Boeing and Chrysler is in a number of buildings in the New Orleans area. The principal facilities in which they are located is the Barone Building in which there is leased space of 240,000 net square feet, the Clayburne Towers of 45,000 net square feet; the Lowitz, 75,000 net square feet, and the Masonic Temple with approximately 60,000 net square feet.

Colonel GOULD. Are there any of the permanent Government employees occupying leased space at the present time?

Mr. LILLY. No, sir; there are not.

Colonel GOULD. These contractor personnel that are occupying leased space are they primarily administrative and engineering-type personnel?

Mr. LILLY. Primarily engineering design type.

Colonel GOULD. What is your schedule for relocating these people into plant facilities?

Mr. LILLY. The primary time in which the majority of them will be relocated into Government space will be approximately the middle of 1964.

Colonel GOULD. What is the present strength of Michoud broken down between contractor and Government employees, and what will be the end fiscal year 1964 strengths, please?

Mr. LILLY. The present and projected strength at Michoud is as follows:

	Present strength	Fiscal year 1964
Boeing	3,035	5,400
Chrysler	2,313	4,200
Mason-Rust	644	800
NASA	189	380
Total	6,181	10,780

Colonel GOULD. During previous testimony I believe there was an indication that total contractor personnel at this facility would be about 3,200. I believe this was in the opening hearings before the full committee. Can you verify that figure, please?

Mr. LILLY. I don't recognize the figure of 3,200, Colonel Gould.

Colonel GOULD. With regard to the cafeteria included as part of this project, a cafeteria in the plant proper already exists. What is the size and capacity of this cafeteria?

Mr. LILLY. The capacity of the present cafeteria is approximately 740 seats serving approximately 2,000 people.

Colonel GOULD. You stated yesterday that your criteria for cafeteria projects was predicated on a 2½-hour feeding time and a turnover of five persons in the period. This figure you have just quoted differs from that criteria. Is there any reason for this?

Mr. LILLY. The present cafeteria must be considered along with the total which is planned for the entire complex. Existing space, that is, the current cafeteria, will handle approximately 2,000. The proposed cafeteria on the mezzanine will handle approximately 3,200, and the one in the new engineering building will handle approximately 1,800, giving us a total of about 7,000 spaces for people to be fed.

This is based upon a total estimated strength of approximately 10,000 persons in the complex. The actual ratios are in some of the spaces somewhat different than the ratio you figured, principally because the production personnel in the main plant are required to use the cafeteria for lunch even if they carry their lunch, primarily for safety reasons.

The cafeteria which will be provided in the engineering building will not be readily available to the personnel in the manufacturing space because of its distance of approximately a third of a mile away from the building.

Colonel GOULD. How many shifts operation will this plant operate?

Mr. RAFEL. It will be somewhere between a single shift and a double shift basis depending on the areas of work involved.

Colonel GOULD. Are you telling me that all the personnel at this plant will not all be employed during the same time in any given day?

Mr. RAFEL. Yes.

Colonel GOULD. What will be the normal strength of a single shift operation at this plant?

Mr. LILLY. The normal single shift plan during fiscal year and earlier 1965 will be approximately 8,400 people.

Colonel GOULD. Is the cafeteria and other support requirements predicated upon 8,400 people working in the plant at any given point in time?

Mr. LILLY. That is correct.

Colonel GOULD. Included in this project is also a requirement for central maintenance shops. Which contractor will use these facilities?

Mr. LILLY. These facilities will be used by the Mason Rust Co.

Colonel GOULD. How many personnel will be employed?

Mr. LILLY. The total strength of Mason Rust will be approximately 850.

They will have approximately 710 people by July 1, 1963. This is made up of approximately 490 shop personnel, 220 office-type personnel.

Colonel GOULD. What is being used to meet this need now?

Mr. LILLY. At the present time the Mason Rust personnel are scattered throughout the plant.

Colonel GOULD. Where will the offices for this contractor be located eventually?

Mr. LILLY. The office personnel for Mason Rust will be located in the present administration building.

Colonel GOULD. How long do you anticipate the production will be at peak capacity in the main plant?

Mr. SMOLENSKY. Our current production rates for approved programs will be reached in 1964 for the Saturn I and I–B program and in 1965 for the Saturn V program. This will continue in the case of the Saturn I and I–B program for about 1 to 2 years, 1½ to 2 years for our current approved requirements. Beyond that period we are also planning for increased requirements which will increase the rate for both the Saturn I and the Saturn I–B and the Saturn V to be prolonged for an indefinite period.

Colonel GOULD. This project also includes a requirement for hazardous test facilities. In fiscal year 1963 a high pressure test facility was authorized at an estimated cost of $1 million. What is the relationship between the previously authorized facility and this one?

Mr. LILLY. The facility that you refer to is the high pressure test facility which is being provided for testing fuel tanks and high pressure tubings of the S–IC booster. The type of tests that will be conducted are high pressure hydrostatic proof testing and pneumatic leak testing as required on gaseous nitrogen and helium tanks and tubing.

The facility that we are proposing—the hazardous test facility—is in support of the S–1 stage. It will provide increased capacity for improvement in engineering testing. Work will include repetitive environmental test in pneumatics, cryogenics, vacuum, thermoshock and impact tests.

The first facility, that is, the high pressure facility, is for the S–IC. The second one is for the S–I stage.

Colonel GOULD. Apparently then there is no duplication in the 1963 and 1964 item?

Mr. LILLY. No, sir, there is no duplication.

Colonel GOULD. As to the structural test facility included in this project; similar facilities for the Saturn I are available or programed at Marshall. Why do you need facilities at both sites?

Mr. SMOLENSKY. The present structural test facility is for the S–I program. This laboratory will increase the capacity and flexibility for production improvement.

The vibration and static load capabilities will be provided. Also we are undertaking a very aggressive weight reduction program which will be used to increase our payload capabilities. The present structural test area will not be able to handle the increased heating, vibration, and loading requirements for the new structures.

Colonel GOULD. This project also includes a requirement for manufacturing area offices. How many personnel will use the administrative and laboratory space being provided?

Mr. LILLY. This administrative space for the manufacturing office area is approximately 12,500 square feet. The criteria that was used in establishing the office space requirement was 130 square feet per person Total number of personnel are approximately 98 people These people are primarily for plant supervisory, plant supervisory type personnel such as safety, quality control, material control, production control

Presently they are located in the open manufacturing area So what we will be doing is enclosing the space they are presently using.

Colonel GOULD. What are they using for office equipment at the present time?

Mr DIAZ. They are using desks and equipment and they are sitting out in the open.

Colonel GOULD. You have asked for $155,000 for new office equipment for these offices. Are you telling me they have no office furniture at the present time?

Mr. LILLY. All of the people aren't on board at this point in time. The new ones will require it. This requirement was based upon the additional people and the equipment that would be required to support them.

Colonel GOULD. The modifications to the plant proper shown on page CF 10–13 or such minor modifications as the master substation, the boiler plant, test facility, structural test facility, assembly station frames, and even the manufacturing areas offices all appear to come within the purview that is provided in your operating funds for minor alterations, additions, extensions and new construction.

I know we discussed this yesterday, but I would note in the record here that the amount within the NASA budget for this purpose has increased from $13.4 million in fiscal year 1962 to $20.9 million in fiscal year 1964. While it is recognized that the total plant available within NASA is expanding every year, it would appear that many of these minor modifications to existing facilities could be made within this authority.

Furthermore, by using this authority, you would eliminate the two to two and a half year programing time that you have in your normal construction of facilities programing system.

Would you care to provide further comment on this, please?

Mr. LILLY. The category to which you refer, Colonel Gould, refers to the maintenance alterations and minor new construction at NASA's Government-owned installations such as the Marshall Space Flight Center, the Manned Spacecraft Center and others.

It does not include the normal maintenance, alterations, repairs, minor new constructions that are carried out in contractors' plants which are funded under R. & D. contracts.

The estimates that have been provided are those required to maintain our own facilities. As we discussed yesterday, I would have no objection and see considerable advantages to funding such items under the "Research and development operations" appropriation.

However, the NASA policy has been in this case to consider the Michoud plant as a government facility funding all of these items as if they made up one single project which obviously then exceeds our $250,000 limitation.

I would certainly not object to using the research and development authority if this were possible, however.

Colonel GOULD. Mr. Lilly, this is not a research and development authority as I read the NASA program. This is purely operational money. I was not of the opinion that the Michoud plant was classed as a contractor's facility.

Mr. LILLY. It is not classed as a contractor's facility, Colonel Gould, but it is classed as a NASA installation. Therefore, when costs in total exceed $250,000 for modifications or alterations, the NASA policy has been to classify this as a construction facility project as opposed to repair, alteration, and improvement.

Colonel GOULD. Have we spent any fiscal year 1963 money for minor alterations, additions, and extensions for new construction at Michoud?

Mr. LILLY. There was one case I believe we mentioned yesterday which was the roof repair at Michoud which was classed as a repair cost as opposed to construction and facility cost.

Colonel GOULD. Projects in this category out of operating funds, what is the approval authority of the directors at the field installations?

Mr. LILLY. The authorities for approving minor construction, operations, and improvement projects less than $250,000 are delegated to the program directors on the following basis—all projects below $50,000 which are not considered to be extensive new structures, may be approved by the program directors.

In the case of the manned space flight centers, this authority has been redelegated to the Centers. Therefore, the Centers—Marshall, Houston, and the launch operation center have authority up to $50,000.

Colonel GOULD. So that within available operating funds at a given installation, the director may expend up to $50,000 for minor modifications and new construction?

Mr. LILLY. That is correct, with certain limitations as I expressed.

Colonel GOULD. You are asking for $320,000, I note here in communications, photographic, and reproduction equipment. What is being used to meet that need at the present time?

Mr. LILLY. There are certain equipments; principally makeshift equipment, that is presently on hand. The funds requested here are to provide a centralized duplicating and reproduction capability. The equipment to be purchased with these funds are nine duplicating machines, a photocamera, two Diazo machines, one 240 Xerox machine, one microfilm camera, and support-type equipment, such as collators, binders, et cetera.

PARKING AND SECURITY IMPROVEMENTS

Colonel GOULD. In addition to the rehabilitation to the airstrip that we discussed on May 8, 1963, I notice that additional parking space is going to be provided. How many vehicles can be accommodated in the existing temporary parking lot?

Mr. LILLY. The existing temporary parking spaces provide space for approximately 2,476 vehicles.

Colonel GOULD. What is the nature of this temporary parking lot? What is its surface?

Mr. DIAZ. The surface of the parking lot now is shell type.

Colonel GOULD. Are your requirements for the additional parking spaces plus improvement to the existing temporary parking lot predicated on the same criteria of one space for every two personnel?

Mr. LILLY. That is correct.

Colonel GOULD. This is based upon the ultimate strength of this plant?

Mr. LILLY. That is correct, Colonel Gould. The parking spaces with the approximately 3,000 spaces available with this new and reconditioned space and 2,000 spaces at the engineering building will bring us to approximately 5,000 spaces for a peak estimated strength of around 10,000.

Colonel GOULD. The personnel are not all going to be working at the same time as previously testified.

Mr. LILLY. That is correct. This also provides parking spaces for visitors and vendors.

Colonel GOULD. Are there any commercial bus systems serving this plant?

Mr. LILLY. I do not know the exact service that is provided, but it is my understanding that what is there is completely inadequate to provide adequate transportation.

Colonel GOULD. I notice that this project includes security fencing, a patrol road and lighting. How is this need being met at the present time?

Mr. LILLY. There does exist some security fencing there in certain areas. There is at the present time no protection on the canal side. What fencing does exist is in poor condition and must be replaced.

Colonel GOULD. What type of security road is being provided?

Mr. DIAZ. It will be a shell-type road.

VEHICLE COMPONENT AND SUPPLY BUILDING

Colonel GOULD. Many of the support items shown as requiring covered storage lend themselves to outside storage such as lumber, piping, structural steel and roofing. Why do you need covered storage for items of this nature?

Mr. LILLY. The space that we are requiring for this particular area for the support contractor, Colonel Gould, is not intended to, as the justification may have indicated, to place all of these items under storage.

We do need storage areas for such support functions in such things as Diazo-type papers, storage of bond reproduction papers, and several of the other kinds of items that we mention. However, we do not intend to provide space for all of the lumber and the other items that you mentioned.

This question was answered during the May 3 hearings.

Colonel GOULD. Will the S–I and S–IC stage components be received in boxes or crates or unpacked? If they are received in boxes and crates, it would appear possible that outside storage might serve this need.

Mr. LILLY. The majority of these items will not be in boxes or crates, Colonel Gould.

MISSISSIPPI TEST FACILITY

ADVANCED SATURN FIRST STAGE (S–I) STATIC TEST FACILITIES

Colonel GOULD. Why is a stage storage building at an estimated cost of $1,415,000 requested?

Mr. LILLY. This stage storage building would provide facilities for pre-test or post-test storage of the advanced Saturn S–IC stages, service modification and repair of booster vehicles while mounted on their transporters.

Colonel GOULD. What equipment will go into this building for $200,000?

Mr. LILLY. Principally stage handling equipment.

Colonel GOULD. What does this consist of?

Mr. DIAZ. It consists of cranes and other special handling devices for the particular vehicle.

Colonel GOULD. I notice that you call for canopies over the entering and leaving roads. Why is this necessary and and what are the costs of these items?

Mr. LILLY. The canopies are designed to afford a measure of protection from the elements for guards, visitors, vendors, and others seeking admission to MTF. Rainfall exceeds 60 inches per year and summer sun is intense. The cost of the canopies is estimated to be $4,000.

Colonel GOULD. What is the special power supply in the amount of $865,000? What does that consist of?

Mr. LILLY. The pertinent features of the special power system are one 480-volt distribution panel, two 500 static rectifiers, two hermetically sealed 30-volt nickel cadmium storage batteries, one 5-kilovolt-ampere 400-cycles per second 3-volt Delta-connected generator driven by 440-volt 60 phase synchronomous motor. Six 15-kilovolt-ampere regulators, connected into 120/208 configuration. One 30-kilovolt-ampere set for the digital computer. Remote control circuit protected devices, circuit conductors and grounding.

Colonel GOULD. It seems to be a pretty complete list, Mr. Lilly.

During a recent trip to this site it was learned that certain of the fiscal year 1964 items are already under design.

Could you identify these in the cost estimate, please?

Mr. LILLY. All items in fiscal year 1964 that had increments in fiscal year 1963, are currently under design. Included are: Advanced Saturn (S–IC) static test facilities, Advanced Saturn (S–II) static test facilities, control center and data acquisition and handling facilities, the navigation lock, transportation and parking facilities, utility additions and extensions and warehouse addition and storage facilities.

Design and engineering services funds requested in fiscal year 1964 were determined after taking into full account fiscal year 1963 allocations for these services. In most instances the fiscal year 1964 increments are required for supervision and inspection.

Colonel GOULD. Were they taken into account in establishing the requirement for $2,418,000 for design and engineering services shown in this estimate?

Mr. LILLY. Yes. To answer your question specifically these were taken into account since it was started prior to the preparation of this.

ADVANCE SATURN SECOND STAGE (S–II) STATIC TEST FACILITY

Colonel GOULD. For this project, NASA reprogramed $7 million from within the construction of the facilities program in fiscal year 1963 and $17.3 million from R.D. & O. funds for the S–II complex. How much of this $24.3 million has been obligated?

Mr. LILLY. Obligations as of the 31st of March are approximately $6,450,000.

Colonel GOULD. Are these funds actually under contract or are they merely committed to the Corps of Engineers?

Mr. LILLY. These funds are obligated to the Corps of Engineers.

Colonel GOULD. Do you know how much is under contract at the present time?

Mr. LILLY. I do not have a list, but it is principally the design work.

Colonel GOULD. When will the balance of these funds be obligated?

Mr. LILLY. We expect all of these funds to be obligated by September of this year.

Colonel GOULD. What is included in the item, "Stage service and storage building equipment" for $1,800,000?

Mr. LILLY. A prefiring and postfiring check will be made of all systems. This will require computer checkout equipment. This amounts to about a million dollars worth of equipment. The $800,000 will include handling equipment for the vehicles such as motorized crane. If you would like I can give you the breakdown of this equipment.

Colonel GOULD. It is not necessary, but I note that the equipment for the stage storage building in the S–I side only cost $200,000. Why this difference?

Mr. LILLY. The S–IC checkout will be performed at Michoud whereas the S–II will be accomplished at MTF.

Colonel GOULD. Have advance design funds been committed for the balance of the work to be done?

Mr. LILLY. This again is an incrementally funded project into which design was started under 1962 funds, continued in 1963, so I cannot readily separate the design applicable to the particular 1964 portion. However, all of this was taken into consideration in the development of the investment.

BRIDGE FOR U.S. INTERSTATE HIGHWAY NO. 10

Colonel GOULD. Has the agreement between NASA and the Bureau of Public Roads with reference to this requirement for a new bridge been reduced to writing?

Mr. LILLY. Mr. Webb has written a letter to the Bureau of Public Roads informing them that we were budgeting $4,500,000 for this item and requested the Bureau of Public Roads to take the necessary action.

Colonel GOULD. It is my understanding that the original bridge that was planned by the Bureau of Public Roads was estimated to cost $800,000. As a result of the requirement for a high-level bridge, the Bureau of Public Roads revised their estimate to $5.3 million, of which NASA is expected to fund $4.5 million. Is this the correct story?

Mr. LILLY. That is correct.

Colonel GOULD. To the best of your knowledge, is this estimate on the part of the Bureau of Public Roads a firm estimate or is it preliminary in nature?

Mr. LILLY. To the best of our knowledge, this is a firm estimate by the Bureau of Public Roads.

Colonel GOULD. At some future date when the operating machinery is required to be installed on this bridge, who will finance the $150,000 required?

Mr. DIAZ. NASA will finance it.

ONE ENGINE SYSTEMS TESTING

Colonel GOULD. What stage contract are we speaking of at the top of page CF 11-35?

Mr. LILLY. Stage contractor referred to here is Boeing for the S-IC.

MAINTENANCE FACILITIES

Colonel GOULD. Will this vehicle shop have a rebuild capability?

Mr. SMOLENSKY. It will not have a rebuild capability.

Colonel GOULD. As a matter of interest, to what standard does NASA maintain their mobile equipment?

Do you use GSA standards for this purpose?

Mr. LILLY. In general, NASA uses a combination of GSA standards and the manufacturer's maintenance guide for maintaining mobile equipment.

Colonel GOULD. The cost of the test maintenance shop included in this project appears excessive.

It shows $27.50 per square foot.

Can you tell me what the basis of this estimate is, please?

Mr. DIAZ. Colonel Gould, this shop will have a high bay area. That, essentially, is what causes the cost, a little bit higher than normal for this type of structure.

Mr. LILLY. I might point out also that the cost estimate for this facility was based upon the construction and equipment costs estimates prepared by Sverdrup & Parcel.

SECURITY CONTROL FACILITIES

Colonel GOULD. When will MTF be fully operational?

Mr. SMOLENSKY. We will reach our full capability for the testing activities there by late 1965.

Colonel GOULD. When will full security measures have to be in effect?

Mr. LILLY. Our plans for having these facilities complete is in November 1964. There will be a considerable amount of materials and equipment which must have full protection prior to the time that the full testing capability is available.

Colonel GOULD. I notice that the north and south control centers will cost $26.10 per square foot and $28.35 per square foot, respectively.

Why is there a difference of $2.25 per square foot difference between these two control centers?

Mr. DIAZ. The design criteria for these two buildings as well as the estimated cost of construction were developed by Everdrup & Parcel, an architect-engineer firm under contract with NASA on the basis of the requirements for each facility and acceptable architectural practices.

Summary of construction cost estimate for the south entrance reception building:

Architectural	$60,200
Structural	22,600
Mechanical	60,100
Plumbing	12,100
Fire protection	200
Heating, ventilating, and air conditioning	47,800
Electrical	31,500
Subtotal	174,400
Contingency	17,400
Total building construction cost	191,800

Summary of construction cost for the north entrance reception building:

Architectural	$33,500
Structural	10,800
Mechanical	28,000
Plumbing	7,100
Fire protection	100
Heating, ventilating, and air conditioning	20,800
Electrical	17,600
Subtotal	89,900
Contingency	9,000
Total building construction cost	98,900

Colonel GOULD. Why does one have a high ceiling and the other not?

Mr. LILLY. Building construction cost: $98,900 divided by 3,790 square feet is $26.10 per square foot.

In summary, the south entrance control building is located at the main gate and thus is designed to provide waiting space for 50 guests as compared to 30 guests in the north building. Consequently, the ceiling clearance in the waiting room of the south building is higher to provide better air circulation. In addition, there is more mechanical heating and air-conditioning equipment in the south building as shown in the estimate to accommodate the larger number of guests.

Colonel GOULD. Has any fiscal year 1963 advance design funds been committed to this project?

Mr. LILLY. Yes, $45,000 was released to this project in January of this year.

SONIC MEASURING FACILITIES

Colonel GOULD. A sonic measuring facility which I believe is also called an acoustical laboratory has already been provided at this site and is housed in an existing dwelling that has been modified at a cost of $19,600.

Why can't this facility be continued in use?

Mr. CRONE. The existing facility at MTF is set up to study the atmospheric acoustic conditions in that area.

They are presently using a recording of a firing made at Marshall which is 30 decibels below the actual level of an S-I stage.

The S-II and the S-IC stages will have different characteristics.

This facility provides for more accurate daily study of the conditions just before firing. This is done in order to predict where the concentration of this sound will occur.

The current facilities are inadequate for this study on a day-to-day basis. (A detailed analysis of the present equipment as compared to the proposed equipment was made a matter of record during the May 3 committee hearing.)

Colonel GOULD. The test stand at Marshall for the S-I or the S-IC will be completed before the ones at MTF.

Couldn't further recordings be made of the initial tests at Marshall and used in this temporary facility?

Mr. CRONE. The equipment that is available there now will not handle the power output that we want to use for this study.

Colonel GOULD. Couldn't we increase the power output on a temporary basis?

Mr. CRONE. It will require all new equipment.

Colonel GOULD. What is the status of design on this project?

Mr. LILLY. The design is not started on that project, Colonel Gould.

Colonel GOULD. When do you intend to start the design?

Mr. LILLY. We intend to start design on this facility in September.

Colonel GOULD. What are the design and construction leadtimes for the project, please?

Mr. LILLY. The design time is estimated at approximately 6 months with construction leadtime approximately 12 months.

Colonel GOULD. Eighteen months total leadtime?

Mr. LILLY. That is correct.

Colonel GOULD. When are the first tests scheduled to be conducted at MTF?

Mr. SMOLENSKY. In midcalendar year 1965.

Colonel GOULD. You plan to complete this facility about 6 months in advance of your first tests; is that correct?

Mr. SMOLENSKY. That is correct.

Colonel GOULD. I know all new equipment will be procured for this facility. What disposal will be made of the equipment now existing in the temporary building?

Mr. SMOLENSKY. The equipment in the existing temporary building will be disposed of in the following manner after the new facility is completed:

(*a*) Equipment which can be incorporated economically into the new facility will be retained and used accordingly.

(*b*) All remaining equipment will be returned to the Marshall Space Flight Center for use in connection with other facilities or turned over to salvage for disposition.

TRANSPORTATION AND PARKING FACILITIES

Colonel GOULD. The narrative portion of this request is specific as to the extent or total scope of the roads to be constructed. However, the budget sketch provided is difficult to decipher as to the specific location of roadways previously authorized and those proposed in fiscal year 1964.

If you have a site plan with you, please display it and define specifically the scope and location of the primary, secondary, tertiary and patrol roads to be provided, identifying each with the 1963 program and the 1964 program.

Mr. LILLY. This is a breakdown for the 70 miles of roads requested in fiscal year 1964 budget:

Type of road	Length, miles	Number of lanes	Lane width, feet per lane	Shoulder width, feet	Cost per mile
Primary	5	4	12	8	$300,000
Primary	10	2	12	8	150,000
Secondary	5	2	10	6	125,000
Patrol	50	1	10	2	6,000

The currently authorized funding for roads in fiscal year 1963 is $300,000 which is being used to construct 2 miles of primary two-lane road.

Colonel GOULD. Each project at MTF has an item for roads and parking area included as part of the project. This specific project provides for 2,800 more parking spaces. Taking all previously authorized projects and those in the 1964 program plus this project how many vehicles can be accommodated?

Mr. LILLY. At MTF there will be a total of 2,800 parking spaces programed for personnel vehicles at the ratio of 1 to 1.5 persons. These parking facilities are all requested under the transportation and parking facilities project in the fiscal year 1964 budget submittal.

Parking facilities requested previously and those requested under other projects in the fiscal year 1964 budget submittal provide for the following:

1. Paved aprons to provide access ramps to docking facilities. The access ramp at the warehouse is a good example.

2. Parking for operational-type vehicles such as trucks, cranes, tractors, loaders, and so forth. There will be approximately 600 such vehicles requiring parking at MTF.

3. Paved areas for accommodating equipment and supplies that do not require inside storage.

4. Parking facilities for visitors buses, and personnel checking in and out at the security control building.

5. Employees parking in areas other than their normal duty stations. Parking is provided here only when the distance involved is too far to walk for efficient operation.

Colonel GOULD. Who is going to build the alternate Route 43 shown in the cost estimate?

Mr. DIAZ. Highway 43 will be built by the State of Mississippi.

Colonel GOULD. Has the Mississippi Highway Department been requested to design the alternate road?

Mr. DIAZ. They have. They have been requested to do so.

Colonel GOULD. What funds are being used for the design of the alternate road?

Mr. DIAZ. Construction of facilities funds will be given.

Colonel GOULD. There have been no funds committed to the State of Mississippi for the design of this alternate road?

Mr. DIAZ. That is correct.

Colonel GOULD. Why is it necessary to have primary dual-lane highways within the site?

Mr. DIAZ. The decision to build a four-lane road within the site area was based on a traffic study and analysis by the architect-engineer firm of Sverdrup & Parcel. The road in question is 5 miles long and runs from the south entrance north through the test area to the north entrance. All the rest of the roads in the test area are two lanes or one-lane roads.

The traffic survey revealed that the estimated peak hourly traffic which will occur in the morning for the major shift is 1,610 cars at the south entrance and 1,080 cars at the north entrance.

The A–E recommendation to build a four-lane road to handle this estimated traffic volume is consistent with accepted practice as contained in the Bureau of Public Roads "Highway Capacity Manual," 1950 edition and American Association of State Highway Officials, AASHO publications "A Policy on Geometric Design of Rural Highways," 1955 edition, and "A Policy on Arterial Highways in Urban Areas," 1957 edition.

Colonel GOULD. What type of a road is planned for the alternate State Highway No. 43? Is it a dual-lane road or a single-lane road?

Mr. DIAZ. Highway 43 will be 24-foot pavement with 10-foot shoulders.

It is classified as a dual-lane road.

Colonel GOULD. Would you please explain why it is going to cost $300,000 a mile to build dual-lane roads on the site and only $100,000 a mile off the site?

Mr. LILLY. The off-site road refers to relocation of State Highway No. 43. This road is a primary two-lane road with an estimated cost of $160,000 per mile. The primary roads on site that will cost $300,000 per mile are four-lane roads.

WAREHOUSE ADDITION AND STORAGE FACILITIES

Colonel GOULD. The project description mentions a warehouse authorized in fiscal year 1963. In my review of the 1963 testimony presented I fail to identify this item in the amount of $630,000.

Would you tell us which project it was included under and what the fiscal year 1963 estimate was?

Mr. LILLY. The project was included under utilities, installation, and support facilities.

Colonel GOULD. Would you please define the size of the fiscal year 1963 increment?

Mr. LILLY. The size of the 1963 increment is 66,300 square feet.

Colonel GOULD. The fiscal year 1964 increment requests an additional 108,200 square feet. This, when added to the 1963 increment, will give you a total of 174,500 square feet for inside storage. What is the basis for this requirement?

Mr. LILLY. The planning for this facility was based upon the extensive experience that we had at the Marshall Space Flight Center which showed the extent of warehouse facilities required to support testing operations.

Colonel GOULD. Will this be one of the facilities that will be operated under the GE contract?

Mr. LILLY. That contract has not been definitized yet and I could not specifically give you an answer to that at this time.

Colonel GOULD. According to your recent press release however, negotiations are going to be entered into with GE to take over the housekeeping type of activities in addition to their normal support contract; is that correct?

Mr. LILLY. That is correct.

Colonel GOULD. This would include storage and distribution of various support requirements for the site; is this not correct?

Mr. LILLY. That is correct.

Colonel GOULD. When will the GE contract be in full force, based on present planning?

Mr. LILLY. It is expected that General Electric will be phased in with a gradual buildup of personnel reaching a peak in 1965 with full strength in 1966.

Colonel GOULD. I note that this project includes a flammable material storage building justified as required for drum storage, paint storage and acid storage.

What type of drum storage are you going to use here that requires covered storage facilities?

Mr. SMOLENSKY. For the record, a detailed analysis and breakdown of the drum storage and the flammable material will be supplied.

Colonel GOULD. The justification for the salvage material storage building indicates that certain salvage materials must be protected from the elements. What types of materials would these be?

Mr. LILLY. This material is electric and electronic components although they are classified as salvage. They have continuing value and could be reclaimed.

LAUNCH OPERATIONS CENTER (GENERAL)

Colonel GOULD. Captain Holcomb, would you outline for the record please, the general responsibilities for programing, budgeting, constructing and managing the AMR and the Merritt Island launching area as consummated in the recent agreement between NASA and the Department of Defense under date of January 17, 1963?

Captain HOLCOMB. This division of responsibility is made on the basis of the operational responsibility for a particular facility. The agency having responsibility for a particular function will be responsible for managing the acquisition or modification of the facilities and equipment to perform the function. This includes the construction, development, procurement, installation, checkout, calibration, spare parts provisioning and other services required to place the facility or equipment into operation and maintain it.

Mr. GOULD. What provisions are made in the agreement for jointly operated facilities?

Captain HOLCOMB. The only jointly operated facilities that I believe will exist in this context are actual launch complexes where the same launch complex may support launches of either agency.

Colonel GOULD. Under this agreement——

Captain HOLCOMB. The accountability and the operating responsibility for launch vehicle checkout facilities and launch complexes will rest with the agency conducting the launch vehicle function regardless of which agency is responsible for the payload and the flight mission being served.

I think that you will find that we do not have any launch complex in which two different launch crews from different agencies come in to operate.

If one agency is operating, it may launch a payload of either agency. But the one responsible for the budgeting, the modification, the upkeep of the facility will be the one that actually operates the launch vehicle.

Colonel GOULD. Under this arrangement the DOD is designated as the single manager for the range facilities; is this correct?

Captain HOLCOMB. That is correct.

Colonel GOULD. The Merritt Island launch area is considered to be a NASA installation and according to NASA has the full responsibility for programing, budgeting, and accountability for equipment; is this correct?

Captain HOLCOMB. This is true for all NASA funded facilities. However, the range has a responsibility as a range for providing instrumentation and specific range-type services in the Merritt Island area.

For example, if a radar were to be required to support launches of either DOD or NASA which would be located in Merritt Island, the range would budget for this item, construct it and operate it.

Colonel GOULD. Although the agreement was consummated in January of this year it is my understanding that for fiscal years 1963 and 1964 the current budget and funding arrangements would remain in effect; is this correct?

Captain HOLCOMB. Let me quote from the agreement:

"Each agency will budget and fund for the acquisition of facilities and equipment necessary to perform the functions for which it is responsible. However, for fiscal years 1963 and 1964 current budget and funding arrangements will remain in effect."

ADVANCE SATURN LAUNCH COMPLEX NO. 39

Colonel GOULD. Has the design been started on any of the fiscal year 1964 items?

Mr. LILLY. Yes, design for such items as the arming tower, propellant services, site development and outfitting the vertical assembly building have been started.

Colonel GOULD. Taking all funds previously authorized and appropriated and reprogramed for this facility it looks like the design and engineering costs for complex 39 will be in the order of $37.6 million; is this roughly correct?

Mr. LILLY. That is roughly correct.

Colonel GOULD. What percent of the 1964 increment is presently under design?

Mr. LILLY. Approximately 35 percent of the 1964 increment is presently under design.

Colonel GOULD. What is the operational target date for this complex?

Captain HOLCOMB. The first operational availability of bay No. 1 and pad No. 1 is the first of December 1965.

Colonel GOULD. What is the construction leadtime for the fiscal year 1964 items?

Mr. LILLY. Construction leadtime on the 1964 items is approximately 25 months.

Colonel GOULD. A comparison of the fiscal year 1963 cost estimate as shown in the fiscal year 1963 justification books and as shown in the fiscal year 1964 books differs to a considerable extent.

Aside from the individual differences of the line items involved, the total in the 1963 books was $176,500,000.

The total in the fiscal year 1964 books indicates $167,850,000.

Why did this difference of $9 million occur?

Mr. LILLY. The amount that we requested for fiscal year 1963 of $176 million was reduced as you recall by this committee by approximately $3 million.

The difference therefore becomes $173 million reduced to approximately $168 million.

Colonel GOULD. Would you please compare the fiscal year 1963 items as presented last year and the fiscal year 1963 items as shown in this book and define the reasons for the variances?

Mr. LILLY. The explanation of the variances will be by categories:

1. Site development and utility installations: $4,050,000 in the fiscal year 1963 book versus $4,780,000 in the fiscal year 1964 book.

The 1964 estimate is based on better criteria. The 1963 estimate was submitted before field investigations were completed.

2. Facility construction and modifications: $106,870,000 in the fiscal year 1963 book versus $93,019,000 in the fiscal year 1964 book.

The revised figure is based on the selection of a crawler transfer system in lieu of a rail transfer system. Also the fiscal year 1964 estimate for the vertical assembly building (VAB) is based on a more comprehensive analysis of the operational requirements of this facility.

3. Equipment, instrumentation, and support systems: $48,875,000 in the fiscal year 1963 book versus $53,551,000 in the fiscal year 1964 book.

The fiscal year 1964 estimate is based on completed engineering studies in this area.

4. Engineering services: $16,755,000 in the fiscal year 1963 book versus $16,500,000 in the fiscal year 1964 book.

The fiscal year 1964 estimate was revised to reflect the refinements made in the major categories which engineering services support.

Colonel GOULD. Would you define the functions of the instrumentation facility and its relationship to the range operations facility, please?

Captain HOLCOMB. Actually this instrumentation facility will be used to house antenna which is used in conjunction with the vertical assembly building instrumentation in connection with your RF tie-in to the pad and to the central instrumentation facility. Because your RF signal has to be remote from your operating equipment, it is necessary to separate this building from the vertical assembly building.

Colonel GOULD. What is the cost per mile of crawler roadway?

Mr. LILLY. The cost per mile is approximately $1,580,000.

Colonel GOULD. Per mile?

Mr. LILLY. Per mile.

Colonel GOULD. The transfer system including the fiscal year 1963 and 1964 increments will cost $12.6 million.

Would you define the scope of this work, please?

Mr. LILLY. This will provide approximately 8 miles of transfer system from the vertical assembly to three pads.

Colonel GOULD. I note that the cost of the data link terminal and repeater buildings is $32.15 per square foot.

Could you explain the structural characteristics of this building which make the cost so high, please?

Mr. LILLY. These facilities will be constructed of reinforced concrete and those buildings near the launch pads will have blast protection. Extensive hu-

midity and temperature controls will also be provided to satisfy the requirements of the equipment that will be housed in these buildings.

Colonel GOULD. How many personnel will be provided office furnishings for $600,000?

Mr. LILLY. There will be about 2,000 people operating out of the vertical assembly building complex. Approximately 1,200 of these people will need office furniture and of this number some 300 persons will require only minimum type furnishings.

Colonel GOULD. What type of special power supply are we going to provide in this complex that will cost $9.2 million?

Mr. LILLY. Although these funds are listed for the vertical assembly buildings, they will be for the high and low bay area and the control areas of the launch complex, the pads and the lox.

The equipment procured will provide isolation against feedback and close-tolerance frequency control, synchronization and wave form control.

Colonel GOULD. I note the cost estimate includes $1.2 million for shop equipment, special handling equipment in the amount of $2.1 million, and mechanical equipment costing $1.5 million.

Have you compiled a list of the specific equipment which is going to be purchased for this $5.8 million or is this just a very preliminary estimate?

Mr. LILLY. The estimate is more than just a preliminary estimate, Colonel Guild.

The basis of the cost estimate is for like equipment installed in existing complexes.

We do have lists of equipment. It includes such items as a Siberian test stand, supply platform, supply test stands, recorders, theodolites, voltmeters, oscilloscopes, strip recorders, lab equipment, rate tables, frequency stands, weight recorders, cranes, and dollies.

Colonel GOULD. Most of the things that you read of probably have a procurement leadtime of 12 months or less.

The construction leadtime for this facility is 25 months.

Why couldn't this equipment be deferred until fiscal year 1965?

Captain HOLCOMB. When we speak, Colonel Gould, of having an operational date of the end of November or the first of December 1965, this means that the facility has actually been completely done as far as bay No. 1 is concerned in construction, and in initial outfitting by the end of May.

During this period from May to December we are going through an extensive checkout of the complete facility, including bringing in a dynamic facility checkout vehicle and ringing it out just as if it were a flight article in every respect.

When we say that we have an operational capability then beginning in December we mean at that point we are able to bring in the first flight article, put it on the launcher umbilical tower in the building and check it out for our first launch in early 1966.

Therefore our requirement for this type of equipment is actually a requirement for delivery in installation during the first part of calendar year 1965.

The leadtime would preclude delaying this until a later fiscal year.

Colonel GOULD. When are the transporters scheduled to be delivered?

Captain HOLCOMB. Are you talking about the crawlers?

Colonel GOULD. Yes.

Captain HOLCOMB. The first transporter is delivered in November of 1964 and the second one in March of 1965.

ADVANCED SATURN SUPPORTING FACILITIES

Colonel GOULD. Was there any change in the scope of work authorized in the fiscal year 1963 program and that which is now planned from 1963 funds?

Mr. LILLY. There was no change in the scope of facilities required to support the program as originally planned for the lunar landing mission at the launch operation center.

The fiscal 1963 facilities were planned to support the first phase of the buildup of this area.

The 1964 facilities are a continuation of the support facilities required as a buildup of the personnel and as the mission increases.

Colonel GOULD. What is being used now to meet these requirements and why can't the 1962 facilities when completed plus existing facilities be continued in use?

Captain HOLCOMB. There are no existing facilities at this time on Merritt Island. The only existing facilities are those which are in the cape area.

As the center of gravity of operation moves to Merritt Island in support of the Saturn V operations, the facilities which are currently in use in the cape area will be filled up as rapidly as we empty them by our contractor personnel who will be conducting a large percentage of our actual launches with the Saturn I and the Saturn I–B.

Colonel GOULD. How much storage space in the central supply building was provided in the fiscal year 1963 program?

Mr. DIAZ. Fiscal year 1963, 33,600 square feet was provided as part of the central supply.

Colonel GOULD. In last year's testimony you indicated a requirement for 73,000 square feet.

What change in plans brought about this change in scope?

Mr. LILLY. The scope stated in the fiscal year 1963 budget has not changed. The central supply building provides 33,600 square feet of 73,000-square-foot requirement. This facility was initially planned for the existing area and approved under the project supporting facilities—existing area, it is now included in the Advanced Saturn/Nova supporting facilities project and sited in the new area. The remaining approximately 40,000 square feet, for the total of 73,000 square feet, is for a supply shipping and receiving building that is included in the approved project Apollo mission support facilities. The 73,000 square feet of storage space was approved as two separate facilities and will be built in this manner.

Colonel GOULD. I also note that you have 36,000 square feet existing in the existing industrial area.

What criteria was used in arriving at a total requirement of 109,600 square feet of covered storage?

Would you provide an answer to that question for the record, too?

Mr. LILLY. Included in the central supply requirement of 109,600 square feet are 36,000 square feet of space located in the existing area. These facilities are for the support of the Saturn I and Saturn I–B programs. The remaining 73,600 square feet will be constructed in the new area. This space will be used to support the Saturn V program. The criteria used in arriving at this requirement was based on the experience gained during the Saturn I program correlated to the needs of the Saturn V program.

Colonel GOULD. What do you have to store to support the contractor personnel?

Mr. LILLY. This is used for storing material for the Saturn I program, the 6,000 square feet in the old area.

Colonel GOULD. The addition to plant maintenance facilities will provide an additional 45,000 square feet of maintenance space.

How much do you have at the present time?

Mr. LILLY. We have authorizing plans for 15,000 square feet.

Colonel GOULD. That is from the 1963 program?

Mr. LILLY. Yes.

Colonel GOULD. How is the stated deficit in maintenance space being met now?

Captain HOLCOMB. This is a question of Merritt Island facilities which are not yet constructed.

This plant maintenance facility is to support the operations in the Merritt Island area.

Colonel GOULD. When you complete the 16,000-square-foot facility, will you have enough plant maintenance facilities to meet your requirements?

Captain HOLCOMB. That is correct.

However, it is phased to meet the buildup of the rest of the facilities in the industrial complex and the launch complex 39.

Mr. LILLY. I could add to that that the maintenance facilities that are now under construction in fiscal year 1963 plan to be operational in November 1963 and will be used initially to maintain the facilities in this time period.

We require the additional scope because the construction of the buildings and grounds, roads, and utilities will be at peak in this new area at which time the workload on these facilities will increase and the 1963 scope was planned for the maintenance work required in that time frame.

Colonel GOULD. I notice you call for an addition to the central supply building and addition to warehouse facilities.

Would you define the difference in requirement for these two types of storage facilities, please?

Mr. GRAHAM. This central supply building will be used to store items that are requirements for NASA and its supporting contractors.

The warehouse facilities will store hardware, small electrical items, paint, oil, and lubricant items, lumber, and building and bulky construction materials, and it will also include a humidity controlled area for storage of electrical supplies.

Colonel GOULD. Was there a previous increment to this phase of the project?

Mr. GRAHAM. There was a previous increment for both of these facilities.

Colonel GOULD. What is the size of the previous increment for warehouse facilities?

Mr. LILLY. We have authorized 20,000 square feet in the fiscal year 1963 program as the first increment.

Colonel GOULD. This 80,000 additional square feet that you are asking for will bring you to a total availability of 100,000 square feet?

Mr. LILLY. That is correct.

Colonel GOULD. How about open storage area?

Was any previous increment included in 1963?

Mr. LILLY. No.

Colonel GOULD. The 1964 item constitutes the total requirement for open storage of 6,700 square feet?

Mr. LILLY. That is correct.

Colonel GOULD. Are there any facilities existing which could be used to accommodate the security forces?

Mr. DIAZ. No, sir.

Mr. LILLY. No security forces will be used in the new area until the buildup of facilities of the new area is sufficient to warrant their use.

This facility is timed so it will be available at the time the security forces are required in this area.

LOCK CHANNEL

Colonel GOULD. Has there been any previous NASA authorization for this project?

Captain HOLCOMB. No.

Colonel GOULD. Any reprograming?

Mr. DIAZ. No.

Colonel GOULD. I assume this is part of the civil works project now being programed by the U.S. Army engineers?

Mr. LILLY. That is correct.

Colonel GOULD. I reviewed the civil works project recently and it indicates a total of $700,000 reimbursement from NASA required to meet the larger lock dimensions which have been specified.

Also the civil works project in the amount of $700,000 includes the operations building and the lock operations equipment.

Consequently it appears as though a dual funding might be evident here.

Could you comment on that please?

Mr. LILLY. Colonel Gould, the estimate that we have included in our budget for this project, based upon the requirements supplied to us, are from the estimates supplied by the Corps of Engineers.

If upon checking with the Corps of Engineers they are providing this facility I would agree with you that we would have no use for double budgeting here.

Colonel GOULD. The $15,000 requested for design and engineering services is for what?

Mr. DIAZ. That $15,000 was for the dredging, the site preparation and construction.

Colonel GOULD. Again, the $700,00 includes the design of the lock, to include site preparation and utilities connection. Where or what is the cost of engineering for the channel dredging alone?

Mr. LILLY. The estimate on this, Colonel Gould, is about $12,000.

LAUNCH EQUIPMENT SHOP

Colonel GOULD. Are there no facilities at the industrial area existing that could be used to meet this need?

Captain HOLCOMB. There are no facilities on the cape area which will provide the capability which this shop will have of handling items of the size and weight of such things as your umbilical tower swing-arm attachments, your holddown for the launch vehicle, things of this size and scope.

MODIFICATIONS TO SATURN LAUNCH COMPLEX NO. 34 AND SATURN LAUNCH COMPLEX NO. 37

Colonel GOULD. It is my understanding that complex 34 was originally an Army facility turned over to NASA, is this correct?

Captain HOLCOMB. That is correct.

Colonel GOULD. Since being turned over, it is also my understanding that additions and modifications have been programed in the amount of $13.5 million for this facility.

Have all of these modifications been made?

Captain HOLCOMB. Not all the modifications have been made. Some of them are underway at this time scheduled to be completed the latter part of this year.

Colonel GOULD. This would be basically the fiscal year 1963 increment of modification?

Captain HOLCOMB. That is correct.

Colonel GOULD. What is the equivalent history of complex 37?

Mr. LILLY. Complex 37 was budgeted for one pad in the fiscal year 1961. The amount of money that was originally provided was $18,967,000, and in 1962 an additional $22,951,000 was provided.

In fiscal year 1963 we have programed $1,150,000 for certain modifications. This complex, as distinguished from complex 34, provides two pads.

UTILITIES INSTALLATIONS

Colonel GOULD. Before getting into the fiscal year 1964 item, I would like to explore for the committee a recent reprograming action having to do with a water supply system from Cocoa Beach to serve the Merritt Island area.

Under date of February 21, 1963, NASA notified the Congress of a reprograming action in the amount of $1.1 million from fiscal year 1963 funds for the construction of municipal water facilities in the city of Cocoa Beach. This was justified on the basis of a 2.5 million gallon-per-day requirement to support the Merritt Islan. area and the fact that the city of Cocoa was unable to finance the necessary expansion.

Under this reprograming action, NASA proposes to build three new wells, the construction of and additions to booster pumping stations and water treatment plant, piping from the well field and the treatment plant, and a 2 million gallon water tank.

These facilities, as I understand it, will be built on municipal property in the city of Cocoa Beach. I also understand that NASA proposes to amortize this investment by reduced water rates over the next 35-year period.

The first question is, What was the source of these funds?

Mr. LILLY. The $1.1 million was provided through reprograming authority using the authority to transfer R. & D. funds to construction of facilities.

Colonel GOULD. These were R.D. & O. funds then.

Mr. LILLY. In the first instance.

Colonel GOULD. Does the entire Canaveral complex draw water from Cocoa or are there any Government water plants existing?

Mr. DIAZ. They draw water from Cocoa.

Colonel GOULD. How about Patrick Air Force Base?

Mr. DIAZ. Cocoa.

Colonel GOULD. Has the agreement with the city of Cocoa been consumated?

Mr. LILLY. Yes, it has.

Colonel GOULD. Has construction been initiated on the proposed municipal expansion?

Mr. LILLY. No, sir, just design.

Colonel GOULD. Who will supervise this work, NASA or the city of Cocoa?

Mr. LILLY. The Air Force will actually supervise this work for the Government.

Colonel GOULD. Who is going to accomplish the design work?

Mr. LILLY. A company by the name of G. Jensen from West Palm Beach, Fla., is doing the design on this.

Colonel GOULD. Under the supervision of the Air Force AIO?

Mr. LILLY. Actually they will be working for the city.

Colonel GOULD. After construction who holds title to the capital improvements?

Mr. LILLY. The city will hold title to that property in the city of Cocoa.

Colonel GOULD. Will all these facilities be located on other than Federal land?

Mr. GRAHAM. The mains will be the property of the city of Cocoa to gate No. 2 at the Merritt Island area.

Colonel GOULD. What is the difference in the previous water rates and those that will be in effect after this expansion has been accomplished?

Mr. LILLY. The normal rate is 17½ cents per thousand gallons. Our rate under the provisions of amortization will be 10½ cents per thousand gallons.

Colonel GOULD. In other words, you are going to save 7 cents per thousand gallons for the purposes of amortization which works out to $1,750 per day. On this basis why are you amortizing this work over a 35-year period?

Mr. LILLY. The actual amortization time was originally as you stated estimated at 35 years. However, in the completion of the negotiations and the revisions of the water rate usage, it is estimated that the Government will amortize its investment in a period of 24 years.

In terms of the actual credit, I believe the agreement calls for a delivery charge refund, a credit of 7 cents per thousand gallons on each monthly bill not to exceed 50 percent of the net earnings.

Colonel GOULD. The normal amortization period for improvements to non-Federal properties while not a matter of law, is usually, on a rule of thumb basis, 10 years. The 24-year period of amortization in this case is a little excessive.

Would you define briefly for us, please, the scope of the work involved in the utilities installations for the new area?

Captain HOLCOMB. This project provides additional primary interior and industrial area roads, water, electric, and telephone system extensions and site improvements needed to complement the development of the new Merritt Island area proposed for the fiscal year 1964.

It supplements the fiscal year 1963 project and includes items which did not require an early completion date.

Additional utilities will be required in the future to support subsequent years' construction programs.

Colonel GOULD. How much was authorized in fiscal year 1963 program for these utilities and how much has been obligated to date?

Mr. LILLY. $39,068,000 including $360,000 for advance design, $4,250,000 for relocation of the Intracoastal Waterway is authorized. As of March 31, $23,897,000 was obligated for site roads, access roads, causeways, utilities and communications facilities.

Colonel GOULD. I noticed that you are calling for 9 miles of new two-lane road and bridges between Orsino and Wilson. It works out to about $296,000 a mile. Would you compare this with the roadwork being done in Mississippi, please?

Mr. LILLY. I believe you refer, Colonel Gould, to the estimate we had on the Mississippi highway of $160,000 a mile compared to this one. I believe, however, in arriving at your figure of $296,000 you use the total of $2,675,000 for this 9 miles of road. Approximately $500,000 of this is for bridge construction. Eliminating the bridge construction, the average works down to about $200,000 or $210,000 per mile. The basic difference between this figure and that in Mississippi, is due to the soil conditions, the large quantities of muck in this area which must be excavated and replaced with borrowed material and in order to properly drain the swampy area, an unusually extensive drainage system is needed.

Colonel GOULD. Is this a blacktop highway?

Mr. LILLY. Yes, sir.

Colonel GOULD. Would you define the extent of the water mains portion of this project for $700,000, please?

Mr. LILLY. It includes 2½ miles of 16-inch pipe, 5 miles of 10-inch pipe.

Colonel GOULD. I notice that you request $140,000 for a sewage collection system. What does this consist of?

Mr. LILLY. The Merritt Island launch area will have a sewage treatment plant. This facility with mains to the industrial area was funded in fiscal year 1963. The $140,000 included in the 1964 program is for service lines to serve the facilities included in this program.

Colonel GOULD. Under the item of communications, what is the $160,000 for miscellaneous system items to be used for?

Mr. LILLY. This is to provide the service connections to the main system.

Colonel GOULD. Specifically what will be done in the area improvements project for the 30 square miles of shoreline estimated at $1.2 million?

Mr. LILLY. This item includes the work to clear and drain those low, swampy lands in the vicinity of the shoreline of the river and creeks. The cost is based on similar work that was done in the AMR area.

Colonel GOULD. Is any construction to be accomplished on the lands thus reclaimed?

Mr. LILLY. No construction is planned in this area.

Colonel GOULD. Specifically how deep inland from the shoreline will this area improvement encompass on an average?

Mr. DIAZ. It will be approximately a half mile.

Colonel GOULD. Specifically what will be done in the way of area improvements for the 5 square miles of interior land at $30,000 per square mile?

Mr. LILLY. This is essentially the same as along the coastline with the exception that not as much drainage work will be required.

Colonel GOULD. On the improvements to the shoreline, does this include breakwaters?

Mr. LILLY. No, sir.

Colonel GOULD. I notice that two additional 1,500-square-foot pumping stations are being provided. What relationship do these stations have to the ones being provided in the Cocoa City municipal system?

Mr. LILLY. These stations we are providing will be on site. The city of Cocoa furnishes water at 40 pounds per square inch. On the long lines of mains within the Merritt Island launch area it is necessary to have a booster pump to overcome the pressure loss.

Colonel GOULD. How many pumps are being purchased for $50,000?

Mr. LILLY. Two.

Colonel GOULD. Under communications equipment and cable system I note a requirement for 500 miles of outside plant cable at a cost of $8.7 million. Would you please give us a detailed justification for the requirement of that much cable.

Mr. LILLY. This item includes audio, teletype, data transmission and remote control cabling in most instances, multiple cables are installed between specific points to provide essential backup. The general areas connected by this cabling are:

(1) The existing industrial area and the new industrial area. These areas are approximately 7 miles apart.

(2) The new industrial area and the Launch Complex 39 area. These areas are about 5 miles apart.

(3) The range instrumentation sites and the Launch Complex 39 area, the new industrial area and the existing industrial area.

(4) There are some 23 instrumentation sites and the majority of these facilities are located in remote areas, as an example a high resolution tracking radar site is about 20 miles from the new industrial area.

Colonel GOULD. I also note a requirement for a video switching system. Would you please explain what this consists of?

Mr. LILLY. This system will consist of switching equipment similar to communications type switching gear. The equipment will channel incoming video signals to various points as may be necessary in connection with launch operations.

Colonel GOULD. Included in this project estimate is a requirement for $200,000 for operating spare parts. Isn't it a little unusual to include operating stocks in a construction project?

Mr. LILLY. It is unusual, I think, Colonel Gould, in comparison with the major construction programs that have gone on in most other Government agencies such as the Department of Defense. However, NASA has operated under a turnkey concept which means we include all such costs identified.

Colonel GOULD. Since spare parts and stock items of this type are normally one of operating expense, and since many of the other projects in the NASA budget this year do not include spare parts, my question is why are they included in this project and not in others?

Mr. LILLY. I will certainly check into any inconsistencies in here. Our policy has been to identify them wherever they could be identified and where we knew them in advance.

Colonel GOULD. Will the public address system requested as part of this project serve the entire Merritt Island area?

Mr. LILLY. Yes.

Colonel GOULD. The intercom system for $126,400, what is that specifically for?

Mr. LILLY. The intercom system will provide for communications between key offices. This means of communication will prevent the overloading of the telephone system in these areas of heavy traffic.

This requirement becomes very critical during major tests and launches.

VEHICLE MAINTENANCE AND SERVICE FACILITIES

Colonel GOULD. What facilities are being used now and why can't they be continued in effect?

Mr. LILLY. The current facilities being used are those located in the old cape area. These existing facilities are inadequate to support the increased number of vehicles we will be servicing.

MANNED SPACECRAFT FACILITIES

Colonel GOULD. In fiscal year 1963 there was authorized a spacecraft operations and checkout facility, control systems facility, environmental test and service facility, supply, shipping and receiving facility, a pyrotechnic test facility and a weights and balance facility.

Has construction been initiated on these facilities as authorized?

Mr. LILLY. Construction has started on the spacecraft operation checkout building and the supply facility. Design is underway on the pyrotechnic test and weights and balance facility. Construction is expected to start on these facilities in July of this year.

Colonel GOULD. Has there been any change in scope or intended use of funds subsequent to the 1963 authorization?

Mr. LILLY. The intended use of the facilities hasn't changed. The additional areas are required to support the Gemini program which was not envisoned when the 1963 program was submitted.

Colonel GOULD. Since the 1963 project included $2 million for site development, it would appear that most of the site development has been programed, particularly in view of the fact that the majority of the facilities in the 1964 program are additions to other buildings.

Would you provide furher justification as to the need for an additional $143,600 for site preparation in fiscal year 1964?

Mr. LILLY. The funds required are for the additional site development required for an addition to the facilities, the parking lot, service roads, clearing the area and extension of utility lines.

Colonel GOULD. What makes the cost of the addition to the checkout building so high, $30 per square foot?

Mr. LILLY. This cost is based on the bid prices we received for the initial construction on the building and is the same amount we are using for this addition.

Colonel GOULD. Have any advance design funds been committed for these additional facilities?

Mr. LILLY. We had identified a requirement for $225,000 for advanced design on these facilities. These details were given to your committee, I believe, in the reprograming action. The funding, I believe, has been authorized by the Administrator. I am not certain at this point whether it has actually been released to the Center.

Colonel GOULD. That will be all for the day.

(Whereupon, at 5 p.m., the investigation was recessed.)

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APPENDIX C

Meeting of Subcommittee on Manned Space Flight of the Committee on Science and Astronautics of the United States of America, House of Representatives, held on the 29th day of March, 1963, commencing at 9:45 a.m., in the city of Daytona Beach, Fla., on Route No. 92 at the General Electric facilities in the conference room.

There were present at that time and place the following members of the subcommittee:

Hon. Olin E. Teague, Chairman.
Hon. Joe D. Waggonner, Jr.
Hon. Edward J. Patten.
Hon. Don Fuqua.
Hon. James G. Fulton.
Hon. R. Walter Riehlman.
Hon. Richard L. Roudebush.
Hon. Edward J. Gurney.

And also present on behalf of the General Electric Co. were:

Mr. Richard L. Shetler, general manager, Command Systems Division.
Mr. J. K. Records, director, NASA support program.
Dr. L. E. Saline.
Mr. Henry Lehmann.
Mr. R. S. Grisetti.
Mr. E. T. Maher.

And also present the following NASA personnel:

Dr. Joseph Shea, Deputy Director, Systems, Office of Manned Space Flight.
Mr. James Sloan, director, integration and checkout, Office of Manned Space Flight.

Gail S. Lynch and Associates, official court reporters, Halifax Law Center, Daytona Beach, Fla.

Mr. SHETLER. Good morning, Mr. Chairman, and members of the committee.

It is a pleasure to have you here at Daytona Beach. We are very much aware of the demands on your time, and feel quite fortunate to have this opportunity to discuss our work in support of the Space Administration's Apollo program with you.

If it is agreeable, we will have presentations in each of the major areas of our activity on this program—checkout, integration, and reliability assessment. I will ask several of my associates to lead these discussions in some detail, and we will get on with this program in a moment.

In addition to your committee and the General Electric personnel, we are fortunate in also having with us this morning a number of representatives of the Space Administration. Particularly, we welcome the presence of Dr. Joseph Shea, Deputy Director for Systems of the Office of Manned Space Flight, and Mr. James Sloan, Director of Integration and Checkout for that Office, who are in the audience. Let me make clear that we will not look to these gentlemen to participate. We look on this as our opportunity—and responsibility—to explain our work to you in some detail.

And now to the work at hand. Let me open by recalling a statement Mr. Holmes made to your committee in a hearing a short time ago. I think it may explain in part—perhaps or suggest—why we are here today. He characterized the integration and checkout areas of the Apollo program as less tangible than some others. And so they are, or at first glance seem to be.

They are not as readily visible as a discrete part of the Apollo system machinery—like the spacecraft, a launch vehicle, the lunar excursion module, or the mammoth umbilical tower. And yet after considerable study and analysis we have come to realize that these aspects of the Apollo program have quite as much substance as these other things. The reason for this is that the integrated launch control and checkout equipment will be very much a major part of the

Apollo operational machinery. We would like, in our presentations today, to impart this sense of the very tangible qualities of our work. Our presentations have been framed with that objective in mind.

In addition, our discussions today will focus on the particular areas of interest that developed in the hearing in which our work was reviewed last week. The principal points developed then—and they are very fundamental points, indeed—related to the relationship of our work to the reliability of Apollo system components; our working relations with other Apollo contractors; the question whether this work would be more effectively done in-house by the Government; and the costs of this work—whether this is a tight program.

I am happy to see that the members of the committee who expressed interest in these areas are with us today.

To get the program started, Mr. John K. Records, Director of our NASA support program, will give a brief introduction to explain the Apollo Support Department organization and staff. He will be followed by Linde Saline, Hank Lehmann, and Bob Grisetti, who will respectively review the checkout, integration, and reliability assessment work areas in some depth. I will conclude with a short discussion of the last two points I mentioned. I think that due to the time it would make for a more effective discussion for questions to be put at the conclusion of each of the presentations, but we will try to answer questions as they are asked.

Jack.

Mr. RECORDS. Thank you, Dick.

I want to start off by briefly reviewing our history on the program, from my vantage point at least. In February of 1962 we undertook work against our contract. As you recall, the first phase of this was a 6-month study to see how we would relate to the Apollo program. During this time we also addressed ourselves to the organizational problem to see how we might best organize the work and where we might best be located. We did that kind of thing as well as the technical work.

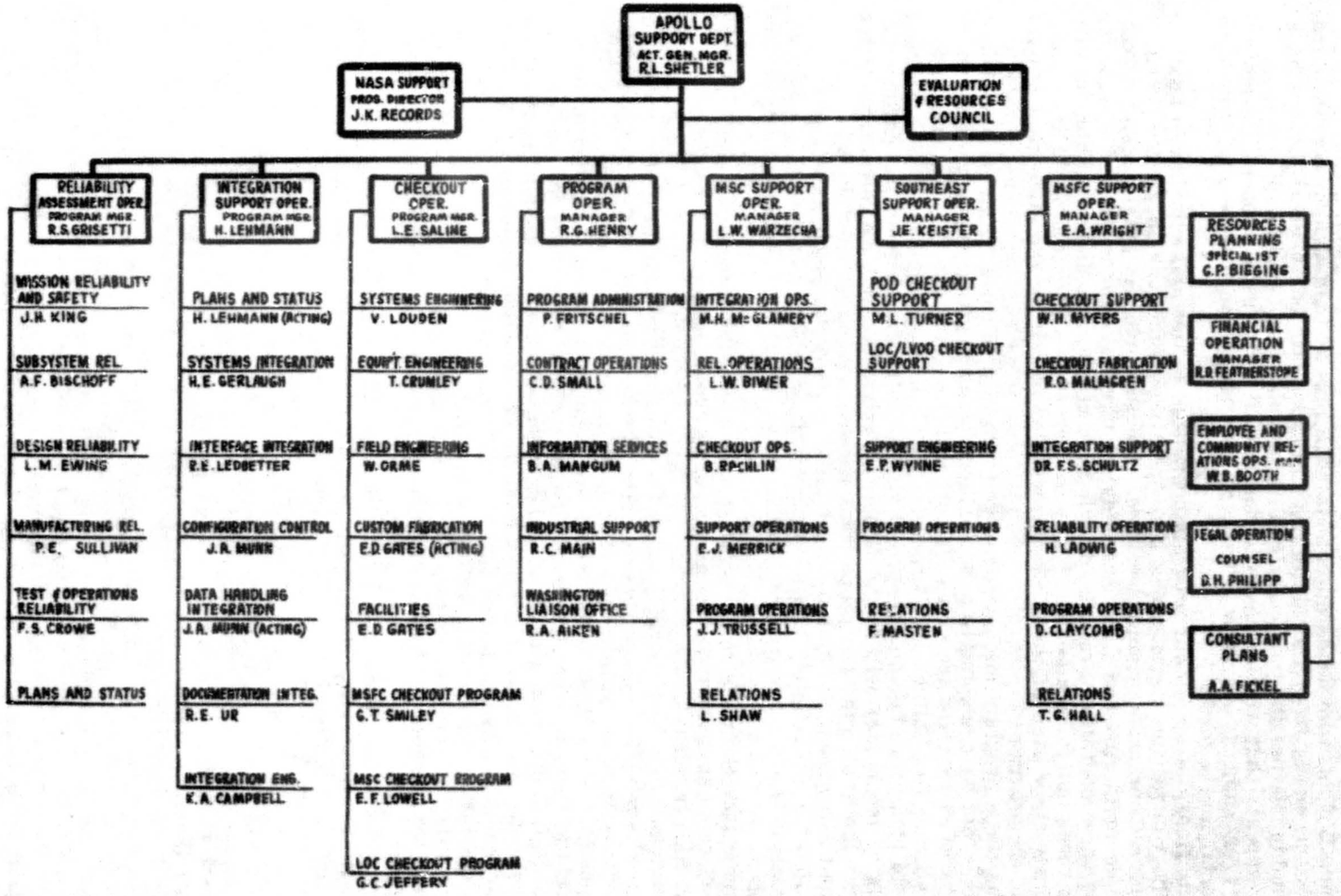
The first conclusion we reached was that a separate department within the General Electric Co. should be formed to more adequately focus our activity on the program. In our theory of organization, we quickly recognized that the three major areas of responsibility we had would necessarily be performed in four major locations, at Cape Canaveral, wherever we elected to put our headquarters, which turned out to be Daytona Beach, at Houston and at Huntsville, wherein the center support managers, our people, would also be responsible for that aspect of checkout, integration, and reliability assessment for the particular Apollo system elements represented at that center.

Now, it turns out that all three areas of this work slice across the major system elements of Apollo in much the same manner.

With that quick background, let me take a quick look at our organizational chart 1 for the department as it has evolved to date.

We have here in Daytona Beach the three program offices and you will be hearing from those fellows so I won't say much about their qualifications for their jobs. You can make your own judgments, as you hear them. I think they are well qualified.

I do want to mention in particular our three center support managers. We have Lade Warzecha, our manager for MSC support operations at Houston. Lade came with us from the Philadelphia operation, the Missile and Space Division, and is eminently qualified for our manned spacecraft work. Jim Keister is our manager of Southeast support operations at Huntsville. He is, of course, supporting LOC as well as the preflight Division out of Houston. Jim has had a wide variety of responsible engineering managerial assignments during his long years with us.


APOLLO SUPPORT DEPT.
ACT. GEN. MGR.
R.L. SHETLER
NASA SUPPORT
PROG. DIRECTOR
J.K. RECORDS
EVALUATION & RESOURCES COUNCIL
RELIABILITY ASSESSMENT OPER.
PROGRAM MGR.
R.S. GRISETTI
MISSION RELIABILITY AND SAFETY
J.H. KING
SUBSYSTEM REL.
A.F. BISCHOFF
DESIGN RELIABILITY
L.M. EWING
MANUFACTURING REL.
P.E. SULLIVAN
TEST & OPERATIONS RELIABILITY
F.S. CROWE
PLANS AND STATUS
INTEGRATION SUPPORT OPER.
PROGRAM MGR.
H. LEHMANN
PLANS AND STATUS
H. LEHMANN (ACTING)
SYSTEMS INTEGRATION
H.E. GERLAUGH
INTERFACE INTEGRATION
R.E. LEDBETTER
CONFIGURATION CONTROL
J.A. MUNN
DATA HANDLING INTEGRATION
J.A. MUNN (ACTING)
DOCUMENTATION INTEG.
R.E. UR
INTEGRATION ENG.
K.A. CAMPBELL
CHECKOUT OPER.
PROGRAM MGR.
L.E. SALINE
SYSTEMS ENGINEERING
V. LOUDEN
EQUIPT. ENGINEERING
T. CRUMLEY
FIELD ENGINEERING
W. ORME
CUSTOM FABRICATION
E.D. GATES (ACTING)
FACILITIES
E.D. GATES
MSFC CHECKOUT PROGRAM
G.T. SMILEY
MSC CHECKOUT PROGRAM
E.F. LOWELL
LOC CHECKOUT PROGRAM
G.C. JEFFERY
PROGRAM OPER.
MANAGER
R.G. HENRY
PROGRAM ADMINISTRATION
P. FRITSCHEL
CONTRACT OPERATIONS
C.D. SMALL
INFORMATION SERVICES
B.A. MANGUM
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R.C. MAIN
WASHINGTON LIAISON OFFICE
R.A. AIKEN
MSC SUPPORT OPER.
MANAGER
L.W. WARZECHA
INTEGRATION OPS.
M.H. McGLAMERY
REL. OPERATIONS
L.W. BIWER
CHECKOUT OPS.
B. RICHLIN
SUPPORT OPERATIONS
E.J. MERRICK
PROGRAM OPERATIONS
J.J. TRUSSELL
RELATIONS
L. SHAW
SOUTHEAST SUPPORT OPER.
MANAGER
J.E. KEISTER
POD CHECKOUT SUPPORT
M.L. TURNER
LOC/LVOO CHECKOUT SUPPORT
SUPPORT ENGINEERING
E.P. WYNNE
PROGRAM OPERATIONS
RELATIONS
F. MASTEN
MSFC SUPPORT OPER.
MANAGER
E.A. WRIGHT
CHECKOUT SUPPORT
W.H. MYERS
CHECKOUT FABRICATION
R.O. MALMGREN
INTEGRATION SUPPORT
DR. F.S. SCHULTZ
RELIABILITY OPERATION
H. LADWIG
PROGRAM OPERATIONS
D. CLAYCOMB
RELATIONS
T.G. HALL
RESOURCES PLANNING SPECIALIST
C.P. BIGGING
FINANCIAL OPERATION
MANAGER
R.B. FEATHERSTONE
EMPLOYEE AND COMMUNITY RELATIONS OPS. MGR.
W.B. BOOTH
LEGAL OPERATION
COUNSEL
D.H. PHILIPP
CONSULTANT PLANS
A.A. FICKEL

CHART 1

Gene Wright, who heads up our Marshall Space Flight Center support operation came to us from the Malta Test Station. He has a great deal of background in missiles and particularly in the propulsion and engine field.

It appears that we also have the classical kind of general support, the general kinds of support operations that are required for a business of this sort, financial, and so forth.

Gus Henry heads up our program operations section and supplies, in addition to the contracting negotiations and operations functions in general, what I would call program-oriented services. For example, in program administration he maintains the documented data control system wherein the data for these three operations, reports, drawings, et cetera, are made available on call. This turns out to be an efficient way to operate in a program of this type, particularly since each of these three areas need to call for the same kind of data out of the program.

The three program managers are going to talk in some detail in the amount of time that we are going to have available today to give you our understanding of the work that we are doing. I just want to make one further point before introducing Dr. Saline. We are very proud of the people that we have been able to bring together on this program. We have drawn from the various elements of technology within the General Electric Co. and we certainly haven't stinted the quality of the people that we are putting on this job, even though we had a tremendous buildup. Last fall when we completed the study we had a staff of approximately 200 people. As Mr. Shetler remarked last week, we have about 1,250 on board now, but we have not stinted on the quality of the people.

Now, Linde Saline is going to talk to you about the integrated launch control and checkout systems and other aspects of checkout. Linde.

Dr. SALINE. Thanks, Jack.

Gentlemen, checkout is the process for assessing the readiness of a system to achieve its mission. When we talk about checkout in relationship to equipment, we usually refer to certain tests that are performed in a given sequence on that equipment. Now, these tests, which are usually operational and calibrational are said to indicate a positive result if the results of those tests fall within some prescribed limits. On the other hand, when checkout is used in conjunction with people, the checkout process consists of tests and inquiries to ascertain if the people are available and that they are capable and ready to proceed with the preparation for and the performance of that mission. We are going to take a look today at checkout in view of the definitions that I have given for checkout and we are going to look at checkout particularly as it applies to the Apollo program.

Now, to get the proper focus from this checkout point of view, we are going to be a little parochial. I am sure that the spacecraft people have their view and the launch people have their view and we have our view of the Apollo system (chart 3). The important system elements that we look at are the spacecraft, the launch vehicle, the ground support equipment, the flight and ground crews. Checkout for the Apollo program goes over the whole duration of the Apollo mission from the time the equipment is assembled in the contractor's factories through the recovery phase of the program. However, today our particular attention is going to be given to checkout through the launch phase of the Apollo mission.

Now, when we take that view of checkout and when we look particularly at checkout through the launch phase, the purpose that we have in checkout is to support the launch director in making the launch decision with maximum confidence of achieving the mission success and flight safety.

Now, with those general ground rules, we are going to look in a lot more detail at what constitutes the checkout process. Now, to do this we are going to use a number of charts that we will explain in some detail to give you a feeling for what the checkout process really is.

APOLLO CHECKOUT....

SYSTEM ELEMENTS

SPACECRAFT
LAUNCH VEHICLE
GROUND SUPPORT EQUIPMENT
FLIGHT AND GROUND CREWS

DURATION OF C/O PROCESS

FACTORY
THROUGH
RECOVERY

PURPOSE

TO SUPPORT LAUNCH DIRECTOR IN MAKING LAUNCH DECISION WITH MAXIMUM CONFIDENCE IN ACHIEVING MISSION SUCCESS AND CREW SAFETY.

CHART 3

This particular chart that I am putting up here (chart 4) describes this whole process from the contractor's factory which is labeled here as "Pre-Mila," the Merritt Island launch area, operations through the entire process, the entire Apollo mission, until we get down to this box which is the recovery stage of the Apollo mission.

Now, I am going to point out some of the things that take place in the checkout operation to give you a feel for what this job is. That will form a basis for how we are going about designing the system and what some of the problems and challenges are in accomplishing this kind of work.

First of all, the general area of spacecraft. We have here arriving at Mila certain elements of the spacecraft system, the lunar excursion module, the command module, the service module, the adapter, the parachute and the launch escape system. When these arrive at the operations and checkout building, which is part of the industrial complex of Mila, these go through certain visual inspections. Certain assembly work is done on them. There are certain checkout tests and other kinds of operations performed in preparation for the launch. These go through such things as an assembly area, a cleaning area, where they are tumbled and vacuum cleaned. They go into certain areas where the weight distributions of the various systems are determined and checked out.

Certain of these modules, such as the command module, and the lunar excursion module, have to be taken out of the O. & C. building and they are sent off to remote facilities that have to do with the hypergolic tests and the cryogenic tests to ascertain if the propulsion systems are in a state of readiness.

Mr. FULTON of Pennsylvania. Could I suggest that you use the names rather than the initials?

Dr. SALINE. What is that now, sir?

Mr. FULTON of Pennsylvania. By the O. & C. building, and Pre-Mila if you will say it out for us, it will make it a little easier.

Dr. SALINE. Fine, sir; I will certainly do that.

Then after they have gone through some of these tests in certain remote facilities these various modules are again returned to the operations and checkout building for the final kinds of checkout tests and assembly tests that take place prior to the mating with the launch vehicle. These other kind of tests at that stage of the operation concern altitude chambers, vibration tests areas and such tests as that.

Now, let's take a very quick look at what happens with the launch vehicle. These stages of the launch vehicle arrive at Merritt Island and are put into the vertical assembly building. The S–IV–B and the S–II are sent immediately to the low bay areas of the vertical assembly building. The S–IC and the instrument unit are sent to the high bay areas. The S–IC is mounted immediately on the launch umbilical tower where it stays throughout the whole process down at Merritt Island.

Now, these stages again go through the visal inspections and certain basic subsystems tests and various visual inspections, preparations and so forth for the various stages of the launch preparation.

We then start going through the mating process where the S–2, for example, is mated to the S–IC and at that stage when they are put together there are more tests to see they are working in the proper manner as an integrated two-stage group as compared with the one-stage group. Then we go through additional mating processes where the S–IV–B is added and the instrument unit is added.

Finally we get down to the stage where the spececraft is moved the 5 miles from the operations and checkout building to the vertical assembly building and here we have the complete space vehicle assembled for the first time.

Now, at this particular stage of the preparation, the entire space vehicle system is put through simulated countdown and other preparations prior to its movement out to the launch pad and this, as you know, is a goodly distance, somewhere between 3 and 6 miles, depending on which launch pad is going to be used.

When we get out to the launch pad area, we have the mating of the launch umbilical tower to the launch pad itself and all of the attendant checks to be sure that that part of it is right. We have certain preparations that have to do with purging the propulsion systems, and adding the ordnance work, and so forth, to the overall system in preparation for the launch and finally we get down to the point where we are in the actual countdown operations that start a couple of days before the actual launch is planned.

After the launch we go through more checkout operations in each of these various phases. For example, in the Earth parking, orbit, when we get on the Moon, and when we are starting back into the reentry phases, and so forth.

PRE-MILA SPACECRAFT OPERATIONS

OPERATIONS & CHECKOUT BUILDING

S/C MODULE CHECKOUT AREAS
1. Receiving Inspection
2. Subsystem & System Checkout

S/C - ASSEMBLY AREA
Assembly & Checkout

S/C - MODULE CLEANING AREA
Cleaning by Tumbling & Vacuuming

S/M WGT. & C.G. AREA
Determine S/M Wgt. & C.G.

HYPERGOLIC TEST BUILDING
1. Reaction Control System Checkout for C/M, S/M, & LEM
2. Propulsion System Checkout for S/M & LEM

WEIGHT, BALANCE & INSTALLATION FACILITY
1. Install Pyrotechnic Devices in All Modules
2. Assemble All Modules, Weigh & Balance Spacecraft

ENVIRONMENTAL CONT. TEST BUILDING
Environmental Cont. System Checkout C/M - S/M & LEM

C/M - S/M & LEM TEST AREAS
1. Mated C/M - S/M Integrated Systems Tests
2. LEM Integrated Systems Test

PARACHUTE - PARAWING BUILDING
Inspect & Store Parachute

ORDNANCE INSPECTION & STORAGE BUILDING
Store LES

PARACHUTE - PARAWING BUILDING
Receiving Inspection & Storage

ORDNANCE INSPECTION & STORAGE BUILDING
Receiving Inspection & Storage

NASA INDUS

PRE-MILA LAUNCH VEHICLE OPERATIONS

MSFC HUNTSVILLE, ALABAMA
1. Subsystem Checkout
2. I.U. Assembly
3. I.U. Mfg. Checkout

DOUGLAS AIRCRAFT HUNTINGTON BEACH, CALIF.
1. Subsystem Checkout
2. S-IVB Assembly
3. S-IVB Mfg. Checkout

DOUGLAS AIRCRAFT SACRAMENTO, CALIF.
1. Pre-Static Checkout
2. Static Test
3. Post-Static Checkout

NORTH AMERICAN SEAL BEACH, CALIF.
1. Subsystem Checkout
2. S-II Assembly
3. S-II Mfg. Checkout

MISS. TEST FACIL. "B" WAVER, MISS.
1. S-II Pre-Static C/O
2. S-II Static Test
3. S-II Post-Static C/O
4. S-IC Static Test

BOEING CO. MICHOUD, LA.
1. Subsystem Checkout
2. S-IC Assembly
3. S-IC Mfg. Checkout (Pre-S/A/C)

BOEING CO. MICHOUD, LA.
S-IC Post-Static C/O

A TIME SEQUENCE IN ONE HIGH BAY

S-IVB Low Bay Area
1. Receiving & Inspection
2. Equipment Installation
3. Subsystem Checkout
4. All System Checkout
5. Prepare for Mating with S-II

S-II Low Bay Area
1. Receiving & Inspection
2. Equipment Installation
3. Subsystem Checkout
4. All System Checkout
5. Prepare for Mating with S-IC

1. Prepare for Installation
2. Install & Align S-IC on LUT
3. Inspection & Equipment Installation
4. S-IC Subsystems Checkout
5. S-IC All Systems Checkout
6. I.U. Subsystems Checkout
7. I.U. All Systems Checkout

1. Align & Mate S-II to S-IC
2. Interface Checkout

1. Align & Mate S-IVB to S-II
2. Interface Checkout

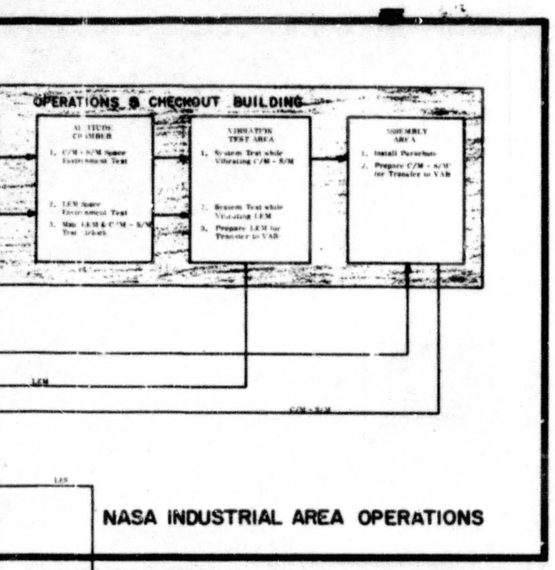
1. Align & Mate I.U. to S-IVB
2. Interface Checkout

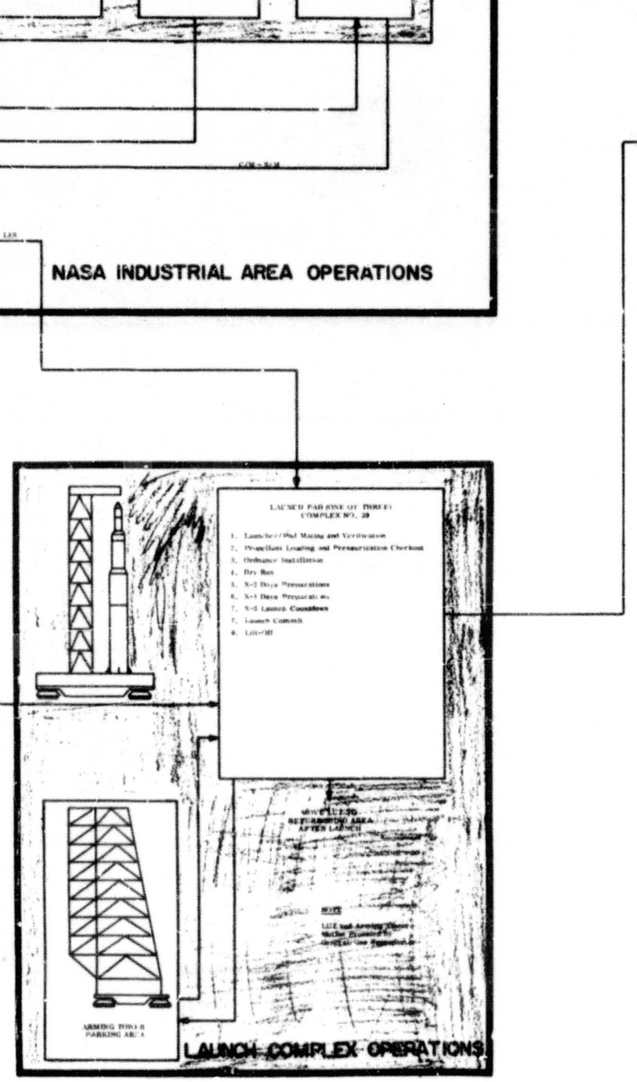
1. Align & Mate Spacecraft to Launch Vehicle
2. Space Vehicle All Systems Checkout
3. Space Vehicle Structural Countdown, Launch and Flight Checkout
4. Prepare for Transport to Launch Pad

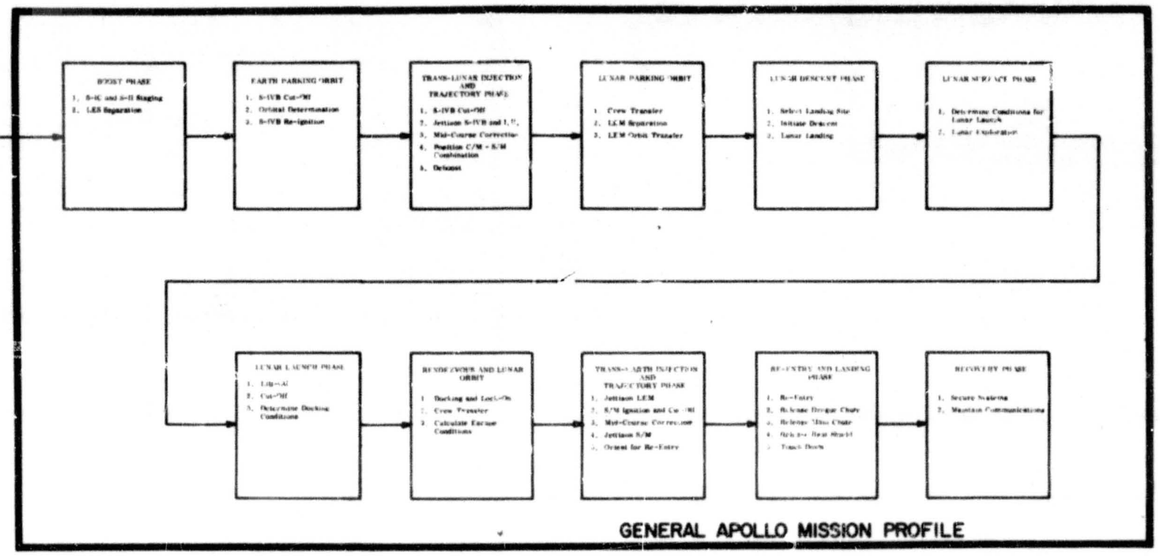
VERTICAL ASSEMBLY BUILDING OPERATIONS

ARMING TOWER PARKING AREA

CHART 4







SUMMARY OF APOLLO SPACE VEHICLE ASSEMBLY, CHECKOUT & MISSION EVENTS

SYSTEMS SYNTHESIS UNIT-CHECKOUT SECTION - ASD 3-13-63

Now, again, I would like to emphasize that what we are going to be talking about today concerns primarily the work up to this point on this flow diagram through the launch phase of the Apollo mission.

I would like to take just a moment now and go into a little more detail about what would happen typically at this stage for example, of the checkous process and then how that might vary as we get closer to the actual launch time, and I am going to use for an example here the test on the instrument unit. In particular here, when we look at the instrument unit which contains the guidance equipment and certain communications equipment, and so forth, we will look at one subsystem that would be called a transponder. At this particular point a typical test on a transponder would be conducted from a manual test bench. The transponder would be mated with this test bench and certain functional tests would be performed. The typical test that I have in mind is one that would take 15 minutes for two men operating the test bench to perform. They would measure certain things to see that this transponder was indeed operating as a functional unit.

Well now, as this instrument unit gets mated into the whole system it is no longer very convenient to conduct the test on that basis and so rather than to make sure, say, after 3 or 5 or 7 weeks after that initial test, to make sure that that transponder is still operating properly, we have to figure out some better way of ascertaining that it is in an operational mode.

Here, then, the experts that understand the transponder in intricate detail have devised what are called a number of test points that could be measured in some functional way to ascertain with the greatest probability that if the readings on those test points are right then the whole ransponder would, indeed, be working properly.

For example, we might choose a test point that would, say, measure the power supply voltage for the transponder and if that fell within certain prescribed limits, we would say that we should continue in the preparation of the countdown procedure and that indeed it is highly likely, very close to certainty, that everything would be all right as far as that transponder is concerned. I want to give you the feel here that we have to go from tests that are almost certainty to things that are somewhat less than certainty because of the time element involved, the tremendous complexity of the system, with all of its millions of parts, that would actually preclude, as we get closer and closer to the launch countdown, repeating these tests as frequently as we need to have the assurance that we are in a go position.

Now, the next thing that we are going to look at is a little bit about the actual kind of details of these tests descriptions, that are needed to plan and to execute this kind of a responsibility in the whole Apollo program.

What we are going to do here (chart 5), is to look at a symbolic chart that indicates the procedures and tests that must be conducted.

Now, this is a hierarchial chart because that is what checkout is when we look at all of the tests and procedures. You have looked at one flow diagram here that gives the overall test flow and checkout flow for this operation. Now, I have got here [Dr. Saline picked up a book] something that I don't expect you to look at in detail but I want to just walk you through this thing quickly because it will give you the kind of feeling of understanding that I think you are interested in. This particular block diagram, if you will just look at it here, is effectively a one-to-one correspondence with that big diagram I had here.

If, for example, we talk about the instrument unit and the transponder in particular to find out how we get from saying we want to test something functionally early in the checkout game to what is the specific test that is conducted, we take this particular block here which says the launch vehicle preassembly and assembly flow and this gives a little number. It happens to be S.K. 1.10—that isn't very important. The point is here that one block becomes blown up into another stage of blocks. We can then look into another block here and we can go down farther into the detail and we continue as we go farther into the actual hierarchy of the testing where we get down to the point where we have got a word description that says, "transponder test," and it gives several steps under this.

Now, the actual description that comes out is documented at that level of the heirarchy. A test description includes what actually occurs, what are the conditions, an estimate of the time involved and some of the technical details that have to be met before this test can be conducted.

Mr. GURNEY. I have a question.

Dr. SALINE. Yes, sir.

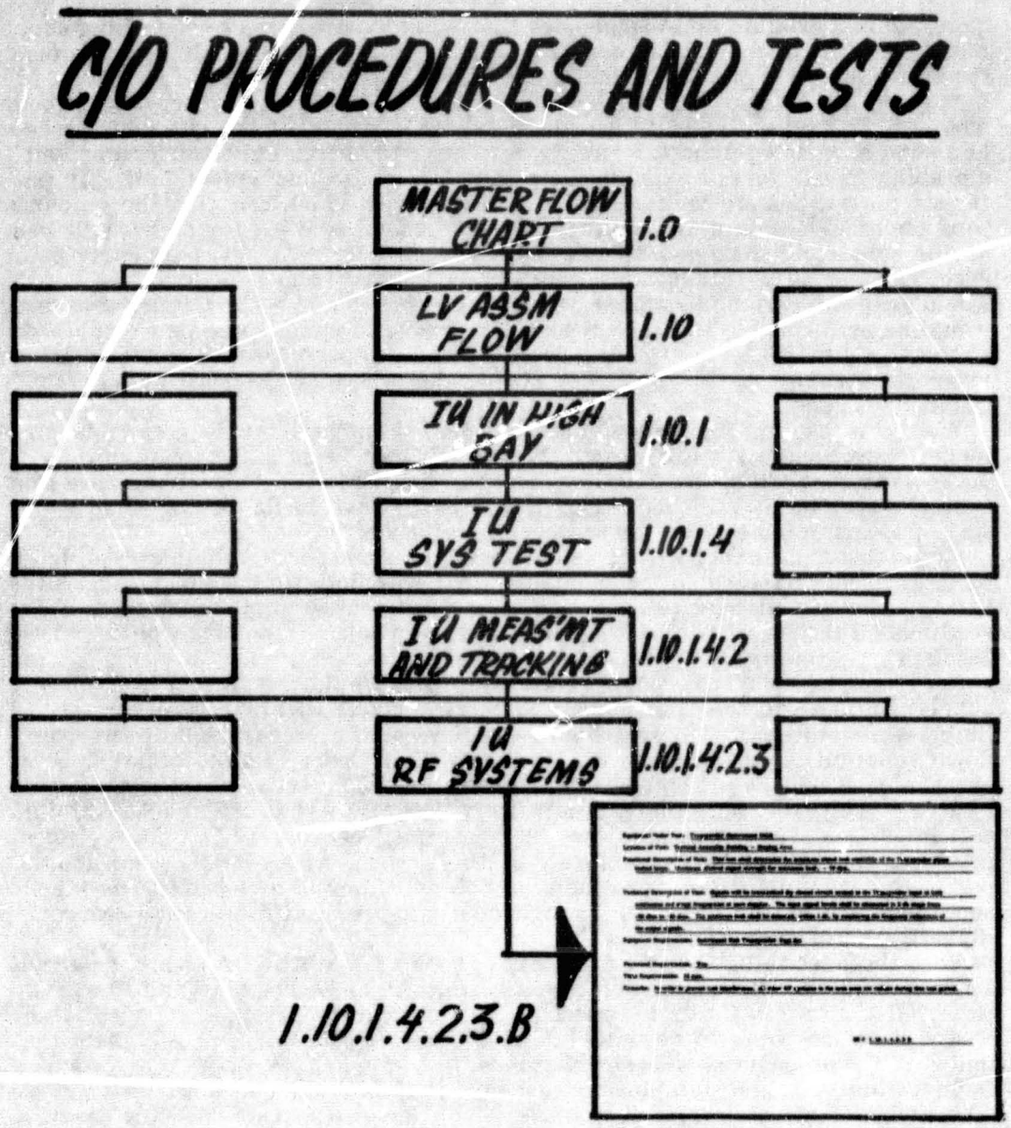


CHART 5

Mr. GURNEY. Are these charts done here in Daytona Beach?

Dr. SALINE. Yes sir, we are working on the description of these flows. However, a little bit later in my presentation I will show some of the information flow that it takes to derive these kind of charts. I would hasten to add, also, that we are just getting started on this kind of work, really. We will end up with literally many volumes of this kind of information to describe all of the details that are necessary to conduct these tests. That is one of the pieces of work that we are doing.

Mr. FULTON of Pennsylvania. Why doesn't NASA do that originally as an administrative and management function?

Dr. SALINE. Why doesn't NASA do that originally?

Mr. FULTON of Pennsylvania. Yes; as a management function on their own planning?

Dr. SALINE. They are contributing, of course, very heavily to this kind of work. This is really a joint process between NASA, its prime contractors, and ourselves. For example, take this particular unit here, this transponder. The prime contractor on the transponder, just like the prime contractor on the space vehicle, must be the technical expert who says if we measure these points and the readings come out right, that particular part of the overall system is in a go position.

We don't believe that General Electric or any other organization could be the expert to determine every aspect of the technical detail of a system of this kind. This is a joint effort that is underway and we are the ones who are documenting this and are going to work it out as I will show here. It is the overall program to accomplish the detailed procedures and tests that are necessary.

I would like to just say that we are in the process of doing this now. It is our estimate that there will be somewhere in the order of 2,000 or more of this kind of descriptive documents to detail exactly what has to happen along the way.

Well, now; I have indicated that some of these kinds of documents are to use a manual test set, for example, to check out some small subsystems. Well now, as we go farther down the pike, I indicated that we had to have more specific test points that could be checked out in lieu of the opportunity to do it in a more detailed basis.

It is our estimate now (chart 6), from the knowledge that we have, that the number of total test points that are going to be needed to check out the Apollo system in its launch operation are going to number 7,000. They will be roughly divided as follows: 1,400 in the spacecraft, 300 in the instrument unit, 1,000,

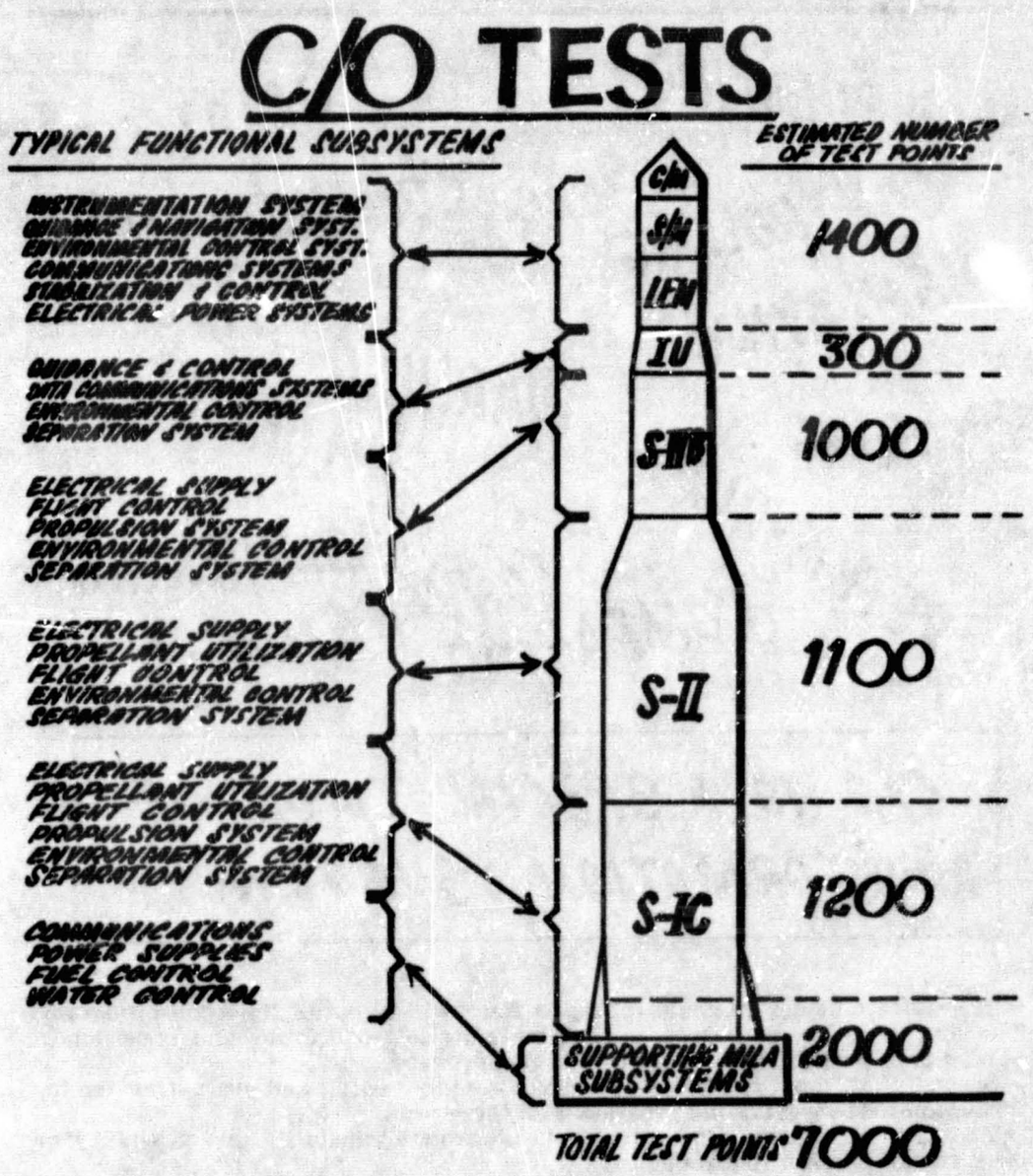


CHART 6

1,100, and 1,200 in the respective stages of the launch vehicle, and about 2,000 for the supporting subsystem at the Merritt Island complex.

I think you can get the idea that what is necessary here is a means for handling a great deal of information (chart 7). We are sensing information. We are communicating it. We are comparing it, we are storing it and we have to retrieve it. We have to manipulate it in various ways, what it really ends up with is that checkout is a very special case of an information system.

Well now then, we are getting a little feel at this point in our discussion this morning about what the overall job of checkout is, but we still have to get into how it is really going to be accomplished.

CHART 7

There are four design goals (chart 8) for the checkout of the Apollo program. The first of these, of course, is that we must have accuracy and consistency of results as we proceed through the checkout process.

Secondly, we must provide a means for rapidly testing and evaluating the information that we get as we progress with these tests.

The third is that we must provide basic growth capability and flexibility to meet future mission requirements.

Fourth, we must have early experience in the operational environment. We know what we are trying to do now. We know some of the design goals. We

APOLLO % DESIGN GOALS

- ACCURACY AND CONSISTENCY OF RESULTS
- RAPID TESTING AND EVALUATION
- BASIC GROWTH CAPABILITY TO MEET FUTURE MISSION REQUIREMENTS
- EARLY EXPERIENCE IN OPERATIONAL ENVIRONMENT

CHART 8

can then ask ourselves: What is the design approach that is going to be used to implement this work?

The first of these is that checkout is going to be performed in an integrated system (chart 9). We are not going to have one kind of system that does some-

APOLLO % DESIGN APPROACH

- ILCCS
- AUTOMATED GENERAL PURPOSE SYSTEM
- BACK-UP MANUAL MODE

CHART 9

thing for spacecraft and then something else that does something almost independently for launch vehicles and something independently for ground support equipment. What we are going to do is to have an integrated launch control and checkout system and this is referred to generically by the acronym ILCCS and if I slip in using that it's because it's like changing the color of my eyes to say anything else, but I will try to refer to it as the integrated launch control and checkout system.

Now, the second design approach is that we are going to use an automated, general purpose type of checkout system and the third part of the design approach is that we are going to provide a backup manual mode for that automated system.

I want to give you a feel now for what this ILCCS is going to consist of. I am not going to show anything that is going to resemble a great big detailed diagram connecting all of the various pieces of hardware together (chart 10).

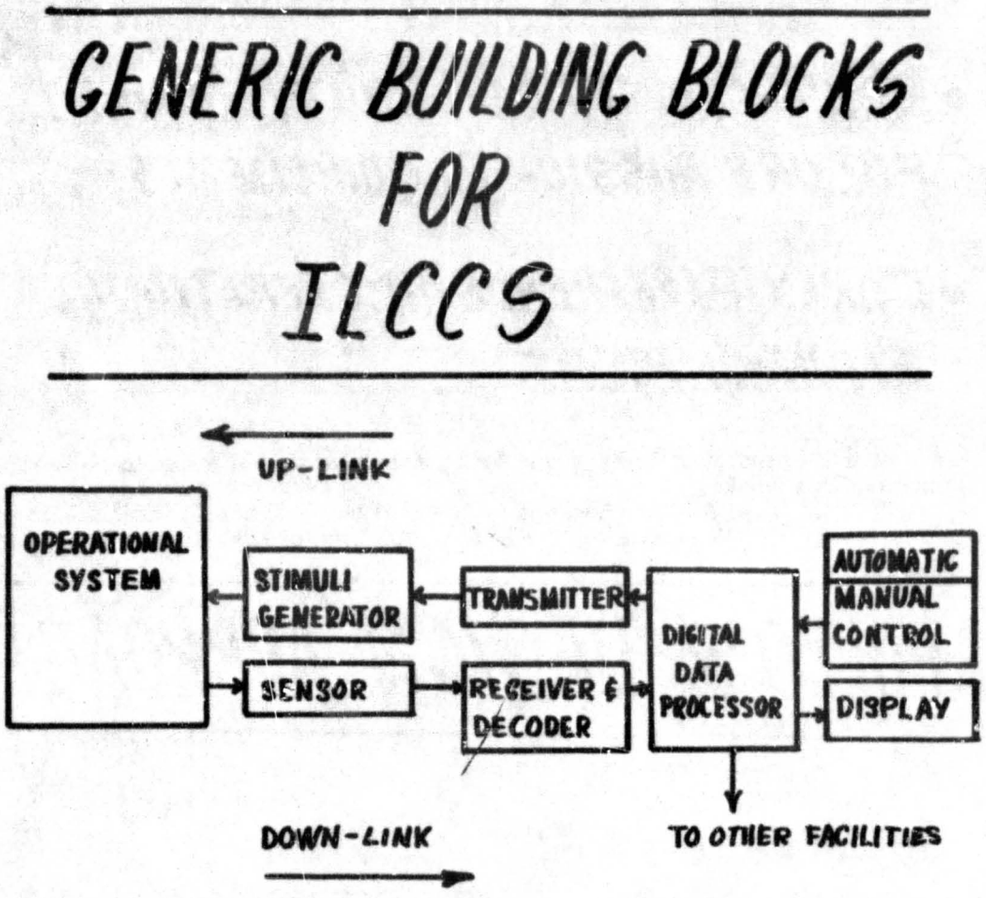


CHART 10

I am going to explain here, though, what the basic building block is. There are various ways to show this but I think this will be one that will be meaningful and helpful to you.

First of all, we have automatic and manual control functions that we use to initiate the checkout operation. We send a command through the digital data processer, and transmit that command through the up-link to the stimuli generators. The stimuli generators cause some element or arrangement of elements in the operational system to do something. You may measure a voltage, you may test a position of some mechanical linkage, or some other indication of that kind. Whatever happens in those operational elements or arrangement of elements is detected by these sensors.

The sensed information is then transmitted through the down-link to receivers and decoders that prepare this information for use in the digital data processer.

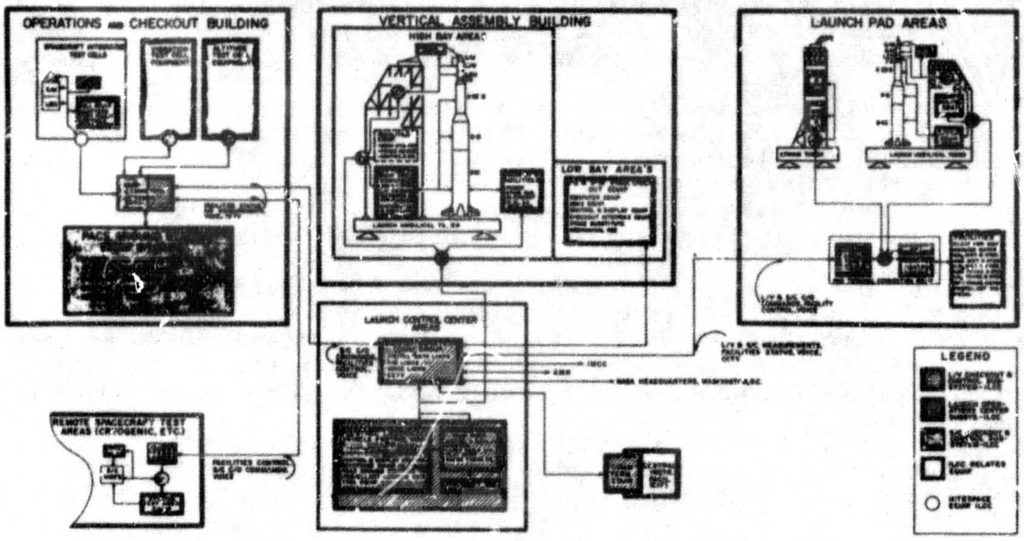
Now, the digital data processer performs some arithmetic manipulation, it may compare this information with the previous information and test it to find

out if it is within certain limits. Then if it is within these certain limits either of several things can happen. If it is in an automatic mode of operation, the system may say go on to the next step in your sequence of operations and send some other commands to do something else, and so forth. If it is in a manual mode, it may be desirable to have this information displayed for the test operator so that he can get a feel for what is happening with the overall performance and readiness of this system or it may be that both of these things occur simultaneously.

Nevertheless, we can get the feeling here, we have someone in command that is aking questions effectively of the readiness of this system and within the planned program of the whole system we can then proceed with the inquiries and the information that we need to assess the readiness of this system.

Now, at the present time, we are at the state in the description of the ILCCS, the integrated launch control and checkout system, where this has been fairly well documented in a general way. I am going to explain to you what this general way is.

We have here again some of the main geographic locations (chart 11). The operations and checkout building, the vertical assembly building, the launch control center, the launch pad, and certain kinds of remote facilities that are needed at Merritt Island for the overall launch preparation.



ILCC & RELATED FACILITIES FOR MILA

CHART 11

We have listed and put down various groups of pieces of equipment and, when I talk equipment here, I am also talking about certain soft ware aspects, and the people that go with this equipment. I will talk about this a little bit more a little later in the presentation. We have shown these groups of equipment and have related them one to the other and have described them in a little booklet that we call the integrated launch control and checkout center specifications although really it's more of a technical description than a specification at its current state of development.

If we look at the colors, the blue area on the chart signifies those areas that are particularly associated with the spacecraft checkout.

For example, we have here the PACE ground station—PACE is an acronym for preflight automatic checkout equipment—and this part of it relates particularly to spacecraft. Now, the other blue parts that you see here are related pieces of equipment that are going to be physically located in the launch control center.

Still you will see other bits of blue that are out on the launch umbilical tower and that are in some of these remote facilities that I alluded to earlier in the presentation.

Now, similarly the green color indicates the equipment that is primarily related to the launch vehicle checkout. The red equipment is that most closely associated with the launch operation center kind of activity. The yellow outlines

indicate that kind of equipment related very closely to but not a part of the ILCCS. Now to approach this kind of a system specification requires a great deal of information so far as what is going to happen, what has happened, what are some of the design goals, what is the overall approach that I mentioned to you earlier. To arrive at this kind of a description or specification we are using both a bottom-up approach and a top-down approach.

Let me describe what I mean by that. Already NASA and other contractors that have been participating in various space programs have done a great deal of work and have developed a great deal of experience in this kind of activity. We are building on the work that has already been accomplished to derive what this kind of a system should look like. We are not going to go out and invent a lot of new ideas that have not been tried or reinvent old ones. We are not going to go out and try to theorize about what an ideal system would look like.

The time constraint and urgency of the program do not permit that kind of academic luxury.

On the other hand, we are not just going to take the three building blocks, namely, the work for spacecraft, the work for launch vehicles, and the work for the launch operation center, and just set them side by side and say, "We'll put them down there and that is the way it will go." This is where the top-down look comes from. We are looking at it as an overall system, also, with systems engineering studies, and so forth, to make sure that we are getting the proper tradeoffs wherever appropriate among the various hardware and software so that they are related together in a sensible, reasonable, manner to accomplish the overall job that is needed for Apollo checkout in an economic and timely manner.

For example, one of the kinds of specific pieces of work that you may be interested in is an effectiveness model that we are deriving here in Daytona Beach for the overall integrated launch control and checkout system. This effectiveness model describes this particular system from the mathematical and logical viewpoint in the precise ways that all of this equipment and the actual procedures and methodology and people relate together to achieve the checkout objectives.

That is what we are going to use this model for after it becomes developed and it is another one of these things that is getting underway in good shape.

We don't have the total model written by any manner of means. We are still a ways off. What we are going to be able to use this for is to assess the validity of certain trade off and the effectiveness of the overall performance of the checkout system.

Well now, up to this point we have been describing essentially what the Apollo checkout program is, from the viewpoint of our company at any rate, and this is basic general information, to give you a feel for what our overall sphere of checkout activity is.

Specifically, General Electric's role as far as checkout is concerned (chart 12) is to supply the design, fabrication, installation, maintenance and operation, and logistic provisioning for the integrated launch control and checkout system at the Merritt Island launch area and for the integrated launch control and checkout system-related equipments at contractors plants.

Now, what I am going to do is to tell you about what this entails in the way of specific work and outputs.

Mr. ROUDEBUSH. Before you leave that I would like to ask a question. Who originally determined the need and method of checkout incorporated in a vertical assembly building? Was that your suggestion to NASA?

Dr. SALINE. That actually was derived by NASA and was set down as a general guideline for the approach to checkout.

Mr. ROUDEBUSH. Did you develop it after you received the general guideline?

Dr. SALINE. Yes, sir. The general guideline came from NASA.

Mr. ROUDEBUSH. Then the design of the building and the need for the building was your suggestion?

Dr. SALINE. No, we had nothing to do with the design of the facility at Merritt Island.

Mr. ROUDEBUSH. I was speaking of the test facility.

GENERAL ELECTRIC'S % ROLL

TO SUPPLY THE DESIGN, FABRICATION, INSTALLATION, MAINTENANCE AND OPERATION, AND LOGISTIC PROVISIONING FOR THE ILCCS AT MILA AND FOR ILCCS RELATED EQUIPMENTS AT CONTRACTOR PLANTS.

CHART 12

Dr. SALINE. Not of the test facility either; no. We have not contributed to that work. I think you can get an idea from this particular chart (chart 13) about the tangibility of checkout system for Apollo program. This is our best estimate at this stage of the program as to the actual hardware that is going to be required to implement the integrated launch control and checkout system.

The total number of cabinets is 4,150. Let me describe to you what we mean by a cabinet. We have chosen to describe this in the terms of an equivalent cabinet, when obviously there are many kinds of electronic cabinets used. We have chosen as a basic unit of measure a typical 19-inch-wide, 6-foot-high relay rack that is full of electronic gear, instrumentation, and recording apparatus of the typical kind that we have been using. This varies anywhere from large screen displays down to consoles that operators actually use to control the system and operate the system to the actual racks of the kind that I have described.

I would like to mention very briefly where we are at the present time in each of these main areas of work.

We currently have underway in the spacecraft area the engineering work for the PACE system. This is the preflight automatic checkout equipment. We have the engineering work well underway, and we are currently expecting the go-ahead on certain parts of the hardware procurement sometime within the next 2 or 4 weeks. As you walked through the building coming here you might have noticed an empty floor. It looks empty as far as actual in-line production is concerned, and this is correct. We moved into this building less than a month and a half ago and we are currently in the state of setting up the factory so that we can start the actual production of this gear in very short order.

In the launch area, we are currently writing a detailed program plan which will describe the overall approach to the launch vehicle checkout area including the fabrication plans, the design plans and all the other kind of supporting activities.

In the launch operation center, we expect that we will be starting to write our program plan within the next 2 months and as you notice here, I mentioned contractors' plants. Some of this equipment comes out of these spacecraft areas and other areas; it is related functionally and actually physically very strongly to the same equipment that we are designing and fabricating for the Merritt Island complex.

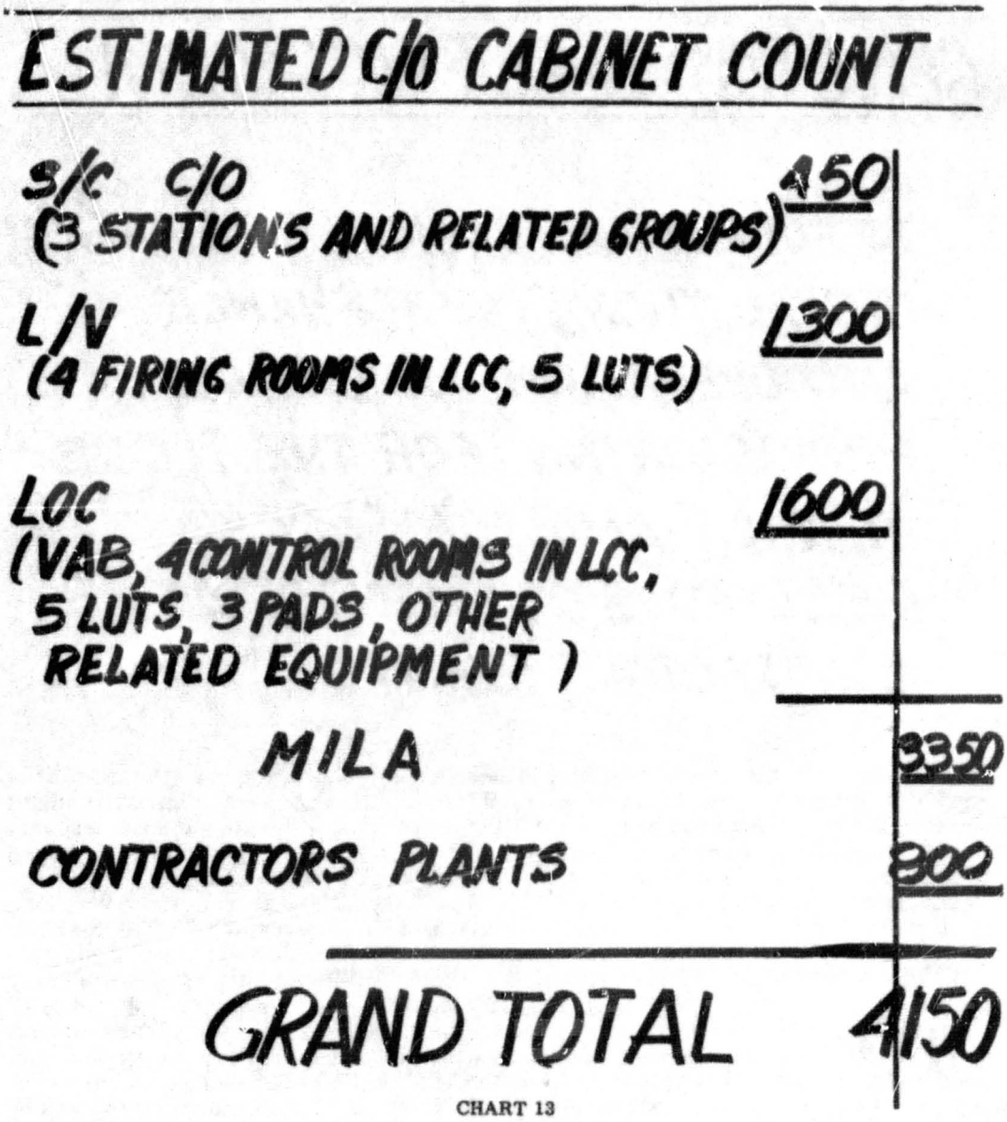


CHART 13

The grand total of this kind of equipment is over 4,000 cabinets. To give you an idea of something that might be representative of the type of things that we are going to be doing, this is at least symbolic of it (chart 14). I think that all of you have been exposed to this kind of control in blockhouses and so forth. This happens to be an artist's conception of a launch control center. We have large-screen displays. There are consoles, there are computer controls, and you'll see, off at the side, banks of electronic gear and this is the kind of equipment that we will be designing and fabricating here.

Some people may regard it as somewhat intangible; I hardly regard it as that, when I think of the number of racks and the kind of facilities, that we are talking about.

Mr. RIEHLMAN. May I ask a question, please?

Dr. SALINE. Certainly, sir.

Mr. RIEHLMAN. There is a lot of equipment displayed there that looks quite similar to the equipment that is presently being used for this purpose. Will there be any duplication of the type of equipment that is already available?

Dr. SALINE. I would hesitate to say that there won't be some duplication because to run a complex of the Cape Canaveral variety one must have some duplication of equipment. Let me hasten to say that there is going to be a minimum amount of reinventing the wheel, however. We are not just going to put in a lot of equipment in each site for the sake of the equipment. This is part of the

CHART 14

trade-offs that have to be studied that relate to launch schedules and plan and use of the equipment and so forth.

Mr. RIEHLMAN. Well, isn't there already equipment available to carry out this type of program?

Dr. SALINE. You mean available down at the cape, for example?

Mr. RIEHLMAN. Yes; has some other company already designed this type of equipment?

Mr. TEAGUE. Would it get to the heart of your question if he told us what will be the difference?

Mr. RIEHLMAN. That is a better way to put it.

Mr. TEAGUE. We fired a Saturn yesterday. Surely the same work was done for the checkout on that Saturn. What will be the difference when you are actually operating; what happens in the future, and what happened on the Saturn yesterday? Would that be your question?

Mr. RIEHLMAN. That would be about it.

Dr. SALINE. I will take a stab at this although I will hasten to add I am not an expert on the checkout equipment that was used for the Saturn flight.

Mr. TEAGUE. I was thinking not of the equipment but who did the work? Who did the work on the Saturn yesterday, and when you really become operative who is going to do the work? Obviously you will but what will happen to the checkout system that was used on the Saturn yesterday?

Dr. SALINE. I believe that a lot of the checkout equipment that was used on the Saturn yesterday was fabricated within the facility of MSFC at Huntsville.

Mr. TEAGUE. I am not as interested in the equipment as who did the work. When General Electric begins operating, you will do the work that someone else did on the checkout yesterday, either NASA, a private contractor, or——

Dr. SALINE. You say you are not interested in the equipment. Do you mean operating the equipment then?

Mr. TEAGUE. Yes, sir. Who does the work?

Dr. SALINE. The actual operation of the equipment will be done by NASA as far as the responsibility for making the decision that the system is ready to go. Now, General Electric will provide in this whole area maintenance people and operators to work at NASA's direction on our portion of the equipment.

Mr. TEAGUE. In other words, NASA will use equipment that General Electric has created, and will use your people in that blockhouse to whatever degree necessary to check out the Saturns of the future?

Dr. SALINE. What do you mean by "future"?

Mr. TEAGUE. I mean when General Electric really gets into it.

Dr. SALINE. When we get into it—I will hasten to add, though, that it is my understanding that the plan is that the people sitting at the test consoles and operating and managing that actual checkout procedure will be NASA personnel, they will not be our personnel.

Mr. WAGGONNER. NASA personnel that will be following your prescribed procedures as given to you in detail by the subcontractors that provided the overall integral part of the program?

Dr. SALINE. This is right. This is a joint program to develop what those procedures are.

Mr. ROUDEBUSH. At this stage of the game, do you anticipate being able to use some of the equipment already on hand at Cape Canaveral for checkout?

Dr. SALINE. I would doubt very much that we will be physically able to use very much of the equipment that you can see down at Cape Canaveral today.

Mr. ROUDEBUSH. Why?

Dr. SALINE. Because I don't believe it will meet the requirements of this system to accomplish the actual checkout procedures in the right time frame of reference and because much of the checkout equipment that is down there today I believe is a lot more special purposed than what we need to accomplish this mission.

Mr. ROUDEBUSH. Has any thought been given to redesigning the checkout so that we could utilize some of the equipment that we already have on hand?

Dr. SALINE. There has been much thought given to this but the actual degree of automaticity, for example, of the checkout equipment that is down at the cape right now is not sufficient to meet the degree of automation that we visualize necessary at this time.

Dr. SHEA. Mr. Roudebush, if I could interject a word.

Mr. ROUDEBUSH. Yes, go ahead.

Dr. SHEA. The checkout equipment at NASA complex No. 34—I think that is where you were yesterday?

Mr. ROUDEBUSH. Right.

Dr. SHEA. And that at complex No. 37 are not specifically part of the GE contracts. Those facilities, however, will continue in existence after the Apollo program has started. They will be launching either the C–1 or the D–1 launch vehicle and all of that equipment that is peculiar to the Saturn I program, the Saturn 1–D program and particularly the Saturn V will continue in existence.

Now, obviously there are detailed changes between the equipment used to check out Saturn I and the equipment used to check out Saturn V and the changes exist both in the drawings themselves, which is the design of the circuits, and in the overall approach where we are really evolving from a manual type of approach that we had on Saturn I to the automatic approach that Dr. Saline has been describing as used on Saturn V.

Mr. TEAGUE. Doctor, you are saying we are going from the Ford-type checkout system to the Cadillac system?

Dr. SALINE. I don't like to think of it in that way, sir. I like to think that both provide adequate means of transportation, to use your analogy. I think of it as instead of using a Ford to get from here to there I must use something like a jet aircraft because the distance is a lot greater and the time constraint in which I have to get from here to there is a lot different. Both ways have their very appropriate applications but in the application here it must be recognized that we are not just designing something that is fun to do, although it has been a lot of fun I can assure you because it is a very challenging program. But from our best technical judgment, this is absolutely necessary if this program is going to go.

Mr. FULTON of Pennsylvania. Could I comment? Isn't the General Electric Co. becoming systems manager for the Saturn and not just doing the checkout and inspection work. You are really operating and putting systems together?

Dr. SALINE. I have to answer that question in two levels. If you are talking about systems manager for the Apollo system, the answer is negative. General Electric is not in the role of being systems manager for that kind of activity. On the other hand, I will answer that for the implementation, and that includes the design, fabrication, installation, and these other things to meet the requirements that NASA has imposed on us in the system performance specification that they have given us, General Electric has indeed that responsibility as systems manager.

Mr. FULTON of Pennsylvania. Then why shouldn't your employees operate the panels and the equipment at the time of launch? Why is there the division of responsibility if you are doing all of this other work right with NASA as a partner?

Dr. SALINE. I think that that is a question that NASA has to decide. They are the overall system manager for the Apollo program and whenever one approaches a complex problem of this kind, it is customary to divide the work into various discrete packages that the systems manager can handle and they have chosen to divide it up in this way.

I personally would concur wholeheartedly that, as the overall systems managers for Apollo, NASA should reserve that particular operating responsibility for itself.

Mr. FULTON of Pennsylvania. Why shouldn't GE, at the time of launch, merely move into an inspection level so that it can certify that everything is ready for operation, rather than be sitting up there with another steering wheel in the automobile?

Dr. SALINE. I don't understand your analogy, sir.

Mr. FULTON of Pennsylvania. Well, obviously you are taking an effective part at the time of launch by supplying the checkout, and actually participating with NASA employees who are operating the panels and equipment. It would seem to be much more of a partnership than if you were in a position of inspection.

Dr. SALINE. What do you mean by inspection? I am afraid I don't understand the role of inspection that you refer to as you go into the countdown phase.

Mr. FULTON of Pennsylvania. Well, didn't you previously have to inspect for reliability?

Dr. SALINE. Yes, sir.

Mr. FULTON of Pennsylvania. You had to inspect to get the merchantability for the particular use to which the equipment was to be put, as well as to its usability over a certain period.

Dr. SALINE. Yes.

Mr. FULTON of Pennsylvania. Likewise, General Electric had to inspect to see that the costs are within reason to protect the American taxpayer; that there is no overlapping or duplication; that the systems are well integrated, efficient, and reliable. When you come to the launch GE is also there operating the panels, and operating checkout equipment together with NASA employees which is a division of management. My question was, Should there be this divided management at the time of launch?

We have had some experience on the Atlas-Agena where there has been divided management between the Air Force and NASA, and they have had some failures. It seems that where there is direct responsibility and single management, there are often better results.

Dr. SALINE. Yes, sir.

Mr. FULTON of Pennsylvania. That is my question: Should there be a single manager at time of launch so that your function is clearly defined in respect to NASA?

Mr. SHETLER. May I try that from an overall vantage point for Congressman Fulton?

What we are providing NASA in this case is a tool, a very complex tool, which they will use and operate. After we have furnished that tool, our participation in its use will be in the role of a repairman, if you will, to say that if it is not operating properly these are the things that are not properly operating as relates to our tool alone. But the management of the single, overall system must be retained by NASA and we are simply servants of them during this countdown. So that if something in the checkout system is not functioning properly our people are available to say, "When these kinds of symptoms develop, then this is the part that should be modified." But when the data shows the total system has certain tolerances, NASA must make the management decisions as to the probability of success of the total mission. You can't split that management responsibility.

Mr. WAGGONNER. Your people are available under the same circumstances in the overall program, for example, that IBM personnel would be available to you in the instrument program at the checkout period?

Mr. SHETLER. That is precisely right.

Mr. FULTON of Pennsylvania. You are replacing the present system of checkout whereby certain contractors are there with their people checking out individually. You have the sole responsibility?

Mr. SHETLER. Yes, I think one of the things we have to look at is that the current system we are talking about is, in contrast to the total program, a very small piece. It looks big and it does many complex things, but when you begin to stack all of the Apollo system elements up and put a man-rated capsule on top, then you have a requirement to be able to look at the whole, a very complex whole. The reason for doing an integrated checkout system is so that you can do it—look at it—in a timely fashion. If you were to do each one of these pieces as they are now being done, and they are being done well, each single piece as a nonintegrated piece, you probably could never walk down this road in a predictable fashion.

Mr. FULTON of Pennsylvania. What is your relation to the individual contractor whose system you are working on?

Mr. RIEHLMAN. Before we get away from this I want to get back to that chart and clarify my position. The one down here that you have on the floor [indicating chart 14].

You showed us a picture of all of the new types of equipment that are going to be used, and you referred previously to 4,150 different types of cabinets.

Dr. SALINE. I didn't say "different types of cabinets."

Mr. RIEHLMAN. All right, then, cabinets.

Now, the point that I want to make is, are you following this type of equipment to make sure that you are not designing new GE equipment when equipment is already available to carry out this type of responsibility?

Dr. SALINE. This, of course, is part of our responsibility. There are a number of considerations that have to be taken into the overall evaluation of this thing. For example, there is cost, there is delivery, there is the maintainability, there is the reliability of the equipment, and so forth. There are many considerations that go into a decision that one should buy from company A or company B or make it in General Electric because it would be better for the program to do so.

Mr. SHETLER. I think that Linde is hitting at the nub of the problem that you suggested. There are really two steps in this approach. One is after the system is designed in raw detail, and there are 4,100 cabinets, let's say, as an example. Each one of these cabinets has certain panels. When you describe those panels you have to make a decision. Are those panels available in previous space work, in complete detail? If they are you make the decision to use those previous things because you have a reliability history on them, or you make a decision not to use them because the reliability history has been inadequate. Many of these things will become then what we call off-the-shelf components or off-the-shelf cabinets. It is simply that time, money, and availability of technical manpower would not permit you to redesign the whole system, nor would it be good judgment to do that. Then, when you decide that this is an off-the-shelf item, you have to make the next decision as to whether you buy it from the source that has it on the shelf. Many times these off-the-shelf items can be available from two or three different sources and as part of our responsibility we must necessarily have competition to see who can furnish it most reliably and most economically.

Mr. RIEHLMAN. And that is your responsibility?

Mr. SHETLER. Yes, sir.

Now, I must add one other thing as is normal in all our contracts with the Government. We have a Government agency sitting over us. Before we place a contract with some outside supplier, there are usually fixed requirements, for all purchases over x dollars which must be not only justified by us as to the supplier—that we have indeed made a source evaluation on these points that I have mentioned—but before we actually place the contract the agency for which we are prime contractor signs off, indicating that indeed we have been diligent in this matter.

There is a two-step approach there which protects the interests of the Government.

Mr. RIEHLMAN. Mr. Chairman, I think that this is very important because we are going to be faced with the responsibility of furnishing the money for these programs. We frequently hear that there is a great possibility of duplication of equipment and effort on the part of NASA contractors. In a project as costly as this, our committee should be well informed that there isn't a lot of duplication. We must assure ourselves that there is coordination in the procurement of equipment, and that new equipment is not designed unless it is absolutely necessary.

Mr. SHETLER. A great share of our design effort is spent in looking at the state of the art and the availability of existing equipment. I think in as vast a program as this you simply cannot afford either on a time basis, as Linde says, to reinvent the wheel or not use what is available and what fits both reliability and economic standards.

As I said, there is a two-step approach to insure that we are properly implementing our responsibilities and this is one of the things that we watch very, very carefully. Design people being what they are, people being what they are, we have a very diligent program to do that. We have a "make or buy" structure with NASA looking over our shoulder to make sure that we are in order.

Mr. GURNEY. How do you know that something hasn't been done before in the way of an idea or a piece of equipment?

Mr. SHETLER. This is a very good question, because no matter how you answer it you may get into trouble. It is difficult to get enough knowledge of what has been done. But I must say this, With hardware it is less difficult to determine what has been done, but the ideas that are in peoples's minds are somewhat more difficult to uncover. We have tried to solve this problem. In this case, we tried to solve this problem by getting a very broad cross-section of people in the company who have been, over many years, involved in space and weapons programs, if you will, missile programs, to be sure we have a vital and up-to-date technical base.

I feel that it stands on the people and we have the quality of people to be sure that we are indeed up to date. I don't think we are behind.

Mr. RIEHLMAN. Let me ask just one more question, Mr. Chairman. I think this will clarify it for myself and, I hope, for the committee.

When you make a decision that new equipment must be designed, NASA still has an opportunity to take a look at that before you go ahead; is that correct?

Mr. SHETLER. Oh, yes, indeed.

Mr. RIEHLMAN. And NASA can make a final decision and judgment as to whether or not it is proper?

Mr. SHETLER. Yes, I must say that we don't bring these problems lightly unconsidered to NASA's attention. In the organizational hierarchy we review this very carefully as we go up the line before we come to the requirements viewpoint as to whether a new piece and a new design is required.

Mr. FULTON of Pennsylvania. With your later description, of your activities and responsibility, Mr. Shetler, it strikes me that this is a contract with tremendous responsibilities and not just a supply of IBM equipment type of thing.

Mr. SHETLER. I know that.

Mr. FULTON of Pennsylvania. I would respectfully disagree with that particular statement. Could I ask you this: Who in NASA checks you to see that you are dong a good job?

Mr. SHETLER. It is the Office Manned Space Flight that has the responsibility to make sure that we are fulfilling our contract competently.

Mr. FULTON of Pennsylvania. Does NASA have liaison method to oversee you, or how does NASA do it?

Mr. SHETLER. Yes, they have. I wouldn't call it a liaison arrangement. They have a contractual control over us I consider liaison control one without basic authority. The Office of Manned Space Flight has set up an organization to review our programs to insure we do what is necessary, in time and economically for the total integrated launch control and checkout system.

Mr. FULTON of Pennsylvania. As general manager of Commands System Division of General Electric, who is your counterpart in NASA?

Mr. SHETLER. My counterpart in NASA would be Joe Shea. The man who is the opposite number of Jack Records would be Jim Sloan who is here this morning.

Mr. FULTON of Pennsylvania. And their titles?

Mr. TEAGUE. They are already in the record.

Mr. GURNEY. Let me ask you one other question. I understand there is something called ASTIA, which is sort of a bank or a library of technical information. Do you use this at all?

Mr. SHETLER. Yes, indeed.

Could I call on Henry Lehmann? Henry, would you give the best answer as to our use of ASTIA?

Mr. LEHMANN. ASTIA is the basic Government (armed services) technical library service which we call on very heavily. It is utilized by both Government and industry in this program. We are on the mailing list and we receive

automatic distribution of much information and we use it as well for specific requests for official documents.

Mr. ROUDEBUSH. Mr. Chairman, can I ask one other question?

We are being asked to authorize many millions of dollars for construction of new facilities and the purchase of various types of test equipment, and so forth. If during your studies you determined that some of these things could be redesigned or integrated thereby making some of this construction unnecessary, do you feel free to report this to NASA?

Mr. SHETLER. We certainly would.

Mr. ROUDEBUSH. Do you anticipate that some of the systems that you have outlined can be redesigned or integrated? Do you anticipate finding some shortcuts of testing and checkout?

Dr. SALINE. Our continuing goal in checkout is not to expand the number of test points, for example, that are necessary to carry this out. We hope that the systems engineering studies may be able to show us where we need fewer test points. I don't believe I can stand here today, sir, and tell you that there are dramatic cost savings that we are going to propose, and I can't say that there are not going to be. We are still in the stage of the program where we are formulating our technical approach and our technical studies and we are continually trying to simplify the overall system which would then, of course, if we achieve true simplification, cause certain cost savings.

Mr. ROUDEBUSH. It looks as if one of our big problems is that so many of these things require a long leadtime such as the construction of facilities. One of the difficulties is to make these discoveries and shortcuts in time so that maybe we can reprogram and change some of those?

Dr. SALINE. This is part of the basic design of the kind of system that we are contemplating here. If we were designing what I will call a special purpose system that is only good for checking out the second stage of the launch vehicle, we might have real problems if the launch vehicle people discovered something a little bit later on that had to be modified. This is one of our reasons for approaching it in the general purpose way. So that it will have the inherent flexibility to meet such changes as would develop as the program matures.

Mr. TEAGUE. Mr. Shetler, how far are we behind schedule?

Mr. SHETLER. On this morning's meeting, we are a half hour behind.

Mr. TEAGUE. It is a most interesting meeting. I wish we had all day, but I think the members should restrict their questions to as few as possible. I would certainly like you to cover the subjects you have outlined to us.

There are a number of charts that I wish could be in the hearing. I don't think all of them are necessary, but there are a number that we should include if we possibly can get them into the hearing.

Mr. MAHER. Mr. Chairman, we will try to supply them all and leave it to your staff to select those that you think are most desirable.

Dr. SALINE. I'd like to make one comment. We had a start of a discussion on the particular chart (15) relating to standardization. We are, for example, developing what we call our Project Data Book which is specifically for this project in which we have engineering design standards and so forth. Now, we are not reinventing these standards, we are probing the depth of General Electric's experience to take out the standards that have been developed on previous programs.

Also, for example, we are using as a basic library for our engineering designers what we call our Mistran card library which has some 300 basic circuits in it that have already been proved and developed on other programs that we have run. This is a typical kind of a card that would be used from that card library. We estimate very, very conservatively and we can't really say how much it would cost to start from scratch because so much has gone into the whole program of standards and so forth, but just through our General Electric Co. background from a design viewpoint we feel that this has saved $5 million to this point on this particular program to have these standards and this card library available.

Now, also from a standard program of costs, we believe that we are going to enhance the basic reliability of the checkout equipment because we have a lot of operating experience on cards of this kind that are going to be useful in developing our overall system and then, for example, the cost saving of the standard program as it relates to the maintainability of a system of this magnitude is quite considerable.

HARDWARE STANDARDS

COST SAVINGS

RELIABILITY

MAINTAINABILITY

CHART 15

For example, if there weren't some standardization throughout a program of this kind the logistic provisioning for all of the spare parts and other kinds of test gear that are needed would be quite horrendous. But we believe it is going to become a manageable program because of the way we can, by using the integrated approach to launch control and checkout, effect economies both in dollars and operational time.

I wanted to mention another very important aspect of this kind of work and that is the programing of the digital data processers or computers for the operation of this system (chart 16).

There are a number of steps that have to be gone through. I mentioned earlier a couple of thousand descriptive documents that tell in very fine-grain detail which has to be accomplished. These have to be translated into computer-type flow charts to show what the interrelationship is and the specific tasks that must be undertaken to perform these tests.

This then has to be translated into computer language and computer instructions and we estimate, that to run one of these checkout flows and preparations down at Merritt Island, will require over a million instructions to the various computers.

Then, finally, we have to prepare them for entry into the computer itself.

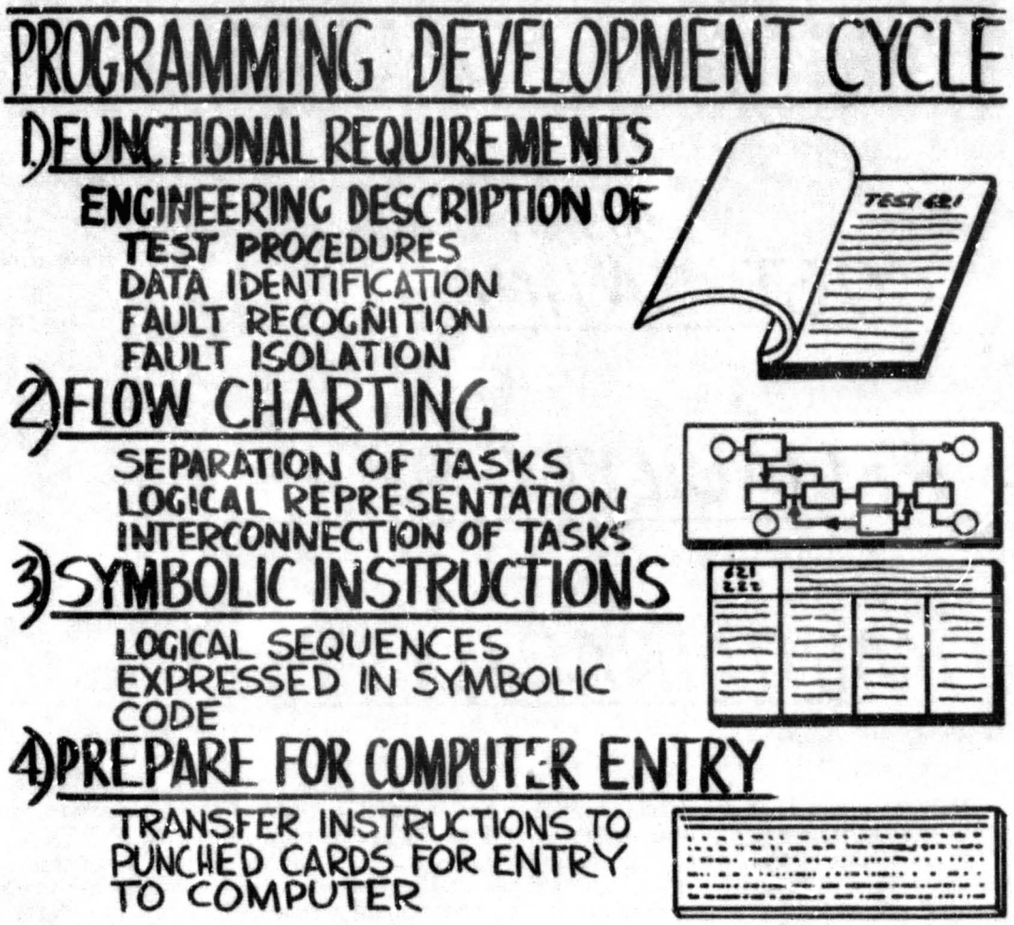


CHART 16

Another aspect of this work is what we call field operations work (chart 17). This is the work of actually installing and checking out the checkout equipment. There is a considerable amount of this kind of activity. There is the maintenance operation and modification of both hardway and software for this kind of program, logistic support. There is a preparation of technical manuals that describe the operation of the equipment and the maintenance procedure. There is the training of maintenance people and operators and then there is the continual data-gathering activity on the performance of this information in the field so that we can improve the overall performance of some of this equipment.

I also want to show you very briefly the checkout interphases that we have with NASA and some of these other prime contractors because we know you have interest in this (chart 18). NASA has, of course, the direct contractual control, management control of General Electric. Also for the prime contractors and for Bellcomm. Bellcomm has in turn a subcontract to Rand Corp. These are the formal contractual channels that NASA has established for us and there are what I will call the informal communication channels so that we have relations with Bellcomm, with Rand, and with the prime contractors.

FIELD OPERATIONS

- INSTALLATION AND C/O OF C/O HARDWARE

CY	1964	1965	1966	1967
RACKS	800	1500	1500	350

- MAINTENANCE/OPERATION/MODIFICATIONS (HARDWARE AND SOFTWARE)
- LOGISTICS SUPPORT
- TECHNICAL MANUALS
- TRAINING
- EVALUATION/RELIABILITY

CHART 17

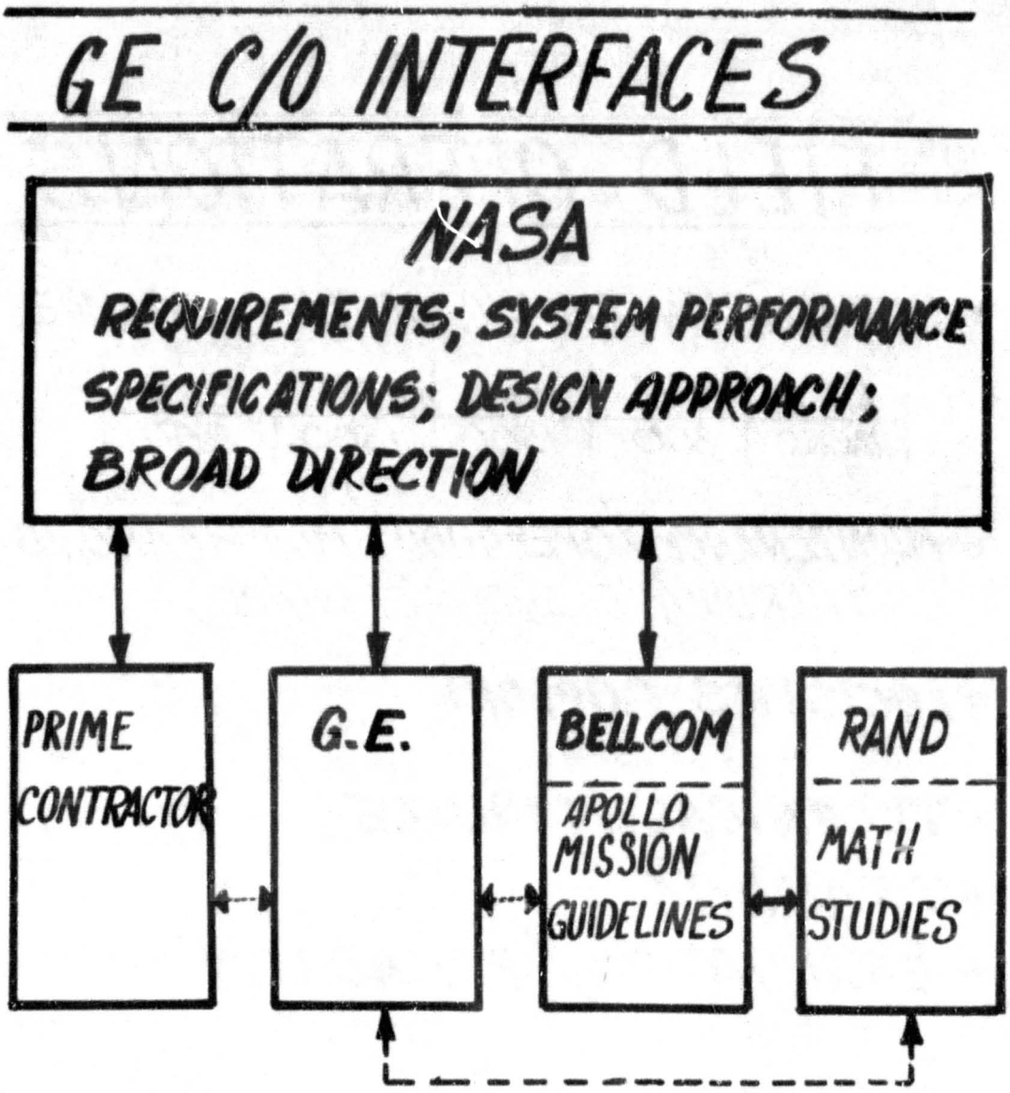


CHART 18

There are a number of different kinds of interfaces that we have to concern ourselves with (chart 19). There are equipment interfaces that have to be treated slightly differently. There are different mechanisms that we use to accomplish this.

I won't go into the details at this particular time but the machinery is well in gear so that we are getting to the point where the information is flowing at a better rate as far as we are concerned.

Finally, then, I will summarize it by saying what are our primary challenges that I see from the checkout viewpoint (chart 20). There are three of them:

The technological complexity of the work itself, the time urgency, and, of course, the continual problem of how to do a job of this magnitude on dollars that are somewhat restricted.

In spite of these challenges we have assembled a real good team and we are confident that we are going to meet the schedule and provide the capability that is going to be necessary to achieve the Apollo program.

Mr. RECORDS. One point I would like to check with Linde. I believe that Rand is a prime contractor and not a subcontractor for Bellcomm?

(Discussion off the record.)

G.E. CHECKOUT INTERFACES

TYPE OF INTERFACE	ORGANIZATION				
	PRIME CONTRACTOR	NASA	BELL COM	RAND	TECHNIQUE FOR HANDLING INTERFACE
EQUIPMENT	X	X			ICTS AND IWG
PROCEDURAL	X	X			IWG AND C/O PANELS
INFORMATION	X	X	X	X	IWG: C/O PANELS. TECHNICAL WORK SESSIONS

CHART 19

MAJOR C/O CHALLENGES

- TECHNOLOGICAL COMPLEXITY
- TIME URGENCY
- COST CONSTRAINTS

CHART 20

Mr. LEHMANN. I would like to spend just a few minutes to give you a brief description (chart 21) of my understanding of the total integration job that has to be done on this program and spend most of the time in describing our particular activities in support of NASA's role in this integration area.

APOLLO

INTEGRATION

SUPPORT

CHART 21

I have tried here to summarize what in my estimation is the overriding integration problem (chart 22). We see a map of the United States and look at the black dots which are NASA installations and at the triangles which are some of

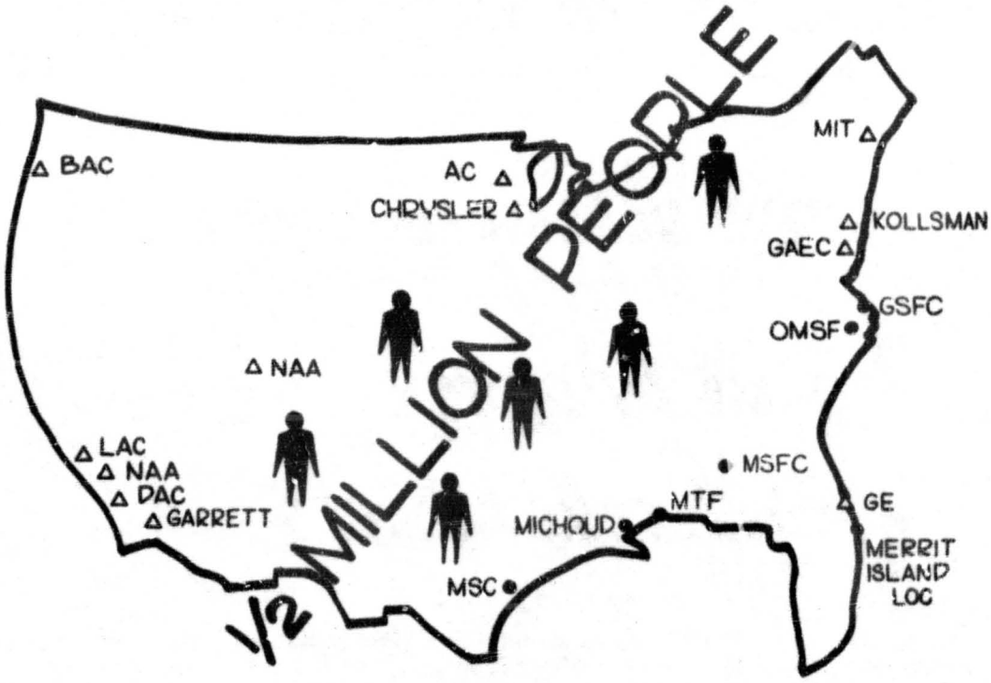


CHART 22

the key contractors involved and we see that, as this program progresses through tiers of contractors and vendors, there will probably be in excess of half a million people involved.

It is the communication between these people and these various groups which is the overriding integration problem.

We have defined this as that effort to assure the compatibility of the major system elements with each other and with the system objective (chart 23). This

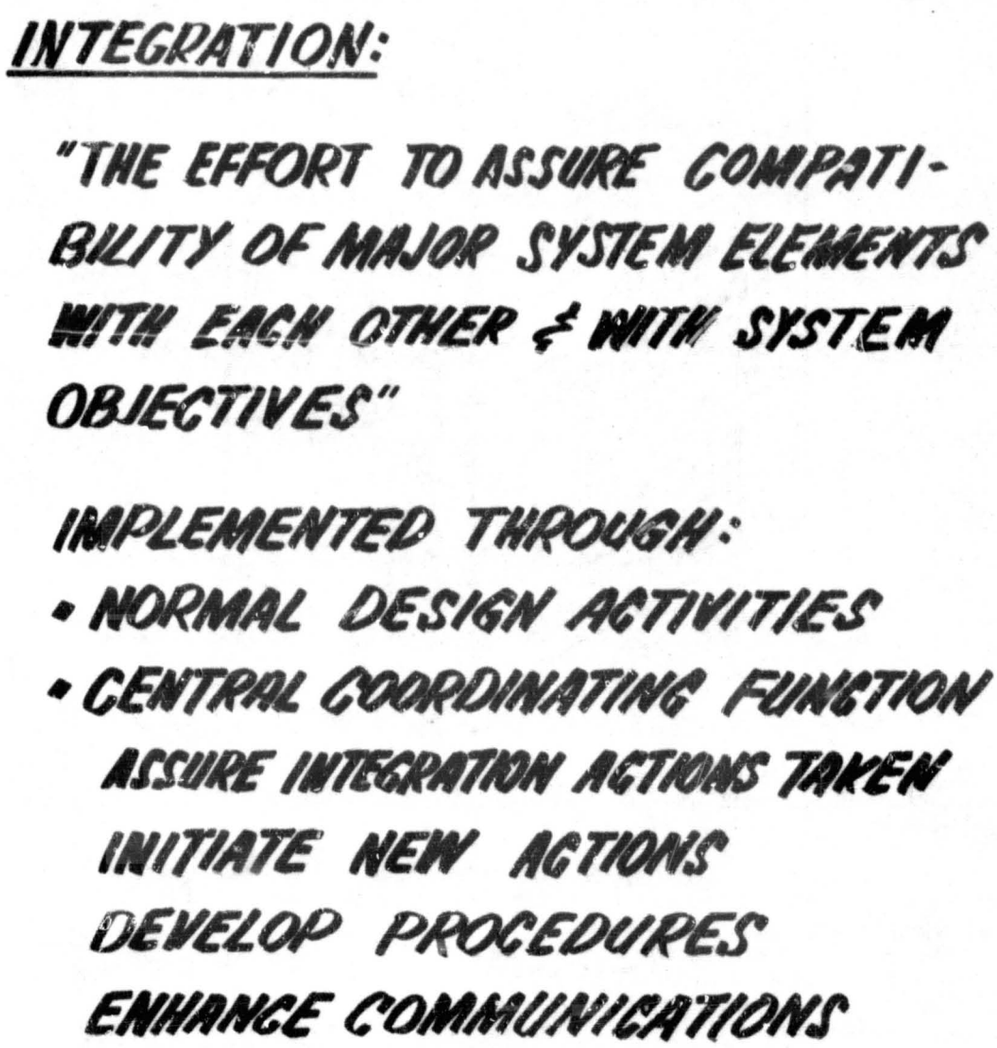


CHART 23

has been the key definition that we have used. We feel that it must be implemented mostly through the first item, which is the normal design activity; engineers in one portion of an organization having free access to talk to other engineers in another portion of the organization or in another organization to solve normal day-to-day problems of achieving compatibility between their designs.

In addition to this, there is a need for a central coordinating function which performs the elements indicated here to assure that the various steps are being taken that will result in an integrated system; to initiate new action in those areas where insufficient action is being taken; and to develop the procedures to bring about this integrated action. As I mentioned before, the overall problem is to enhance the communication between all the participants.

From a gross standpoint, we can look at integration as shown in this multidimensional chart (chart 24). We have in one dimension the major elements

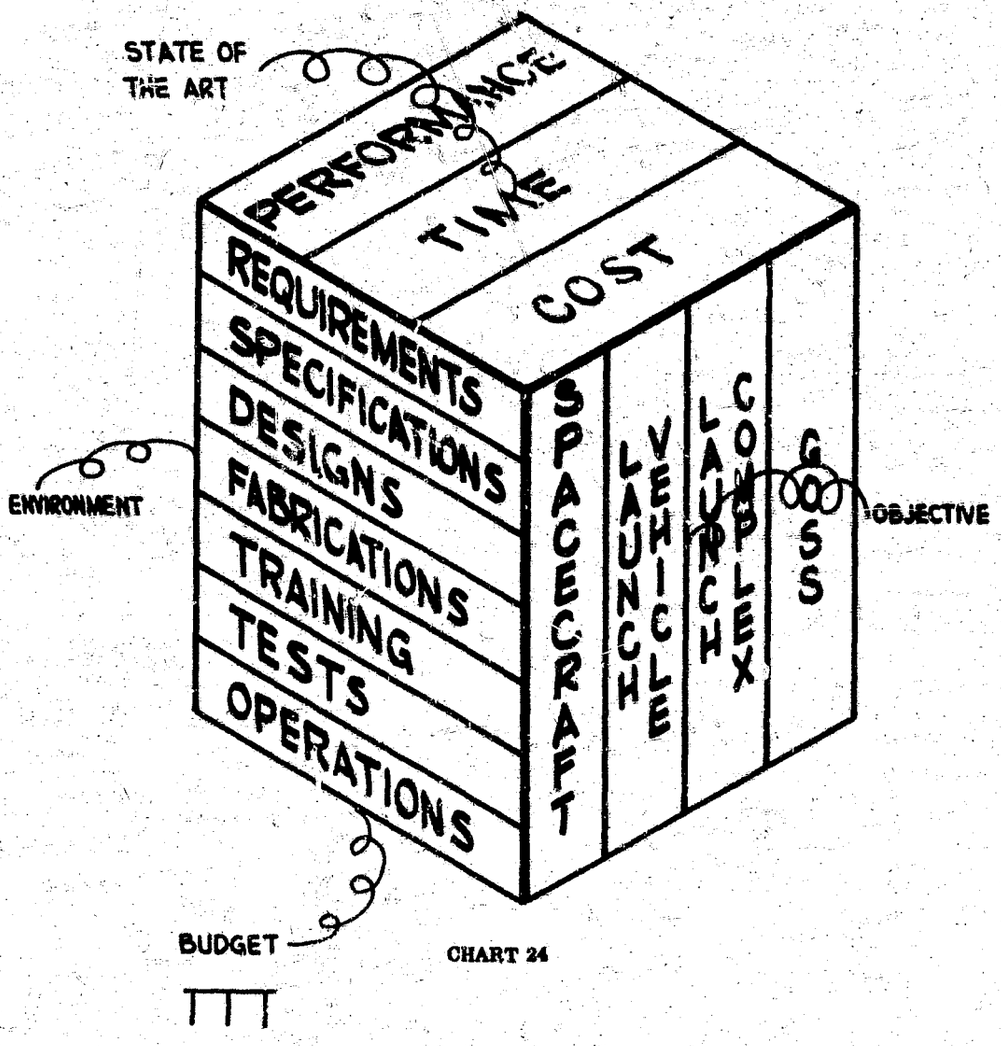


CHART 24

of the Apollo program, the spacecraft, the launch vehicle, the launch complex at Merritt Island, and the ground operations support system which is the communications network on a global basis.

Compatibility between the major elements must be achieved in the area of performance, the area of time and schedule, and in the area of costs. This compatability must be achieved from the early stages of the requirements all the way through; through design and fabrication to the operational level. It is insufficient to expect compatibility at the equipment level unless you are first assured of the compatibility at the requirements and specifications level.

On top of this multidimensional chart we have external forces acting on a time varying basis; variations in the objective improvement, in the state of the art, changes of our knowledge of the environment, and, of course, variations in the budget.

It is the continuous solution of this problem which is NASA's role in the overall integration effort. Now, our objective in support of NASA in this total integration effort is summarized here (chart 25). One of our major areas of activity is an attempt to cross-fertilize information; to make certain that people over on one side know what has been done in another area. The other objectives are to support NASA in the development of procedures and methodology for their management control of the entire program, and to continuously search for specific problems that are not receiving sufficient attention, to point these out and to make sure that they are given the adequate attention which they need.

OBJECTIVES:

CROSS FERTILIZE INFORMATION

DEVELOP PROCEDURES

SEARCH FOR UNATTENDED

PROBLEMS

CHART 25

The approach to this integration is a threefold approach (chart 26). There is a top down integration in the form of directions from NASA headquarters to the participating agencies. Most of the integration, as I mentioned before, is the relationship within the centers and their contractors directly with each other. The particular aspect that we are addressing ourselves to and to which the rest of my discussion will bear this morning, is an integration support contractor, in this case, the General Electric Co., working and having personnel stationed both to support the headquarters organization as well as each of the major contributing centers.

Through performance of similar kinds of tasks for every portion of the organization—tasks which are closely related to each other—we hope to bring about integration and to support NASA in bringing about integration of this program. A very excellent example of this is the development of a segment of an engineering documentation system, a common drafting method. We have been asked by the various centers to support them in the development of a common drafting methodology. We have been working with the various personnel at each of the centers and look at their particular problems and have been working directly with the Office of Manned Space Flight to develop a common methodology and in this way we are working throughout the organization to develop a common drafting system.

APPROACH

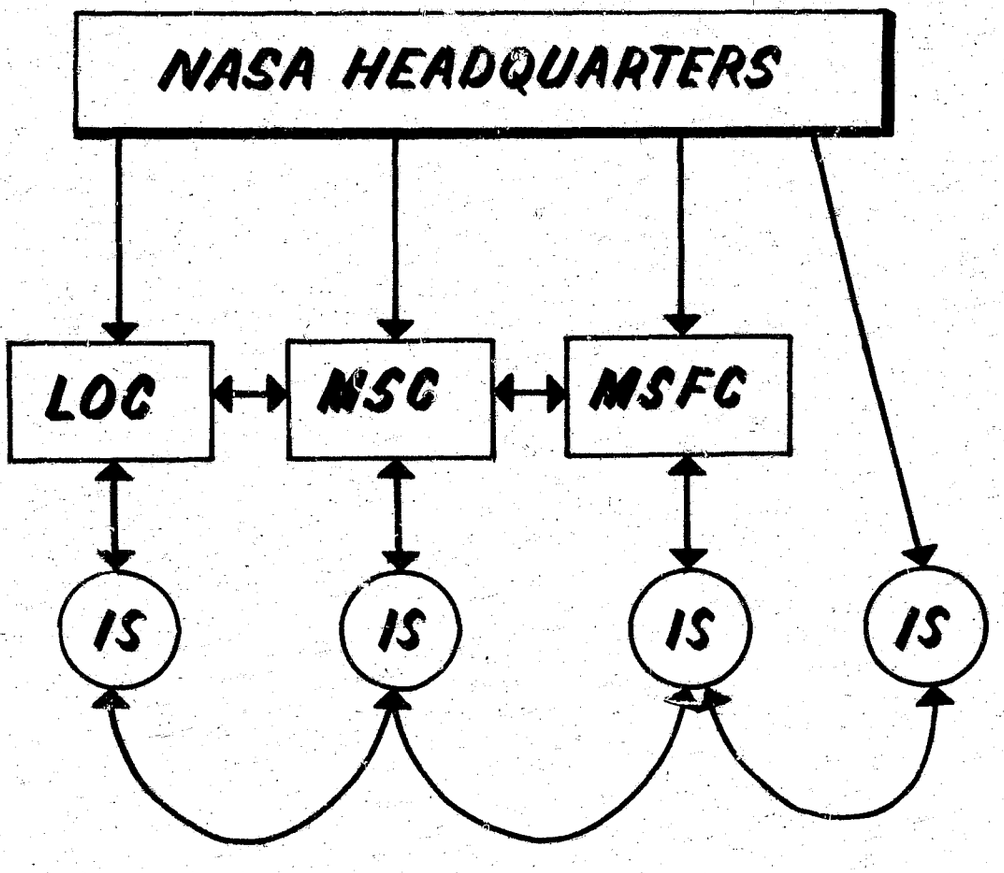


CHART 26

The specific activities to which we have addressed ourselves are listed here (chart 27). One, the area of integration assistance; two, the major problem of the compatibility of the physical and functional interface of the major system elements; three, the area of configuration control; four, the total engineering documentation system; five, the area of data handling and; six, some additional support for the centers which cannot be logically categorized in the above areas.

I would now like to discuss each of these individually (chart 28). One of the prime activities in the integration assistance area has been the writing of a systems description. Back at the start of the contract it was NASA's recommendation that a total systems description should be issued. This is a complimentary document that follows the systems specification which was written by the Office of Manned Space Flight with the assistance of Bellcomm. This description describes the equipment as it is actually being designed and hence it serves as a very excellent vehicle to exchange information between all of the participants, so that one group knows what the other equipment looks like and can make sure that what it is designing is compatible with it.

It also serves as a document, if you wish, which will determine if the equipment as designed really satisfies the objectives of the overall systems specifications.

These three volumes here were first the edition of this systems description and you can get a feeling of the depth of information which went into it. It is cur-

ACTIVITIES:

INTEGRATION ASSISTANCE

INTERFACE INTEGRATION

CONFIGURATION CONTROL

DOCUMENTATION INTEGRATION

DATA HANDLING

CENTER SUPPORT

CHART 27

rently being revised and we are working very closely with each of the NASA centers to make sure that the information in here is truly authentic and accurate.

An additional small study that we have been performing for the Office of Manned Space Flight is an examination of the problems that may arise in connection with the lunar excursion module. This is one example of what I mentioned before: unattended problems that should be brought to people's attention.

In the area of enhancing communication between all of the parties contributing to the system, we started an effort going quite early in the program to develop a common terminology. There have been many efforts going on in the area of terminology. We are working very closely with other people who are currently doing this type of work. We have accumulated practically every aerospace terminology book and we are extracting from them those terms not for general usage but which have special meaning in the Apollo context, so that when somebody speaks of an attitude control system in one part of the Apollo project it has the same meaning in another part. Admittedly it may have some different meaning in another program, but at least within the total Apollo program we want to make sure that we minimize the semantic difficulties.

We have just published a document which is really a compilation, or a library search, if you wish, on the environment of the moon as the experts around the world know it. It is not represented as any original work as such but is a compilation in a fairly convenient reference form of data that has been accumulated over many years in numerous professional journals by astronomers and scientists throughout the world. This document has been given very wide distribution to the various contractors working on this program and it is a common and handy reference for the information.

In addition we are supporting a variety of small studies as NASA and the contractors may request us to do so.

INTEGRATION ASSISTANCE

SYSTEM DESCRIPTION

LEM CONTINGENCY

TERMINOLOGY STD

LUNAR ENVIRONMENT

OMSF SUPPORT

CHART 28

One of the major actiivties that we have been undertaking is the area of the interface compatibility and interface integration between the spacecraft launch vehicles, and so forth (chart 29.) We have developed a sample interface book with a sample interface description. The description used as a model the SA5 vehicle. The intent here primarily was one to develop the methodology, the content and the format as a sample which could then be used for the official interface documentation for subsequent shots. We have done the same thing in the area of what we call functional line diagrams. These turn out to be drawings which actually trace through the signals, not within one capsule or one stage but across the stages to perform one function. This one happens to be the destruct system. The destruct system crosses various stages and you can trace it all through here and make sure all of the interfaces are adequately compatible.

We have worked very closely in direct support of the Office of Manned Space Flight in the last few months to develop an interface control plan. This plan is intended to insure, first of all, that all the key interfaces are properly identified. I think the No. 1 problem is to assure that they are known and duly recorded.

Secondly, that adequate responsibility is assigned by NASA for the solution of these particular interface problems and a time schedule is established which will insure the solution in a time that is compatible with the overall program schedule.

INTERFACE INTEGRATION

DEVELOPED SAMPLE INTERFACE BOOK

DEVELOPED SAMPLE FUNCTIONAL LINE DIAGRAMS

DEVELOPED INTERFACE CONTROL PLAN

- INSURES I/F IDENTIFICATION
- INSURES ASSIGNMENT OF RESPONSIBILITIES
- INSURES TIMELY SOLUTIONS

CHART 29

The plan further insures that once the solution of an interface has been reached it is properly documented and properly distributed to all the participants (chart 30).

It has a provision in it to enable NASA to generate status reports at various levels of management to define where the status of resolution of an interface stands at any one time. It preserves, throughout, the technical authority of the centers to actually solve the technical problems.

The reason we feel very strongly about this, if I may digress for just a moment, is that we believe that, in any kind of an organizational structure, if an organization has been delegated responsibility for a given design, the higher level organization can only establish the external parameters (chart 31). Whatever decisions are made within this organization which are strikingly internal is their design prerogative. However, any changes which they may wish to make which would affect external considerations have got to go back and be thoroughly integrated to make sure that any change which is done in one area affecting another group is properly reflected.

INTERFACE INTEGRATION... (CONT.)

- INSURES APPROPRIATE DOCUMENTATION
- PROVIDES MANAGEMENT STATUS REPORTS
- PRESERVES TECHNICAL AUTHORITY OF CENTERS

CHART 30

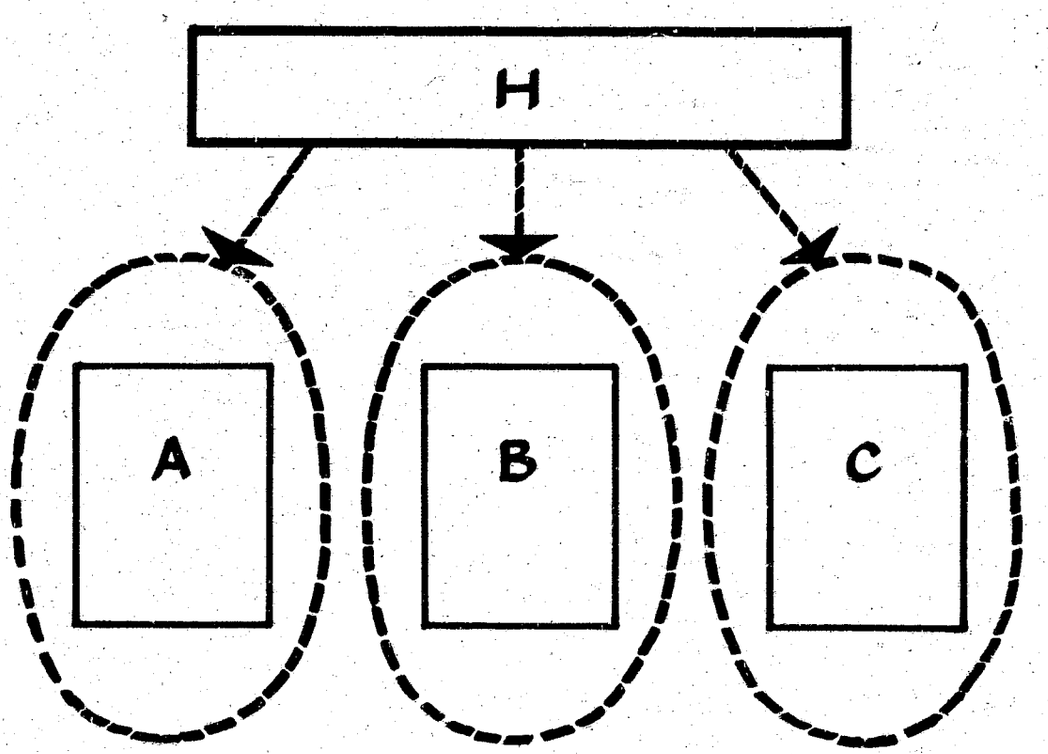


CHART 31

The area of configuration control (chart 32) is basically the process of knowing exactly what the configuration is of each one of these vehicles, and recognizing that each one is somewhat different from the previous one. The effort to date has been primarily to study what has been done in other missile and space programs. We have talked extensively with people in the aerospace industries who have worked on ballistic missile programs and space programs. The conclusion from these talks has generally been that we have had configuration control systems and that they should have been even tighter to solve the problems more adequately.

CONFIGURATION CONTROL

- STUDIED OTHER MISSILE AND SPACE PROGRAMS.
- STUDIED CURRENT NASA SYSTEMS.
- DEVELOPING TIERED PLAN AND PROCEDURES FOR ADOPTION BY NASA AND CONTRACTORS.

CHART 32

We have worked with various groups within NASA to understand what they are currently doing and we are in the process right now of developing, again, what I call tiered plan and procedures. By tiered plan I mean what I have indicated in the previous chart. Configuration control cannot be exercised at any one particular point in the organization for it would become a paper bottleneck, but it must be performed at the various levels at which responsibility for equipment exists and passed on up through the chain in ever diminishing granularity. This plan is being worked on and will be developed with NASA for adoption by the centers and their contractors.

We have touched briefly on the question of the data handling area and Jack Records mentioned that very early in the program (chart 33). We recognized the fact that the overall aspect of checkout, integration, and reliability required a great number of documents and we wanted to make sure that we had convient and rapid access to this documentation to minimize the number of individual requests for such information.

At the start of our activities on this contract we established what we call a documented data control system. A central repository of information from which individual technical people draw the information which they need. Since then we have conducted a study to examine with more care how many documents we have to have, what kind of services this group has to perform, and with what speed access to information must be available.

We have drawn very heavily upon knowledge of these kinds of systems which have been developed by the Armed Services Technical Information Agency and various other major libraries throughout the country. We have completed improvement studies on this system and are currently planning the implementation to determine just what is necessary, if automation equipment is needed to do this, and so forth.

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DATA HANDLING

PROBLEM:

- LARGE NUMBER OF DOCUMENTS.
- CONVENIENT RAPID ACCESS.

ACCOMPLISHMENTS:

- ESTABLISHED DDCS.
- COMPLETED IMPROVEMENT STUDY-DEC '62.
- PROCEEDING WITH IMPLEMENTATION PLANNING.
- STUDYING INTER-LOCATION TIE IN.

CHART 33

We are also currently studying an additional aspect of this problem of information handling, which is how we adequately tie in the virious physical locations that we have so that we don't have to duplicate the information at the various centers.

In the field of enginering documentation, the overall intent is to work toward a very long-range objective; to develop and implement an integrated enginering documentation system (chart 34). This has received a great deal of attention. We have gone through studies which have been made by the Air Force and very excellent study has been sponsored by Senator Smathers in this area. The general results of these studies are that we must improve communications. Engineering documentation is one means of doing this. We need to know what should be written down and in what form. A good engineering documentation system can reduce the time by having documentation available when it is needed in the form that it is needed. It will reduce the errors and most certainly reduce costs. Numerous studies have been made which show that there is a 4- or 5-to-1 return for every dollar spent on developing good documentation systems in resultant savings in the total program.

The objective which we have is to minimize the amount of documentation. Numerous studies have indicated that too much paper is being required or that the requirements are obsolete. If people cannot find what is required they will generate more specification and procedures of their own, further contributing to the confusion. Maximizing the usefulness of the documentation is required.

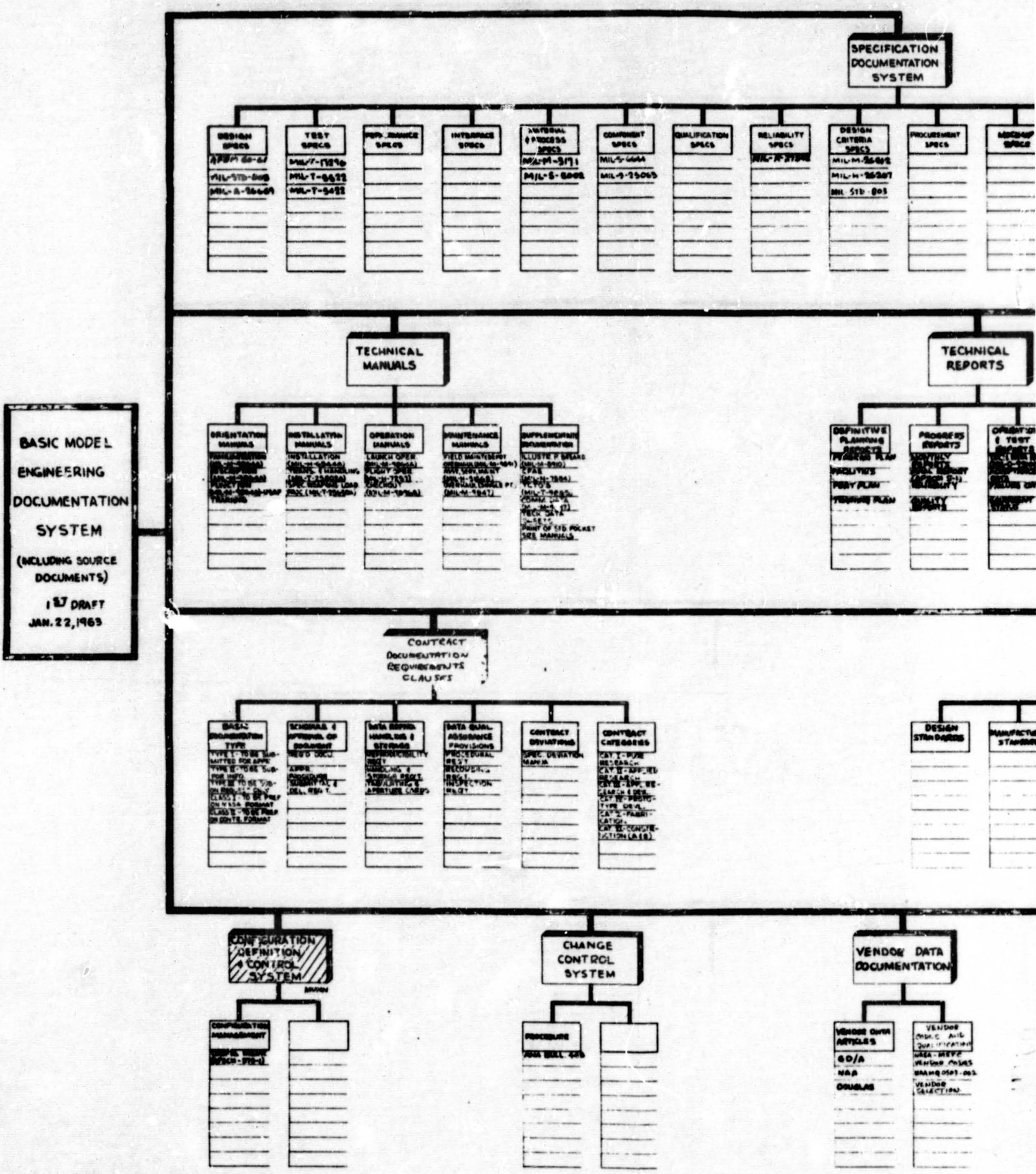
BASIC MODEL ENGINEERING DOCUMENTATION SYSTEM (INCLUDING SOURCE DOCUMENTS)
1ST DRAFT
JAN. 22, 1963
SPECIFICATION DOCUMENTATION SYSTEM
DESIGN SPECS
TEST SPECS
PERFORMANCE SPECS
INTERFACE SPECS
MATERIAL & PROCESS SPECS
COMPONENT SPECS
QUALIFICATION SPECS
RELIABILITY SPECS
DESIGN CRITERIA SPECS
PROCUREMENT SPECS
TECHNICAL MANUALS
ORIENTATION MANUALS
INSTALLATION MANUALS
OPERATION MANUALS
MAINTENANCE MANUALS
SUPPLEMENTARY DOCUMENTATION
TECHNICAL REPORTS
DEFINITIVE PLANNING REPORTS
PROGRESS REPORTS
CONTRACT DOCUMENTATION REQUIREMENTS CLAUSES
BASIC DOCUMENTATION TYPES
SCHEDULE & APPROVAL OF DOCUMENT
DATA REVIEW, HANDLING & STORAGE
DATA QUALITY ASSURANCE PROVISIONS
CONTRACT DEVIATIONS
CONTRACT CATEGORIES
DESIGN STANDARDS
CONFIGURATION DEFINITION & CONTROL SYSTEM
CHANGE CONTROL SYSTEM
VENDOR DATA DOCUMENTATION
VENDOR OWN ARTICLES
G.D/A
NAA
DOUGLAS

CHART 35

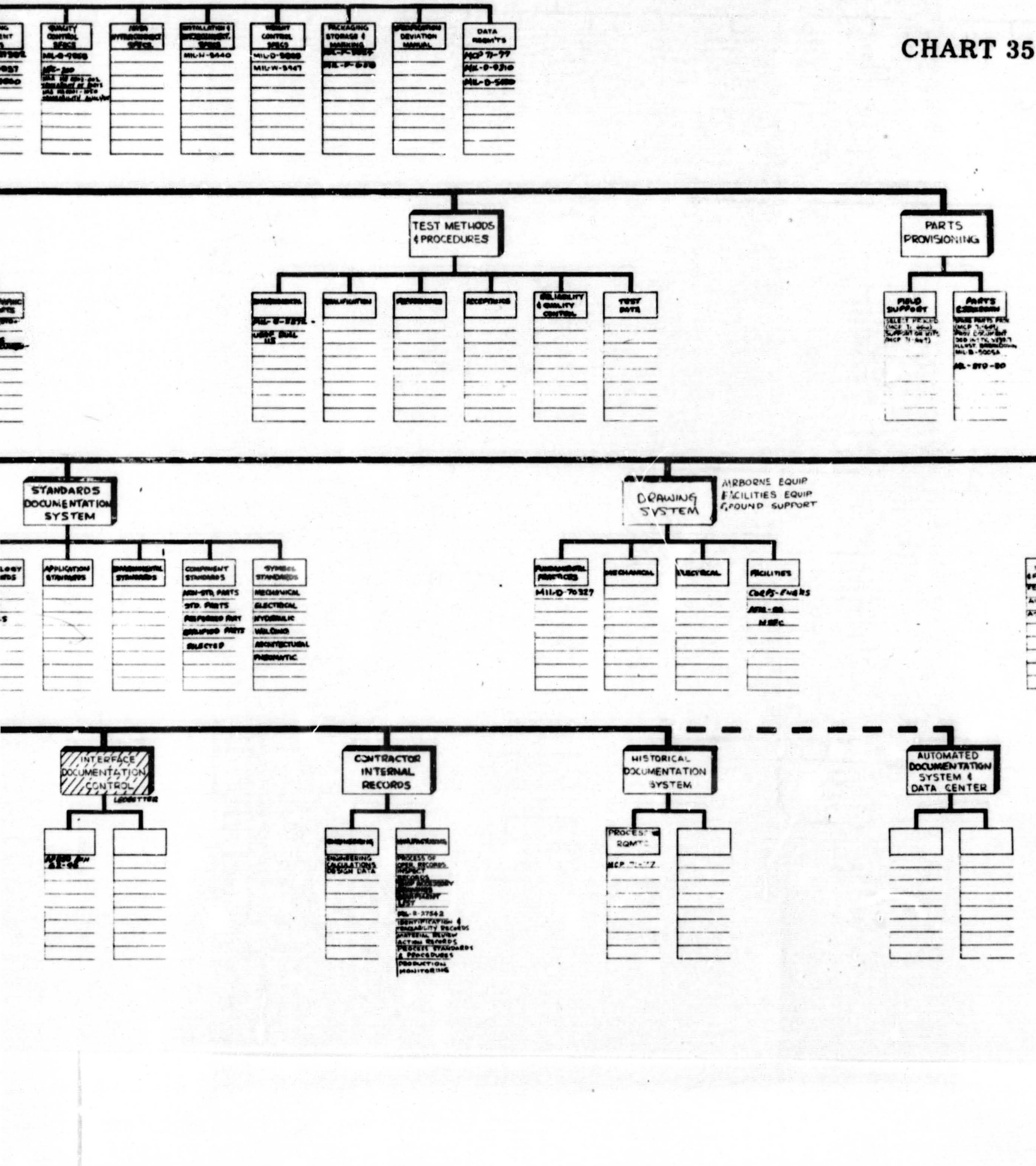
QUALITY CONTROL SPECS
MIL-Q-9858
INSTALLATION & INCREMENT. SPECS
MIL-W-5440
PACKAGING STORAGE & MARKING
MIL-P-116
OPERATION DEVIATION MANUAL
DATA REQMTS
MCP 71-79
MIL-D-9310
MIL-D-5010
TEST METHODS & PROCEDURES
QUALIFICATION
RELIABILITY & QUALITY CONTROL
TEST DATA
PARTS PROVISIONING
FIELD SUPPORT
PARTS STANDARDIZATION
MIL-STD-80
STANDARDS DOCUMENTATION SYSTEM
APPLICATION STANDARDS
ENVIRONMENTAL STANDARDS
COMPONENT STANDARDS
MIL-STD. PARTS
STD. PARTS
PREFERRED PART
STANDARD PARTS
SELECTED
SYSTEMS STANDARDS
MECHANICAL
ELECTRICAL
HYDRAULIC
WELDING
ARCHITECTURAL
PNEUMATIC
DRAWING SYSTEM
AIRBORNE EQUIP
FACILITIES EQUIP
GROUND SUPPORT
MECHANICAL
ELECTRICAL
FACILITIES
MIL-D-70327
CORPS-ENGRS
MISC.
INTERFACE DOCUMENTATION CONTROL
CONTRACTOR INTERNAL RECORDS
ENGINEERING CALCULATIONS DESIGN DATA
PROCESS OF MFGR. RECORDS
MIL-S-27542
IDENTIFICATION & TRACEABILITY RECORDS
MATERIAL REVIEW ACTION RECORDS
PROJECT STANDARDS & PROCEDURES
PRODUCTION MONITORING
HISTORICAL DOCUMENTATION SYSTEM
AUTOMATED DOCUMENTATION SYSTEM & DATA CENTER

CHART 35

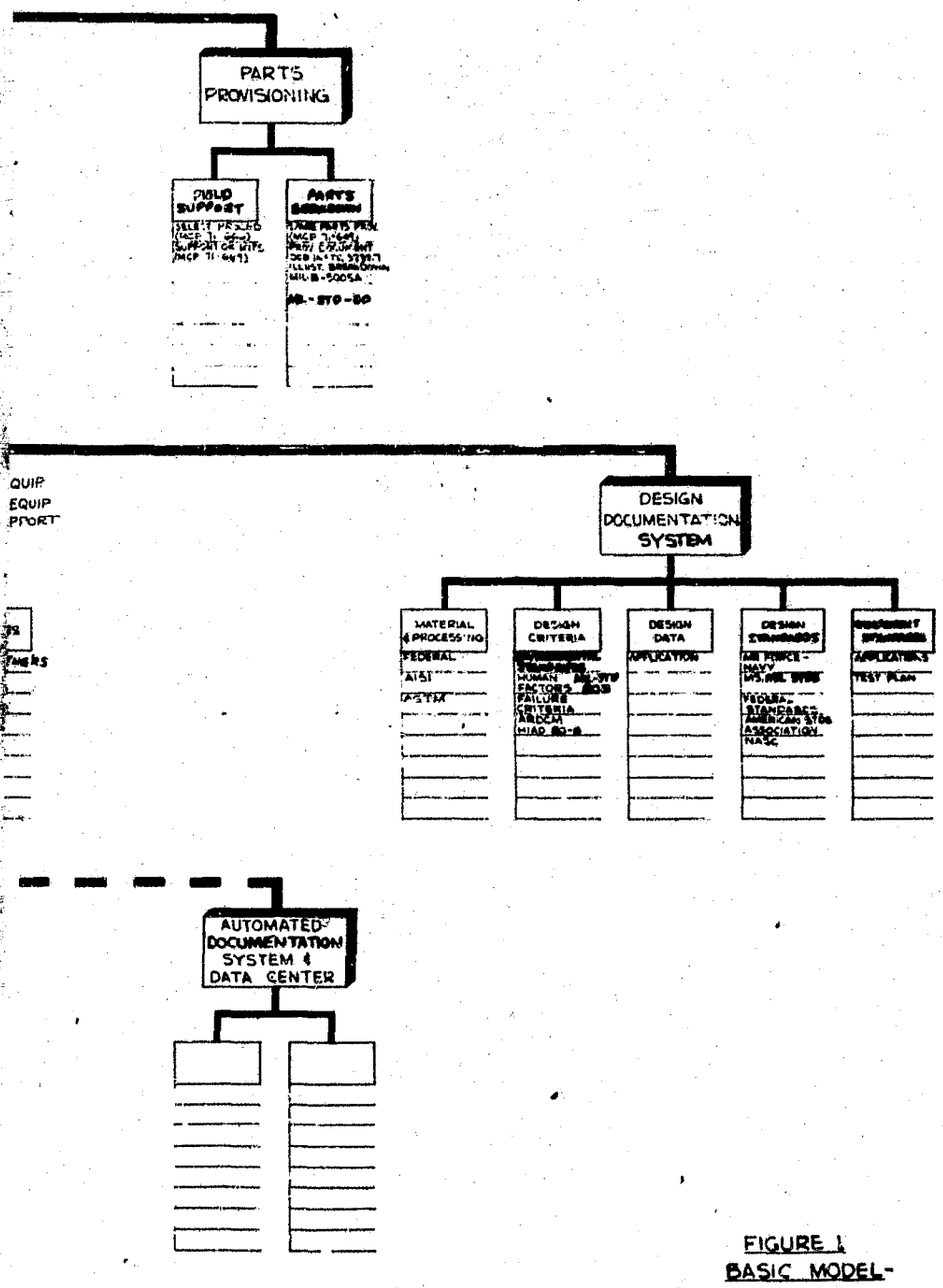

FIGURE 1
BASIC MODEL-
ENGINEERING DOCUMENTATION
SYSTEM

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DOCUMENTATION INTEGRATION

- DEVELOP AND IMPLEMENT INTEGRATED ENGINEERING DOCUMENTATION SYSTEM.
  - IMPROVE COMMUNICATIONS.
  - REDUCE TIME.
  - REDUCE ERRORS.
  - REDUCE COSTS.
- MINIMIZE AMOUNT OF REQUIRED DOCUMENTATION.
- MAXIMIZE USEFULNESS OF DOCUMENTATION.

CHART 34

When you talk about a total engineering documentation system, the first thing you should look at is a model and this is an across-the-board picture (chart 35) of what we can visualize as a total engineering documentation system for any program. It includes a specifications system, technical manuals test methods and procedures, the actual contract documentation requirements, the configuration control, the change control, standard drawing systems and so forth. This is an integrated approach which we are trying to develop. The areas which are sheded in red are the areas which we are currently working on. I think it will be a long-term process to try and complete this entire chart. I think we have charted the road map as to where we want to head and we are making diligent progress to get there.

The first thing that we have to do is to develop a model (chart 36), and then review the past programs and studies which we are presently doing. The tough part of the job comes in filling out the model. What we want to do is select existing documents, specifications and procedures and absolutely not reinvent any when they are not applicable. We have been working very closely with NASA and some of the contractors, and objections have been raised when somebody rewrites a specification to change a couple of words because you now have to read through both of them and convert careful comparison to determine the changes.

APPROACH

- DEVELOP DOCUMENTATION MODEL.
- REVIEW PAST PROGRAMS AND STUDIES.
- SELECT EXISTING DOCUMENTS.
- MODIFY EXISTING DOCUMENTS.
- DEVELOP NEW DOCUMENTS.

CHART 36

We developed a method where we use the old one with a simple cover sheet defining the changes. These simplifications have resulted in a great deal of time saving. In some areas we have to develop a new documentation that doesn't exist.

These specific activities have been conducted in support of Apollo Engineering Documentation Board which is an across-the-board NASA organization, which the General Electric Co. has been supporting in the area of these methods and procedures (chart 37). We have looked at the contract data and requirements, and have just published a report which analyzed the major contracts in light of their requirements in the engineering documentation field. We are trying to generate some common language that can be incorporated in all of the work statements to establish uniform requirements.

We have been working on the area of drawing systems. There is a meeting today, as a matter of fact, where we hope that all of the major NASA centers will agree to a common drafting specification which is a modification of the Department of Defense specifications and is a great simplification.

To give you an example, the current specification contains over 400 specifications referenced in it and the total number of references is over 4,000. We have reduced this and simplified it without changing the basic content or the basic quality to some 39 individual references to subspecifications. I think it is this kind of simplification that will help expedite the program.

We are currently working first with NASA and again with the contractors to develop listings of standard and qualified parts. These are listings for the sake of cross fertilization of information. We are not in this aspect attempting to

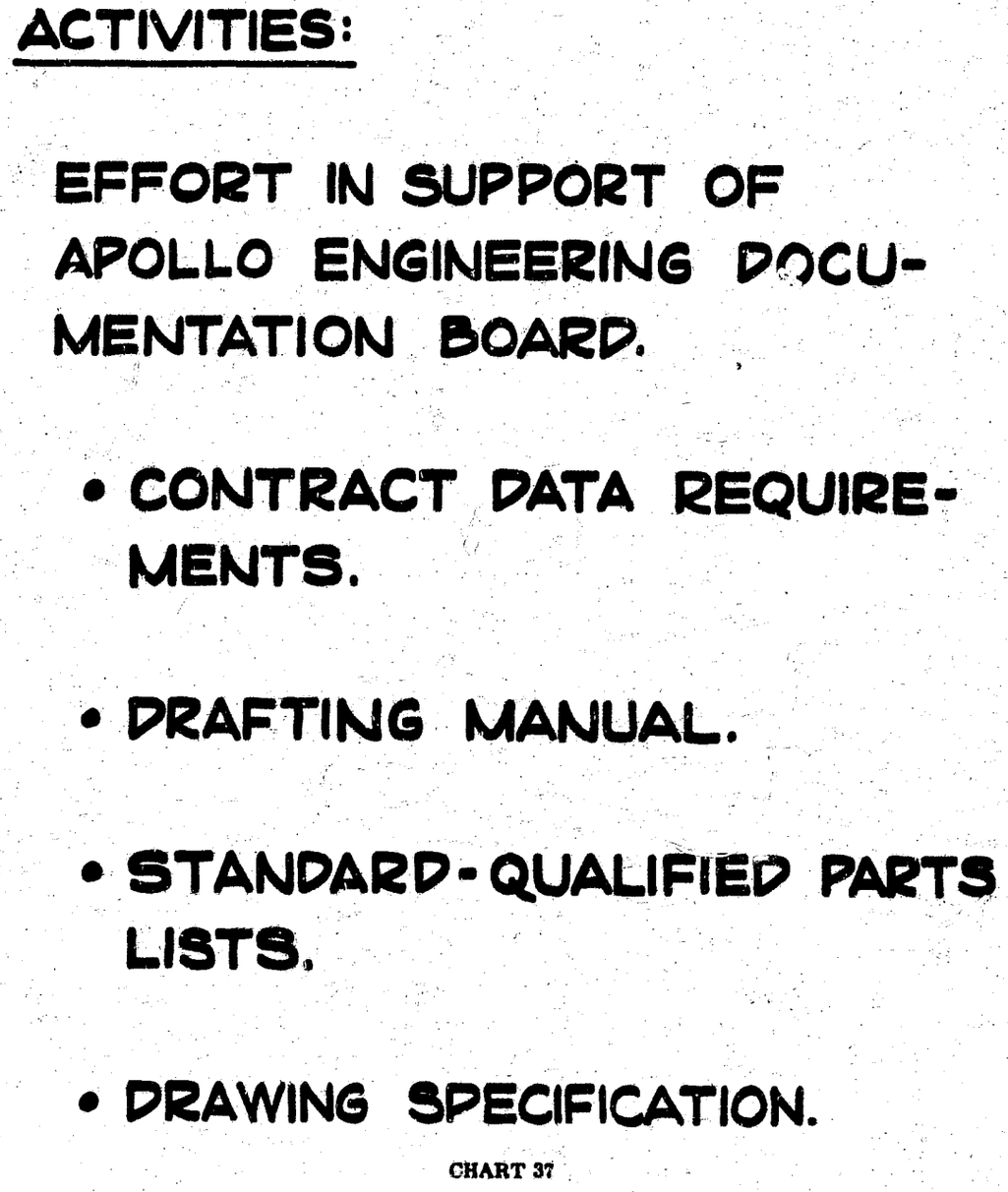

CHART 37

qualify or exercise any judgment on the acceptability of those parts, but merely to make available information from one part of an organization to another as to what parts exist and hence to avoid the time, cost, and expense of having to go through and redevelop a part which somebody else already has.

We have, in addition to these broad activities, a series of tasks at the various centers, many of which tie in directly to the above areas and others which are in direct support of specific needs under the integration activities which a particular center may have.

This briefly summarizes our activities in the integration area.

Mr. TEAGUE. Would you take a couple of minutes to tell us how you coordinate with the contractor to prevent duplication? Take your abort study, for example, what part do you contribute and what part does the contractor who is making the abort systems contribute? Do you actually draw the plans and specifications?

Mr. LEHMANN. No, sir; this particular study was one which we were asked to perform by the Manned Spacecraft Center in terms of their activity to inte-

grate the total spacecraft. They told us specifically what studies they wanted us to make and we did this study and submitted it as a report to them. We have had no responsibility in developing specifications and in a case like this similar studies are probably going on by several groups. I think that this is wise so as to make sure that there are independent approaches to assure that the analysis that have been made are actually correct. This is a very small effort. It lasted only a matter of a few weeks.

Mr. GURNEY. Following that further, let's take the LEM. Do you work with Grumman?

Mr. LEHMANN. Not directly. We have no direct responsibility for LEM, so that we would not directly be working with Grumman. These activities that I described are going across the board. We hope, for example, that activities such as Grumman's effort on the LEM will tie in directly to our interface and configuration plan and in that manner and we hope to develop the methodology which will bring about a compatible, uniform approach to the program. From a design standpoint, and performance and specifications standpoint, we have no responsibility for LEM.

Mr. PATTEN. Mr. Lehmann.

Mr. LEHMANN. Yes, sir.

Mr. PATTEN. Every contractor we visit we get pin buttons and are told everything is secret. On your integration and checkout, if everything is classified how do you tie it all in? What does General Electric tell Westinghouse?

Mr. LEHMANN. We have been working with both the NASA centers and, with the consent of NASA, with some of the key contractors. It has pleased me personally to see how receptive the contractors have been to this approach. For example, in this area of standard and qualified parts, we discussed this with North American and Douglas and they were very receptive. They feel that this can result in savings of time and money, and they are perfectly willing to make available their list of standard parts if in return they receive the other people's. This is the approach we are taking and I believe it will be reasonably successful. We recognize as I indicated in my first chart that the problem is one of people and whenever we deal with people there are going to be problems in convincing them that this is the best approach.

We have also been very careful not to interfere with their prerogatives in doing their job but rather develop the methods and procedures which would help them to do their job better and to ask for their suggestions and to incorporate their methods and suggestions so that they have partly helped create this system and have voluntarily accepted it. Thus they are willing to live with it.

Mr. TEAGUE. Take a company that does work similar to General Electric; do they furnish sufficient information to a competitive company for you to accomplish your mission, or do they just tell you that they are not going to furnish the information? One company told me that they will not give you the information that you have asked for. This is a company that does a lot of the same work General Electric does.

Mr. LEHMANN. Well, the approach that we have been taking is to request the information from NASA. NASA generally has the information if the work has been done on a contract for NASA and if they believe that we need this information they will make it available to us. Right now I don't know of a single case in the integration area that we have not had access from the particular contractors when we have requested the contractor to give us the information.

Mr. FUQUA. I have a question that may not be directly related to the subject of integration. Can GE still bid on some of the other projects within the Apollo program? In other words, can General Electric set up specifications in such a way that it would be the only company that could produce the item?

Mr. SHETLER. May I answer that question?

Mr. FUQUA. Certainly.

Mr. SHETLER. We have over the past year in which we have been working on this contract agreed with NASA that we would not participate in those competitive arrangements where we had received advance information through this contract. This position, I think, is somewhat of a safeguard. Most, if not all, of the major contracts have already been let in this area.

Mr. FUQUA. In other words, you would not be in the position whereby GE is supposed to check on GE?

Mr. SHETLER. That is correct.

We voluntarily, in the case of two items that I can think of, did not bid where our talents and experience were very great even though we did not have advance information, nor did we participate in the establishment of the specifications. In an attempt to insure that good faith was maintained in this area, we voluntarily did not bid on the two items. One related to guidance and one related to the control center at Houston.

Mr. FULTON of Pennsylvania. Obviously in the Mercury and in the Saturn programs so far, there has been NASA personnel performing the integration and checkout functions. Now what will happen? Will GE still keep the NASA people on, or do you replace them, or do you use them?

Mr. SHETLER. The vastness of this program requires additional emphasis and we do not replace those NASA people in the area of integration. We are in support of NASA rather than responsible for the integration. We supply the many hands and arms and head and ideas that are required for the reports they need to enable them to do their jobs.

Mr. FULTON of Pennsylvania. Therefore, NASA should keep all its integration and checkout personnel because GE will be supporting them. The next question is, if they should not be replaced, do they now need more in NASA?

Mr. SHETLER. I really could not and should not answer that question. I believe that answer should come from NASA in relation to integration problems. In the checkout areas, which is a complex hardware system, I do not believe that NASA has performed this operation on previous space programs, other than to establish the design requirements and the performance requirements. It has been found practical in this area for industry at large to supply the hardware and to couple the hardware together so that it indeed acts as a hardware system.

Mr. FULTON of Pennsylvania. It concerns me how through General Electric's efforts and organization, that the major contractors will now transfer among each other or through NASA these standard parts and their information. Obviously it has not been done previously if it has to be done now and therefore, it has cost more time and money by not having a system of this kind in operation before this.

Mr. SHETLER. I don't believe that I could agree that it has not been done before. We are really talking through time frames. What has been to date and what needs to be done out through the period when we actually land a man on the Moon is quite a stretch. The complexity and the added attention to the man rated space vehicle specifically for space flight and space environment is going to be quite a bigger job than what has been done in the past. The development of the booster which carried the space capsules that we have so far was quite different, and they are quite less complicated from those we will need to carry a man to the Moon.

Mr. FULTON of Pennsylvania. While carrying on your particular contract function, does General Electric expect to sell hardware and equipment to NASA or to other contractors in this program? Are you going to be dealing in the hardware business as well as doing the monitoring and the organizing of these systems within the Apollo program. If so, don't you think that might be an adverse interest?

Mr. SHETLER. I would like to say that we are not monitoring or managing the prime contractors who are associated with the whole Apollo program.

Mr. FULTON of Pennsylvania. No; I don't mean to infer that. You are certainly setting up systems.

Mr. SHETLER. Systems which can be followed. In the normal practice of doing such a complex program we would expect to sell those new pieces of hardware which are developed under the checkout system to NASA and to the prime contractors in the interest of performance in the total system, and in the interest of economy.

Mr. FULTON of Pennsylvania. Does that give GE an advantage by having done the development work?

Mr. SHETLER. My answer to this would be that any time you are under prime contract to do something unique which requires development, and when you have accomplished this development, then you do, indeed, have an advantage in building that hardware because you have that background in the development area.

I think that's part of the private enterprise system. When you have a contract for hardware, you, indeed, expect to get the hardware delivered.

Mr. FULTON of Pennsylvania. Then conversely, is GE going to make available to the industry at large what these developments are as well as your shop practices, trade secrets, and patents?

Mr. MAHER. I think there may be two separate questions here, Mr. Fulton. The 410 contract is a contract for General Electric to supply the integrated-launch-control checkout system, to design, fabricate, and build it. Now, this will entail our supplying a very considerable amount of that hardware, and it will also entail us buying certain portions of it from our suppliers. Outside of the integrated-launch-control system, and that would embrace all of the many, many other procurements that NASA will make, General Electric would assume that it would participate in these procurements the same as any other supplier would participate in them except in those cases, as Mr. Shetler has said, in which we agreed not to participate because our performance of the 410 contract would entail some possible unfair competitive advantage. Against that background, the knowhow which is developed in the fabrication of this hardware is governed as in the normal case by our obligation to furnish specified data to the Government. This is the normal contract practice and we will furnish that data to the Government for the Government to use as it sees fit under the contract provisions.

Mr. SHETLER. Next on the program I would like to introduce Mr. Robert Grisetti.

Mr. GRISETTI. Gentlemen, I would like to review with you (chart 38) some of our activities in the support of the NASA Apollo reliability assessment program.

RELIABILITY ASSESSMENT

CHART 38

I would like to review first the emphasis that has been given to the program activities to date. We have been in support of two basic activities for the Office of Manned Space Flight. The first has to do with mission reliability and safety assessment (chart 39). Our prime interest to date has been in the development of the techniques and methods for use in mission reliability and safety assessment. This a technical or more nearly scientific kind of an activity, as opposed to the next area of activity involving reliability and quality programs and plans and procedures, et cetera. Emphasis to date has been on techniques and methods for use by NASA in the assessment of the reliability and quality programs plans of the contractors. It is a two-stage approach; a technical approach, and a reliability and quality program support approach. In addition to this, we have been assisting the NASA centers; Marshall, the Manned Spacecraft Center, and the Launch Operation Center on those reliability tasks which are responsive to their most urgent needs. We feel that this has been extremely important, and has enabled us to become acquainted with and to develop a mutual regard and respect as well as solving some very important problems for these people at the NASA centers.

We feel that this background of the development of techniques and methodology plus the development of relationships will enable us to build toward an integrated Apollo reliability assessment.

RELIABILITY ASSESSMENT PROGRAM EMPHASIS

- MISSION RELIABILITY AND SAFETY ASSESSMENT
- RELIABILITY AND QUALITY PROGRAM PLANS AND PROCEDURES ASSESSMENT
- ASSIST NASA CENTERS ON RELIABILITY TASKS RESPONSIVE TO THEIR MOST URGENT NEEDS
- BUILD TOWARD AN INTEGRATED APOLLO RELIABILITY ASSESSMENT PROGRAM

CHART 39

I would like to review with you the characteristic of the tasks in support of the Office of Manned Space Flight (chart 40). As I mentioned earlier there are two basic categories: mission reliability and the safety assessment activity, and the reliability and quality programs and procedures assessment activity.

In the former, in the mission and safety assessment activities, we have been engaged in three basic task areas. First of all, in the development of techniques and methods for the estimation of the mission success and flight safety probabilities. We have in addition been supporting efforts in the development of techniques and methods for what we might call mission failure effects analysis. We have in addition been developing a reliability and failure data system approach compatible with our documented data control system, actually to serve the total activities underway in the areas, these are, if you will, technical areas.

In the area of reliability and quality programs and plans assessment, we have been underway in the development of check lists and scoring methods for use by NASA in the review of reliability and quality program planning.

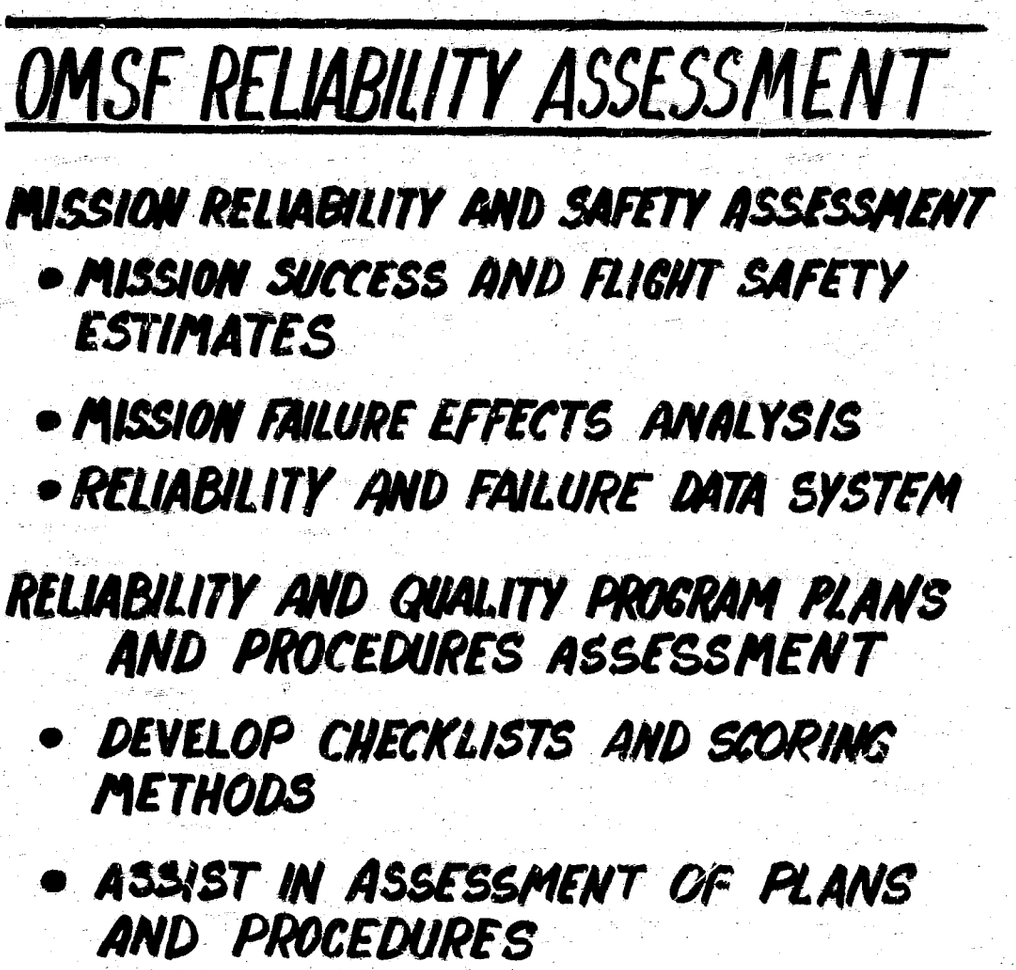

CHART 40

Now, I would like to give you a feeling for the emphasis timewise (chart 41). As I stated, the emphasis to date in all of these areas has been in the development of techniques and methods for use in the operation of the NASA Apollo reliability assessment program. I would like to discuss with you and give you a feel for some of the problems entailed (chart 42). I will discuss first the mission success and flight-safety estimation area.

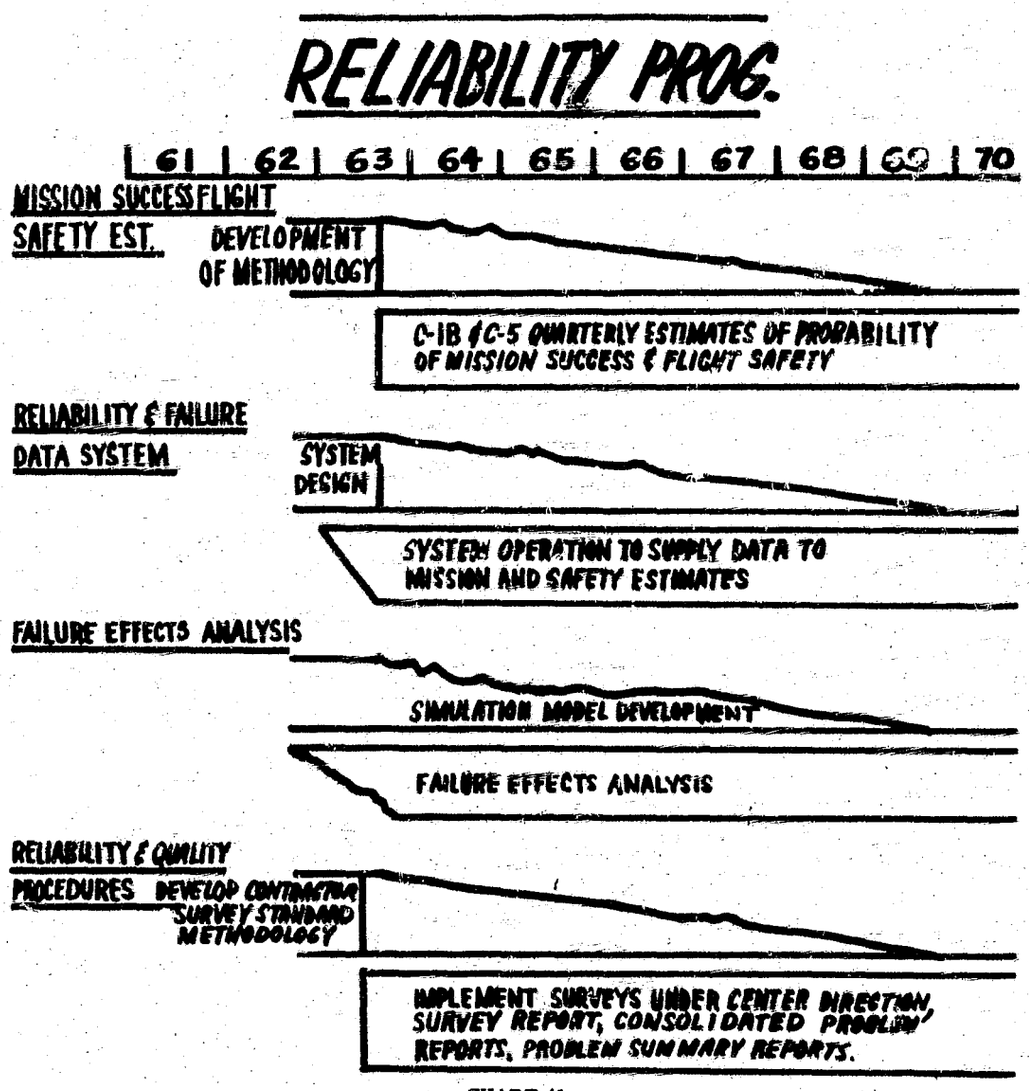

CHART 41

MISSION RELIABILITY & SAFETY ESTIMATION

CHART 42

What do we mean by this? First of all, let's have some definitions of terms (chart 43). What is meant by mission success? The interpretation that we have been using in the development of our techniques is the landing of the astronaut crew of two on the surface of the Moon with scientific instrumentation; the gathering of scientific data and samples; and the successful recovery of the three astronauts and of those samples on the surface of the Earth.

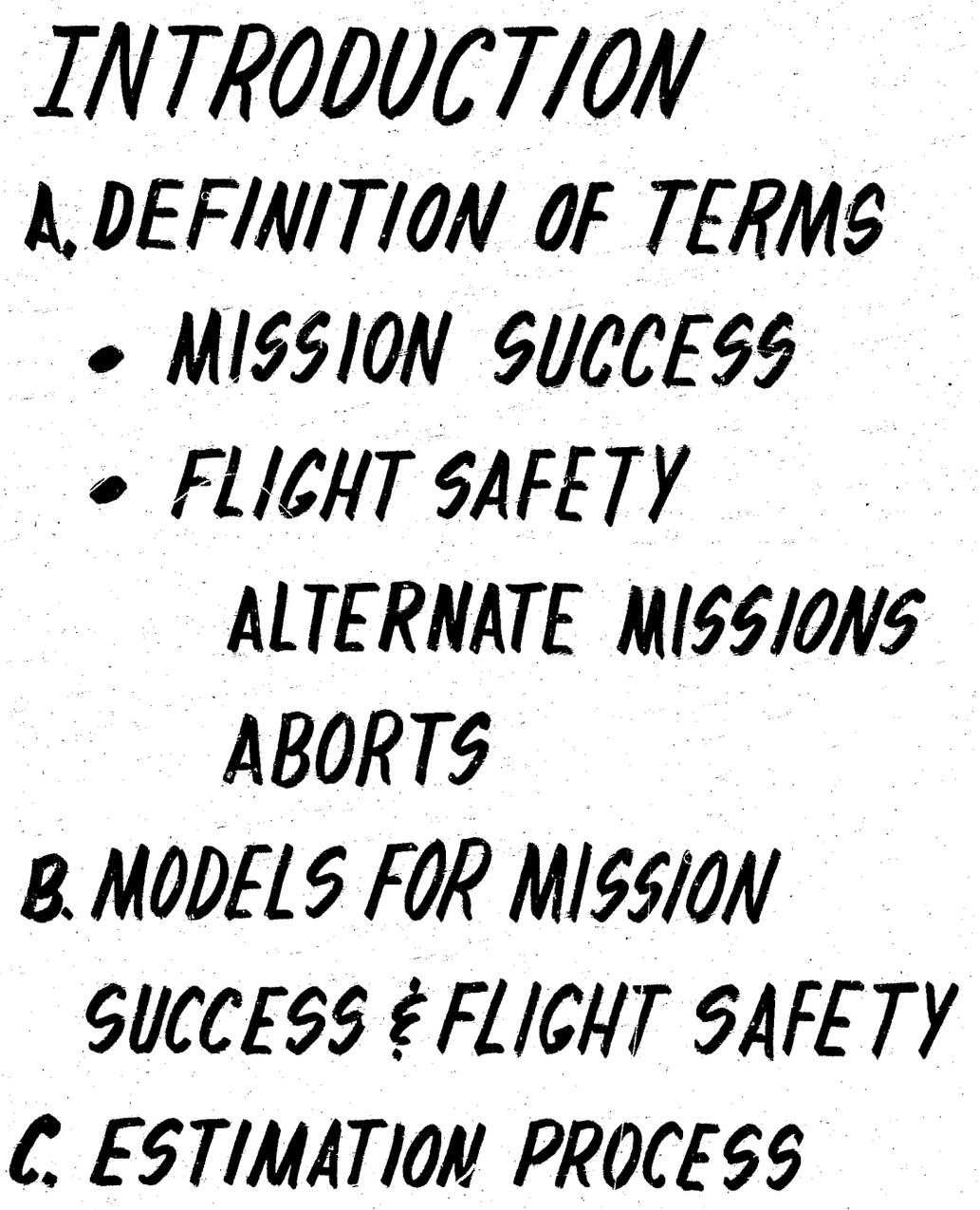

CHART 43

What do we mean by flight safety? Here we are concerned with the process of saving the crew at all costs. This certainly can be done by achieving a successful mission itself. That indeed is a flight-safety capability. But in addition consideration is being given to alternate missions.

What do we mean by an alternate mission? An alternate mission is still a scientific exploratory mission but it may involve relaxed goals as the progress of the mission proceeds. Much as in the early Mercury program, as you will recall, the designated mission consisted of three orbits. However, decision was retained by Mercury control to shorten the mission duration to two orbits, or possibly to one orbit if there were any unforeseen events that made such a change desirable in the interest of flight safety.

However, there may be circumstances as a result of malfunction that have a direct threat to the safety of the crew when you want to recover the crew in the minimum possible and most reliable fashion, that is, the minimum time and most reliable fashion.

This is how we designate an abort sequence, wherein immediate initiation of recovery is undertaken and no concern for gathering additional mission information is deemed appropriate.

Now, in the area of mission reliability and flight-safety estimation, we get involved in the development of models for mission success and flight safety. What basically are these models? They are analytical tools and methods using block diagrams which enable us to logically think through the system from a period before lift-off to the time of successful recovery on Earth, taking into account the functional performance that must be provided by each of the elements in the system throughout the entire mission duration.

You will see in the back of the room we have given examples of what these models in part look like. We see represented in the extreme rear the first phase of the launch operation and preflight checkout. The block diagram essentially summarizes and represents the functions performed by the equipment during each of the key events during the mission.

We see the launch operation here and we follow around the room to the right and go across the room and complete the mission down at the end. I will touch on this a moment later in more detail.

Making use of the models of this type we then proceed to develop the techniques for the estimation process for the NASA Apollo reliability program (chart 44). For the purpose of the development of the estimation techniques and the assessment techniques, we have developed a mission model which is drawn from the mission description in profile information much of which came from Henry Lehmann's system description which was a very valuable guide to us.

We then proceeded to take the mission profile and break it into some 13 phases, such as the launch phase, Earth orbital flight phase, the translunar trajectory phase, and the lunar orbital operation phases.

Each of these phases we broke into a number of events, like the staging of the Saturn S–V first stage. There are some 112 key events during the progress of the mission. We then took these phases and events and developed what we call a functional flow chart. This is a functional flow chart for the currently assembled. (Exhibit on wall.)

I might mention before I go on that the functional flow chart that you see back there essentially represents the primary mission itself; namely, the actual mission to the lunar surface and return.

Now, in additon to the consideration of the primary mission itself, we must somehow in the development of our techniques and methods provide a capability for handling the several alternate missions and the number of aborts that might be established as the program progresses and specifically we are underway in developing a model which includes some 7 alternate missions and some 17 aborts (chart 45). Those photo-reduced functional flow charts are 40 feet long. It is envisioned that the functional flow charts for the overall missions, including the alternate missions, may run about 500 feet. This is to give you a feel for the complexity of events that occur during the progress of the flight itself.

MISSION MODELING & ESTIMATING PROCESSES

MISSION DESCRIPTION

- MISSION PHASES & EVENTS

13 PHASES

112 EVENTS

- MISSION FUNCTIONAL FLOW CHARTS

CHART 44

These are some examples of alternate missions that were used during the process of developing this methodology of these techniques (chart 46). For example, an Earth orbital mission might be an alternate mission, very comparable to Mercury. A circumlunar flyby in which you go around the lunar surface, gather useful scientific information, reconnaissance information and what have you. We may have a lunar orbital reconnaissance in which you actually go into orbit around the Moon, or a lunar excursion module low flyby; where instead of slowing down sufficiently to land on the Moon you slow down sufficiently to approach the Moon to gather more detailed reconnaissance information than could be achieved safely by the lunar orbital operation.

I don't want to go into these in greater detail. These are not formal NASA alternate Apollo missions. We have used these, however, as a means of sizing to be sure that the techniques and methods developed were adequate to handle the many alternate missions and abort sequences that may be selected by NASA for possible use.

- ALTERNATE MISSIONS & ABORT PHASES & EVENTS
  - 7 ALTERNATE MISSIONS
  - 19 ABORTS
- ALTERNATE MISSIONS & ABORT FUNCTION FLOW CHARTS

CHART 45

Here are some of the abort considerations that we have used (chart 47). The launch escape tower ejection in the event of some difficulty before liftoff; the suborbital velocity reentry. If there was a malfunction before orbital velocity had been achieved and it was necessary to immediately recover the crew, a reentry would be achieved similar to the early Redstone-Mercury flight. An orbital velocity reentry would be more similar to a Mercury recovery.

An upper orbital velocity recovery would be similar to the kind of recovery techniques being employed in Project Fire, for example.

Again these are not formal NASA abort designations, but rather they are those that we used in sizing these capabilities.

ALTERNATE MISSIONS

1. EARTH ORBITAL MISSIONS
2. CIRCUM-LUNAR FLY-BY
3. LUNAR ORBITAL RECON.
4. LEM LOW FLY-BY
5. SHORT STAY LANDING
6. HIGH INCLINATION LUNAR ORBITAL RECON.
7. LUNAR LOGISTICS

CHART 46

ABORTS

1. LAUNCH PAD LET
2. IN-FLIGHT LET
3. SUB-ORBITAL VELOCITY RE-ENTRY
4. ORBITAL VELOCITY RE-ENTRY
5. SUPER-ORBITAL VELOCITY RE-ENTRY
6. DIRECT RETURN FROM TRANS-LUNAR TRAJECTORIES
7. CIRCUM-LUNAR RETURN

CHART 47

Now, in developing the models that have been used in the systems technique work, one of the first things that is done is to relate the equipment of the overall Apollo system to the mission phases and the mission events and the environment, by the functions that are performed (chart 48).

For example, attitude stabilization equipment obviously performs the functions of stabilization during portions of the flight. The attitude stabilization gear in the command module may be active following lunar injection or it may be standby such as in the situation where we are in launch-powered flights when the attitude stabilization of the Saturn S–V launch vehicle provides the stabilization. Or the equipment may be operating continuously, such as the environment control, or the life support system which operates throughout the entire flight or intermittently as the case may be.

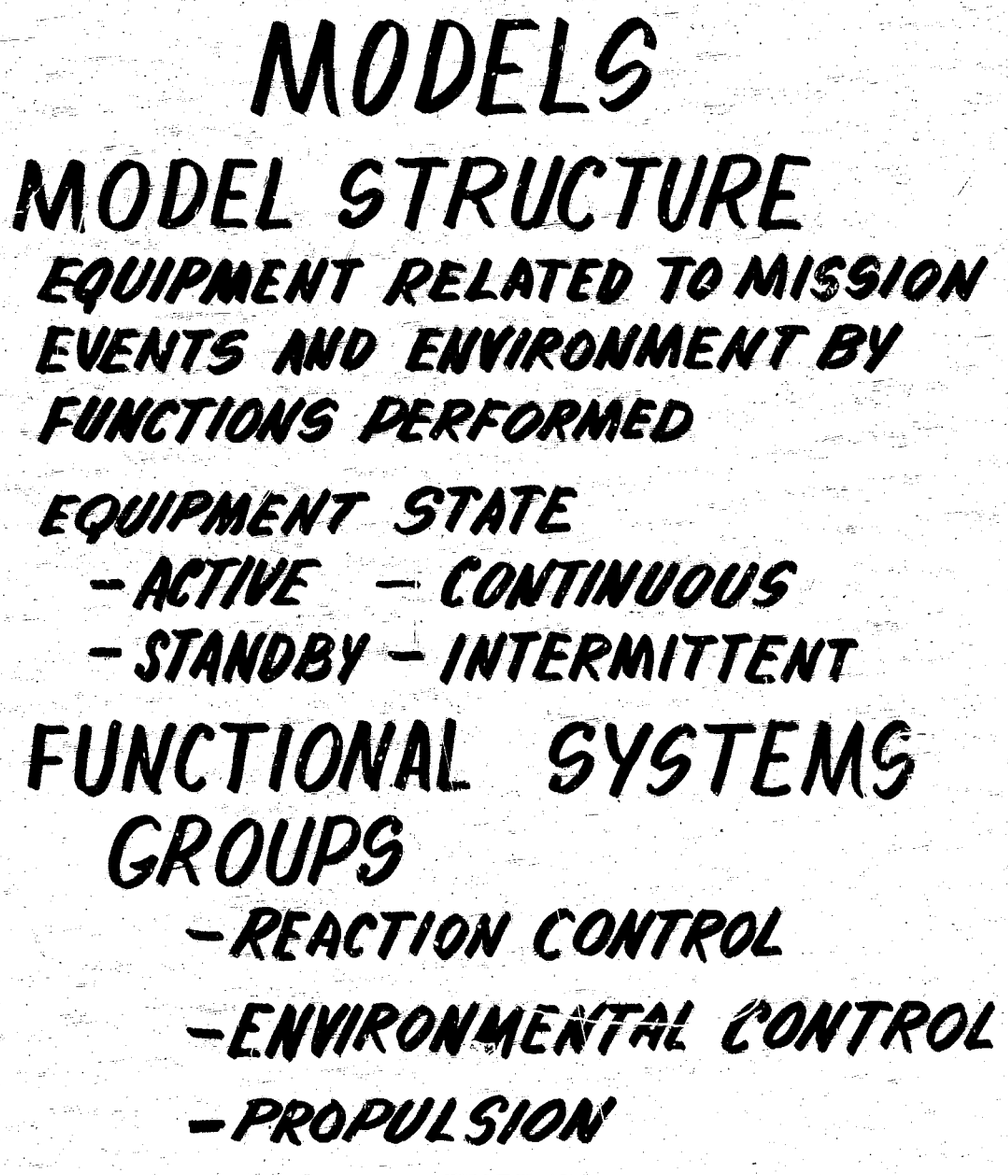

CHART 48

These factors must be taken into consideration in the development of the model structure. The first step in this is on these charts that you see to your left [referring to wall charts] in which the mission phases and events are scheduled and the various functional equipments are laid out against those events. So that for every single event in the mission there is an indication of a function to be performed by the specific equipment in the system.

The next step is to go from this set of charts to the functional flow charts themselves. Now, we have linked these equipments into what we call functional systems groups such as reaction control, or environment control or propulsion because many redundancies do exist throughout the system. Should one item fail it may be possible to use functionally that system from one of the other modules. We have grouped equipment in this fashion rather than by individual modules so that you can see the reactions and interfaces.

Now, the next step in this reliability estimation process is the translation of the functional flow and a hardware configuration into what we call the functional system reliability diagram (chart 49). In this case we show a functional system reliability diagram for a single specific event. Now, these little blocks represent the functional elements of the system for a single event. We

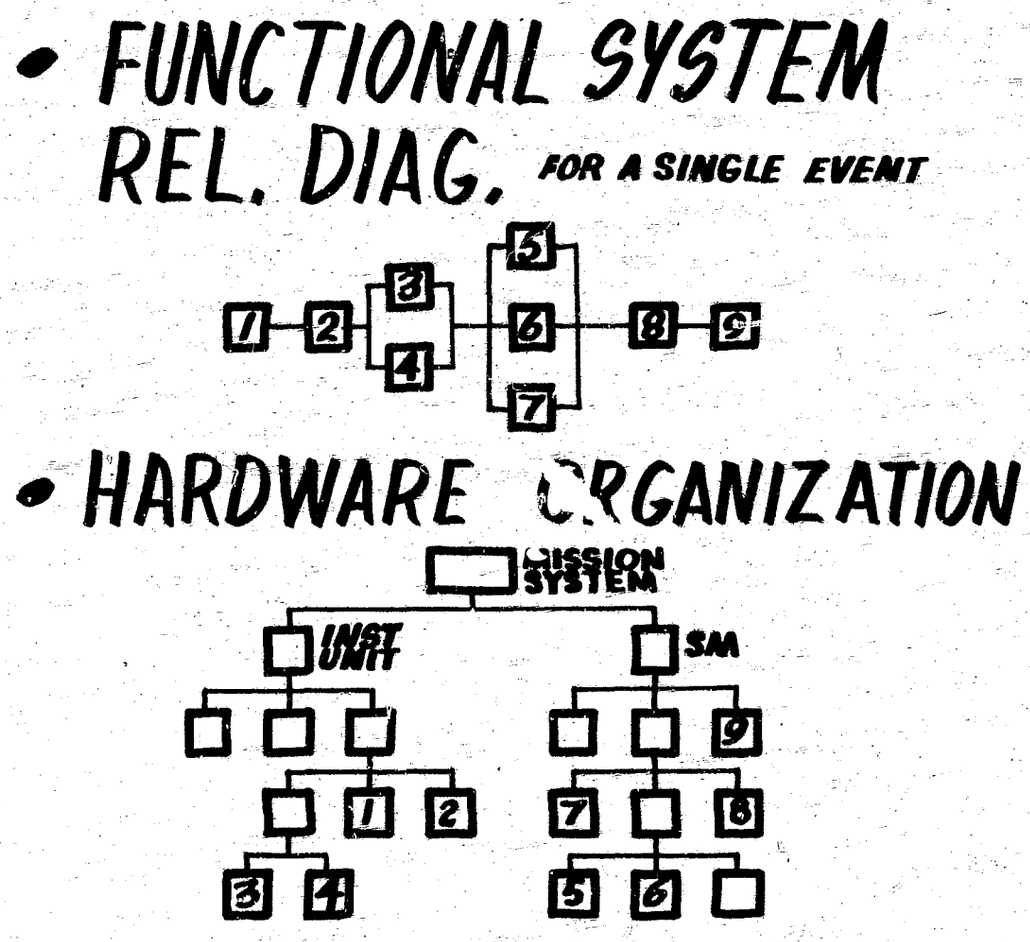

CHART 49

look down here and we look at the hardware organization of the system. We have taken, for example, the instrument unit of the Saturn S–V launch vehicle family and the service module just to give you a feeling for this and we show by the indenture, the level of indenture, the various equipments that are in this hardware organization.

These, for example, might be two batteries. This might be the entire service module, propulsion system.

In this modeling effort, the depth of detail needed and thus the level of indenture in the module, is primarily dependent on the degree of interaction and redundancy involved and the contribution of a given equipment to flight safety.

Now, the meaning of this reliability kind of diagram is this. It is what we call a probabilistic block diagram. But you can get a physical picture for it in this way: For a given single event to be performed it is necessary that equipment (1) the functional system, (2) and systems (8) and (9) all operate successfully. It is necessary, however, that only equipment (3) or (4) or both function so that we have redundancy. In the case of (5), (6), and (7), this event can occur reliably if only one of these equipments performs satisfactorily.

Now, the process of estimation then is taking the reliability estimate for the equipments for these events and combining these probabilities together appropriately to come up with a probability for this event taking place properly.

Then when the overall system is put together, composed of all of these many events, in this case 112 events for the current system, we are then able to provide a capability and technique by which NASA can estimate the probability of mission success.

Now, we have developed a digital computer program using a technique commonly called Monte Carlo simulation. This technique has been used as a means for developing the capability for making mission success and flight safety estimates. The current model is composed of over 600 separate hardware items. As we go later into the flight safety model, including the alternate missions, these hardware items will be used over and over again, with multiplicity (chart 50).

Now, I have talked a little bit about the process of the estimation of the probability of mission success of flight safety (chart 51). This is the methodology,

CHART 50

t. e technique involved in mission success and flight safety estimation. And certainly this is one of the major goals in the reliability assessment program.

Later I will discuss briefly some of the considerations involved in the data systems that serve this process of mission success and the flight safety estimation.

We feel very strongly that dealing with these numbers alone will not give credibility to the reliability assessment effort. We feel that it is essential that an understanding indeed be provided to support what might be called the "numbers game," and it h~ ~ been many times called the numbers game, by an understanding of the m' .on phases and events, and the systems making up the mission. We think a1 important tool for this, integral with the reliability assessment program is v .at has been called mission failure effects analysis.

Now, what does this involve? It involves the single thread of thinking through the effects of an equipment failure. Suppose a propulsion system fails. What effect does that have on the stage loss? What effect does it have on mission loss? What effect does that have on our ability to recover the crew safely? This has been called, if you will, a single-thread failure effect analysis.

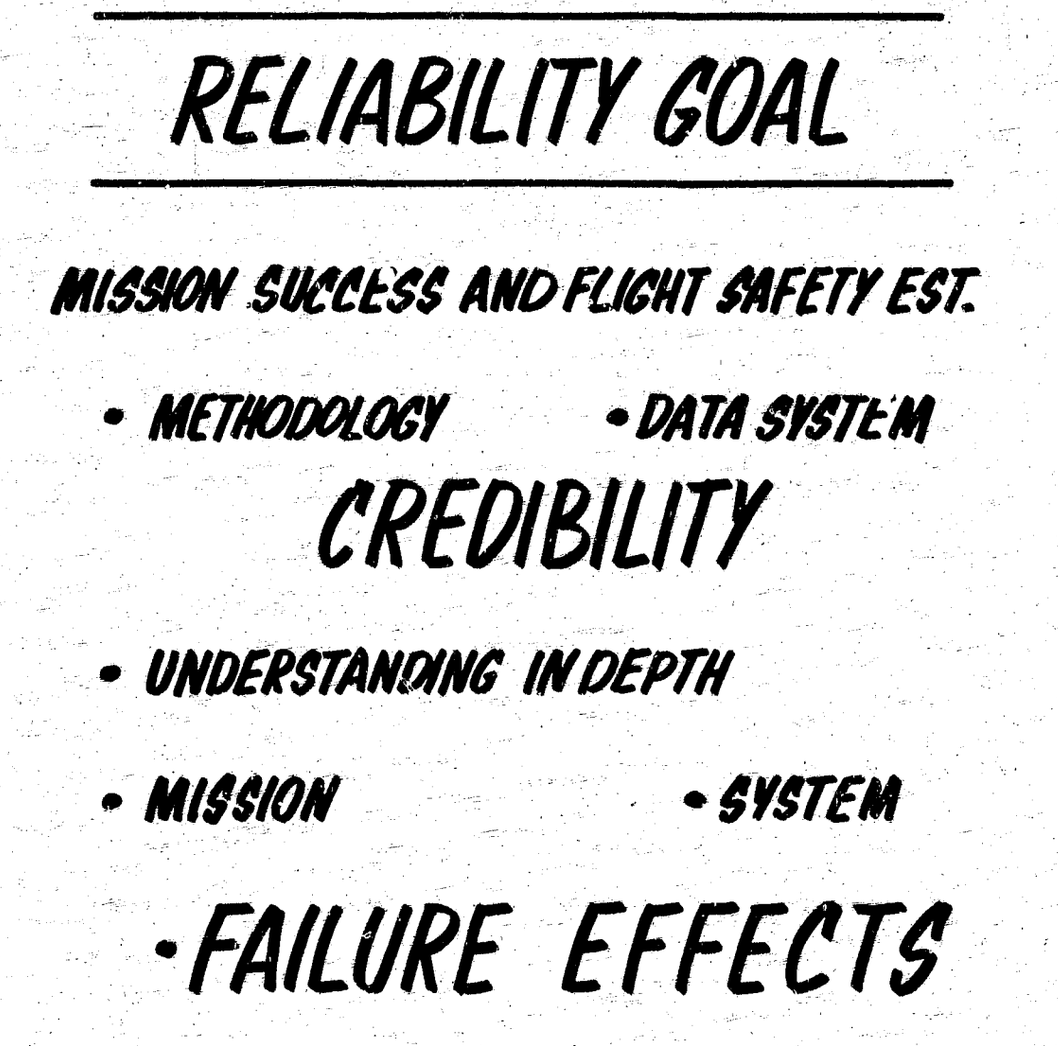

CHART 51

Now, in addition, perhaps a nastier problem in many respects is the problem of dealing with failures that aren't nice and discrete, that don't involve an abortive failure of a package, but rather result in an out-of-tolerance performance or a marginal performance, such as excessive drift in a gyroscope or many, many others that could be envisioned. When these kinds of situations arise there are interactions with other equipment.

Now, for example, if the launch vehicle thrust was below tolerance so that the insertion velocity into translunar trajectory was below the nominal plan. This is very unlikely with the kind of reliable launch vehicle developed by the Marshall Space Flight Center but I think it is an example. Do the guidance and navigation system and the service module have sufficient latitude and flexibility to make adjustment for this out-of-tolerance behavior of the launch vehicle, this new trajectory. We feel that this kind of a tolerance failure effect analysis is a very important element in the reliability assessment program.

The kind of activity underway in this area has involved the development of dynamic models and then makes use of system and equipment dynamics as opposed to probabilistic models (chart 52). Here we are interested in the actual performance variations involved.

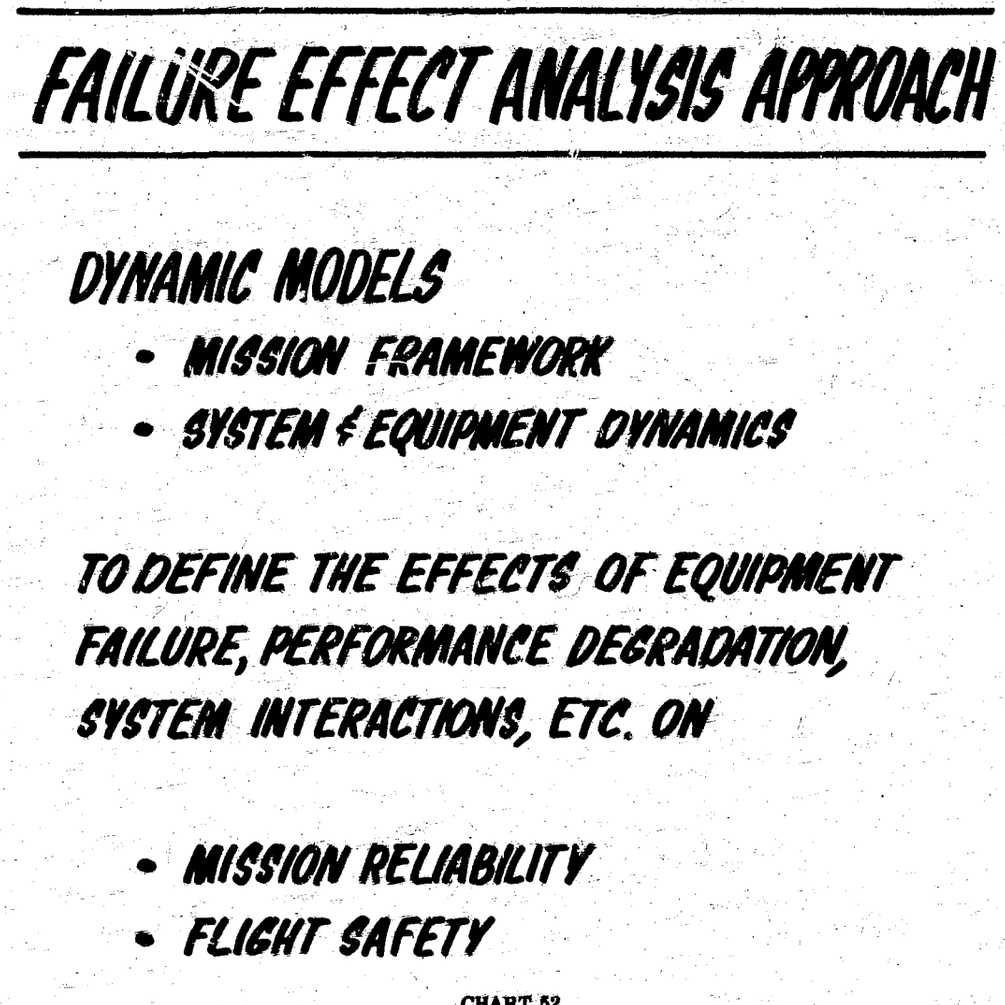

CHART 52

Then the problem is to analyze the effects of the equipment failure, the performance degradation kind of failures and the system interaction that results throughout, and assess their effects on mission reliability and flight safety.

Now, we may draw some conclusions about this area of work involved in the estimation of the probability of mission success and flight safety NASA is undertaking (chart 53) to derive from a program of this nature a measure of

the probability of mission success and flight safety. This in itself is certainly important, to get a feeling for where the program stands.

Perhaps equally important is the capability to use these techniques to evaluate trade-off considerations. For example, what happens if it has been decided to do something a little different, to change the mission or the system in some way? What effect does that have on the "odd." Also, we feel that the kind of effort involved; that is, logically thinking through the mission, gives a guideline for identifying insufficiencies in critical problem areas. This we feel also is very important.

CONCLUSIONS

- A MEASURE OF PROBABILITY OF MISSION AND SAFETY SUCCESS
- TRADE OFF CONSIDERATIONS
- IDENTIFICATION OF INSUFFICIENCIES CRITICAL PROBLEM AREAS

CHART 53

I would like to now talk about another important element (chart 54); namely, the reliability and failure data system. And here are some of the objectives outlined for us on the program.

First, the review of NASA Center and contractor data in the category of not reinventing the wheel. In the process of this activity, we have reviewed many of the reliability programs of the Department of Defense and NASA for data that is applicable to these areas.

Another objective is to develop a reliability and failure data system as part of the documented data control system that Hank Lehmann spoke of and to develop standard reporting procedures such that when the data is incorporated into the data system you don't have a lot of data conversion problems. And then the objective is to collect, consolidate, store, and process data for reliability

RELIABILITY AND FAILURE DATA SYSTEM

OBJECTIVES

- REVIEW NASA CENTER/CONTRACTOR DATA SYSTEMS
- DEVELOP A RELIABILITY AND FAILURE DATA SYSTEM
- DEVELOP STANDARD REPORTING PROCEDURES
- COLLECT, CONSOLIDATE, STORE AND PROCESS DATA FOR RELIABILITY MODELS AND ESTIMATES
- CONSOLIDATE AND PROCESS CENTER AND CONTRACTOR MODEL AND RELIABILITY ESTIMATES FOR USE IN MISSION RELIABILITY AND SAFETY STUDIES
- SUMMARIZE RELIABILITY AND FAILURE STATUS FOR NASA MANAGEMENT GUIDANCE

CHART 54

models and estimates and finally to consolidate and process center and contractor models and reliability estimates and failure effects analysis for use in the reliability and safety studies activities.

I think another very important objective of the reliability and failure data system is to provide a capability for summarizing reliability and failure status for NASA management guidance, on specific problems that exist within the program.

Now, what are the data sources involved here (chart 55)? Certainly the Office of Manned Space Flight has provided us with a good deal of data. To do a credible job it is essential that specific data be provided by the NASA centers, contractors, and subcontractors such as the Marshall Space Flight Center, and so forth.

Certainly the Department of Defense and other NASA activities and their many contractors are an important source of reliability and failure data. Why? Because such data banks represent the sum and substance of the state of the art. This is the technology in this country with regard to such things as mean time between failures, state of the art of guidance computers, propulsion systems, environment control systems, as guidlines for the overall assessments. As

DATA SOURCES

- OMSF
- NASA CENTERS, CONTRACTORS AND SUB-CONTRACTORS MSFC, MSC, LOC/LVOD/POD, ETC.
- DOD AND ITS CONTRACTORS

RELATED PROGRAMS: POLARIS, TITAN, MINUTEMAN, ETC.

CHART 55

part of our activities we have explored a good many of these programs—Mercury among them.

We envisioned the Apollo reliability assessment program to involve the submission of functional subsystem data, first of all the models, the kind of models we have talked about (chart 56), we will need reliability estimates from the centers and their contractors. Maintainability estimates. One such maintainability estimate is defined as the mean time to detect a failure. Certainly you cannot maintain or correct a malfunction unless you can detect that the malfunction occurred. Another is the estimates of the mean time to repair. How long does it take to repair the device after a malfunction has been detected, and so forth? Other estimates concern the feasibility of in-flight maintenance on many of the critical subsystems.

The failure effects analysis that have been performed by the contractors, the functional block diagrams and so forth, all will be needed.

Now, in the mission area much of the data comes from the Office of Manned Space Flight. The profile, the mission profile and flight objectives, environment, operating times, aborts, and alternate missions must be obtained, and also occasionally specific, in-depth data to deal with critical problem areas such as failure summaries on the various competent parts.

ULTIMATE NASA CENTER AND HEADQUARTERS DATA SUBMITTALS

- SUBSYSTEM
  - MODELS
  - RELIABILITY ESTIMATES
  - MAINTAINABILITY ESTIMATES
  - FAILURE EFFECTS ANALYSIS
  - FUNCTIONAL BLOCK DIAGRAMS
- MISSION
  - PROFILES AND OBJECTIVES
  - ENVIRONMENT
  - OPERATING TIMES
  - ABORTS AND ALTERNATE MISSIONS
- GENERAL
  - OCCASIONAL SPECIFIC IN-DEPTH DATA
  - FAILURE SUMMARIES

CHART 56

Now for the status today (chart 57). We have reviewed various data systems in NASA in industry and a number within the General Electric Co. We have developed a manual data system and it is currently being used in the development of these estimation techniques that we have been talking about. It is being used to provide the data with which these techniques are being developed. It is a manual system but it does incorporate coding techniques which will enable later mechanization. We feel that it is better to walk before you run to make darn sure that you have a system that is efficient and does not involve excessive documentation. As such this effort is a combined part of the data studies in which we have been cooperating very closely with Henry Lehmann and his people in the development of this system.

We have collected a great deal of Department of Defense state of the art reliability data, such as the mean to failure and the mean time to repair.

We have collected a good deal of information on Project Mercury and it has been very applicable and very helpful to us. We have developed several procedural handbooks. We have recommended the techniques within them and these have gone through a number of reviews with NASA and are currently under review at headquarters.

This is a reliability modeling estimation procedure. Here we review and delineate the techniques and methods, recommended for program use. The reliability data system and the failure data system highlighting procedures and the

STATUS

- MSFC REVIEWED
- MANUAL DATA SYSTEM DEVELOPED AND IN USE
- CODING SYSTEMS FOR A MECHANIZED DATA SYSTEM DEVELOPED
- DOD DATA COLLECTED AND STORED
- SOME NASA CONFIGURATION DATA COLLECTED AND STORED
- DATA STANDARD HANDBOOKS PREPARED

RA 20 RELIABILITY MODELING AND ESTIMATING PROCEDURES

RA 21 RELIABILITY DATA SYSTEM

RA 22 FAILURE DATA SYSTEM

CHART 57

formats and the techniques for the submission and the handling of the vast quantities of data involved in the program.

I would like now to talk about the other basic area of work in which we have been supporting the Apollo reliability assessment program (chart 58). Three

- DESIGN
- MANUFACTURING
- TEST AND OPERATIONS

CHART 58

areas, design, manufacturing, test, and operation. The efforts in these areas have been in the development of survey techniques, check lists and scoring methods which may be used by NASA in the review and in the assessment of the NASA contractor's reliability and quality programs in these areas.

In a vast program of the type that we are dealing with it has been mentioned that something like a half million people are involved. It would be impossible for one organization, any organization, to keep track of all of the details, specific problems involving many millions of component parts in the program. There is no accurate estimate I am sure at this point. Some have estimated that 10 to 15 million component parts are involved in the whole program. I think that it is a very important function for the reliability assessment program that means be established for developing the techniques for providing adequate reliability controls in the program.

Each contractor must be responsible for the reliability assurance of the hardware he develops.

Now, what are some of the key techniques involved? We have talked about the check lists. The check lists consist of some 1,000 statements or questions that have as guidelines the important elements of a reliability and quality program. In this case, for example, we have a statement. "The published procedures state that signature approval is required for proper control of deviations from the requirements of the standard practices manual" (chart 59). What

PUBLISHED PROCEDURES STATE THE SIGNATURE APPROVALS REQUIRED FOR PROPER CONTROL OF DEVIATIONS FROM THE REQUIREMENTS OF THE STANDARD PRACTICES MANUAL.

CHART 59

does this imply? It implies that a good reliability program involves the development of a standard practices manual. It involves as well, certainly, provisions for variation from standardization, but that there should be a reason for it. I think it would be impossible for any detailed assessment in all of the activities and in all of the contractor's areas to insure compliance but the important thing is that they do have these control and they do have these methods and are using them.

I think it will be clearly the function of NASA, and the Government inspection agencies, to perform these assessments in general. We are merely developing the techniques and methods.

Another example of a question or a statement in these check lists (chart 60) is the statement, "Maximum use is made of standard parts, modules, components, circuits and accessories to achieve a high degree of interchangeability." I think this is important especially from the maintainability point of view.

I recall a story about General Clark at Pusan during the Korean war. It involved certain support handling equipment. At one time he could not assemble from scavenged parts one working functional material handling system for a particular type of truck. This seriously impeded ships unloading at the beachhead.

I think this again points up the need for a basic approach in the contractor's reliability and quality program activities.

MAXIMUM USE IS MADE OF STANDARD PARTS, MODULES COMPONENTS, CIRCUITS, AND ACCESSORIES TO ACHIEVE A HIGH DEGREE OF INTERCHANGEABILITY.

CHART 60

I have several others that may be of interest. This (chart 61) in particular I think is important. "Special analysis is conducted on each critical and major

SPECIAL ANALYSIS IS CONDUCTED ON EACH CRITICAL AND MAJOR FAILURE BY THE RELIABILITY FUNCTION.

CHART 61

failure by the reliability function" of the contractor. Another is (chart 62): "The failure analysis system provides methods for control of discrepant parts

THE FAILURE ANALYSIS SYSTEM PROVIDES METHODS FOR CONTROL OF DISCREPANT PARTS AND COMPONENTS WHICH REQUIRE FURTHER ANALYSIS AND CORRECTIVE ACTION.

CHART 62

and components which require further analysis and corrective action." It is important, for example, that discrepant parts which work partially aren't fed back into the spare parts inventory. This has on occasion happened, of course. It is certainly no way to achieve adequate reliability. It is important, furthermore, that when a failure occurs that a means be explored to find out what caused the failure to determine what corrective action must be taken to correct that failure. I think in most cases the contractor is in the best position to make these corrections. We have also been developing, gentlemen (chart 63), techniques that NASA may use in scoring and evaluating the various reliability

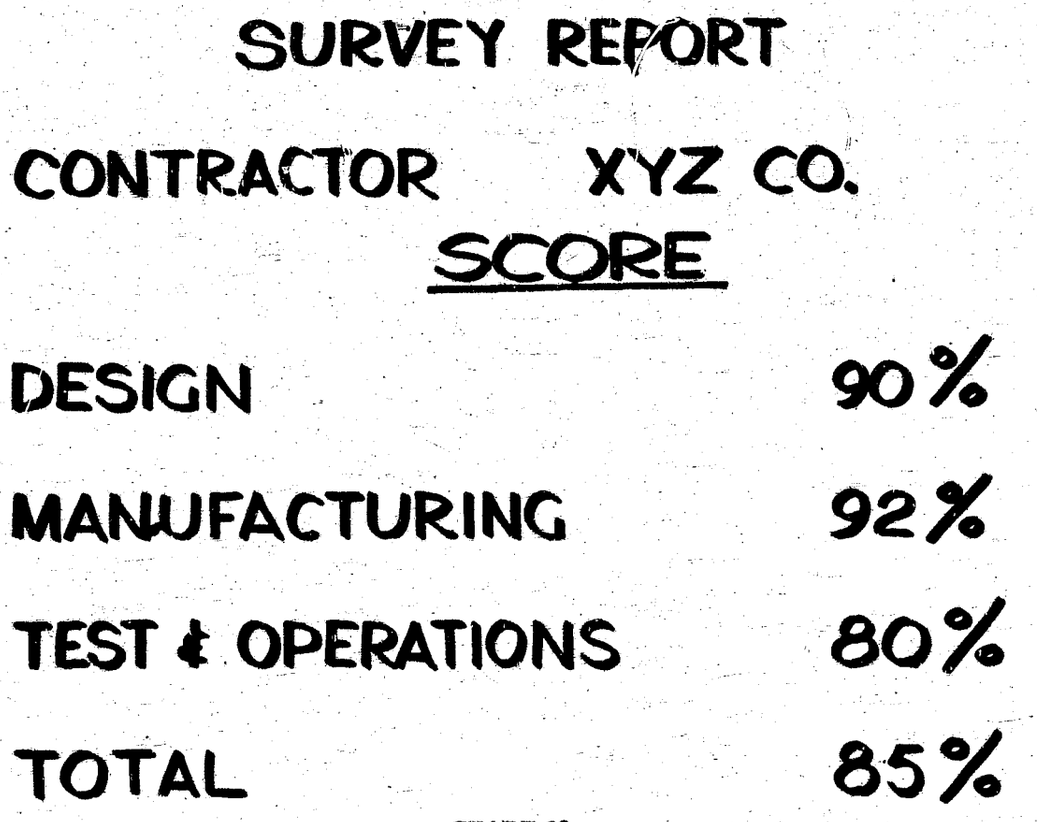

CHART 63

and quality programs in use. This reviews the guidelines (chart 64) that were used in the development of the manufacturing reliability assessment checklists. These are the various kinds of reliability and quality control elements that are felt to be important to the program.

These techniques should provide NASA a tool for highlighting areas where possible improvements could be achieved.

Gentlemen, my time is up. I would be glad to answer any questions.

Mr. TEAGUE. I guess you can go ahead then, Mr. Shetler, since nobody has any questions.

Mr. SHETLER. There are two questions which I promised to address myself to which came up in our previous discussions. One had to do with the in-house versus the contractor approach to the total problem that we are attacking under our contract 410.

We see in this contract a reason for industrial support for several reasons. First, this contract enables the National Government to call on the entire capability of a very diverse element of the industry. We have collected here many kinds of capabilities. It is a team that has had experience in this area, both in the software and in the hardware areas. And we feel very strongly that it would not be in the public interest for the Government to attempt to assemble a duplicate team in-house for the purposes for which this contract has been written.

Second, the central feature of our contract is the integrated launch control and checkout system, which is a major part of the whole Apollo system. This involves the detail design, manufacturing, installation, and logistic support of complex hardware system. The Government traditionally, and we feel very properly, looks to industry, particularly in the rapidly developing electronics technology area, for support for the supply of such equipment.

We feel that there is no reason why this practice should change for Apollo or for the integrated launch control and checkout system any more than it should for other major Apollo equipment systems such as the launch vehicle, the spacecraft, or the lunar excursion module.

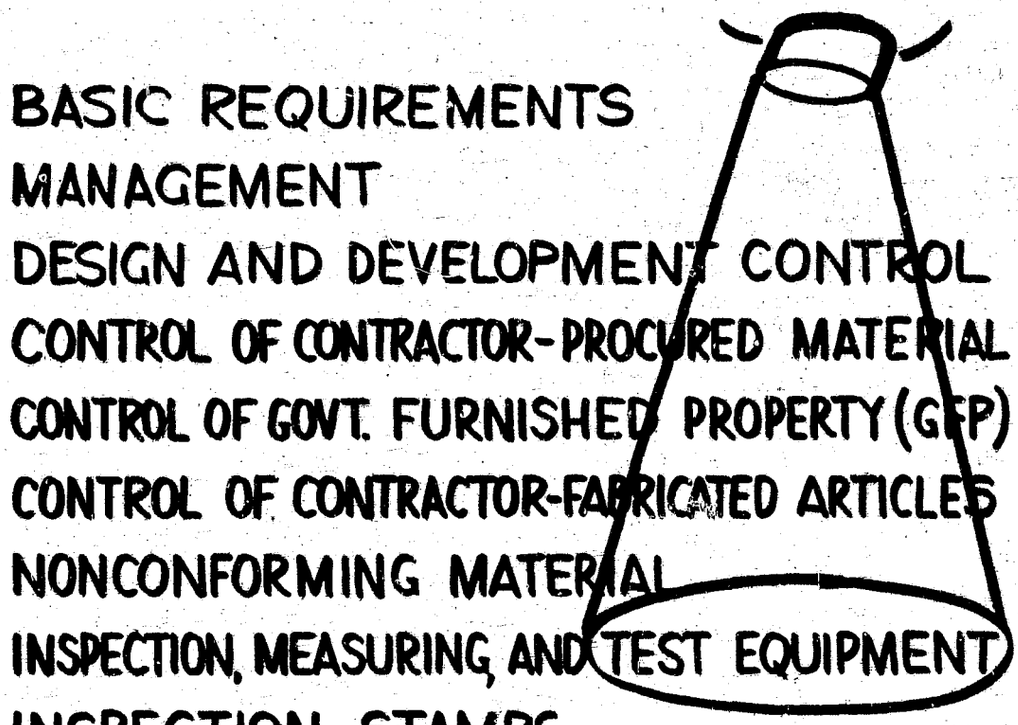

CHART 64

Finally, what we have tried to show this morning is that our contract is an integral whole. Integration and reliability assessment are logical and proper corollaries of the integrated launch control and checkout system.

Those things you need to know for one are required for the other one. We feel that it would make for only inefficiency and poor economy for either or both of these integration and reliability assessments to be separated from the checkout contract and done in-house by the Government.

I have also indicated that I would make a point on the costs which we have currently incurred in this program. Up to the end of 1962 our costs were slightly in excess of $8 million. Through February 1963, we had costs of approximately $12½ million. By June 30, the end of this fiscal year we visualize the costs to be approximately $25 million, without taking into account the hardware which Dr. Saline mentioned earlier relating to the integrated launch control and checkout system.

For fiscal 1964, as I indicated earlier, we are predicting costs of approximately $150 million as our forecast.

Mr. WAGGONNER. What do you expect the total cost of the project will be up to the time of the lunar landing?

Mr. SHETLER. I do not have that. We are in the very formative stages, particularly on this hardware part of the program. Some of the things that Dr. Saline mentioned relating to capability to use things in conjunction with one another may have some grave effects on it. But I do not have it at this particular time.

We feel, from our standpoint, that this has been a tight program, tightly handled, both from a control and a cost standpoint. We feel that we have performed efficiently and well to date.

Are there any other general questions on this subject or anything else that we have talked about this morning?

Mr. PATTEN. Overriding this program and one thing that distinguishes this from all others, especially watching those people yesterday at the firing of the Saturn IV, is the feeling that this isn't business as usual. There is a higher objective which motivates all of us to take additional interest in the success of the project. Even though we don't speak of the military aspects of this program, when that thing went off yesterday I said to myself: "Well, I hope Mr. K. sees that one." Later I picked up the paper and read that Mr. Castro is going to rattle some rockets. Do you consider it a part of your job, or a part of NASA's job, to do as the services do and indoctrinate and appeal to the patriotism of these half a million people to do a better job or the like? Is that being done, to your knowledge?

I think it is a tremendous motivation. I know you all have it. You can sense it from all of the intelligent and informed people in the program. Do you think that it carries down to every worker, and would it be of some value?

Mr. SHETLER. Yes, indeed.

I would like to talk on this at great length. I have had 20 years' experience in the electronic business, all in Government business, and this is a program in which good technical people just rally around. We have here approximately a group of 600 people in Daytona and you can hardly turn them off nights.

I don't believe the difficulty is with the half a million people in Government and in industry who are working on this program. As far as I am able to see these people are dedicated well beyond anything I even saw in World War II when it comes to systems development, design, and production, and to the care and the efforts that these people are putting in. I know of no one, for example, that only works a 40-hour week. Most of the people I see work 60 and 80 hours giving up all kinds of personal time in sheer dedication to the program.

My basic fear on this is not with those half a million people, who in my opinion are very highly dedicated. You could hardly get these people off the program if you tried. The vast group of people who are not working on the program and who are contributing to it only through tax dollars are the problem that it is so difficult to measure. As a nation we may get so tired before 196X comes that we may push the button and try to get to the Moon on the first attempt. The real problem is to sustain the enthusiasm across this whole country.

Pardon me, Mr. Chairman, if I am giving a speech but this is where I really feel we may have difficulty. And the biggest difficulty we will have to face is when we have a major failure of some test vehicle like that one yesterday.

I want to tell you that I lived in considerable fear that that one might fail yesterday and I was a little bit worried about your sense of humor this morning if it had. We have got to prepare, and I am sure it won't be very easy, but we have got to prepare the entire American public for normal test failures.

You know when we design a small piece of electronic equipment and take it into the lab and turn it on and have a smoke test and the whole thing goes to pot you never hear about it. But when you take out one of these big vehicles in what is really a laboratory test and put it on the pad and count it down and it explodes, it is going to be hard to explain, I will say, to the man on the street. And yet this is a normal thing to happen in a vast program of this character.

Mr. FULTON of Pennsylvania. Don't leave out any minus signs like they did on Mariner I. That kind of mistake is hard to explain, and I think it is unnecessary.

Mr. SHETLER. I certainly agree with you, sir.

(Thereupon there was an off-the-record discussion and the meeting was adjourned at 12:40 o'clock, p.m.)

APPENDIX D

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION,
OFFICE OF THE ADMINISTRATOR,
Washington, D.C., April 26, 1963.

HON. OLIN E. TEAGUE,
Chairman, Subcommittee on Manned Space Flight, Committee on Science and Astronautics, House of Representatives, Washington, D.C.

DEAR MR. CHAIRMAN: This is in response to your recent request of Mr. D. Brainerd Holmes, Director, Office of Manned Space Flight, for information concerning a description of the work Bellcomm, Inc., the General Electric Co., and the Aerospace Corp., are doing in providing technical assistance for the manned space flight program in the fields of systems engineering and checkout, reliability assessment, and integration.

In responding to your request, it might be appropriate to review briefly the Bellcomm and General Electric efforts in support of Project Apollo. The Aerospace Corp., a contractor of the Air Force, is different in concept than either Bellcomm or General Electric. In addition to providing systems support, as is the case of Bellcomm and General Electric, Aerospace is providing actual technical direction to the space program of the Air Force. Inasmuch as Aerospace is an Air Force contractor, you may wish to refer any questions regarding the contract to the Department of the Air Force.

The systems engineering function includes the determination of system specifications and conceptual designs of major elements of the program; the review of ongoing programs to identify and evaluate possible alternative courses of actions; study of the impact of funding, schedule, and technical changes on the overall program; devlopment of the overall reliability and system test plans, and preparation of long-range plans; implementation of long-range studies, and participation in project development plans for future manned space flight projects.

Typical of this type of activity was the selection of the mode of flight for the first manned lunar landing, in which the Office of Systems occupied a central role. As the subcommittee knows, three possible ways of implementing the program were studied in great detail—direct ascent, Earth orbit rendezvous, and lunar orbit rendezvous.

The Office of Systems reviewed the data available and defined the additional studies required to provide mission data. These studies were conducted both at NASA centers and by contractors under the direction of the Office of Systems. By June 1962, the results of all the previous study activity had been analyzed against the criteria of mission success, safety, schedule, cost, complexity, and growth potential. The analysis of more than a million man-hours of technical work showed that lunar orbit rendezvous was the most desirable mode of flight.

The Office of Systems now has about half of its planned total complement of 125 members of the technical staff on board. In February 1962, NASA requested the American Telephone & Telegraph Co. to assist in this systems engineering effort. NASA asked A.T. & T. to provide an organization of experienced men able to employ the most advanced analytical procedures necessary to develop the factual bases needed by responsible NASA officials to make the wide range of decisions required for the successful execution of the manned space flight program.

A.T. & T. responded to this request by forming Bellcomm, Inc., in March 1962.

As of this date, Bellcomm consists of 97 technical people and a supporting staff of 64. In terms of educational background of the technical staff, 24 percent have a Ph. D. degree, 46 percent have an M.S. degree, and 29 percent have a B.S. degree.

NASA anticipates that by the end of this year the Bellcomm organization will comprise about 250 people—two-thirds technical personnel and the balance administrative staffing level.

For the 18-month period ending September 30, 1963, the estimated amount of the NASA contract with Bellcomm is approximately $8.5 million. Bellcomm

96-504 O—63—pt. 2b——36

provides skilled and experienced assistance to enable NASA systems engineering to exercise its responsibility and authority in an effective manner.

It is important to note that Bellcomm, Inc., assists and supports a technical office within the Government rather than an administrative office. This important distinction makes it possible for the Government to carry out properly its total technical responsibility, utilizing a contractor for assistance, but maintaining the final technical, engineering, and procurement judgments within the Government itself, to be made by Government employees.

The capital stock of Bellcomm, Inc., which at present is $700,000, is owned jointly in equal amounts by A. T. & T. and the Western Electric Co.

The board of directors is comprised of a chairman, Mr. R R. Hough, vice president (engineering), A. T. & T., and eight others—two from A. T. & T., two from the Western Electric Co., two from the Bell Telephone Laboratories, and two from Bellcomm, Inc. It was intended at the outset that the board be a working board in both a technical and business sense. For this reason it contains highly qualified technical people and people with extensive business experience.

The president of Bellcomm, John A. Hornbeck, and the heads of its two technical divisions came from Bell Telephone Laboratories.

Its vice president and general manager came from the Long Lines Department of A. T. & T. The other officers are a comptroller and a secretary-treasurer, the former from A. T. & T. and the latter from the Western Electric Co.

In February 1962, NASA selected the General Electric Co. to play a supporting role in Project Apollo—to concentrate on checkout, reliability assessment, and integration.

It is appropriate to indicate some of the reasons why such support is required. To carry out a manned lunar landing mission, it is necessary to verify the readiness of all of the needed system elements to properly perform. In order to develop high confidence in NASA's readiness to take the next step in a mission, each piece, part, unit, subsystem, stage, spacecraft module, space vehicle, and ground facility must be checked out most carefully.

Within the framework of organization for the Apollo project, no single contractor could do the entire job of developing checkout equipment and procedures and supplying the equipment for a uniform programwide approach. Therefore, NASA asked the General Electric Co. to begin this work under letter contract NASw-410.

The knowledge gained in the uniform design of checkout equipment and procedures is the same information required to insure detailed integration of major systems, such as the electronic, electrical, and mechanical linkages. The checkout process of necessity delves into almost every system in great detail. Consequently, it was decided to combine the integration assignment with that of checkout.

Another related task is reliability assessment. The success of Apollo will require detailed knowledge concerning the present and projected reliability of the critical system components. This knowledge must be continuously acquired throughout the design, manufacturing, test and operational phases of the program to enable NASA to make an informed judgment about system reliability and safety levels.

The first phase of the work consisted of a series of studies aimed at more specifically analyzing and defining the scope and content of the work. The study phase was completed last fall. The implementation phase of work was begun immediately and continues. Negotiations on a definitive contract have proceeded, and NASA is confident that agreement on all of the provisions of this definitive contract will be reached in the near future.

In the implementation phase, General Electric's work will be in two broad categories. There will be continuing engineering support, which will be required by the Office of Manned Space Flight and the NASA centers in their respective areas of responsibility for integration, reliability assessment, and checkout. Secondly, General Electric will furnish specially designed checkout hardware, including that which will provide for the integrated launch control and checkout system.

General Electric engineering support is now building up as needed at the Manned Spacecraft Center, the George C. Marshall Space Flight Center, and the Launch Operations Center. The organizations at each center call upon the Apollo Support Department at Daytona Beach, Fla., where a staff has been established to support across-the-board tasks. Common use of the Daytona Beach services assures a common approach to checkout, reliability assessment, and integration.

As the program progresses, General Electric will gradually increase the proportionate scope of the Daytona Beach effort as the engineering center of gravity shifts from concept and design to the production of checkout equipment. As the reliability and quality data begin to build up, the General Electric central data effort will also grow. Integration support effort by General Electric will continue at the NASA centers and at the General Electric headquarters to provide assistance to NASA throughout the life of the program.

It is important to note the difference between systems engineering, an activity that requires a relatively small organization of very highly qualified individuals, and checkout, reliability assessment, and integration, which, because of the massive amount of technical detail which must be handled, require large manpower efforts.

In systems engineering, NASA has developed the system concept and is now writing the overall specifications for Project Apollo. A portion of these specifications will include the general requirements on the checkout system, definition of the requirements for reliability assessment, and technical monitoring of the program. Bellcomm supports NASA in this work.

NASA has asked General Electric to provide support in areas in which the details require many people. General Electric is implementing the checkout system, beginning hardware production, and undertaking comprehensive work in integration and related data gathering and processing, which will help to insure that the overall systems engineering requirements are being met in detail.

Annex A and annex B attached are copies of the statements of work contained in the Bellcomm and General Electric contracts.

We believe that the above supplements and summarizes the previous testimony given to your subcommittee on these subjects by Mr. Holmes on March 6–7 and April 9, 1963, by Dr. John A. Hornbeck, president of Bellcomm, Inc., and Mr. Richard L. Shetler, general manager of the Command Systems Division of General Electric and acting general manager of the General Electric Apollo Support Department, on March 20, 1963, and by Dr. Robert C. Seamans, Jr., Associate Administrator of NASA, on April 9, 1963. It is our understanding that the transcript of the briefing given by members of the Apollo Support Department, General Electric Co., Daytona Beach, Fla., on March 29, 1963, has been transmitted to you and will be made a part of the record of your subcommittee hearings.

Sincerely yours,

PAUL G. DEMBLING,
Director, Office of Legislative Affairs.

ANNEX A

BELLCOMM STATEMENT OF WORK

ARTICLE II. STATEMENT OF WORK

The Contractor, as an independent contractor and not as an agent of the Government and in accordance with the terms and conditions hereinafter more particularly described, shall perform the following:

(1) General Mission. The Contractor shall utilize its personnel, facilities, materials, equipment and services on a continuing basis to perform studies, technical fact finding and evaluation, analytical investigations, consulting effort and related professional activities in support of manned space flight and related programs of NASA. Such work may include but is not limited to the following activities:

1. Studies of mission objectives.
2. Studies of methods by which mission objectives can be achieved.
3. Recommendations concerning broad specifications and conceptual design of major subsystems.
4. Objective evaluation of the technological states-of-the-art to assess the developmental potential of various system elements.
5. Objective evaluation of the technical status of programs in light of systems objectives.
6. Trade off studies to provide data required to reach management decision on technical problems.
7. Conduct of detailed and fundamental analyses of systems.
8. Definition of reliability studies.

Quarterly technical reports are to be furnished by Contractor as well as special reports as may be specified by the Contracting Officer.

(2) Special Tasks. In addition to performing the continuing general activities described in (1) above, Contractor, at the request of NASA, will perform other special tasks as agreed upon which may or may not fall within the activities referred to in (1) above. It is contemplated that such tasks will occur in instances where particular emphasis is required for some segment of work because of the nature of the subject matter, the timing or the level of activity involved.

(3) Task Orders. The special tasks referred to in (2) above that are required by NASA from time to time shall each be evidenced by a "Task Order" to be issued by the Contracting Officer in writing, dated, and serially numbered. Each Task Order shall set forth and define the work to be performed, reporting requirements and the estimated completion date. Amendments to Task Orders shall be issued in accordance with the procedures for original Task Orders. Upon written acceptance

of a Task Order by Contractor, the subject task is thereupon a part of this contract and Contractor shall use its best efforts to perform the same. Personnel assigned to the general mission and each Task Order shall be under the direct management and supervision of the Contractor. After completion of each Task Order, the Contractor shall either (i) furnish a technical report giving full disclosure of all work done in the number of copies specified by the Contracting Officer, or, if not required, (ii) furnish the Contracting Officer a certificate of completion substantially in form as follows:

"I certify that the work called for in Task Order number_____ has been completed in accordance with instructions in the order.

BELLCOMM, Inc.

by:_____
Title"

(4) Interim Status Reports. In addition to the reporting requirements set out above in this Article II and of Article VIII, Reporting, hereof, once each month as part of the Financial Management Report referred to in Article VIII, Contractor shall submit a report of (i) the technical effort expended in the previous month, and the cumulative total through that month, for each undertaking under the general mission and each special task, and, (ii) the technical effort forecast to be expended under the general mission and each special task for the balance of the current quarter and for succeeding quarters to the end of the concerned contract period. This report shall identify any significant changes (either increase or decrease) in any estimate previously made respecting the amount of technical effort required to complete a special task or to be applied to general mission undertakings during the contract period.

ARTICLE III. WORK OF BELL TELEPHONE LABORATORIES AND SERVICES OF OTHER BELL SYSTEM COMPANIES

(1) The work called for by this contract may, if the Contractor so determines, be performed in part by or through Contractor's associated company, the Bell Telephone Laboratories, Incorporated (hereinafter called the "Laboratories"). The Laboratories has agreed with Contractor that in the performance of work hereunder it will comply with all duties and obligations imposed on Contractor pursuant to Article IV, Term of Contract and Option to Extend, Article XII, Release of News Information, Article XIV, Visits to Associated Companies' and Subcontractors' Plants, Article XVI, Data and the General Provisions hereof (other than clauses 4 and 22 of said General Provisions), as such duties and obligations relate to the work to be performed by the Laboratories shall not be subject to further approval hereunder.

(2) Without further approval hereunder, Contractor may enter into agreements with any company of the Bell System covering arrangements (i) respecting leave of absence personnel of such company employed by Contractor, (ii) for the services of employees to be made available to Contractor on a temporary basis ("Loaned Employees"), and, (iii) for the furnishing of administrative staff services, such as accounting, legal, personnel, public relations and similar services.

ANNEX B

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Letter Contract NASw-410
Amendment No. 14

Date: December 31, 1962

Contractor: General Electric Company
Post Office Box 2500
Daytona Beach, Florida

Subject: Revised Work Statement

1. Exhibit "A" entitled "Work Statement - NASw-410" dated October 12, 1962 to Letter Contract NASw-410 is hereby deleted in its entirety and the attached Exhibit "A" entitled, "Work Statement - NASw-410" dated December 31, 1962 is hereby substituted in lieu thereof.

2. Paragraph 2.b. of the Letter Contract is deleted in its entirety and the following is hereby substituted in lieu thereof:

"b. Reference in any of the clauses in (a) above or in any portion of the Letter Contract to (i) estimated costs, estimated cost and fixed fee, or delivery schedule(s), or (ii) adjustments to any of the above, to the extent the items under (i) above are not specifically included in this Letter Contract, shall be inapplicable, except that any adjustment required by any such clause in amounts to be paid to the Contractor, or in time of performance shall be made either at the time of settlement of contractor's termination claim or shall be taken into account at the time of execution of the definitive contract contemplated herein."

3. Except as hereby modified, all the terms, covenants and conditions of said contract as heretofore modified or amended shall remain in full force and effect.

IN WITNESS WHEREOF, the parties hereto have executed this amendment as of the day and year first hereinabove written.

THE UNITED STATES OF AMERICA

By _____

(Contracting Officer)

Contractor

(Name of Company or Individual)

By _____
(Signature)

(Typed Name)

(Title)

December 31, 1962
NASw-410
M-W I 6000.002

EXHIBIT "A"

STATEMENT OF WORK

SECTION I - SCOPE OF WORK

1.0 Introduction

The Contractor shall furnish all labor, material, tools, equipment and services (except such as the Government may elect to furnish under this contract) as herein directed to assist NASA in the performance of Checkout, Reliability Assessment Support and Integration Support of NASA's program for landing men on the moon and returning them to earth, currently known as the Apollo Program, as herein provided.

This Section I of the Statement of Work (hereinafter referred to as Section I) expresses the general scope of the work to be performed and the general manner in which it shall be performed by the contractor under this contract. Section II of the Statement of Work (hereinafter referred to as Section II) sets forth only those portions of the total work (i.e. those tasks) which the contractor has been ordered to perform and for which the estimated cost and fixed fee are included in the contract. Section II will be amended from time to time until all work provided for in Section I is contained in Section II.

The contractor shall not commence any portion of the work provided for in Section I until ordered to do so by Section II or by Task Orders under Section II. The contractor shall be obligated to promptly accept and proceed with tasks within the general scope of Section I which are ordered either (i) by Task Order under Section II or (ii) by Section II. Each Task Order shall be issued in writing by the Contracting Officer, shall be dated, numbered consecutively under this contract, shall describe the work to be performed and the performance period(s), and shall state a dollar figure, which shall be the limitation on the Government's obligation under such Task Order. Each Task Order will be later superseded in entirety by amendment to the contract which will: (i) revise Section II to incorporate the task(s) detailed in the Task Order, (ii) identify the Task Order(s) superseded, and (iii) appropriately modify the estimated cost and fixed fee and any other portion of the contract affected.

The Contractor shall perform the work as defined herein in two phases Phase I study, and Phase II implementation. The Phase I study shall be limited to the efforts described in paragraphs 2.1, 3.1, and 4.1.

1.1 In the performance of this contract, the contractor shall work under the over-all direction of the Director of Integration and Checkout (MI), Office of Manned Space Flight, NASA Headquarters. The contractor shall also work under the direction of the NASA Centers, as specified herein. Such direction shall be exercised in the manner detailed in Clause 46 of this contract, "Direction of Effort."

1.1.1 The Contractor shall prepare and submit to the Director of Integration and Checkout a final Program Planning Study Report for the Phase I Study Program of this Contract. This report shall describe the proposed method of implementation of the study phase. This planning study shall describe the recommended Contractor organization, schedules for completion of tasks and other information as deemed appropriate by the Contractor pertaining to the conduct of the study phase. When approved by the Director of Integration and Checkout, this preliminary study report shall be used by the Contractor as a guide in performing the detailed Study (Phase I).

1.2 In order to enable NASA to fully utilize the contractor's capabilities in Checkout, Reliability Assessment Support, and Integration Support areas, the Contractor shall also provide such services as required in support of the work described in paragraph 2.0, 3.0, and 4.0 below as are required to adequately manage this program.

2.0 Checkout

Successful achievement of the objectives of the Apollo program requires (1) Checkout equipment for all elements and phases of the program, designed to a common set of ground rules wherever practicable; (2) a continuing study of means to attain a capable checkout philosophy for the complete program.

2.1 System Checkout Study

The Contractor shall conduct a study based on current developments as well as concepts developed by the Contractor.

2.2 System Checkout Engineering Support

The Contractor shall be responsible for providing Systems Checkout engineering support.

2.2.1 Under the direction of the Manned Spacecraft Center (herein after referred to as MSC both at MSC and the Pre-Flight Operation Division of MSC - herein after referred to as POD), the contractor shall be responsible for providing systems Checkout Engineering support.

2.2.2 Under the direction of the Marshall Space Flight Center (herein after referred to as MSFC) the Contractor shall be responsible for providing systems Checkout engineering support.

2.2.3 Under the direction of the Launch Operations Center (herein after referred to as LOC) the Contractor shall be responsible for providing systems Checkout engineering support.

2.2.4 Under the direction of the Office of Manned Space Flight (herein after referred to as OMSF) the Contractor shall be responsible for providing systems Checkout engineering support.

2.3 Checkout Equipment for the Integrated Launch Control Checkout System (ILCCS)

The Contractor shall supply the equipment (except that equipment which the Government elects to furnish to contractor as Government furnished equipment) defined as the Integrated Launch Control and Checkout System (ILCCS) at Launch Complex 39 and the NASA Merrit Island Industrial Complex (both at Cape Canaveral, Florida). The contractor shall maintain all such equipment both contractor supplied and GFE, and shall provide such logistics and field support as NASA may, at its discretion, order in Section II. The ILCCS consists of display, control, data and signal processing, simulator, communication and other similar equipment. The ILCCS consists of three major sub-systems as follows:

2.3.1 Preflight Automatic Checkout Equipment/Spacecraft (PACE-S/C) Ground Station(s) for the Spacecraft to be supplied by the Contractor under the direction of MSC/POD.

2.3.2 Equipment reflecting the requirements of the MSFC automation plan, to be supplied by the Contractor under the direction of MSFC.

2.3.3 Facility Checkout Equipment and Displays for the Launch Control Center (LCC) to be supplied by the Contractor under the direction of LOC.

2.4 Checkout Equipment and Support Services for Other than the ILCCS

Except for that which the Government may elect to furnish, the Contractor as set forth below shall supply additional items of checkout and control equipment identical or substantially similar to those supplied as part of the ILCCS. The Contractor shall be responsible for installing and maintaining all such equipment, both Contractor supplied and G.F.E., and shall provide such logistics and field support as NASA may, at its discretion, order under Section II.

2.4.1 Under the direction of MSC, the Contractor shall supply partial or complete prelaunch automatic checkout equipment (PACE) Ground Stations for the spacecraft at locations and contractor sites as designated by MSC.

2.4.2 Under the direction of MSFC, the Contractor shall supply equipment reflecting the requirements of the MSFC automation plan at locations and contractor sites as designated by MSFC.

3.0 Reliability Assessment

The successful achievement of the objectives of the Apollo Program requires an extremely high probability of crew survival and mission

accomplishment and thus a highly reliable system. A continuing knowledge of attained reliability and safety levels and related practices is required by NASA throughout the design, manufacturing, test and operational phases of the program by all NASA organizational units with regard to the proportions and phases of the Apollo program for which they have responsibility. Further, it is necessary that such reliability assessments be based on compatible procedures and programs throughout the Apollo program.

NASA and the Contractor recognize and agree that the establishment of appropriate reliability and safety requirements of the Apollo system and of its elements are and must remain the sole responsibility of NASA.

The Contractor shall support NASA's reliability program by providing technical and engineering services. The contractor shall not be responsible for supervising or directing other contractors not under subcontract to the Contractor.

3.1 Reliability Assessment Study

The Contractor shall conduct a study based on current NASA programs and procedures as well as concepts developed by the Contractor.

3.2 Reliability Assessment Engineering Support

The Contractor shall be responsible for providing reliability assessment engineering support.

3.2.1 Under the direction of MSC (both at MSC and POD) the Contractor shall be responsible for providing Reliability Assessment engineering support.

3.2.2 Under the direction of MSFC the Contractor shall be responsible for providing Reliability Assessment engineering support.

3.2.3 Under the direction of LOC the Contractor shall be responsible for providing Reliability Assessment engineering support.

3.2.4 Under the direction of OMSF the Contractor shall be responsible for providing Reliability Assessment engineering support.

4.0 Integration Support

The successful achievement of objectives of the Apollo program requires that the major system elements be conceived, designed, assembled, tested and documented so that they are compatible with each other and meet the objectives of the program. The Contractor shall support each of the NASA Centers responsible for the major Apollo system elements and the Office of Manned Space Flight in the execution of NASA's responsibilities.

4.1 Integration Support Study

The Contractor shall conduct a study based on current NASA developments as well as concepts developed by the Contractor.

4.2 Integration Support Engineering Services and Supplies

The Contractor shall provide Integration Support Engineering services as set forth below. Except for equipment which the Government may elect to furnish under this contract the Contractor shall furnish integration support supplies as set forth below.

4.2.1 Under the direction of MSC the Contractor shall provide Integration support engineering services and supplies.

4.2.2 Under the direction of MSFC the Contractor shall provide Integration support engineering services and supplies.

4.2.3 Under the direction of LOC the Contractor shall provide Integration support engineering services and supplies.

4.2.4 Under the direction of OMSF the Contractor shall provide Integration support engineering services and supplies.

December 31, 1962

SECTION II - WORK PLAN

1.0 Introduction

1.1 The Contractor shall proceed with the Phase I requirements specified in paragraph 2.1 of Section II hereof for the Period of February 26, 1962 to October 12, 1962; paragraph 3.1 of Section II hereof for the period of February 26, 1962 to September 30, 1962; and paragraph 4.1 of Section II hereof for the period of February 26, 1962 to October 2, 1962.

1.1.1 The Contractor shall prepare a final Program Planning Study Report for the Phase I Study Program of this Contract. This Report shall describe the proposed method of implementation of the study phase. This planning study shall describe the recommended Contractor organization, schedules for completion of tasks and other information as deemed appropriate by the Contractor pertaining to the conduct of the study phase. When approved by NASA, this preliminary study report shall be used by the Contractor as a guide in performing the detailed study (Phase I).

Delivery By: During July, 1962

1.2 The Contractor shall proceed with the Phase II requirements specified in paragraphs 2.2 and 2.3 of Section II hereof for the period of October 13, 1962 to September 30, 1963; paragraph 3.2 of Section II hereof for the period of October 1, 1962 to September 30, 1963; and paragraph 4.2 of Section II hereof for the period of October 13, 1962 through September 30, 1963.

2.0 Checkout

General

The Contractor shall provide the services and supplies set forth in the following paragraphs:

2.1 System Checkout Study

The Contractor shall prepare a study based on current NASA developments as well as concepts developed by the Contractor.

2.1.1 This study shall be generated in conjunction with the appropriate NASA centers. Current development efforts by the NASA centers and by the Apollo Program contractors shall be documented in the study by the Contractor, and a report is to be provided to NASA by the Contractor based on this effort. This study will be based on current NASA developments at NASA centers, as well as concepts developed by the Contractor.

2.1.1.1 This integrated system checkout study shall include:

2.1.1.1.1 A comprehensive description of the current development effort at the Marshall Space Flight Center for the Saturn automation project.

2.1.1.1.2 A comprehensive description of the current development effort at the Manned Spacecraft Center for the spacecraft checkout equipment.

2.1.1.1.3 A study of the checkout concepts currently under development by each center which will include analysis of:

1. Basic operational philosophy.

2. Compatibility of equipment design concepts.

3. Compatibility of specific hardware designs.

2.1.1.1.4 A recommended checkout equipment design and development program which considers.

1. Maximum utilization of existing Center developments.

2. Feasible operational integration of the checkout equipment.

3. Current operational schedules for the R&D as well as operational manned lunar space flights.

4. Anticipated developmental status of the launch vehicle and spacecraft.

5. The relationship of the GOSS and its checkout requirements to the development of an integrated system checkout equipment.

2.1.1.2 In order to prepare the study referenced in paragraph 2.1 of this work statement, the Contractor's effort shall include, but not be limited to the following study elements.

2.1.1.2.1 Ground Operational Support Systems (herein - after referred to as GOSS) Relationships

1. Study present GOSS functions and associated equipment characteristics.

2. Study present GOSS checkout Equipment and procedures.

3. Recommend design criteria for GOSS checkout equipment insofar as such equipment is related to the integrated system checkout facility.

2.1.2 Launch Vehicle and Spacecraft Checkout Guidelines and Criteria

These guidelines shall be generated in conjunction with the appropriate NASA centers. These guidelines shall be provided to NASA by the Contractor and shall be based on the current development programs of NASA and its Apollo contractors to the maximum practicable extent. The application of these guidelines to the Apollo program and the Apollo Contractor shall be determined by NASA. These guidelines and criteria shall include such items as:

2.1.2.1 Methods and quantities of measurement.

2.1.2.2 Methods of signal conditioning.

2.1.2.3 Standards of data transmission.

2.1.2.4 Analog signal standards.

2.1.2.5 Digital signal standards.

2.1.2.6 Methods of data display, recording and retrieval.

2.1.3 In order to prepare the recommended stage checkout design ground rules, the Contractor's effort shall consider but not be limited to the following study elements:

2.1.3.1 Spacecraft Guidelines and Criteria

2.1.3.1.1 Prepare spacecraft assembly and checkout flow charts.

2.1.3.1.2 Study and document existing checkout approaches and responsibility.

2.1.3.1.3 Study general guidelines for spacecraft

2.1.3.1.4 Study detailed checkout requirements.

2.1.3.1.5 Study checkout operational criteria.

2.1.3.1.6 Study the relationships between spacecraft checkout and a standardized test philosophy.

2.1.3.2 Launch Vehicle Guidelines and Criteria

2.1.3.2.1 Determine existing checkout approach.

2.1.3.2.2 Observe in-launch vehicle checkout tests.

2.1.3.2.3 Study existing vehicle test specifications as related to system checkout.

2.1.3.2.4 Study existing checkout approaches.

2.1.3.2.5 Study launch vehicle checkout philosophy.

2.1.3.2.6 Study and recommend techniques for evaluating checkout data.

2.1.3.2.7 Recommend changes and/or additions in contractor checkout equipment or procedures to NASA.

2.1.3.3 Integrated Checkout Philosophy

2.1.3.3.1 Study postulated or existing checkout approaches.

2.1.3.3.2 Develop guidelines for integrated system checkout.

2.1.3.3.3 Study merits of crew chief concept.

2.1.3.3.4 Study balance between manual and automatic checkout and criteria for choice of each technique.

2.1.3.3.5 Study optimum approach for static and dynamic testing and identify factors used in optimization.

2.1.3.3.6 Study functions of on-board equipment in pre-launch checkout.

2.1.3.3.7 Study flight crew participation in checkout phases.

2.1.3.4 Design Criteria for Integrated Checkout Equipment

2.1.3.4.1 Study Apollo subsystem design and performance characteristics.

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2.1.3.4.2 Study present subsystem checkout equipment and procedures.

2.1.3.4.3 Recommend general equipment criteria for integrated checkout equipment.

2.1.3.4.4 Recommend design criteria for integrated checkout equipment.

2.1.3.4.5 Recommend a checkout equipment maintenance philosophy.

2.1.3.5 Checkout and Checkout Related Countdown Procedures

2.1.3.5.1 Study the standardization of procedures.

2.1.3.5.2 Study and develop a plan for optimizing use of common factory-field procedures.

2.1.3.5.3 Study and develop a plan for establishing and controlling appropriate factory-field test tolerances and suitable margins through each successive phase of assembly and checkout.

2.1.3.5.4 Study and develop a checkout approach to insure proper mechanical and electric integrity.

2.1.3.5.5 Study and develop a plan for establishing common test equipment utilization between factory and field.

2.1.3.5.6 Study and develop approach to minimization of repetitive tests.

2.1.3.5.7 Study and develop an approach to a simplified countdown as related to checkout.

2.1.3.5.8 Study countdown sequencing as established by NASA.

2.1.3.5.9 Study and develop a plan to related checkout approach to the fulfillment of mission success probability requirements.

2.1.3.5.10 Study the optimization of end-to-end testing during the checkout.

2.1.3.5.11 Study and develop an approach to minimization of tests during integration of the launch site, rapid replacement of spares, and independence of elements.

2.1.3.6 Information Processing Requirements

2.1.3.6.1 Study the problem of test data storage and retrieval as it pertains to the integrated checkout system.

2.1.3.6.2 Study the problem of data display for the integrated checkout system.

2.1.3.6.3 Study the data analysis problem associated with the use and evaluation of integrated checkout system data.

2.1.3.6.4 Study the computational and data-processing requirements pertinent to the design and development of the integrated checkout system.

2.1.3.6.5 Prepare criteria for checkout test data storage and retrieval, processing, computation, and display.

2.1.3.6.6 Study and develop a plan to related Apollo mission data to the data obtained during integrated checkout.

2.1.3.6.7 Study data-handling, data-format, and data-processing techniques for uniformity, compatibility, and standardization and appropriate tradeoffs.

2.1.3.6.8 Develop a plan for collecting, cataloging, processing, and dissemination of data from the Apollo missions as pertinent to the integrated checkout system.

2.1.3.7 Checkout Requirements After Lift-Off

2.1.3.7.1 Study effect of rendezvous requirements on checkout requirements.

2.1.3.7.2 Study the support required from GOSS during rendezvous checkout as related to the integrated checkout of the space vehicle system.

2.1.3.7.3 Study the results obtained from the Gemini rendezvous program in the area of checkout.

2.1.3.7.4 Study the checkout related countdown and the Checkout requirements for the Apollo return flight.

Delivery by: October 12, 1962

2.1.4 Under the direction of MSFC, the Contractor shall be responsible for providing:

2.1.4.1 Support assistance for the design and documentation of the Saturn-I and Saturn-V Launch Site Electrical Support Equipment (MSFC Task #3).

2.1.4.2 Liaison engineering and fabrication of electrical ground support equipment for the Saturn V Launch Vehicle Program (MSFC Task #4). No fabrication is authorized under this task.

2.1.4.3. Engineering assistance in Digital Data Acquisition Systems Design, Development and Documentation (MSFC Task #10). No fabrication is authorized under this task.

2.1.4.4 Engineering support for Control System and Programming for Automatic Checkout at Static Test Facility (MSFC Task #11).

2.1.4.5 Data Analysis and Evaluation for Automatic Data Processing Center (MSFC Task #13).

2.1.4.6 Support Assistance in Checkout Equipment Design Review of stage contractor set and checkout equipment for the Saturn stages, (MSFC Task #15).

2.1.4.7 Engineering support assistance for Review of Stage Contractors Documentation and Checkout (MSFC Task #16).

PERIOD OF PERFORMANCE: September 23, 1962 through October 12, 1962

2.1.5 Under the direction of MSC (both at MSC and POD), the Contractor shall be responsible for providing:

2.1.5.1 Engineering Studies of Subsystems Checkout and Acceptance Test Plans (MSC Task).

PERIOD OF PERFORMANCE: July 16, 1962 through October 12, 1962

2.1.5.2 Electrical Malfunction Excitation Study (POD Task #7).

PERIOD OF PERFORMANCE: July 30, 1962 through October 12, 1962

2.1.5.3 Bench Checkout and Calibration of Instrumentation and Telecommunication Study (POD Task #8).

PERIOD OF PERFORMANCE: July 30, 1962 through October 12, 1962

2.1.5.4 Statistical Analysis of Mercury Data Pre-flight Checkout Procedures (POD Task #2).

PERIOD OF PERFORMANCE: July 16, 1962 through October 12, 1962

2.1.6 Under the direction of LOC, the Contractor shall be responsible for providing:

2.1.6.1 RF Telemetry and Measuring Subsystems Checkout Philosophy (LOC Task #3).

2.1.6.2 Data Processing, Display, Dissemination and Transmission Techniques (LOC Task #4).

2.1.6.3 Study of Hardwire Voice Communication (LOC Task #6).

2.1.6.4 Study of Past, Present and Future Test Planning and Philosophy (LOC Task #5).

PERIOD OF PERFORMANCE: July 30, 1962 through October 12, 1962

2.2 System Checkout Engineering Support

The Contractor shall be responsible for providing systems checkout engineering support activities called for under paragraph 2.2. for the period of October 13, 1962 through September 30, 1963, except for those paragraphs marked separately.

2.2.1 Under the direction of MSC, (both at MSC and POD, the Contractor shall be responsible for providing for systems checkout engineering support as detailed below:

2.2.1.1 Engineering Studies of Subsystem Checkout and Acceptance Test Plans (MSC Task)

The Contractor shall perform studies of subsystems checkout and acceptance test plans for factory through complete checkout and acceptance to ascertain that equivalent levels of test and checkout validation are maintained across the board from subcontractor through associate contractors to final checkout. This will include study of the compatability of test methods and GSE from subsystems through complete spacecraft final checkout. The specific effort will include:

2.2.1.1.1 Assistance in the formulation, review, and evaluation of checkout procedures and Ground Support Equipment requirements for all electrical and electronic systems on the spacecraft modules.

2.2.1.1.2 Performance of similar tasks (above) for Mechanical Systems.

2.2.1.1.3 Performance of similar tasks (as above) for Navigation and Guidance Systems.

2.2.1.1.4 Performance of similar tasks (as above) for Propulsion Systems.

2.2.1.1.5 Performance of similar tasks (as above) to help formulate, review, and evaluate checkout procedures and equipment requirements for Pyrotechnical Systems.

This effort will be conducted under the direction of MSC/Houston Apollo Project personnel.

2.2.1.2 Statistical Analysis of Mercury Data Preflight Checkout Procedures (POD Task #2)

The Contractor shall perform an analysis of Project Mercury Capsule preparation and checkout at Cape Canaveral, Florida. This effort consists of a review, tabulation, and analysis of existing Mercury preparation and checkout documents on four Mercury flight capsules. The data to be used will include: mission preparation sheets, unsatisfactory reports, discrepancy reports, Cape Canaveral requests for engineering changes, and calibration records.

2.2.1.3 Electrical Malfunction Excitation Study (POD Task #7).

The Contractor shall perform the following work under this study through the SA-9 launch.

2.2.1.3.1 Define frequency and level of excitation ranges required.

2.2.1.3.2 Study North American Aviation Spacecraft structural vibration test to determine input locations.

2.2.1.3.3 Determine excitation equipment requirements.

2.2.1.3.4 Develop specifications.

2.2.1.3.5 Supervise installation.

2.2.1.3.6 Consult on initial test operation.

2.2.1.4 Bench Checkout and Calibration of Instrumentation and Telecommunication Study (POD Task #8)

The Contractor shall investigate the problem involved in automatic bench checkout and calibration of spacecraft, instrumentation and telecommunication systems and components and will develop an approach to universal automatic checkout equipment that can be used as design guides for bench checkout and calibration equipment for FM/FM and PCM systems. Period of performance October 13, 1962 through April 31, 1963.

2.2.1.5 Engineering Assistance to MSC/POD in conjunction with Checkout Performed by Spacecraft Contractors and other NASA Centers

The Contractor shall provide engineering service to analyze systems checkout performed by other spacecraft contractors and to assist POD in such effort. The Contractor shall also provide engineering assistance for the analysis of interface requirements of space with checkout equipment provided by other NASA centers. Period of performance November 16, 1962 through September 30, 1963.

2.2.1.6 Engineering Checkout Support Related Manned Space Programs and State-of-the-Art Advances

The Contractor shall monitor NASA Lead-in programs to Apollo, such as Gemini, and provide engineering support to POD to insure operational readiness of checkout equipment used in such programs. In addition, the Contractor shall review state-of-the-art advances in checkout techniques to enable increased operational effectiveness and capability in space. Period of performance November 16, 1962 through September 30, 1963.

2.2.1.7 Engineering Studies of Complex Facilities

The Contractor shall perform detailed "Complex Engineering" studies which will include, but not be limited to, engineering studies in such areas as determining total building requirements and supporting utilities, hard line distances, cabling, microwave lines and remote display sites. Period of performance November 16, 1962 through September 30, 1963.

2.2.2 Under the direction of MSFC, the Contractor shall be responsible for providing systems checkout engineering support as detailed below:

2.2.2.1 Support Assistance for Operation of Automation Checkout Systems Facility, Saturn-V (MSFC Task # 2)

The Contractor shall provide assistance in the operation, maintenance, modification, and documentation of Saturn-V Automatic Checkout System Facility which includes the following:

1. S-IC Simulator
2. S-II Simulator
3. S-IVB Simulator
4. Saturn-V Instrument Unit

2.2.2.2 Support Assistance for Design of Saturn-I and Saturn-V Launch Site Electrical Support Equipment (MSFC Task #3)

The Contractor shall assist in the design and documentation of launch site electrical support equipment for the integrated launch vehicle and its associated equipment relating to the Saturn-I and Saturn-V programs.

2.2.2.3 Support Assistance to Design, Document and Update Various Stage Simulators for the Saturn-V Automation Breadboard (MSFC Task #6)

The Contractor shall provide engineering and drafting support required to design, document and up-date various stage simulators as required to equip the Saturn-V automation breadboard facility at MSFC.

2.2.2.4 Control System and Programming for Automatic Checkout at Static Test Facility (MSFC Task # 11)

The Contractor shall provide technical assistance in the Control System and Programming for the automatic checkout area at the Static Test Facility to include the following:

1. Assistance in gathering, collating, reviewing and disseminating pertinent information for utilization in planning, design, procurement, installation, checkout and operation of automatic checkout and associated equipment.

2. Performance of detailed design as required for development of specialized checkout equipment peculiar to the static test operations and for integration of stage contractor furnished equipment into the test facility.

3. Assistance in developing specifications, standards, and documentation for approved hardware and equipment utilized in the checkout function and the procedure for operation of that equipment.

4. Performance of specialized studies on existing and planned facilities and equipment required to eliminate or prevent extraneous interference with the proper operation of checkout equipment.

5. Assistance in performing specialized operational functions peculiar to the automatic checkout equipment in static test facilities.

2.2.2.5 Instrumentation and Data Acquisition for Automatic Checkout at Static Test Facility (MSFC Task #12)

The Contractor shall provide technical assistance in the Instrumentation and Data Acquisition for the Automatic Checkout area at the Static Test Facility to include the following:

1. Assistance in gathering, collating, reviewing and disseminating pertinent information for utilization in planning, design, procurement, installation, checkout and operation of automatic checkout and associated equipment.

2. Performance of detailed design as required for development of specialized checkout equipment peculiar to the static test measuring and instrumentation operations and for integration of stage contractor furnished equipment into the test facility.

3. Assistance in developing specifications, standards, and documentation of approved hardware and equipment utilized in the measuring and instrumentation portion of the checkout function and the procedure for operation of that equipment.

4. Performance of specialized studies on existing and planned facilities and equipment required to eliminate or prevent extraneous interference with the proper operation of data acquisition and checkout equipment.

5. Assistance in performing specialized measuring and instrumentation operational functions peculiar to the automatic checkout equipment in static test facilities.

2.2.2.6 Data Analysis and Evaluation for Automatic Data Processing Center (MSFC Task #13)

The Contractor shall provide technical assistance at the Automatic Data Processing Center to include the following:

1. Collection and consolidation of test data throughout MSFC and the making of a statistical analysis of same as necessary.

2. Investigation of such test data to the extent necessary to determine standardization, data formats, and similar considerations.

3. Performance of studies and the submission of recommendations with regard to test data with the objective of allowing such studies to mesh with the over-all Data Center plans.

4. Submission of recommendations with regard to test data coding systems to be used by the various MSFC test data generating divisions.

5. Performance of a study and submission of recommendations as to which supplemental information should be made available with the test results for identification purposes.

2.2.2.7 Support Assistance in Checkout Equipment Design Review (MSFC Task #15)

The Contractor shall provide technical assistance to the MSFC Checkout Project Office in its mission of detailed design review of stage contractor test and checkout equipment for Saturn stages. The personnel will be grouped into four teams associated with particular stages. They will review and furnish comments, ideas, information, and recommendations on technical documents, preliminary design approaches, preliminary and final designs, schematics, logic circuits and equipment.

2.2.2.8 Support Assistance for Review of Stage Contractors Documentation (MSFC Task #16)

The Contractor shall provide technical assistance to the Performance Test Branch of MSFC in the checkout area. This will include review of test procedures and documentation issued by stage constractors, and origination of test procedures for system test of Saturn-V stages.

2.2.3 Under the direction of LOC, the Contractor shall be responsible for providing systems checkout engineering support as detailed below:

2.2.3.1 (For record purposes only)

2.2.3.2 Saturn and Advanced Saturn Launch Support Electrical Interfaces (LOC Task #9)

The Contractor shall provide technical assistance in the definition of the Saturn and Advanced Saturn electrical interfaces with the launch support equipment.

2.2.3.3 (For record purposes only)

2.2.4 Under the direction of OMSF, the Contractor shall be responsible for providing systems checkout engineering support as detailed below:

2.2.4.1 Over-all Checkout Systems Studies

The Contractor shall conduct engineering studies and analyses required for the support of the Apollo Checkout effort at NASA. These will include but not be limited to analysis of the adequacy and compatibility of checkout philosophy and checkout instrumentation and programming throughout the Apollo program as the various elements of the Apollo system get assembled culminating in the Space Vehicle assembly and checkout at Cape Canaveral, as well as the post launch checkout through-lunar landing and return. The effect of experience gained in early spacecraft and vehicle programs (such as Gemini and Saturn-I) on checkout philosophy will be considered as well as applicable experience on various U. S. military missile and space programs.

2.2.4.2 Integrated Space Vehicle Checkout System Specification

The Contractor shall develop a description of the Integrated Space Vehicle Checkout System which will define a recommended Integrated Space Vehicle Checkout System for Complex 39 at Cape Canaveral and its interfaces with all other equipment that will be present there. This effort will include but not be limited to preparation of test requirements, flow diagrams, operational philosophy, equipment descriptions and interfaces, facility requirements, data storage and evaluation requirements, programming requirements, checkout equipment reliability models and maintenance, logistics, and training plans.

2.2.4.3 Test Procedures vs Effectiveness Studies

The Contractor shall conduct studies to determine and recommend the optimum trade offs in test procedure versus checkout effectiveness throughout the Apollo program. These studies will consider at least the following factors:

1. Mathematical techniques which have been developed to evaluate effectiveness of Checkout Systems.

2. The relation of the level and frequency of tests to the anticipated reliability of the various portions of the Apollo system.

3. The relation of the level of testing to the decision and maintenance action available at various points where checkout is performed on the Apollo Program.

4. The relative desirability of manual versus automatic checkout techniques at various points where checkout is performed on the Apollo Program.

5. The relative desirability of static, dynamic, and "end to end" testing and monitoring at various points where checkout is performed on the Apollo program.

2.2.4.4 Checkout Standardization Studies

The Contractor shall conduct studies to determine and recommend optimum methods and levels of standardization of checkout equipment and procedures throughout the Apollo Program. These studies will consider at least the following factors:

1. Consistency and adequacy of procedures for setting of the test tolerances, and plans for continuously identifying, specifying and controlling factory-field test tolerances.

2. Consistency and adequacy of standardization of Checkout Data Processors, computer language, programming procedures, and plans for controlling and updating test programs as changes are made in the Space Vehicle.

3. Consistency and adequacy of guidelines establishing the nature, level and accessibility of test signals from various portions of the Space Vehicle and their compatibility with the checkout instrumentation at all points where checkout is performed on the Apollo program.

4. Consistency and adequacy of standardization of checkout equipment items (other than Checkout Data Processors) such as displays, printouts, stimulus generators, adaptors, and commonly used measuring devices throughout the Apollo Program.

2.2.4.5 Studies of Application of Advanced Checkout Techniques and Procedures

The Contractor shall conduct studies to determine the applicability of advanced checkout techniques and procedures to the Apollo Program. These studies shall include consideration of at least the following:

1. The Crew Chief concepts of operation in the Apollo checkout effort.

2. Advanced fault location and prediction techniques, devices, and programs.

3. Novel test, measuring, monitoring and maintenance techniques (such as single parameter testing).

4. Special techniques and procedures required for checkout and maintenance during the "in flight" portion of the Apollo mission.

5. Special techniques and procedures required for checkout and maintanance during the portion of the Apollo mission which takes place on the lunar surface.

2.3 Checkout Equipment for the Integrated Launch Control and Checkout System (ILCCS) For Record Purposes Only

2.3.1 For record purposes only

2.3.2 For record purposes only

2.3.3 For record purposes only

2.4 Checkout Equipment and Supporting Services for Other than the ILCCS

The Contractor shall provide design services as described in this paragraph (2.4). No equipment covered by the design shall be fabricated or procured by the Contractor until ordered by amendment to this paragraph or by task order thereunder.

2.4.1 Under the direction of MSC/POD the Contractor shall be responsible for providing:

2.4.1.1 Design of PACE-S/C Ground Support Equipment

The Contractor shall assist in the preparation of performance specifications for ground components of the Prelaunch Automatic Checkout Equipment Spacecraft (PACE-S/C) and perform detailed design of the ground station equipment. Period of performance November 16, 1962 through September 30, 1963.

2.4.1.2 Design of Instrumentation for PACE S/C Control Room

The Contractor shall assist in the preparation of performance specifications for the necessary instrumentation required in the PACE S/C Control Room and perform detailed design of such equipment. Period of performance November 16, 1962 through September 30, 1963.

2.4.2 Under the direction of MSFC, the Contractor shall be responsible for providing:

2.4.2.1 Electrical Ground Support Equipment for the Saturn-V Launch Vehicle Program (MSFC Task #4)

The Contractor shall work with MSFC in order to establish procedures and work out equipment design details prior to start of actual fabrication (which will be specifically authorized by the Contracting Officer) and shall maintain liaison with MSFC throughout this effort to insure proper coordination of requirements. Period of performance October 13, 1962 through September 30, 1963.

2.4.2.2 Digital Data Acquisition Systems (DDAS) Design, Development, (MSFC Task #10)

The Contractor shall provide technical assistance in DDAS design, development, documentation of:

1. Equipment for updating of Saturn-I breadboard DDAS.

2. Saturn-V breadboard DDAS.

3. DDAS receiving equipment for Complex 39.

Period of Performance October 13, 1962 through September 30, 1963.

3.0 Reliability Assessment

The Contractor shall provide the services and supplies set forth in the following paragraphs.

3.1 Reliability Assessment Study

3.1.1 The Contractor shall prepare reliability assessment studies covering the following areas. These studies shall be delivered by September 30, 1962.

3.1.1.1 Reliability and Maintainability Progress

3.1.1.2 Reliability Assessment Implementation Plan

3.1.1.3 Data Flow Procedures for Reliability Assessment

3.1.1.4 Reliability Assessment Data System

3.1.1.5 Test and Operations Reliability Summary

3.1.2 Under the direction of MSC (both at MSC and POD), the Contractor shall be responsible for providing the following services for the period February 26, 1962 through September 30, 1962.

3.1.2.1 Support Engineering Assistance in the evaluation of Contractor Reliability Programs and in the Analysis of Mission Reliability Programs

3.1.2.2 Fault Function Coding System Study (POD Task #1)

3.1.2.3 Perform Materials and Malfunction Study (POD Task #4)

3.1.2.4 Perform Spacecraft Expendable Materials Study (POD Task #6)

3.1.3 Under the direction of LOC, the Contractor shall be responsible for providing the following services for the period February 26, 1962 through September 30, 1962.

3.1.3.1 Radio Frequency Interference Studies (LOC Task #2)

3.2 Reliability Assessment Engineering Support

The Contractor shall be responsible for providing reliability assessment engineering support during the period of October 1, 1962, through September 30, 1963.

3.2.1 Under the direction of MSC (both at MSC and FOD) the Contractor shall be responsible for providing reliability assessment engineering support in the following areas.

3.2.1.1 Assess Subsystem Failure Mode and Effects Analyses

Assess failure mode and effect subsystem analyses of MSC contractors and subcontractors.

3.2.1.2 Conduct Subsystem Failure Mode and Effect Analyses

Conduct failure mode and effect analyses on critical subsystems of MSC contractors. This task may include assessment of designs of MSC contractors in the following areas:

1. Environmental Control Systems
2. Escape motor
3. Tower jettison motor
4. Stabilization and flight control systems
5. Parachute landing system
6. Spacecraft telecommunication systems
7. Other on-board systems of Command, Service, and Lunar Excursion Modules.

3.2.1.3 Conduct Analyses of Failed Parts

Conduct failure analyses of failed parts upon request from Apollo Spacecraft Project Office. Also assess parts standardization programs of MSC contractors and subcontractors as directed.

3.2.1.4 Review Contractor Reliability and Quality Programs

Review and provide comments as directed by the Apollo Spacecraft Project Office on MSC contractors reliability and quality control programs and documents. Assess implementation of such programs, including material and process procurement specifications.

3.2.1.5 Develop Reliability and Quality Scheduling Systems

Assist the Apollo Spacecraft Project Office as directed in the development of a reliability and quality program scheduling system. The schedule should reflect major reliability and quality control milestones coordinated to the milestones of the over-all Apollo program scheduling plan.

3.2.1.6 Review Contractor Reliability Models and Test Plans

Review and assess as directed by the Apollo Project Office, reliability models, qualification and reliability test plans for MSC contractors and subcontractors.

3.2.1.7 Determine Reliability Data Requirements

Assist the Apollo Spacecraft Project Office as directed in determining data requirements for reliability data center use.

3.2.1.8 Develop Fault Function Coding System (POD Task #1)

Study and formulate a fault function coding system and identification and isolation of discrepancies requiring engineering action. This will include but not be limited to DRs, MPRs, URs, Squawks, MPRRs, and EMRs. Review this coding system to assess the efficiency of the system during actual capsule checkout. Included for this purpose, but not limited to these capsules, will be discrepancies for capsules 13, 16, 18, and 20.

3.2.1.9 Perform Materials and Malfunction Investigations (POD Task #4)

Provide technical support of chemical, metallurgical, and structural investigations of materials anomalies which will include the following areas: Recommendation for analytical equipment instrumentation and facilities required; Study to include inventory of present AMR vicinity laboratories. Preparation of specifications and installation of additional equipment required. Implementation of investigations to determine the nature and origin of anomalous materials and the malfunction of components due to materials defects.

3.2.1.10 Perform Spacecraft Expendable Materials Study POD Task #5)

Review and analyze current procurement and operational specifications, sampling techniques, analytical methods, stock level control, storage transfer and quality control of expendable spacecraft materials and recommend modification of procedures and practices. Monitor (inspect and observe) criteria for procuring, sampling, analyzing, stocking and maintaining adequate stocks of high quality expendable materials and monitor such test programs and studies as are necessary to the maintenance of high reliability and purity of expendable spacecraft fluids.

3.2.2 Under the direction of MSFC, the Contractor shall be responsible for providing reliability assessment engineering support in the following areas:

3.2.2.1 Mathematical Modeling of Saturn Launch Vehicle Systems for Reliability Assessment

Breakdown launch vehicle operations into a symbolic logic diagram that can be programmed for computer calculation to provide rapid, timely reliability assessment.

3.2.2.2 Designing a Saturn Launch Vehicle Data Collection System

3.2.2.3 Saturn Launch Vehicle Data Collection

Collection of data from:

1. Past and current missile and space programs data

2. Qualified and other pertinent parts listings; inspection testing and checkout data

3. Design and design evaluation data

4. Manufacturing data

5. Launch operations data

3.2.2.4 Saturn Launch Vehicle Reliability Data Reduction and Analysis

Treat the data obtained by statistical techniques and combine the resulting reliability assessment numbers in the mathematical model to provide launch vehicle reliability assessments. Reliability assessment results will be forwarded for incorporation into mission reliability and mission safety assessment models for Apollo missions.

3.2.2.5 S-I Reliability Prediction

Based on reliability prediction techniques developed under 3.2.4.1.3 update reliability prediction for Saturn S-I Stage, as follows:

a. Predict structural reliability, using Saturn S-I design data.

b. Predict electronic reliability for revised configuration.

c. Re-examine propulsion reliability in light of static and flight-test data collected since previous study.

d. Re-evaluate engine-out capability.

The above items shall be based on Block I design boosters (SA-1 through SA-4) and subsequent configurations depending on availability of design and test data.

3.2.2.6 S-IV Test Program

Devise reliability test program for S-IV stage; specifically:

a. Analyze static-firing test results for RL10A-3 engine singly and in clusters, and propose additional tests to uncover possible failure mechanisms.

b. Propose a structural reliability test program aimed at providing high assurance of reliability under flight conditions.

c. Propose a reliability test program for the electronics system under simulated flight conditions.

3.2.2.7 C-1 Reliability Prediction

Based on prediction techniques developed under 3.2.4.1.3 predict the reliability of the overall C-1 launch vehicle (less payload); specifically:

a. Analyze staging problems

b. Make a reliability prediction analysis of the combined S-I plus S-IV stages, including stage separation, with allowance for various engine-out combinations in either or both stages (as allowed by mission requirements).

c. Based on an overall reliability goal to be specified by NASA, allocate reliability goals among the various C-1 systems and subsystems.

3.2.2.8 S-1 Test Program

Apply results of the Saturn S-1 reliability test program study specifically:

a. Review completed and current test programs at MSFC and LOD.

b. Assist MSFC in implementing tests recommended previously and in analyzing results thereof.

c. Select and carry through a practical illustration of the methodology developed.

3.2.3 Under the direction of LOC (LVOD where noted) the Contractor shall be responsible for providing reliability assessment engineering support in the following areas:

3.2.3.1 Reliability Program Requirements (LOC Task #15)

Provide engineering assistance to review LOC documents to assure that reliability requirements have been incorporated. Assist in evaluating reliability program submittals.

3.2.3.2 Reliability Programs Submittals (LOC Task #16)

Assist in evaluating contractor reliability program and design review submittals as required. Help resolve specific problem areas as requested, e.g., assist in plant surveys.

3.2.3.3 GSE Failure Mode and Effects Analyses (LOC Task #17)

Perform failure mode and effects analyses on C-1 and C-5 Ground Support Equipment under the cognizance of the launch support equipment office.

3.2.4 Under the direction of OMSF, the Contractor shall be responsible for providing reliability assessment engineering support in the following areas:

3.2.4.1 Mission Reliability and Safety Assessment Procedures

3.2.4.1.1 Publish preliminary mission reliability and safety assessment procedures for OMSF coordination and Center review. Develop related computer programs and trial runs. Support OMSF in arriving at "state-of-the-art" mission reliability and safety estimates. Submit Apollo estimates based on Center sub-system submittals. Maintain and update quarterly.

3.2.4.1.2 Develop methodology report for OMSF coordination and center implementation in developing subsystem estimates. Maintain and update semiannually.

3.2.4.1.3 Develop reliability prediction procedures appropriate to the Apollo Program in the following areas:

a. Propulsion reliability

b. Electronic reliability

c. Structural reliability

3.2.4.2 Subsystem Reliability Assessment Procedures

3.2.4.2.1 Establish reliability and maintainability format and procedure at the sub-system level and submit for OMSF co-ordination and center review and implementation. Consolidate subsystem reliability models and failure effects analyses based on Center submittals. Summarize quarterly Apollo subsystem reliability and maintainability estimates (for use in mission reliability and safety estimation) based on Center submittals.

3.2.4.2.2 Review Center/contractor reliability and failure data systems. Determine OMSF reliability and failure data system equipment requirements. Submit related reliability and failure data system flow charts and procedures for OMSF coordination and Center review.

3.2.4.3 Design Reliability Assessment Procedures

3.2.4.3.1 Review NASA and industry design reliability checklists. Develop design reliability assessment checklists, procedures, and scoring methods. Implement design reliability assessment surveys under Center direction. Publish survey reports for Center utilization. Publish comparative reports based on survey results for Center utilization.

3.2.4.3.2 Consolidate design problems reports based on Center submittals. Publish design reliability problem summaries for Center utilization.

3.2.4.4 Manufacturing Reliability Assessment Procedures

3.2.4.4 Review NASA and industry manufacturing reliability checklists. Develop manufacturing reliability assessment checklists, procedures and scoring methods. Implement manufacturing reliability assessment surveys under Center direction. Publish survey reports for Center utilization. Publish comparative reports based on survey results for Center utilization.

3.2.4.4.2 Consolidate manufacturing reliability problem reports based on Center submittals.

Publish manufacturing reliability problem summaries for Center utilization.

3.2.4.5 Test and Operations Reliability Assessment Procedures

3.2.4.5.1 Review NASA and industry test and operations reliability checklist, procedures and scoring methods. Implement test and operations assessment surveys under Center direction. Publish survey reports for Center utilization. Publish comparative reports based on survey results for Center utilization.

3.2.4.5.2 Consolidate test and operations reliability problem reports based on Center submittals. Publish test and operations problem summaries for Center utilization.

4.0 Integration Support

General

The Contractor shall provide the services and supplies set forth in the following paragraphs:

4.1 Integration Support Study

The Contractor shall conduct integration studies and shall prepare an Integration Support Implementation Plan recommending a program of integration support to NASA. The period of performance is from February 26, 1962 through October 12, 1962.

4.1.1 The Integration Support Implementation Plan shall include:

4.1.1.1 A summary system description

4.1.1.2 A description of the major functional system and equipment interfaces between launch vehicle and spacecraft and GOSS

4.1.1.3 A recommended configuration control system plan

4.1.1.4 A current standard program terminology summary

4.1.1.5 A recommended drawing and specification handling system

4.1.1.6 A plan for establishing current "one line" electrical, hydraulic, and mechanical space vehicle system functional diagrams

4.1.1.7 A plan describing means by which collected data may be retrieved upon request by NASA and Apollo contractors.

4.1.2 In order to prepare the Integration Support Implementation Plan, the Contractor's effort shall consider but not be limited to the following study elements insofar as effort related to the Checkout (paragraph 2.1) and the Reliability Assessment (paragraph 3.1) areas is not duplicated.

4.1.2.1 Collect system performance specifications

4.1.2.2 Collect system design specifications

4.1.2.3 Collect functional interface data

4.1.2.4 Collect equipment interface data

4.1.2.5 Collect and summarize program documentation requirements and standards

4.1.2.6 Collect and summarize standard program terminology

4.1.3 Under the direction of MSC (both at MSC and at POD), the Contractor shall be responsible for providing:

4.1.3.1 Support Engineering Assistance on System Integration Problems and Definition of Major Interfaces and General Systems.

4.1.4 Under the direction of LOC, the Contractor shall be responsible for providing:

4.1.4.1 Descriptions of the Saturn-I, Saturn-IB and Saturn-V Ordnance Systems (LOC Task #1).

4.1.4.2 LOC Drawing and Design Standards Study (LOC Task #7).

4.2 Integration Support Engineering

The Contractor shall be responsible for providing integration support engineering during the period of October 13, 1962, through September 30, 1963.

4.2.1 Under the direction of MSC (including Preflight Operations Division) the contractor shall provide Integration support engineering in the areas of:

4.2.1.1 Review and assess documentation of the major functional system and equipment interfaces between launch vehicle LEM and spacecraft and GOSS.

4.2.1.2 Develop a plan under the supervision of the Apollo Spacecraft Project Office for logging in detail, all functional and equipment interfaces between launch vehicle, spacecraft LEM and GOSS.

4.2.1.3 Collect and maintain interface data on networks and power sources.

4.2.1.4 Collect and maintain interface data on instrumentation and guidance and control.

4.2.1.5 Collect and maintain interface data on structures and power plants.

4.2.1.6 Collect and maintain interface data on ground support equipment and on GOSS.

4.2.1.7 General engineering support for systems integration tasks.

4.2.1.8 Study the mission abort problem in the region from injection into lunar orbit to injection into the transearth trajectory.

4.2.1.9 Document the latest known data on lunar environment and cislunar space.

4.2.1.10 Study the operational consequences and effect on crew safety if lunar logistics supplies are situated too far from the landing post of the lunar excursion vehicle.

4.2.1.11 Conduct a time, motion and error analysis of data transmission by voice (only) from the ground to the spacecraft during the more critical phases of the mission.

4.2.1.12 Conduct a time and workload analysis of the crew operations in lunar orbit, lunar landing and lunar launch operations.

4.2.1.13 Mechanical Design layout (POD Task #5).

The Contractor shall provide mechanical design layout support to assist in the evaluation of field design changes to spacecraft ground support equipment in the mechanical engineering area.

4.2.2 Under the direction of MSFC the Contractor shall be responsible for providing integration support engineering in the areas of:

4.2.2.1 Systems Integration of Saturn Launch Vehicle, Electrical Support Equipment (MSFC Task #5).

The Contractor shall perform work relative to the establishment, documentation, and implementation of design standards and specifications to be used in the design of Saturn launch vehicle electrical support equipment. This effort will include the following: Assist in documentation of standard hardware lists; review and establish qualification of such hardware; establish standard electrical symbols and electrical documentation formats for schematics, change orders, and waivers from standard hardware lists; review drawings to ensure compatibility with the over-all vehicle system integration effort.

4.2.2.2 Standards and specifications for documenting electrical design practices and procedures (MSFC Task #8).

The Contractor shall provide engineering support necessary to establish and maintain the required standards and specifications to adequately document the electrical design practices and procedures utilized by MSFC. The standards and specifications will be primarily in the following areas: Cable harness, electrical symbols for drafting, component purchase descriptions, stage electrical installation, test method, and system description.

4.2.2.3 Formulating, documenting, publishing and maintaining Saturn V electrical interface documents (MSFC Task #9).

The Contractor shall provide engineering support required to formulate, document, publish and maintain Saturn V electrical interface documents defining the electrical interface between stages and between launch vehicle and payload.

4.2.2.4 Systems Integration for the Saturn-Apollo Family of Launch Vehicles. (MSFC Task #17).

The Contractor shall assist in gathering, collating and revealing of electrical, mechanical and aerodynamic criteria which relates to the launch vehicle/payload interface. The Contractor shall also perform specialized studies in the field of man-rating and emergency detection.

4.2.2.5 Support Assistance to Design Document and Test Subsystems of the Saturn V Vehicle (MSFC Task #18)

The Contractor shall provide engineering support required to perform detailed design, investigation, documentation and testing of various areas of technical interest of the Saturn V vehicle electrical system such as exploding bridgewire systems, solid state relay logic, distributor concepts and design and component listing.

4.2.3 Under the direction of LOC, the Contractor shall be responsible for providing integration support engineering in the areas of:

4.2.3.1 Documentation of Ordnance System for complete vehicles, including operational aspects. (LOC Task #1).

4.2.3.2 Standardization of drawing and design specifications. (LOC Task #7).

4.2.3.3 Pneumatic, hydraulic and electrical firing accessories. (LOC Task #10).

4.2.3.4 Automatic Propellant transfer, pneumatic supply and environmental control systems. (LOC Task #11)

4.2.3.5 Launcher, umbilical tower and transporter. (LOC Task #12)

4.2.3.6 LOC Lightning Protection Problems (LOC Task #8).

The Contractor shall evaluate methods of providing lightning protection at LOC and shall recommend protective methods to minimize the chances of lightning damage at and between the assembly area, the checkout facility and the launch area. Upon completion of the study and the delivery of a preliminary study report to LOC, by December 31, 1962, the Contractor shall await NASA approval before proceeding with any implementation.

4.2.3.7 RF Interference Study (LOC Task #2)

The Contractor shall provide support of the Launch Operations Center by studying the effect of radio frequency interference on electrical equipment.

4.2.3.8 Investigation of Communications and Tracking Systems for Operation Flight Control (LOC Task #18)

The Contractor shall conduct an investigation to determine in what manner and to what extent existing and programmed worldwide communications and tracking systems can be applied and integrated into the Operation Flight Control (OFC) concept. The investigation shall include

determination of what additional communications and tracking systems would be required to meet the needs of CFC as well as specification of equipment input/output requirements and an estimate of the cost of new equipment required.

4.2.4 Under the direction of the GMSF, the Contractor shall be responsible for providing integration support engineering in the areas of:

4.2.4.1 System Description Techniques

Study methods and techniques to increase the contribution of the System Description to the Apollo Program.

4.2.4.2 Configuration Control Methods Study

Conduct studies towards improving the methods and techniques of accomplishing configuration control. Collect information on methods presently employed in the Apollo Program and in other appropriate technical programs. Submit reports covering the studies.

4.2.4.3 Documentation Requirements

Collect, study and summarize contractual requirements for engineering documentation under NASA contracts with Apollo Program participants. Study practices and requirements associated with other applicable programs. Recommend standards for contractual requirements for Apollo Program documentation, with consideration given to placing the minimum necessary requirements on participants.

4.2.4.4 Drawing Specification and Standards

Locate, study and summarize existing methods, for the preparation and utilization of drawings, specifications, standards, and procedures as used by Apollo Program participants. Prepare and submit recommended standards, specifications, and procedures, based on existing documentation to the maximum extent possible, for NASA review and approval.

4.2.4.5 Terminology Standards

Locate, collect, and catalogue applicable information. Recommend terminology standards for use by Apollo Program participants. Prepare documentation of standard terminology. Documentation shall be maintained and updated.

4.2.4.6 Parts Qualification Documentation

Collect and study data and information on parts standardization, qualification testing, and provisioning procedures currently in use for applicability to the Apollo Program. Prepare documentation of appropriate qualified, tested, and/or standard parts, together with suitable test data references. Recommend unified and standardized methods for accomplishing parts standardization and provisioning standardization.

4.2.4.7 Equipment Interfaces

Locate and collect applicable information. Identify and document the physical, functional and environmental equipment interfaces of operational and support equipment associated with two or more of the following: Launch vehicle, spacecraft, launch and control complex, and ground support systems. Documentation shall be maintained and updated. Documentation shall include the following:

4.2.4.7.1 Interface description, which shall describe equipment interfaces by words, sketches, photographs, diagrams, or other appropriate means, and

4.2.4.7.2 Interface identification, which shall contain information relative to equipment interface drawings, models, simulators status, responsible activities and other appropriate information.

4.2.4.8 Procedure Interfaces

Locate and collect applicable information. Identify and document procedural interfaces of assembly, operation, servicing, maintenance, and handling associated with two or more of the following: Spacecraft, launch vehicle, launch and control complex, and ground support systems. Documentation shall be maintained and updated.

4.2.4.9 Functional Line Diagrams

Locate and collect applicable information. Prepare and publish over-all system functional line diagrams representing the Apollo system. Documentation shall be maintained and updated.

4.2.4.10 Data Handling Support

Review and analyze the Contractor's Apollo support requirements, methods, and procedures of data handling; submit recommendations for improving data handling.

4.2.4.11 OMF Engineering Studies

4.2.4.11.1 General engineering studies as directed, including human factors, lunar logistic systems, and on-board equipment status.

4.2.4.11.2 Environmental handbook compilation.

4.2.4.11.3 Study potential integration problem areas on Lunar Excursion Module Project.

4.2.4.11.4 Weight Standards and Specifications for use on the Apollo Program.

4.2.4.12 Integration Methods and Plans Support

Study Integration methods, techniques, and procedures used on other large development programs; review these for applicability to the Apollo Program. Recommend Integration activities considered necessary for the successful achievement of program objectives. Support the OMF/MI in carrying out its responsibility for the preparation and maintenance of an Integration Plan for the Apollo Program.

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APPENDIX E

EXECUTIVE OFFICE OF THE PRESIDENT
BUREAU OF THE BUDGET
WASHINGTON 25, D. C.

BULLETIN NO. 60-6 March 18, 1960

TO THE HEADS OF EXECUTIVE DEPARTMENTS AND ESTABLISHMENTS

SUBJECT: Automatic Data Processing (ADP) Program of the Executive Branch: Studies preceding the acquisition of ADP equipment

1. Purpose. This Bulletin transmits "Guidelines for Studies to Precede the Utilization of Automatic Data Processing Equipment," copy attached.

2. Background and status of the report. The attached report was prepared by a task force of the Interagency Committee on Automatic Data Processing, accepted by the Committee and submitted to the Bureau of the Budget with the recommendation that it be published for the guidance of all concerned.

Experience to date in the acquisition and utilization of ADP equipment has demonstrated that a thorough analytical study should be conducted before decisions are made relative to the economic and operational feasibility of any ADP application. For use in studies of this kind, the attached report provides useful guidelines which have been developed from the experience of the people in the agencies who have been directly involved in ADP analytical studies.

MAURICE H. STANS
Director

Attachment

GUIDELINES FOR STUDIES TO PRECEDE THE ACQUISITION OF AUTOMATIC DATA PROCESSING EQUIPMENT

AN ATTACHMENT TO

BUREAU OF THE BUDGET BULLETIN 60-6

DATED MARCH 18, 1960

PREFACE

At its meeting in February 1959, the Interagency Committee on Automatic Data Processing approved the establishment of a task force to determine and review current practices and viewpoints relative to studies made by Government agencies prior to reaching decisions to acquire and use automatic data processing equipment. Members of the task force were:

Mr. Nicholas F. Schauer, Department of the Treasury (Chairman)
Mr. Robert W. Coggeshall, Department of the Interior
Mr. Robert A. Fernsler, Department of the Army
Mr. Leonard Sokolower, Veterans Administration
Mr. Eric G. Stewart, Department of State
Mr. Ernest Weiss, Mr. William P. Legge, Interstate Commerce Commission

The task force in May 1959 submitted to the Committee a preliminary draft of its findings. The preliminary draft was discussed at the June 1959 meeting. A revised draft was presented to the Committee at its October 1959 meeting, at which time it was accepted by the Committee and approved for submission to the Bureau of the Budget. The report appears in the following pages as approved by the Committee.

The Bureau of the Budget believes that this report by the Interagency Committee will provide valuable guidelines for all agencies contemplating or planning to use ADP systems.

[The following report was prepared by a Task Force of the Interagency Committee on Automatic Data Processing, approved by the Interagency Committee and submitted to the Bureau of the Budget, November 1959]

ATTACHMENT TO BUREAU OF THE BUDGET BULLETIN NO. 60-6
DATED MARCH 18, 1960

SUBJECT: Guidelines for Studies to Precede the Utilization of Automatic Data Processing Equipment 1/

I. Purpose and Scope

The purpose of this report is to provide guidelines to all government agencies as a basis for planning and conducting studies (excluding those which have military tactical objectives) preceding a decision to utilize automatic data processing equipment.

Studies as described herein include complete systems analyses and functional surveys of areas subject to possible automatic data processing application.

II. Selecting Areas for Study

1. A knowledge of the missions, functions and systems of an agency plus an orientation in the capabilities of automatic data processing will usually permit a determination to be made as to those areas worth exploring.

In general, such areas are characterized by one or more of the following:

a. Large volume repetitive operations.
b. High clerical costs.
c. Complex computational problems.
d. Urgent time scheduling factors.

2. Some of the more effective applications have been in:

a. Statistical data processing and analysis.
b. Traffic analysis.
c. Account maintenance.
d. Supply activities.
e. Payroll activities.
f. Personnel activities.
g. Engineering cut-and-fill computations.
h. Load scheduling.

This is not a definitive list - many other areas have been exploited.

1/ Studies of this nature have in the past been referred to as feasibility studies. These guidelines provide for systems analysis to follow a preliminary analysis or "feasibility study." (See IV).

3. The areas for study may be selected by one knowledgeable individual or a very small group. The object is to select the general area for a study. The selection may cover a wide range of activities cutting across many organizational lines or it may be limited to a specific operation.

III. Planning the Study

1. Problem Definition. When the organization or area to be studied has been selected the objective and scope of the study should be clearly defined. A time schedule and an order of priority should also be established. A directive or authorization from an official having high level responsibility should have sufficient information and the necessary authority to explore and review all pertinent activities.

2. Obtaining Top Management Support. One of the most vital preliminary steps in planning an automatic data processing study, as in the case of any significant undertaking, is to obtain top management support. To accomplish this, suitable presentations, orientations, and briefings have proved to be of considerable value. Management support must be insured because of the time involved in gathering facts, and the systems analysis involved in the study. Support is also required to effect organizational and procedural adjustments which may be necessary to improve the selected system prior to commencement of a study. It must, therefore, be made clear to all concerned that management is desirous of effective results from the study.

3. Employee Relations. The initiation of ADP studies sometimes results in alarm on the part of the staff and working force because of a concept that modern machines displace people. Employees should be completely informed so as to obtain their full cooperation. Some agencies have adopted a policy which provides that any resultant personnel adjustments may be accomplished by attrition or minimized by reassignment in preference to reduction-in-force procedures.

IV. Preliminary Analysis

An ADP study can be a lengthy, complex, and costly undertaking. For these reasons, a preliminary analysis or "feasibility study" should be made to determine the overall soundness of applying ADP to the operations of an organization. The following actions are suggested:

1. Informational requirements. Establish an inventory of data processing by major functional areas such as those described in Section II, paragraph 2. Additionally, it is necessary to secure or develop a distribution of man-hour effort and other significant cost elements to be used in identifying costs by major operation, function and/or organization.

2. Analysis. The analysis of data developed should be undertaken in a logical sequence. Several starting points are suggested, namely, unmanageable

backlogs, those operations which are the most costly, take the most time, or are presently mechanized. The analysis should be made from the point of view of determining the best method to accomplish the mission and to expedite the workload, and not of merely substituting an electronic computer for manual or mechanized methods. In examining these methods, it should not be assumed that every operation being performed is essential to the over-all mission of the organization, to the segment of the organization, or that the operation is authorized. In other words, it is important, initially, for the study group to determine along with staff personnel, the data requirements which are considered necessary to effectively manage the respective operations. The elimination of voluminous or costly reports, records, or operations may make the difference between the need for a large computer or medium and small computers or whether ADP is needed at all. In certain activities where fast information is the most important objective, speed over economy would receive primary consideration.

It naturally follows that when needs of management have been established, determination must be made as to the source data available to provide the end products required by management and, if not available, how the source data can best be made available. Only after this has been accomplished can measures be taken to determine the most appropriate system (ADP, manual, or conventional type equipment) to satisfy the needs of management.

3. Determination of impact. The end product of the preliminary analysis should include determinations regarding the areas susceptible to immediate or ultimate application, the size and cost range of equipment, the extent of the conversion problem, the sufficiency of available resources to support ADP, the expected economies and benefits, and the over-all effect of computer use on the personnel, procedures, and organization. The preliminary analysis should identify the organizational units that might be affected by the possible utilization of ADP and make adequate provision for participation by staff representatives of such units in the subsequent studies.

4. Decision. If the preliminary analysis shows that application of ADP is generally justified, further and more definitive plans are in order to proceed with a full systems study.

V. The Task Force

1. Composition. The careful and judicious selection of competent personnel is vital to the success of any ADP study. The chairman, and as many additional personnel as are necessary, should be relieved of all other work and assigned to the Task Force on a full-time basis. A small full-time Task Force is to be preferred to a larger part-time "Committee-type" group. This Task Force should have sufficient permanence and the continued service of personnel so as to properly accomplish the objectives of the study. The Task Force should include personnel with the following skills:

a. Familiarity with the systems and operational and management needs of the organization.

b. General understanding of the theory, operation, capabilities, and limitations of computers, punched card equipment, and conventional office machines.

c. Background in management engineering techniques, systems analysis and design.

2. Responsibility to Management. The Task Force should be organized and conducted so as to keep top management fully informed of the following:

a. Justification for the expenditure of manpower and funds to continue or extend the study.

b. Problems which may require policy decisions at a higher level of authority.

c. Management improvements which may be made during the course of the study or at a later date depending upon the benefits to be derived from improvements.

d. Circumstances and justification for a decision that Automatic Data Processing would not be applicable and that further consideration for the procurement of ADP equipment would not be necessary.

e. The identification of processes which can be improved without resorting to ADP.

VI. The Systems Study

The principles of systems analysis and other management engineering techniques are essential to the successful accomplishment of the systems study. The basic elements of a systems study are discussed below:

1. Recording the Facts. Establishing the relationship of documents, one to the other, and to the organizational elements engaged in processing such documents, is the starting point in reflecting the detailed description of the present system. Strong emphasis is placed on the importance of documenting in detail what is being done, where it is done, uses made of it, the frequency required, and an accurate reflection of how it is done and the complexity of the process. The use of flow charts, sequence and process charts, and organizational tables will facilitate recording the facts.

2. Preliminary Evaluation. An over-all examination and evaluation of the facts and the flow process charts should be made to establish

the basis for eliminating duplication, combining details, rearranging sequences, validating records and reporting requirements, or eliminating a process or processes which are not necessary. Conversely, this would result in the addition of a process not now being performed but which should be performed so as to provide essential records and reports not heretofore established.

3. Basic Systems Design. The success of the systems design will depend largely upon the degree to which certain basic principles are applied. Some of the more important basic principles are described as follows:

a. Adopt a uniform approach. Effective results in the review and analysis of information developed in the fact-finding phase require that personnel assigned to the study accomplish their findings in the same manner, and record their results uniformly; otherwise, the findings will be of little value. To insure a common approach, it is necessary that a well-planned program be developed.

b. Apply machine logic when recording facts about current systems. The meticulous, detailed programming of instructions is the largest single task in converting an operation to automatic data processing equipment. If machine logic and the language of the computer were applied during the design of the system, a tremendous step toward ultimate machine programming would be assured.

c. Capitalize on the capabilities of the equipment. The ability to store reference data internally, with rapid access time, is one of the principal advantages of electronic digital computers. This advantage usually eliminates the need for intermediate documents and manual data manipulation. An additional advantage lies in the flexibility of the equipment, through programming, which can produce an end product in multiple formats. These and many other capabilities provide the basis for integrated data processing to an extent not heretofore possible with conventional type equipment.

d. Convert to machine language at the earliest possible processing stage. The early conversion of source document information to machine language is an important factor in designing an optimum automatic data processing system. The ideal process would be the simultaneous preparation of the source document and input data in machine intelligible language.

e. Integrate data processing to the maximum extent. Whenever source documents are used for multiple purposes, thorough

consideration must be given to the possibility of integrating the systems involved. For example, a source document used for item accounting is also used in accounting for dollars. An integrated system would permit the updating of item and dollar accounting from one entry of the source document data into the system.

f. Employ the exception principle. ADP can produce complete reports for reference, audit and record. However, whenever possible, management reports should contain only those items of information which vary significantly from the normal and require the attention of management.

An understanding of the general capabilities and limitations of these equipments (including basic programming) will provide a proper background to determine whether desirable end-products are possible, and how the systems must be designed to produce desired results and a well-balanced system. The new system must be constructed in the form of schematic and flow process charts and source document designs. Also, organizational, supervisional and clerical requirements must be restated in view of the new procedures.

4. Development of systems specifications. During the design of the new system, specifications should be developed to provide a sufficient base to relate and evaluate the various equipment potentials. The following systems specifications represent the minimum information for this purpose:

a. Input. A description of all known input, including:

(1) Method or medium by which data will be received or developed.

(2) Format, message length, alpha-numeric or other identifying characteristics.

(3) Daily volume, including cyclical peaks.

(4) Hourly rate at which equipment should receive data.

b. Maintenance of information. A description of the information to be maintained, including:

(1) Volume of records.

(2) Methods of file maintenance.

(3) Proposed record lengths.

(4) Alpha-numerical requirements.

(5) Requirements for interrogation.

c. Data handling. A detailed description of each type of transaction or computation to permit a proper assessment of the problem. It is not desirable, necessarily, at this point, to prescribe specifically how each transaction will be processed because different types of equipment may require deviations in procedural steps while accomplishing the same results.

d. Output. A description of output needs, including:

(1) Kind of output and distribution thereof, i.e., punched card, paper tape, printed copy, etc.

(2) Daily volume by type of output.

(3) Required formats.

(4) Time after cutoff within which output should be produced.

(5) Time cycle to accomplish each transaction.

e. Other requirements.

(1) Date for equipment delivery and installation.

(2) Arrangements for maintenance of equipment.

(3) Requirements for compatibility with other equipment.

(4) Expandability to accomplish added workloads.

(5) Other requirements peculiar to the application.

5. Equipment evaluation and selection. Selection of equipment within the framework of the systems specifications developed may be accomplished through:

a. Analysis of manufacturers' brochures and government contract schedules.

b. Consideration of knowledge of personnel concerned with the study and information obtained from users.

c. Negotiations with or solicitations of proposals from manufacturers.

Qualified sources of supply should be considered and equal information opportunity and facilities be made available to each potential supplier. There is no requirement, however, to consider any equipment that does not exist in at least prototype form but there is no restriction against considering such equipment. Analysis of equipment should proceed so as to develop equipment costs, including make, model and quantity of components and any supporting conventional punched card equipment. The inability or reluctance of a

qualified manufacturer to make a specific proposal does not absolve the agency from its responsibility, in its own interest for considering that particular equipment. Consideration should also be given to personnel requirements related to the various models and kind of equipment available. Other costs which should be included in this consideration are space and air-conditioning, site preparation, maintenance, power, and miscellaneous electrical installation.

Evaluation and selection of equipment requires a detailed analysis of the following:

a. Capabilities of the machine to do the job.

(1) Acceptance of input documents and data.

(2) Sufficiency of storage and processing capacity.

(3) Adequacy of data handling.

(4) Production of output in required form.

(5) Adequacy of controls and accuracy.

(6) Adaptability to long-range plans.

b. Time taken to do the job.

(1) Hours of use in relationship to potential hours.

(2) Capability to achieve processing and interrogation cycles.

(3) Potential for expansion.

c. Acceptability.

(1) Availability.

(2) Adequacy of maintenance and training services.

d. Advantages of use.

(1) Timeliness of data production.

(2) Production of data desired but previously not available.

(3) Economy.

(4) Other tangible or intangible benefits to be gained.

6. Items to be included in the ADP systems study recommendations. A carefully documented ADP systems study would normally include the following:

a. Definitive indications of the benefits that are expected to accrue from the proposed system that cannot otherwise be attained, and justification for these benefits in terms of economic gains or improved management effectiveness.

b. A general description of the data processing needs of the activity in relation to the basic mission of the activity.

c. Workload and employment statistics describing the magnitude of the activity's problem.

d. A chart depicting the organizational effect of ADP on the activity as well as showing the location of the proposed data processing function.

e. Flow charts supplemented by clear and precise narrative indications of the nature and scope of each application. There should be included for each application the following:

(1) A description of the contents and purpose of proposed outputs.

(2) A description of the content and source of all input data.

(3) Record lengths and number of records.

(4) Processing frequencies.

f. Narrative descriptions of those present systems which correspond to the proposed applications.

g. Detailed comparative cost data for the proposed system and the present system, adjusted by improvements developed in the course of the study.

h. Indication of personnel implications in terms of reduced or augmented staffing needs.

i. Indications of the availability of and expected costs of site preparations.

j. Projected schedule should be provided covering plans for equipment selection, detailed application development, personnel training and orientation, site preparation, installation, transition and attainment of normal operations.

k. Indications that consideration was given to locating or obtaining equipment which could be shared with other bureaus in your agency, or with other agencies.

l. All factors which might have a bearing upon top management's decision, including problems or disadvantages.

VII. Evaluating the ADP Systems Study

Results of the ADP systems study should be evaluated in the light of the following:

1. Improved operational effectiveness, economy, and efficiency are the principal objectives.

2. Integration of Data Processing. Planning for ADP should take into account the interrelations (both horizontal and vertical) among the needs of management for information.

3. Systems improvement. Mechanization of existing methods may merely compound existing inefficiencies. Speeding up existing procedures is not enough; the real aim is not to speed up an old job, but to do a better job. Adequate planning should start with the end product or final program requirements of the whole activity, with minimum regard for prevailing organization, methods, and equipment.

4. Operational benefits. Emphasis should be directed toward those areas with the greatest potential "before and after" difference in effectiveness, efficiency, or economy of the entire operation or entire sequence of information flow within which an ADP system can be only a segment. Thus, some installations may produce large over-all savings by increasing the effectiveness of program operations even though direct data processing costs are increased.

5. Management by exception. Planning for ADP should provide for using the computer to make routine logical decisions and to print-out for detailed analysis only those exceptions to established routines which require human judgment.

6. Reorganization. ADP planning should anticipate and reflect possible changes in organization and procedural concepts to utilize the capabilities of ADP systems as management tools.

7. Alternative ADP organizational placement. At the bureau or departmental level consideration should be given to:

a. The possibility of obtaining equipment capable of combining the proposed ADP application with one or more applications at a higher organizational level;

b. The possibility that the proposed ADP application could be relocated and combined with activities of other organizational offices of the same agency or department;

c. The possibility of centralizing a particular operation or service nation-wide in scope (such as the processing of paid money orders in the Post Office Department or paid checks in the Treasury Department).

8. Economic considerations. An expectation of direct or indirect economic advantage should be evident, and generally the equipment should be on a break-even basis within a reasonable time after installation; however, this principle does not preclude consideration of intangible benefits. If an ADP system can do the job, a basic question is, will an ADP installation economically pay off? It is hard to evaluate on a strict dollar basis the benefits to be derived from having heretofore inaccessible information that an ADP system may provide.

However, the Task Force can and should weigh the cost of an ADP system against (1) clerical savings, (2) saving in presently-used machines, (3) the value of greater accuracy and speed, and (4) savings due to less space devoted to files and storage.

The report of the Task Force should include in some detail data on expected savings if an ADP system is recommended. In determining these savings such factors as cost of the equipment, cost of preparing facilities for the equipment, labor costs with and without the equipment, supplies, power requirements, and storage costs, should be considered. Savings may not be realized until the equipment is in use for a reasonable period of time after the system has been installed. Cost savings due to systems improvements resulting from the study should not be reflected in this analysis as savings resulting from the use of ADP, but, rather, should be set out separately.

9. Selecting specific equipment. If the Task Force recommends adoption of an ADP system, and if the recommendation is accepted, the problem arises as to the type of equipment to obtain. Normally, the Task Force should propose specific equipment in its recommendation. Equipment available from several manufacturers should be considered in making a decision as to the type and make of equipment to be ordered. Due consideration should be given in selecting ADP equipment to the availability of repair and maintenance service, especially when an agency is located in a remote area.

10. Adequacy of the ADP Systems study. It is difficult to offer a complete check list for review of a systems study; however, to supplement the reviewing authority's judgment and stimulate thinking in this area, the following should also be considered:

a. Was the composition of the Task Force such that they could be reasonably expected to make an adequate and objective study?

b. Was the approach of the Task Force the more desirable one of reviewing and redesigning procedures, or merely of using the proposed equipment to do more rapidly what already is being done? Was a functional survey made and a careful and critical study of existing data processing methods and reporting requirements conducted?

c. Was consideration given to results of studies of ADP made at similar segments of the same agency or at other agencies?

d. Were block-diagram flow charts prepared?

e. Were architectural and engineering requirements fully considered?

For example:

(1) Space layout,

(2) Floor loading factors,

(3) Power requirements,

(4) Air conditioning, humidity and dust control,

(5) Lighting and accoustics.

f. Was too much reliance placed on data from one manufacturer? Before specific equipment is selected, the characteristics of various machines should be studied and compared.

g. Were the relative merits of purchasing and renting equipment considered?

h. Was full consideration given to the economic advantages and disadvantages of acquiring an ADP system? The cost of an ADP system should be weighed against the anticipated benefits of clerical and other savings and the value of greater speed and accuracy.

i. If dollar savings are forecast in the study, was provision made to review the estimates for reasonableness and to relate the actual experience of the installation to these predicted savings?

j. Did the Task Force review reports on other studies for ADP equipment used in similar types of programs in order to ascertain whether any items requiring consideration might have been overlooked in the study?

The above suggestions are not intended in any way to restrict the reviewing authority's ingenuity in reviewing automatic data processing system studies. Such reviewing authorities may contact the ADP staffs of the Bureau of the Budget or the General Accounting Office for consultation or suggestions as to methods of reviewing studies. However, it should be understood that in all cases the decision to acquire and utilize ADP equipment rests solely with the agency involved, subject to its internal departmental or other controls.

EXECUTIVE OFFICE OF THE PRESIDENT
BUREAU OF THE BUDGET
WASHINGTON 25, D.C.

October 14, 1961 CIRCULAR NO. A-54

TO THE HEADS OF EXECUTIVE DEPARTMENTS AND ESTABLISHMENTS

SUBJECT: Policies on selection and acquisition of automatic data processing (ADP) equipment

1. Purpose. This Circular prescribes policies on (a) making selections of equipment to be acquired for use in the automatic data processing (ADP) program of the executive branch, and (b) making determinations as to whether the ADP equipment to be acquired will be leased, purchased, or leased with an option to purchase.

2. Scope. The ADP equipment affected by the policies stated herein includes:

a. Electronic digital computers, irrespective of use, size, capacity, or price;

b. All peripheral or auxiliary equipment used in support of electronic computers, whether or not cable-connected and whether selected and acquired with the computer or separately;

c. Punched-card equipment, whether used in conjunction with or independent of an electronic computer; and.

d. Data transmission or communications equipment that is selected and acquired solely or primarily for use with a configuration of ADP equipment which includes an electronic computer.

Analog computers are covered only when computers of this type are being used as equipment peripheral to a digital computer.

Items of ADP equipment that are (a) physically incorporated in a weapon, or (b) manufactured for the Government under a developmental contract, are not affected by the policies stated herein.

3. Applicability. The policies herein apply to ADP equipment acquired by the Government and to that ADP equipment which is acquired and operated by Government contractors solely to process Government data at Government expense (e.g., Government-owned, contractor-operated facilities). These policies do not apply to ADP equipment acquired by universities and similar institutions with financial assistance through grants-in-aid of Government funds.

The policy provisions of this Circular become applicable when a determination has been made that the utilization of ADP equipment is essential. It is assumed that such determinations have been preceded by and are based upon the results of well-documented studies which provide an adequate factual basis for concluding (a) that the functions or processes for which the ADP equipment can be used are essential to perform, and (b) that the systems, procedures, and methods to be employed in performing these functions or processes have been designed to achieve the highest practicable degree of effectiveness with optimum efficiency and operational economy. Guidelines for planning and conducting studies preceding a decision to utilize ADP equipment, for the development of system specifications, and for equipment evaluation and selection are contained in Bureau of the Budget Bulletin No. 60-6, "Automatic Data Processing (ADP) Program of the Executive Branch: Studies preceding the acquisition of ADP equipment," dated March 18, 1960.

4. Policies on equipment selection. The selection of ADP equipment includes the initial selection of ADP equipment, the selection of ADP equipment additional to that on hand, the selection of ADP equipment to replace ADP equipment on hand, the modification of equipment on hand, usually for the purpose of increasing memory capacity, computational capability, or speed of input or output, or combinations of the foregoing. In all these circumstances, the following policies apply:

a. The selection of ADP equipment will not be made until system specifications are available to serve as a basis for selection. For purposes of this Circular, the term "system specifications" means (1) the delineation of the objectives which the system is intended to accomplish; (2) the data processing requirements underlying that accomplishment, i.e., a description of the data output and its intended uses, the data input, data files, volumes of data, processing frequencies and timing; and (3) such ADP equipment capabilities as may need to be identified. System specifications will be designed to insure free competition among equipment manufacturers.

b. The officials responsible for making decisions on the selection of ADP equipment will assure that the selection process accords equal opportunity and appropriate consideration to all manufacturers who offer equipment capable of meeting the system specifications. In this connection, the selection process may be facilitated by written invitations to manufacturers to submit proposals as a means for obtaining information regarding the capabilities of ADP equipment to meet the system specifications.

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c. Two prime factors will be considered in the selection of equipment: (1) its capability to fulfill the system specifications, and (2) its overall costs, in terms of acquisition, preparation for use, and operation. The term overall costs, as used in this paragraph, will be interpreted to include such cost elements as personnel, purchase price or rentals, maintenance of purchased equipment, site preparation and installation, programming and training. When ADP equipment of two or more manufacturers meets the system specifications, the equipment which represents the least overall cost to the Government will be selected. Factors which do not relate directly or indirectly to the capability of ADP equipment to meet system specifications or overall costs normally will not be included in the considerations unless a conclusive judgment cannot be made on the basis of the two prime factors.

5. Policies on equipment acquisition. Most commercially available ADP equipment can be acquired by purchase or by lease, with or without an option to purchase. The General Services Administration has contracts with principal manufacturers, listed in Federal Supply Schedules (FSS), for the rental of ADP equipment. GSA currently is negotiating contracts for the purchase (including provisions for trade-in allowances) and maintenance of ADP equipment. Until such time as these contracts appear on the Federal Supply Schedule, it will be necessary for departments and agencies to negotiate purchase and maintenance transactions. All ADP equipment acquisition transactions are subject to prevailing policies, laws and regulations governing procurement by Federal Government agencies. In addition, except for equipment that can be acquired by the purchase method only, the following policies are applicable:

a. The method of acquiring ADP equipment will be determined after careful consideration of the relative merits of all methods available (i.e., purchase, lease, or lease-with-option-to-purchase). The method chosen will be that which offers the greatest advantage to the Government under the circumstances which pertain to each situation. In this connection, the following general guidelines will be taken into account:

(1) The purchase method is preferred when all of the following conditions exist:

(a) The system study which preceded the selection of the equipment has established a reasonable expectancy that the ADP equipment under consideration can be successfully and advantageously used.

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(b) A comparative cost analysis of the alternative methods of acquisition, of the types illustrated by Attachments A and B, indicates that a cost advantage can be obtained by the purchase method in six years or less after the date of delivery. This analysis usually will include the following cost elements under each method: for the lease method--rental costs, including maintenance; for the purchase method--purchase costs, including purchase price, maintenance, and other one-time costs applicable only to purchase; for the lease-with-option-to-purchase method--rental costs, and purchase costs less credits applicable upon purchase. In addition to the cost elements described above, the residual value of equipment to the Federal Government will be considered as a factor in a comparative cost analysis. Trade-in allowances quoted by manufacturers may be used as a representation of the residual value.

(c) The capabilities of the ADP equipment will continue to be needed and will be sufficient to satisfy the system requirements, current and projected, for a period beyond the point in time at which the purchase method begins to provide a cost advantage. The possibility that future technological advances will render the selected equipment comparatively obsolete before the cost advantage point is reached should not rule out purchase if the selected equipment is expected to be able to satisfy the system requirements.

(2) The lease-with-option-to-purchase method is indicated when it is necessary or advantageous to proceed with the acquisition of the equipment that meets system specifications, but it is desirable to defer temporarily a decision on purchase because circumstances do not fully satisfy the conditions which would indicate purchase. This situation might arise when it is determined that a short period of operational experience is desirable to prove the validity of a system design on which there is no previous experience, or where decisions which might substantially alter the system specifications are imminent.

(3) The lease method, without option to purchase, is indicated only when it is necessary or advantageous to proceed with the acquisition of equipment that meets system specifications and it has been established conclusively that any one of the conditions under which purchase is indicated is not attainable.

b. Negotiations or renegotiations of equipment delivery dates will be conducted in a manner which insures that firm and final commitments by the Government to accept delivery of ADP equipment on a specific date will not be made until it has been determined through a readiness review that the using agency will be prepared to use the equipment productively as soon as it becomes operational

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6. Review of current or pending lease transactions.

a. Lease or lease-with-purchase-option transactions in effect at the time this Circular is issued, and which are expected to remain in effect until fiscal year 1964, will be reviewed in the light of the provisions of paragraph 5. If it is found to be to the advantage of the Government to purchase leased ADP equipment in this category, steps will be taken to make such purchases during the earliest fiscal year in which funds for this purpose are available to the agency. Reviews of current lease transactions should be undertaken as soon as practicable and completed by June 30, 1962.

b. The method of acquisition of ADP equipment selected but not yet accepted for delivery at the time this Circular is issued will be reviewed for adherence to the policies herein stated, and, when indicated, the basis of acquisition will be changed to conform if permitted by the terms of the contract or agreement.

7. Documentation. System studies (sometimes referred to as applications studies, feasibility studies, and by other terms), system specifications, and readiness reviews will be fully documented. Decisions on the selection of ADP equipment, on the method of acquisition, and on the review of the current status of the method of acquisition also will be documented to reflect adequately the considerations taken into account and the basis for the decisions.

8. Administration of policies. The head of each executive department and establishment will establish the necessary framework of procedures, including appropriate reviews and controls, that will assure compliance with the policies herein stated.

By direction of the President:

DAVID E. BELL
Director

Attachments 2

(No. A-54)

ATTACHMENT A
CIRCULAR NO. A-54

LEASE VS. PURCHASE
REPRESENTATIVE ADP COMPUTER SYSTEM
BASED ON TWO-SHIFT USE

ITEM OF COST	COSTS BY FISCAL YEAR					
	1962*	1963	1964	1965	1966	1967
1. Purchase basis:	$	$	$	$	$	$
a. Purchase costs.	600,000	0	0	0	0	0
b. Maintenance, cumulative.	45,000	90,000	135,000	190,000	245,000	300,000
c. Cumulative, purchase basis.	645,000	690,000	735,000	790,000	845,000	900,000
2. Lease basis, cumulative (including maintenance).	200,000	400,000	600,000	800,000	1,000,000	1,200,000
3. Purchase basis exceeds lease basis.	445,000	290,000	135,000	--	--	--
4. Lease basis exceeds purchase basis.	--	--	--	10,000	145,000	300,000

* Year acquired, utilized full year.

ATTACHMENT B
CIRCULAR NO. A-54

LEASE VS. LEASE-WITH-
OPTION-TO-PURCHASE
REPRESENTATIVE ADP COMPUTER SYSTEM
BASED ON ONE-SHIFT USE

ITEM OF COST	COSTS BY FISCAL YEAR					
	1962*	1963	1964	1965	1966	1967
1. Lease basis, with-option-to-purchase: (Option exercised at end of first year).	$	$	$	$	$	$
a. Lease.	150,000	--	--	--	--	--
b. Less, credit upon purchase.	-75,000	--	--	--	--	--
c. Purchase costs.	600,000	0	0	0	0	0
d. Maintenance, cumulative.	26,000	52,000	78,000	108,000	138,000	168,000
e. Cumulative, lease/option basis.	701,000	727,000	753,000	783,000	813,000	843,000
2. Lease basis, cumulative (including maintenance).	150,000	300,000	450,000	600,000	750,000	900,000
3. Lease/option exceeds lease basis.	551,000	427,000	303,000	183,000	63,000	--
4. Lease basis exceeds lease/option basis.	--	--	--	--	--	57,000

* Year acquired, utilized full year.

APPENDIX F

REPORT TO THE CONGRESS OF THE UNITED STATES

STUDY OF FINANCIAL ADVANTAGES OF PURCHASING OVER LEASING OF ELECTRONIC DATA PROCESSING EQUIPMENT IN THE FEDERAL GOVERNMENT

(By the Comptroller General of the United States, March 1963)

COMPTROLLER GENERAL OF THE UNITED STATES,
Washington, March 6, 1963.

To the President of the Senate and the Speaker of the House of Representatives:

Herewith for the information of the Congress is the report on our study of the relative financial advantages of purchasing over leasing of electronic data processing equipment in the Federal Government.

The Federal Government is a large user of data processing equipment in its operations, but most of the equipment is leased. Of a total of 1,006 electronic computers installed in the Government at June 30, 1962, 867, or 86 percent, were leased. Rental payments for the fiscal year 1962 on such equipment were about $145 million. These statistics exclude equipment used in certain classified military, intelligence, and surveillance operations.

Our study shows that very substantial amounts of money could be saved if the Federal Government purchased more of its data processing equipment needs. The detailed cost comparisons of 16 different electronic machine models, which constituted the principal part of our study, indicate potential savings of about $148 million over a 5-year period. These significant possible savings apply to only 523 of approximately 1,000 electronic data processing systems installed or planned for installation on a lease basis by June 30, 1963. For additional use of the 523 machines after 5 years, there would be further savings at the rate of over $100 million annually.

We believe that, to fully realize savings of such magnitude, basic changes in the Government's overall management system will be necessary. Decisions as to the financial advantages of purchasing will have to be made from the standpoint of the Government as a whole, and not primarily from the standpoint of individual using agencies as has been the practice in the past. In addition, more attention needs to be given to obtaining more complete utilization of the equipment acquired. We believe that the only practicable way in which the kind of coordinated management can be practiced to achieve the possible financial savings cited is through the establishment of a small, highly placed central management office in the executive branch of the Government. Accordingly, we are recommending to the President of the United States that he establish such an office in his organization.

The report also contains a general recommendation to the heads of all using departments and agencies that they arrange for a prompt and complete reappraisal of their current plans to lease data processing equipment and take such action as is possible to realize the financial savings that may be available from purchasing such equipment and fully utilizing it.

Copies of this report are being sent to the President of the United States, to the Director, Bureau of the Budget, and to the heads of all departments and agencies that use electronic data processing equipment.

JOSEPH CAMPBELL,
Comptroller General of the United States.

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EXHIBITS (NOT INCLUDED HEREIN)

Exhibit A.—Estimated savings available to the Government through purchasing 523 of the 1,006 electronic computer systems scheduled to be leased as of June 30, 1963.
Exhibit B.—Summary of comparison of lease versus purchase costs of selected EDP systems over a 5-year period.
Exhibit C.—Comparison of lease and purchase costs over a 5-year period for 18 selected systems.
IBM 7090 tape system.
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UNIVAC III card and tape system.
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IBM 1410 card and tape system.
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Honeywell 400 card and tape system.
IBM 1401 card and tape off-line system.
IBM 1401 card and tape system.
IBM 1401 card system.
CDC 160A paper tape system.
RCA 501 tape system.
RCA 301 card and paper tape system.

APPENDIXES (NOT INCLUDED HEREIN)

Appendix I–A.—Report to Committee on Post Office and Civil Service, House of Representatives, Subcommittee on Census and Government Statistics, lease versus purchase of ADP equipment (interim report) August 26, 1960 (B–115386).
Appendix I–B.—Report to Committee on Post Office and Civil Service, House of Representatives, Subcommittee on Census and Government Statistics, lease versus purchase of ADP equipment November 8, 1961 (B–115386).
Appendix I–C.—Bureau of the Budget Circular No. A–54, policies on selection and acquisition of automatic data processing (ADP) equipment.

REPORT ON STUDY OF FINANCIAL ADVANTAGES OF PURCHASING OVER LEASING OF ELECTRONIC DATA PROCESSING EQUIPMENT IN THE FEDERAL GOVERNMENT

INTRODUCTION

In the period of a little over 10 years since the introduction of the first general-purpose electronic computer at the Bureau of the Census in the Department of Commerce, the use of electronic computing devices has expanded widely throughout the Federal Government. This equipment is being used in a great variety of Government operations and for many different purposes.

As of June 30, 1962, there were approximately 1,006 electronic computers[1] installed in Federal Government agencies. Of this total, 867, or 86 percent, were leased and only 139 had been purchased by the Government. Rental payments for the use of leased equipment were approximately $145 million for the fiscal year 1962.

The General Accounting Office has made a study of the relative financial advantages of purchasing the electronic data process (EDP) equipment used by the Federal Government over the practice of leasing such equipment. This study was prompted in the first instance by the Subcommittee on Census and Government Statistics of the Committee on Post Office and Civil Service, House of Representatives, which conducted hearings in 1959 on the use of electronic data processing equipment in the Federal Government.

At that time, members of the subcommittee raised a question as to the economic aspects of the apparently predominant practice in the Federal Government of leasing electronic data processing equipment rather than purchasing it. The suggestion was made that the General Accounting Office and the Bureau of the Budget inquire into this policy. Other congressional committees have also expressed interest in this problem.

Federal agency policies and practices in the procurement of EDP equipment were studied by both our Office and the Bureau of the Budget. On August 26, 1960, and November 8, 1961, our Office submitted to the subcommittee two short reports on the results of these joint studies. The second of these reports transmitted a copy of Bureau of the Budget Circular No. A–54, which had been issued in October 1961 to prescribe policies on selection and acquisition of automatic data processing equipment to be observed by Federal agencies and contractors operating Government-owned facilities. These reports and the Circular A–54 summarize the principal factors requiring consideration in management decisions as to the method of acquiring ADP equipment and are accordingly included in this report as appendix I.

In the meantime, the General Accounting Office undertook a more comprehensive study of the relative financial advantages of the two basic methods of procuring the use of EDP equipment, and the results of this extended work is the subject of this report.

General scope of study

The principal part of our additional study consisted of selecting 18 electronic data processing system models, which we consider to be generally representative, and computing the comparative costs over a 5-year period of use of such machines by leasing and by purchasing.

The factors considered in making these computations are described on pages 15 to 18, and the results of these computations are summarized in exhibits A, B, and C.

During this study, we also reviewed selected instances as to individual Federal agency action on price reductions announced by manufacturers for the purchase of data processing equipment.

SUMMARY OF CONCLUSIONS AND RECOMMENDATION

The cost comparisons made in our study demonstrate that very substantial amounts of money can be saved by the Federal Government in the years to come if, in acquiring the use of needed data processing equipment, proper cost comparisons are made in advance, action is taken to purchase equipment when such comparisons indicate the financial advantage of such action, and effective procedures exist to obtain the fullest, practicable utilization of such equipment by Government agencies.

The cost comparisons with respect to 16 of the 18 machine models studied during our review indicate potential savings of approximately $148 million over a 5-year period (see exhibit A). The 16 different electronic machine models used for our study represent 523 of the approximately 1,000 electronic data processing systems installed or planned for installation on a lease basis by June 30, 1963. For additional use of the 523 machines after 5 years, there would be further savings at the rate of over $100 million annually.

[1] Electronic data processing machines estimated to be installed in Federal Government operations, exclusive of those used for military tactical operations, intelligence, surveillance systems, and certain other military programs. The source of these statistics is the Inventory of Automatic Data Processing (ADP) Equipment in the Federal Government published by the Bureau of the Budget, August 1962.

The general conclusions which we have reached on the basis of our study are as follows:

1. If possible and substantial savings are to be fully realized, management decisions as to whether data processing equipment should be purchased or leased should be made from the standpoint of advantage to the Government as a whole and not from the standpoint of the individual using agencies.

2. Because of the substantial savings that may be available, all decisions to acquire the use of data processing equipment should be suported by specific computations showing the comparative costs of acquiring by lease and by purchase.

3. Where purchasing is financially advantageous, the realizable savings increase in proportion with the increase in utilization of the machines.

4. The savings possible through purchasing are more pronounced for the larger and more complex machine systems.

5. While significant savings may be realizable in many instances through purchasing rather than leasing, for some types of electromechanical equipment, it is more advantageous financially to lease rather than to purchase.

With the present system of decentalized management in the Federal Government under which each agency makes its own decisions as to whether the use of data processing equipment should be acquired by lease or by purchase, there is no effective coordinating machinery at work to give consideration to these alternatives from the standpoint of benefit to the Government as a whole. Because of the very substantial financial savings that can be realized through more extensive purchasing of such equipment and the related need for directing and coordinating its utilization throughout the Government, we are recommending to the President of the United States that a central management office suitably empowered to perform these functions be established in his organization. We are convinced that the establishment of such an office is the only practicable way to provide the kind of management that will make possible the realization of savings of hundreds of millions of dollars in the years to come.

EXPANDING USE OF ELECTRONIC DATA PROCESSING SYSTEMS IN THE FEDERAL GOVERNMENT

In our report to the Congress on "Review of Automatic Data Processing Developments in the Federal Government" (B–115369, Dec. 30, 1960), we stated that there had been a continuous, upward trend in both the quantity and complexity of electronic data processing equipment being used in Government operations. This trend continues. New areas of computer use are being pioneered in such fields as automatic retrieval of information and in communication systems where electronic computers seem destined to play an increasing role. Also, the application of many new scientific management techniques depends on computers to process the enormous number of calculations that are required to carry out such advanced techniques.

Evolution of equipment

During fiscal year 1960, Federal agencies began receiving deliveries of the more advanced solid-state equipment. This new equipment was brought about through the development of the transistor and other solid-state devices which are used in place of the vacuum tube found in earlier computer models. Transistors are but a fraction of the size of vacuum tubes, require less power, generate less heat, and are generally more reliable. The diminutive size of transistors has led to miniaturization of circuitry so that whole circuits can be placed on small card forms. In contrast to the vacuum tube systems, the solid-state systems are more compact, require less floor space and reinforced flooring, require less special power and air-conditioning facilities, are more easily maintained, and operate at faster speeds and with greater versatility. Today suppliers offer a broad range of solid-state equipment that can be applied to many operations throughout Government, as well as business and industry.

Number of systems in use or planned

For the past several years, the Bureau of the Budget has published an inventory report setting forth statistics on the Federal Government's use of automatic data processing equipment. These reports are based on data submitted by all Federal agencies. They exclude information on data processing systems used for military tactical operations, intelligence, surveillance systems, and certain other military programs.

Statistics on electronic systems set forth in these reports show—

	Number of systems	Number leased	Number purchased	Percent purchased
At June 30:				
1960 actual	531	433	98	18.5
1961 actual	730	613	117	16.0
1962 estimated	1,006	867	139	13.8
1963 projected	1,169	1,006	163	13.9

THE PRACTICE OF LEASING

The Federal Government's practice of leasing data processing equipment originated prior to the development of electronic computers, at a time when mechanized data processing systems consisted primarily of electric accounting machines (EAM). Most of these machines were supplied by the International Business Machines Corp. (IBM), whose policy was to lease rather than to sell this type of equipment. In view of this policy, as well as certain conditions considered to be of a monopolistic nature, the Attorney General of the United States, on January 21, 1952, entered a complaint against this company in the District Court of the United States for the Southern District of New York, charging violations of sections 1 and 2 of the "act to protect trade and commerce against unlawful restraints and monopolies" (commonly known as the Sherman Anti-Trust Act).

Final judgment was filed and entered in a consent decree 4 years later on January 25, 1956, by which time IBM was also manufacturing electronic data processing equipment. Among other provisions, the judgment provided that IBM offer data processing equipment for sale as well as for lease. In accordance with this decree, IBM has since offered its equipment for lease or for sale.

This change in policy did not have any immediate effect on the practice of Government agencies of leasing this kind of equipment, and it has not subsequently had any material effect on the practice. For example, at the present time, more than 7 years after the equipment was offered for sale, most EAM equipment manufactured by IBM is leased and, of the 670 EDP machines manufactured by IBM and reported to be on hand at the close of fiscal year 1962, only 37, or 6 percent, had been purchased.

In addition to the International Business Machines Corp., about 20 other manufacturers supply the Government with electronic data processing equipment. All of these manufacturers offer equipment on a purchase as well as on a lease basis. The following tabulation lists the manufacturers furnishing such equipment to the Federal Government as of June 30, 1962, and shows the total number of systems in use, the number leased and purchased, and the percentage the purchased systems bear to the total number of systems. This information is summarized from the "Inventory of Automatic Data Processing Equipment in the Federal Government," published by the Bureau of the Budget, August 1962.

Manufacturer	Total number of systems	Number leased	Number purchased	Percentage purchased
Advanced Scientific Instruments, Inc	1		1	100.0
Bendix Computer Division, Bendix Corp	36	26	10	28.0
Burroughs Corp	37	23	14	38.0
Control Data Corp	28	20	8	29.0
Alwac Computer Division, El-Tronics, Inc	7		7	100.0
General Electric Corp	6	6		
General Mills	1		1	100.0
Librascope Division, General Precision, Inc	4	1	3	75.0
Minneapolis-Honeywell Regulator Co	9	9		
International Business Machines Corp	670	633	37	6.0
Monroe Calculating Machine Co	2	2		
Autonetics Division, North American Aviation, Inc	24	12	12	50.0
The National Cash Register Co	11	9	2	18.0
Packard Bell Electronics Corp	5	4	1	20.0
Philco Corp	6	6		
Radio Corporation of America	42	40	2	5.0
Univac, Division of Sperry Rand Corp	64	48	16	25.0
Royal McBee Corp	37	27	10	27.0
Sylvania Electric Products, Inc	1	1		
Others [1]	15		15	100.0
Total	1,006	867	139	13.8

[1] Manufacturers that furnish computer systems built specifically for a particular application. Generally they are not easily adapted to other applications.

Increased use of electronic data processing systems

The following tabulation shows as of the close of fiscal year 1962 the number of computer systems used by each department or agency, the number leased, the number purchased, and the percentage those purchased bear to the total.

Department or agency	Number of computer systems	Number leased	Number purchased	Percentage purchased
Department of Defense:				
Office of the Secretary	27	26	1	4.0
Department of the Air Force	263	244	19	7.0
Department of the Army	158	133	25	16.0
Department of the Navy	178	151	27	15.0
Total	626	554	72	12.0
Atomic Energy Commission	112	72	40	36.0
National Aeronautics and Space Administration	83	76	7	8.0
Department of the Treasury	34	34		
Department of Commerce	29	20	9	31.0
Department of Health, Education, and Welfare	28	28		
Department of Agriculture	15	13	2	13.0
Federal Aviation Agency	15	12	3	20.0
Post Office Department	13	13		
General Services Administration	10	10		
Veterans' Administration	9	8	1	11.0
Department of the Interior	8	6	2	25.0
All others	24	21	3	13.0
Total	1,006	867	139	13.8

Bureau of the Budget Circular No. A–54

After studying the various factors affecting lease-purchase decisions, the Bureau of the Budget issued Circular No. A–54, in October 1961, prescribing policies to be observed by Federal agencies in acquiring automatic data processing equipment. This circular requires that agencies use a 6-year factor in ascertaining which method is most favorable from the standpoint of expenditures. In other words, if rental charges over a 6-year period exceed purchase and related maintenance costs, the decision to purchase should be made. Normally, most systems would be purchased under this policy. However, the application of the policy is dependent upon the user's having a continued need for the particular equipment throughout the 6-year period. If a user anticipates changes in data processing requirements which might necessitate equipment changes prior to the expiration of the amortization period, he need not purchase.

As indicated by the statistics on computers in use or planned (see p. 7), the Bureau's circular has apparently had little effect so far on lease-purchase decisions by individual agencies.

LIMITED PERSPECTIVE USED IN DETERMINING THE USEFULNESS OF DATA PROCESSING EQUIPMENT TO THE GOVERNMENT

With more than 1,000 systems now in use—exclusive of certain military tactical, intelligence, and surveillance systems—the Federal Government is the world's largest user of electronic data processing equipment. For the most part, the equipment is general purpose in nature; that is, it can be used to perform numerous different kinds of tasks once programed to do so. Because of the wide variety of Government equipment needs, most equipment installed can be considered to be useful to the extent that, if purchased and no longer needed for its originally intended purpose, it can be placed in use for other purposes in other activities.

Government applications range from critical scientific and defense operations to many less demanding administrative functions. In making lease versus purchase determinations, each Federal agency considers only the various factors involved from its own standpoint, and this practice has had much to do with the fact that 86 percent of the systems now in use are leased. If, however, the usefulness of equipment is considered from the standpoint of advantage to the Government as a whole, including consideration of use for subsequent or less demanding tasks as well as for the primary or originally intended purposes, the economic advantage of purchasing becomes more evident. Had this viewpoint

been used in making lease versus purchase decisions in the past and if an effective procedure had existed for transferring equipment within the Government, the fears of a loss of flexibility through purchasing, which has to some extent influenced individual agency decisions to lease, should have been overcome.

In some cases, because of defense or other critical national needs, it is necessary to use the latest models of equipment. However, most electronic data processing equipment is general purpose in nature and it could fulfill data processing needs in less demanding areas for a number of years after it has outlived its usefulness for the original task.

Economic obsolescence versus technological obsolescence

Development of new equipment has been so rapid that much electronic equipment is technologically surpassed by more advanced models by the time it is installed. However, from an economic point of view, considering overall Government needs, most equipment can be considered as having a useful life of at least 5 years. The physical life of such equipment may extend well beyond a 5-year period after which maintenance and upkeep charges become the main cost factors to be considered. If the originally installed equipment can be productively and satisfactorily used at a lower cost than newly developed equipment, it would seem that, unless timeliness of data processing or some other feature becomes the overriding factor, the older equipment should be retained in use until the cost advantage favors conversion to the technically superior equipment.

DETAILED COST COMPARISONS

During our study, we selected 18 electronic data processing models and determined for each component the costs of leasing, purchasing, and maintenance and the interest applicable to these costs. For each component, we then compared the total cost of rental over a 5-year period with the cost of ouright purchase plus the cost of maintenance. All comparisons were made for one-, two-, and three-shift operations. These comparisons are summarized in exhibit B and are set forth in detail for each machine system in exhibit C.

A condensed summary of the results of these comparisons is shown below.

Manufacturer	System identification	Savings or losses (−) from purchasing instead of leasing		
		1 shift	2 shifts	3 shifts
		176 hours	*352 hours*	*528 hours*
International Business Machines Corp.	7090	$644,000	$2,184,000	$3,724,000
Philco Corp.	2000	−143,000	1,181,000	2,505,000
International Business Machines Corp.	7080	333,000	1,397,000	2,461,000
Control Data Corp.	1604	923,000	1,830,000	2,737,000
Minneapolis-Honeywell Regulator Co.	800	112,000	673,000	1,233,000
Burroughs Corp.	5000	315,000	886,000	1,456,000
Univac Division of Sperry Rand Corp.	Univac III	−15,000	276,000	566,000
International Business Machines Corp.	7070	70,000	432,000	795,000
The National Cash Register	315	38,000	83,000	143,000
International Business Machines Corp.	1410	67,000	323,000	579,000
Univac, Division of Sperry Rand Corp.	Univac SS-90.	−21,000	149,000	335,000
Minneapolis-Honeywell Regulator Co.	400	23,000	171,000	318,000
International Business Machines Corp.	1401 [1]	27,000	158,000	288,000
International Business Machines Corp.	1401 [2]	7,000	137,000	267,000
International Business Machines Corp.	1401 [3]	−11,000	41,000	94,000
Control Data Corp.	160A	24,000	75,000	127,000
		200 hours	*484 hours*	*612 hours*
Radio Corp. of America	501	$30,000	$42,000	$45,000
Radio Corp. of America	301	26,000	18,000	23,000

[1] Card and tape system operated as off-line equipment to a larger system.
[2] Card and tape system.
[3] Card system.

Factors considered in making cost comparisons

The factors considered in our computations were:

Time period: 5 years.

Lease: Rentals and interest on rentals.

Purchase: Purchase price, interest on purchase price, maintenance costs, and interest on maintenance costs.

These factors are described more fully in the following sections. Other costs related to the acquisition and use of data processing systems, such as transportations, site preparation, and training costs, are identical under either lease or purchase arrangements and consequently for comparison purposes can be excluded.

Five-year period.—Federal Government experience with electronic data processing devices over the past 12 years has shown that with proper maintenance this type of equipment has a useful life span of at least 5 to 10 years. Some of the machines installed in Federal agencies in the early and mid-1950's are still in service. Generally speaking, the older machines that are still in use are those which were purchased outright by the Government. Also, despite the rapid changes that have taken place in equipment design, a large number of machines that were rented were used for periods of 5 years or more before being replaced by more modern equipment.

It is generally agreed that the new "second generation" solid-state machines will have a considerably longer useful life than the "first generation" vacuum tube type of machines. The question of economic obsolescence versus technological obsolescence related to the useful life of electronic equipment is discussed briefly on page 13.

We selected 5 years as being a conservative estimate of the economic useful life of electronic data processing machines for purposes of making comparisons of lease costs with purchase costs. It should be noted that to the extent that this period is less than the actual useful life of the equipment, the computed savings are understated.

Rentals.—Each year since fiscal year 1958, the General Services Administration on behalf of the Federal Government has entered into contracts with equipment suppliers for the rental of EDP equipment. In fiscal year 1962, 17 rental contracts were in effect. Through January 15, 1963, 16 contracts had been written covering fiscal year 1963.

Basically these contracts are concerned with rental rates and the terms and conditions that bear upon the application of these rates. The rates are established by the supplier and are the same as those charged commercial users of this equipment. These rates are accepted by the General Services Administration for use throughout the Government without further negotiation. The terms and conditions, however, are negotiated. The rental rates appearing in these contracts for use of equipment are the rates used in our computations.

Purchase price.—For fiscal year 1962, for the first time, two of these contracts contained purchase and maintenance sections as well as sections on rental arrangements. In fiscal year 1963, 14 contracts containing purchase sections and 13 containing maintenance sections had been written through January 15, 1963. As in the case of rental prices, purchase prices are set by the suppliers and are not further negotiated by the General Services Administration. Terms and conditions relating to purchasing are, however, negotiated.

Where purchase contracts had been established, the contract prices were used in our computations. In those cases where no purchase contract was in effect, purchase price information was obtained directly from the supplier.

Purchase price data used in our computations relate to new equipment. Most installed equipment is offered for sale to users at reduced prices, usually depending on the length of time that the equipment has been installed. On the other hand, in almost all cases, rental prices do not decrease with the aging of the equipment. To the extent that used equipment was included in our determinations of projected savings, the cost of purchasing is overstated and estimated savings from purchasing are understated.

Maintenance costs.—As mentioned previously, contracts providing for the maintenance of purchased equipment have been written with equipment suppliers for fiscal years 1962 and 1963. For these contracts, as for the rental and purchase contracts, rates proposed by the suppliers are accepted and the terms and conditions are negotiated.

Interest.—It is our position that interest is a cost which is related to all Government expenditures. In our calculations of applicable interest costs, we used the average rate of marketable obligations of the outstanding public debt as of December 31, 1961 (3.146 percent).

Significance of computed savings on individual systems

As indicated in the condensed summary on page 14, 14 of the 18 systems compared for the 5-year base period show a purchase advantage on a one-shift basis. All 18 systems show a purchase advantage on a two- and three-shift basis. These

comparisons show clearly that purchase, rather than lease, of electronic data processing equipment can result in substantial savings. Some widely used models of electronic data processing equipment offer the greatest purchase advantages.

For example, the purchase of a representative IBM 7090 system could result in savings of $644,000 if operated on a one-shift basis, $2,184,000 if operated on a full two-shift basis, and $3,724,000 if operated on a three-shift basis. Continued use of the system past the 5-year period would produce additional savings of from $772,000 to $1,512,000 annually depending upon the extent of use. (These additional savings are measured by equipment rentals [illegible] less estimated maintenance costs.)

According to the inventory of automatic data processing equipment in the Federal Government, issued by the Bureau of the Budget in August 1962, there will be 42 IBM 7090 and 7094 systems in use by June 1963. Of these, 6 are to be purchased and 36 are to be leased. To illustrate the magnitude of savings available through purchasing, the following tabulation projects the estimated amount of savings that could be realized over a 5-year period for the 36 systems if they were purchased rather than leased and the estimated amount of annual savings for each year of continued use beyond the initial 5 years. These projected savings are based on the computed savings applicable to the representative IBM 7090 system shown in exhibit C and on the planned use per month as reported by the respective agencies to the Bureau of the Budget.

Estimated savings available to the Government through purchasing 36 IBM 7090 and 7094 systems scheduled to be leased by June 30, 1963

Agency	Location	Use per month		Estimated savings over 5-year period available through purchase	Estimated annual savings after initial 5-year period
		Hours	Shift equivalent		
Atomic Energy Commission	Albuquerque, N. Mex.	300	1¼	$1 799,000	$994,000
Do	New York, N.Y.	176	1	644,000	772,000
Do	do	350	2	2,184,000	1,068,000
Do	San Francisco, Calif.	616	3½	4,494,000	1,512,000
Do	do	616	3½	4,494,000	1,512,000
Department of Commerce	Washington, D.C.	200	1¼	1,029,000	846,000
Do	do	176	1	644,000	772,000
Do	Denver, Colo.	176	1	644,000	772,000
Do	Washington, D.C.	480	2¾	3,339,000	1,290,000
Do	do	200	1¼	1,029,000	846,000
Department of the Air Force	Dayton, Ohio	210	1¼	1,029,000	846,000
Do	do	354	2	2,184,000	1,068,000
Do	Ft. Walton, Fla.	176	1	644,000	772,000
Do	Washington, D.C.	450	2½	2,954,000	1,216,000
Do	do	215	1¼	1,029,000	846,000
Do	Omaha, Nebr.	340	2	2,184,000	1,068,000
Do	do	176	1	644,000	772,000
Department of the Army	Washington, D.C.	125	1	644,000	772,000
Do	Huntsville, Ala.	260	1½	1,414,000	920,000
Do	White Sands, N. Mex.	264	1½	1,414,000	920,000
Department of the Navy	Washington, D.C.	183	1	644,000	772,000
Do	China Lake, Calif.	176	1	644,000	722,000
Do	Dahlgren, Va.	407	2¼	2,569,000	1,142,000
Do	Baltimore, Md.	272	1½	1,414,000	920,000
Do	Pt. Mugu, Calif.	176	1	644,000	772,000
Do	Washington, D.C.	287	1¾	1,799,000	994,000
Federal Aviation Agency	Atlantic City, N.J.	211	1¼	1,029,000	846,000
National Aeronautics and Space Administration.	Cleveland, Ohio	240	1¼	1,029,000	846,000
Do	Newport News, Va.	200	1¼	1,029,000	846,000
Do	Huntsville, Ala.	528	3	3,724,000	1,364,000
Do	do	528	3	3,724,000	1,364,000
Do	Washington, D.C.	347	2	2,184,000	1,068,000
Do	do	140	1	644,000	772,000
Do	do	140	1	644,000	772,000
Do	do	140	1	644,000	722,000
Do	Mountain View, Calif.	176	1	644,000	772,000
Total				57,449,000	34,373,000

The foregoing tabulation shows that total estimated savings of $57,449,000 could be achieved over an initial 5-year period of use through purchasing rather than leasing these 36 systems. It shows also that estimated savings for each year of continued use past this period would be $34,378,000. (These annual savings represent the amount of rental costs not incurred less maintenance costs.) Thus, if these systems were purchased, rather than rented, and used for 7 years, the Government would realize savings of approximately $126,200,000.

Another example of savings available through purchasing is offered by the IBM 7080 system. The purchase of this model would produce savings of $353,000 when the system is operated on a one-shift basis. Operation on a two-shift basis would produce savings of $1,397,000. On a three-shift basis, the savings would be $2,461,000. Continued use past the initial 5-year period would produce additional annual savings of from $537,000 to $945,000 depending on the extent of use of the equipment.

According to the Bureau of the Budget inventory published in August 1962, there will be 16 IBM 7080 systems in use in the Government by June 30, 1963. One of these is to be purchased and 15 are to be leased. Based on the computed savings applicable to the representative IBM 7080 system, shown in exhibit C, and on the planned monthly use as reported by the respective agencies to the Bureau of the Budget, estimated savings available through purchase, rather than lease, of the 15 IBM 7080 systems would be as shown in the following tabulation:

Estimated savings available to the Government through purchasing 15 IBM 7080 systems scheduled to be leased by June 30, 1963

Agency	Location	Use per month		Estimated savings over 5-year period available through purchase	Estimated annual savings after initial 5-year period
		Hours	Shift equivalent		
Office of Secretary of Defense	Dayton, Ohio	550	3	$2,461,000	$945,000
Do	Battle Creek, Mich	480	2½	2,116,000	894,000
Department of the Air Force	Dayton, Ohio	400	2⅛	1,663,000	792,000
Do	Ogden, Utah	450	2⅜	1,929,000	843,000
Do	Oklahoma City, Okla	400	2⅛	1,663,000	792,000
Do	Harrisburg, Pa	400	2⅛	1,663,000	792,000
Do	Mobile, Ala	400	2⅛	1,663,000	792,000
Do	San Antonio, Tex	400	2⅛	1,663,000	792,000
Do	Memphis, Tenn	400	2⅛	1,663,000	792,000
Department of the Army	St. Louis, Mo	367	2	1,397,000	741,000
Department of the Navy	Harrisburg, Pa	250	1⅓	965,000	639,000
Do	Washington, D.C	220	1⅛	599,000	588,000
Department of Health, Education, and Welfare	Baltimore, Md	442	2⅓	1,929,000	843,000
Do	do	372	2	1,397,000	741,000
Veterans' Administration	Chicago, Ill	380	2⅛	1,663,000	792,000
Total				24,413,000	11,778,000

This tabulation shows that, through purchasing rather than leasing, estimated savings of $24,413,000 could be realized over an initial 5-year period of use and that there would be additional savings of $11,778,000 for each year of continued use past this period. If used for a total of 7 years, the purchase of the 15 systems would produce estimated savings of $47,969,000.

These projections of estimated savings applicable to the IBM 7090, 7094, and 7080 systems and similar projections applicable to 14 systems[2] of the remaining 16 involved in our study show that the possible total savings available over a 5-year period would approximate $148 million. These projections are summarized in exhibit A. For additional use after the initial 5-year period, there would be further savings at the rate of over $100 million a year.

These significant possible savings apply to only 523 of the approximately 1,000 systems that will be leased throughout the Federal Government by June 30, 1963. The full potential of the possible savings that could be realized through

[2] Two of the systems (Burroughs B–5000 and Sperry-Rand Univac III) for which we made cost comparisons are new, and the Bureau of the Budget inventory report showed none of these two systems scheduled to be under lease by June 30, 1963.

a management system that would give full recognition to these possibilities is difficult to estimate. However, we believe that the Government could save hundreds of millions of dollars in the next several years as a result of proper consideration of the financial benefits of purchasing and appropriate action, including the establishment of effective arrangements to promote the fullest, practicable utilization by all Federal agencies of data processing systems.

Need to consider separately each component for lease or purchase

The detailed cost comparisons of the 18 systems set forth in exhibit C demonstrate that each component of a system should be considered separately for lease or purchase. These computations show that the cost advantage of purchasing some electromechanical components, such as printers, card readers, and card punches, is not as great as the cost advantage available through the purchase of electric components. In some cases, it is clearly disadvantageous to purchase electromechanical components. This is due in part to pricing policies of equipment suppliers and to the greater need for maintenance on electromechanical components because of the inherent wearing characteristics of mechanical parts. These factors would have to be weighed heavily in considering the purchase of these components. It might well be that, for the small cost advantage available, it would not be worth the risk of purchasing a component that may cause a serious maintenance problem or one that may have to be completely replaced because of constantly increasing maintenance requirements.

Because of these factors, detailed computations such as those shown in exhibit C should be made in order to provide the financial information necessary for deciding which components should be purchased and which ones should be leased.

Savings available through full use of Government-owned facilities

Our comparisons demonstrate two additional points that should be emphasized. First, the larger or more sophisticated a system, the greater the rate of purchase advantage. This point is illustrated in the following tabulation of selected IBM systems analyzed. The rate of purchase advantage may be expressed as the percentage the purchase advantage (savings) bears to the total cost of purchasing.

IBM system	Cost to purchase [1]	1 shift		2 shifts		3 shifts	
		Amount of purchase advantage	Rate of purchase advantage	Amount of purchase advantage	Rate of purchase advantage	Amount of purchase advantage	Rate of purchase advantage
			Percent		*Percent*		*Percent*
7090	$3,632,000	$644,000	18	$2,184,000	57	$3,724,000	94
7080	2,655,000	338,000	13	1,397,000	50	2,461,000	84
7070	967,000	70,000	7	432,000	42	716,000	74
1410	711,000	67,000	9	323,000	42	501,000	70
1401 [2]	415,000	27,000	7	153,000	34	238,000	57
1401 [3]	411,000	7,000	2	137,000	31	227,000	55
1401 [4]	186,000	−11,000	−6	41,000	20	94,000	42

[1] Includes maintenance for 1 shift only.
[2] Card and tape system operated as off-line equipment to a larger system.
[3] Card and tape system.
[4] Card system.

On a one-shift basis, the percentage of purchase advantage steadily increases with each more costly system—from minus 6 percent for the least costly system to 18 percent for the most costly. On a two-shift basis, these rates run from 20 to 57 percent, and for three shifts, they run from 42 to 94 percent.

A second important point is that the more use made of equipment, the greater the rate of purchase advantage. This factor is also illustrated by the foregoing tabulation which shows in each case that the rate-of-purchase advantage increases with greater use of the system. For example, the IBM 7090 system shows an increase in the rate from 18 percent for a one-shift operation to 57 percent for two shifts and 94 percent for three shifts.

When considered together, these two points demonstrate that significant economies are available through purchase and joint or multiple use of large data processing facilities. The Bureau of the Budget's published inventory of automatic data processing equipment shows that a number of electronic data proc-

essing systems are scheduled for operation on a one- or two-shift basis. For example, 22 of the 23 IBM 7070, 7072, and 7074 systems that will be leased by June 1963 are scheduled to be operated for less than two shifts. Twelve of these systems will be operate for one shift or less. The low utilization scheduled for these machines is a result of individual agency planning and, since the potential savings available from purchasing increases with additional use of the equipment, it seems evident that more effective procedures are needed to coordinate throughout the Government the use of large data processing facilities. This kind of management action should help to significantly reduce the Government's overall data processing costs.

FAILURE TO TAKE PROMPT ADVANTAGE OF REDUCED SALES PRICES

During our study we noted a number of instances where savings could apparently have been realized if prompt action had been taken to purchase installed data processing equipment at reduced sales prices offered by the manufacturers. In these instances, the possible savings are based on considering the action from the standpoint of advantage to the Government overall and not from the standpoint solely of the individual using agencies.

IBM model 704 systems

On September 19, 1960, the International Business Machines Corp. announced that it would sell certain components of IBM 704 systems at 30 percent of the original price. This significant reduction in purchase price was not accompanied by a corresponding reduction in the rental charges for the particular components. According to the Bureau of the Budget inventory as of June 30, 1960, the Government had on hand 30 IBM 704 systems of which 4 had been purchased and 26 were leased. Had prompt action been taken by using agencies to purchase such equipment, the possible savings to the Government would have been relatively significant. Following are some examples:

Federal Aviation Agency.—The Federal Aviation Agency in December 1959 leased an IBM 704 system for use at Oklahoma City, Okla., for use in the control of aircraft in flight and in the flight inspection of ground navigational aids. Under the discounted pricing policy, components of this system renting for $23,400 per month and originally priced at $1,116,800 became available for purchase for $335,000. The Agency decided not to buy this system, however.

Had these components been purchased in December 1960, the Government would have saved $87,500 through June 1962, and would be adding to these savings at the rate of $21,800 for each month of use after that date. These estimates of savings take into consideration the cost of maintaining purchased equipment under a manufacturer's maintenance service contract.

In this case, if the Federal Aviation Agency had purchased rather than continued to lease the components subject to the discount prices, it would have saved $349,000 through June 1963, the anticipated replacement date. At that time, the Government would own the equipment and could relocate it in a less critical area in place of other leased equipment and this procedure would create additional monthly savings to the extent that the rental of the replaced equipment would exceed the cost of maintaining the Government-owned equipment.

Atomic Energy Commission.—The Atomic Energy Commission leased an IBM 704 system for use in research and development work at the Argonne National Laboratory in Argonne, Ill. The equipment was installed in November 1957, at a monthly rental of $47,240. If the system had been purchased originally rather than leased, it would have cost approximately $2 million.

On March 1, 1961, 5 months after IBM offered to sell the system at the discounted purchase price, the Atomic Energy Commission purchased certain components of the system for $598,000 for which it had been paying monthly rentals of $41,290. Had this equipment been purchased in October 1960, when it was first offered for sale at the discounted price, the Government would have saved over $200,000 (5 months' rental charges at $41,290 less estimated maintenance costs).

In this case, the agency attributed the delay in purchasing to fund limitations but has stated that it will give special attention to future situations where delays may cause the incurrence of otherwise avoidable expenditures of Government funds.[3]

[3] This transaction is also described in our report to the Congress on "Review of Selected Automatic Data Processing Activities Under Atomic Energy Commission Cost-Type Contracts With University of Chicago and Midwestern Universities Research Association" (B-146763, Feb. 7, 1963).

IBM model 650 systems

On May 12, 1961, the IBM Corp. established an accelerated discount purchase plan on components of IBM model 650 systems. At that time, 136 of these systems were in use throughout the Government, 5 of which had been purshased and 131 were leased. Under the accelerated discount purchase plan, components were discounted 15 percent for each year used up to a maximum of 5 years or 75 percent. Consequently, components that had been in use for 5 years could be purchased for as little as 25 percent of the original selling price. Examples of possible savings follow.

Air Force Logistics Command.—At the time of the announced price change, the Air Force Logistics Command of the Department of the Air Force was leasing 36 IBM 650 systems. The rentals for these machines range from $4,200 to $23,000 per month. Purchase of some of this equipment under the accelerated discount plan could have resulted in significant savings. For example, eight of the nine components that made up three of this Command's small-scale systems could have been purchased at approximately the cost of 1 year's rental; purchasing would have produced savings of about $146,000 over the intended period of use.

Air materiel area, Hill Air Force Base, Ogden, Utah: At this location, two of the three components of a small-scale 650 system originally priced at $167,540 could have been purchased under the accelerated discount plan in July 1961 for 31 percent of the original price or $52,000. This amount was less than 1 year's rental for these components. If these components had been purchased at the time of the announcement and taking into account the cost of maintaining purchased equipment under a manufacturer's maintenance service contract, the Government could have realized savings through June 1962 of $600. Beginning in July 1962, recurring monthly savings of $4,300 would have accrued to the Government. We have been advised that this system is to be replaced in April 1963; however, savings to the Government of $53,600 could have been realized up to that date had these two components been purchased under the accelerated discount purchase plan. In addition, this equipment would be Government owned at that point in time and would be available for transfer to another Government electronic data processing facility for use in lieu of other identical equipment being rented.

Air materiel area, Oklahoma City, Okla.: At this location, all three components of the system could have been purchased under this plan in July 1961 for $68,000—less than 1 year's rental. This action would have produced savings of $1,500 through June 1962, plus recurring monthly savings, beginning July 1962, of $5,500. This system also is scheduled to be replaced in April 1963; however, the purchase of these components under the discount plan would have produced total savings to the Government of $56,500.

2709th Air Force Vehicle Group, Memphis, Tenn.: At this location, all three components of the system could have been purchased in July 1961 at 25 percent of the original price of $209,000, or $52,000. The purchase of this system would have produced savings of $2,100 through July 1962, and beginning in August 1962 recurring monthly savings of $4,000 would have accrued to the Government. The purchase of this system, scheduled to be replaced in June 1963, would have produced total savings of $46,100.

At these three Air Force installations, for each month after the replacement dates that the eight components could be productively used, additional savings to the Government of at least $10,750 would be obtained.

The Department of the Air Force has informed us of its awareness that "had the selected 650's in the Air Force Logistics Command been purchased at the time the discount was announced, a savings in equipment cost would have resulted." This agency also informed us that it was not notified by the manufacturer of the price reduction for the IBM mobel 650.

Post Office Department.—In the Post Office Department 13 small-scale IBM model 650 systems have been leased for use in a number of Post Office regional offices. These machines were installed over a period of 4 years beginning in September 1956.

Under the accelerated discount plan, two of the three components of the system operated in the Richmond office, originally priced at $161,000, could have been purchased in July 1961 at 26 percent of the original price or $42,000. If these two components had been purchased at that time, the Government would have realized savings of $500 through the end of August 1962. Then, beginning with September 1962 recurring savings of $3,000 would be realized

for each month that the Post Office Department used the equipment productively, either at the original location or at other locations to replace the 650-type equipment being rented.

At Minneapolis, all three components of a similar system, originally priced at $199,000, could have been purchased in July 1961 at 29 percent of the original price or $57,000. Had this system been purchased, the Government would have realized savings of $3,000 to October 1962 and in November 1962 would have started realizing recurring monthly savings of $3,700.

Other model 650 components in use in the Post Office Department could also have been purchased at greatly reduced prices. The percentage of the original sales prices at which these components could have been purchased as of July 1, 1962, is shown below:

[In percent]

Location	IBM 650 components		
	650	655	533
Philadelphia	31	31	31
Cincinnati	31	31	25
Atlanta	29	29	29
Boston	41	41	41

In November 1962, an IBM 1401 system was installed in the Richmond office to replace the existing IBM 650 system. Current post office plans call for the replacement of the remaining 12 IBM 650 systems with 10 IBM 1401 systems. It is anticipated that this conversion will be completed prior to December 1963. As in the case of the IBM 704 systems, saving could have been realized had some components of the 650 equipment been purchased when the accelerated discount plan was announced. For example, if the two components at the Richmond office had been purchased at the discounted price in July 1961, savings of $15,500 would have been realized through January 31, 1963; additional savings would be realized at the rate of $3,600 for each month that the components could be productively used at either Richmond or some other post office regional office.

If the system at Minneapolis had been purchased in July 1961, savings of $14,100 would have been realized through January 1963. Also, additional savings would be realizable at the rate of $3,700 for each month past that date during which there was productive use of the system at either Minneapolis or some other post office regional office. Upon replacement, these five components would contribute further savings at the rate of $6,700 for each month that they could be used productively elsewhere in the Government in lieu of rented equipment.

The Post Office Department has expressed disagreement with these observations on the basis that funds were not available to it for purchasing such equipment at the time the reduced prices were announced and that by the time funding authority could have been obtained purchase action would have resulted in losses rather than savings.

The Department's views are expressed primarily from the standpoint of its own management problem. We recognize that the availability of funds is an important problem. However, our observations concerning the acquisition of such equipment and the possible savings from such action are based on the advantage to the Government overall rather than the advantage to an individual agency.

POSSIBLE EFFECTS OF INCREASED GOVERNMENT PURCHASING

The cost comparisons made in our study as to the relative financial advantage of purchasing or of leasing data processing equipment are based on the pricing terms of existing contracts between the Government and the manufacturers or on pricing information obtained directly from the manufacturers.

The possibility that prices would be increased if the Government purchased more equipment is a factor that cannot be fully evaluated at this time. We believe that there is some protection against increased purchase prices under the terms of the consent decree filed and entered in 1956 by the United States

of America against the International Business Machines Corp. Paragraph (a) of section IV of this judgment, identified as Civil Action No. 72-344, states:

"(a) It is the purpose of this section IV of this final judgment to assure to users and prospective users of IBM tabulating and electronic data processing machines at any time being offered by IBM for lease and sale an opportunity to purchase and own such machines at prices and upon terms and conditions which shall not be substantially more advantageous to IBM than the lease charges, terms and conditions for such machines."

As IBM is the Government's largest supplier of EDP equipment, with 67 percent of the numerical volume, this provision should give some protection against unwarranted price increases.

Maintenance

The purchase of equipment carries with it the responsibility for maintaining it in efficient working order. Maintenance service may either be provided by employees of the Government or be obtained by contract with manufacturers. For our cost comparisons, we used the quoted maintenance price terms of the manufacturers under their maintenance contracts.

Throughout our study, we could find no indication that the quality of maintenance provided under the terms of manufacturers' maintenance service contracts was not as good as that provided under lease agreements. As in the case of prices, the possibility that the quality of maintenance provided for purchased equipment might suffer if the Government were to adopt a purchase policy cannot be fully evaluated at this time. Here again, however, we believe that the interests of the Government are reasonably well protected by the terms of the above-mentioned final judgment. Section VI provides as follows:

"IBM is hereby ordered and directed:

"(a) *to offer to render*, without separate charge, *to purchasers* from it of tabulating or electronic data processing machines *the same type of services*, other than maintenance and repair services, *which it renders without separate charge to lessees of the same types of machines;*

"(b) *to offer*, commencing 1 year after the entry of this final judgment and so long thereafter as IBM shall continue to render repair and maintenance service, *to maintain and repair at reasonable and nondiscriminatory prices and terms IBM tabulating and electronic data processing machines for the owners of such machines*; provided that, if any such machine shall be altered, or connected by mechanical or electrical means to another machine, in such a manner as to render its maintenance and repair impractical for IBM personnel having had the standard training and instruction provided by IBM to such maintenance and repair personnel, then IBM shall not be required by this final judgment to render maintenance and repair service for such IBM machine; and

"(c) *to offer to sell at reasonable and nondiscriminatory prices and terms, to owners of IBM tabulating or electronic data processing machines* (whether or not the purchaser receives IBM repair and maintenance service) and to persons engaged in the business of maintaining and repairing such machines and during the period when IBM has such parts and subassemblies available for use in its leased machines, *repair and replacement parts and subassemblies* for any tabulating machines or electronic data processing machines manufactured by IBM." (Italic supplied.)

It is of interest to note that, in addition to the maintenance services covered in paragraphs (b) and (c), the services, such as machine time to test programs, training, systems analysis, counseling, and software, which are extended without charge to lessees of equipment are guaranteed to purchasers of equipment under paragraph (a).

CONCLUSIONS

On the basis of our study, we conclude that the Government can save very substantial amounts of money through more extensive purchasing of data processing equipment. We have also reached the following general conclusions:

1. If possible and substantial savings are to be fully realized, management decisions as to whether data processing equipment should be purchased or leased should be made from the standpoint of advantage to the Government as a whole and not from the standpoint of the individual using agencies.

2. Because of the substantial savings that may be available, all decisions to acquire the use of data processing equipment should be supported by specific computations showing the comparative costs of acquiring by lease and by purchase.

3. Where purchasing is financially advantageous, the realizable savings increase in proportion with the increase in utilization of the machines.

4. The savings possible through purchasing are more pronounced for the larger and more complex machine systems.

5. While significant savings may be realizable in many instances through purchasing rather than leasing, for some types of electromechanical equipment, it is more advantageous financially to lease rather than to purchase.

NEED FOR MORE EFFECTIVE MANAGEMENT OF THE PROCUREMENT AND UTILIZATION OF DATA PROCESSING EQUIPMENT IN THE FEDERAL GOVERNMENT

In our report to the Congress on review of automatic data processing developments in the Federal Government (B–115369, Dec. 30, 1960), we stated that—

"Generally, the practice of each Government agency is to procure equipment for its own needs (on either a purchase or a rental basis) and to trade in purchased equipment or exchange older rented equipment for newer models in accordance with its own particular needs. Possible needs of other agencies for the traded-in or exchanged equipment are generally not considered. However, it is possible that such equipment can be used to serve the needs of other Government agencies.

"At least one major equipment supplier offers terms under which used equipment can be purchased at a reduced price depending on the period of time the equipment has been in use. However, we believe that a Government-wide approach is needed to determine which machines should be purchased at the reduced prices and retained for Government use in lieu of new procurement. Likewise, before trading in purchased equipment which is no longer suitable for the original using organization, efforts should be made to determine the possibility of transferring the purchased equipment to other Government organizations requiring such equipment in lieu of new procurement.

"We believe that a mechanism should be established in the Government to provide the necessary arrangements whereby the procurement and transfer of data processing equipment between Government activities would be fully coordinated so as to keep costs as low as possible consistent with obtaining needed processing facilities."

We are aware of no significant progress toward an effective coordinating mechanism in the Federal Government for achieving the interrelated objectives cited.

Our current study of the financial advantages of purchasing data processing equipment over leasing it further emphasizes the great need in the Federal Government for a better coordinated and integrated management system for achieving the fullest degree of economy and efficiency in acquiring and utilizing this kind of equipment.

Under the present system of decentralized management, each agency makes its own decision as to the method of acquiring this equipment. There is no effective coordinating machinery at work to give proper consideration to lease-purchase decisions from the standpoint of advantage to the Government as a whole. Unless adequate measures are taken to provide a stronger management system, millions of dollars of unnecessary expenditures will continue to be made. We are convinced that the establishment of a strong central management office in the executive branch of the Federal Government is essential to bring about the kind of management improvement that is needed to minimize such wasteful expenditures.

Recommendation to the President of the United States.—In view of the need for more effective and coordinated management of the procurement and utilization of data processing equipment in the Federal Government and the substantial financial savings that can be realized through improved management of this function, we recommend that the President of the United States establish in his organization a central management office suitably empowered with authority and responsibility to make decisions on the procurement and utilization of data processing equipment with the objective of obtaining and utilizing all needed facilities at least cost to the Government.

Recommendation to heads of using departments and agencies.—In view of the substantial savings that may be realized from more extensive purchasing, we recommend that the heads of all using departments and agencies, as an interim measure pending action on the above recommendation, arrange for a prompt and complete reappraisal of their current plans to lease data processing equipment and take such action as is possible to realize the financial savings that may be available from purchasing such equipment and fully utilizing it.

APPENDIX G

AMD research tasks by title and brief description broken down into 4 broad areas:

I. Life support.
II. Aerospace medicine.
III. Radiobiology.
IV. Human performance.

I. LIFE SUPPORT

Task 630101, physical protection of man against ionizing radiation.—To investigate and establish new methods of protection and design criteria for personal protective equipment which will attenuate the multiple hazards of proton, electron, and neutron energies; the energies of other particulates and of gamma and X-ray energies all of which are associated with the Van Allen Belts, nuclear power sources, the "Bremsstrahlung" generated within the vehicle itself, and minor solar flares. Attenuation of the hazards associated with the energies of relativistic solar flares, and primary cosmic radiation fields, will be attempted insofar as it is feasible to do so.

Task 630102, personnel protection in aerospace systems.—To establish design criteria for personnel protection against aerospace systems environmental hazards of abrupt and short period acceleration, toxic atmospheres, and extreme thermal conditions.

Task 630193, vision enhancement and protection in aerospace environments.—The objective of this task is to establish design criteria and demonstrate the technical feasibility of methods, devices, and/or systems for the protection and/or enhancement of the human visual system in all conditions which may be encountered in aerospace systems and extraterrestrial environments. The objective will result in proven design criteria for protection device development and furnish measures for augmenting the visual functions of aerospace systems personnel.

Task 637302, respiratory support equipment.—Studies will be made to determine the technical feasibility of various processes, methods, and equipment necessary to sustain man in closed-space environments. Combinations of physicochemical methods of atmosphere control are planned and various supplies of oxygen will be investigated. The intent is to provide the most efficient breathing atmosphere for each anticipated mission profile. This will consist of recirculating atmospheres for short-duration missions and the reduction of carbon dioxide and the electrolysis of water for longer missions. Investigation of the possible buildup of byproducts and tract materials from the various life support components will be carried out and techniques for control of these materials will be considered.

Task 637303, nutritional support equipment.—Manned aerospace missions of more than a few day's duration will require provisions for the storage, refrigeration, processing, heating, and containing and dispensing of foodstuffs if optimal acceptability of the feeding program is to be realized. Data and technical information resulting from this task will be applicable to the design of food storage and preparation equipment, a water system, and methods for containing items of food that will be capable of operating in various pressure, temperature, humidity, and vibration levels, and in a weightless environment, and which require minimum space, weight, and power. Investigation involving the application of solar radiation, electric ovens that will accept canned foodstuffs, types of blanket heaters for cans and tubes, and other unique methods, have shown promise as techniques for food preparation. A combination freezer and chiller that requires no power and uses superinsulation and the food as the heat sink has developed high hopes of a real advance in the state-of-the-art in refrigeration of foodstuffs during aerospace missions.

Task 637305, life support accommodations, integration, and analysis.—The objective of this task is to establish and continuously refine design criteria, to

design, and to demonstrate the technical feasibility of sealed environmental life support systems of various types for aerospace missions of different durations and crew sizes, and to combine all systems and equipment into one complex. Efforts of this task will include the acquisition of new knowledge and techniques related to the requirements and to the development of aerospace vehicle cabin furnishings and personal accommodations, the evaluation of life-support systems and system components, and the study and analysis of proposed aerospace weapons systems for the formulation of life-support system requirements.

Task 6770, biosciences studies in advanced space vehicles, bioastronautics.—The overall objective is the development of a system capable of supporting biological subjects in space of the size and weight characteristics which render them practical for securing meaningful results. Although not planned for operational systems, development stages will require means to measure the psychophysiological response of the biological component to the space environments and must provide methods of collecting the resulting meaningful information for evaluation. The end product must provide, during all mission phases, complete biological support compatible with the psychophysiological requirements of man.

Task 689201, biological specimen support (Biospecimen support).—Zoological speciments in adequate numbers and types are provided for premission tests and actual missions. Original baseline biological data on all colony specimens are obtained for premission selection of proper test subjects and to improve postmission evaluation. New handling and restraint techniques, improved husbandry, and clinical treatment methods are under constant development and investigation.

Task 689202, altered environments for biological specimens.—These studies will determine what tolerance levels are safe for contin ous exposure of the animal subject. In addition, an attempt will be made to extend the tolerance limits by protective methods. Furthermore, the feasibility of telemetering specific physiological parameters, based upon the selection of those parameters which are the most indicative of each stress as well as multiple stress, will be determined.

Task 689203, postmission analyses of biological specimens.—The objective of this task is the detection of postmission changes in biological subjects which are attributable to simulated or actual space flights. Postmission diagnosis and treatment will depend on these findings.

Task 689204, biomedical capsule evaluation.—The objective of this task is to test inhabited space vehicle life-support systems by subjecting them to the gravity forces, vibration spectra, acoustic noise, pressures and temperatures, as functions of time, that they will encounter during actual operations. Data obtained during tests are analyzed to determine if a physiological habitable environment can be maintained by the systems. Failures or inadequacies of the systems are identified by analyses of test data. Preparation (countdown) procedures for the systems are devised or modified if necessary during these tests.

Task 689205, biophysical measurements.—Measurement techniques and instruments are developed to detect, record and analyze the various parameters relating to the biological subject and its environment. An inventory of specialized electronic devices and off-the-shelf instruments for biosciences R. & D. is maintained. This effort and these items are for the use and support of the other tasks of this and other projects of the Laboratory.

Task 716401, advisory capability for bioastronautics research.—The objective of this task is to provide, on a quick reaction basis, a consultant advisory capability in the bioastronautics research area.

Task 716402, neurophysiological measures of performance.—Plans for manned space vehicles call for extensive animal experiments. One of the ways to monitor an animal's reaction to his environment is by electrophysiological measures of nervous function. These measures may, in the case of animals, be from implanted electrodes or they may lead from the scalp and other surfaces of the body. The techniques for using such measures is advancing rapidly, and it appears to be certain that they can be combined with modern telemetry developments and computer techniques to make great advances in our ability to monitor either human or animal performance at great distances and to make accurate interpretations of the degree of physiological deviations from the normal.

Task 716403, environmental biology.—The specific objective of this task was to provide physiological and biochemical knowledge, data, criteria and parameters to establish scientific principles concerning all living organisms or their processes for the biological maintenance as food systems of single and multiman

crews in orbiting space vehicles, permanent space stations, and extraterrestrial colonies.

Task 716405, nutrition and sustenance.—The objectives of this task are to provide the data and criteria related to the biochemical, metabolic, and physiological requirements of man for nutrients under conditions of long- and short-time aerospace flights and extraterrestrial habitation. Also, biomedical criteria and data will be established and provided for the development of techniques and equipment for water recovery, personal hygiene, waste management, and sanitation, and will include water potability criteria for application to water recovery systems.

Task 7164, systemization of biological knowledge.—To present authentic numerical data of medicine and biology in convenient and accessible form for ready reference. It will standardize accepted constants as a basis for correlation, establish common standards for statistical studies, and provide normal values and tolerances for research, diagnostic, and therapeutic purposes. A second objective of this task is to provide high-level scientific expert advice in the field of biophysics, physiology, psychology, and other selected areas which are relevant to the Aeorspace Medical Research Laboratories' studies of the human factors in high altitude flights.

Task 622201, psychophysiology of flight.—To investigate the stresses and effects of unusual environments encountered in aerospace flight on human functional capabilities; devise means for assessing and predicting individual capabilities for adaptation to or tolerance of multiple stresses. The full potential of the program is to provide techniques and methodology for assessing stress resistance.

Task 722202, acceleration in flight and escape.—To delineate man's physiologic reactions to and tolerance of all types of simple and complex accelerative forces, with the exception of landing impact and windblast (these aspects to be correlated with projects 7231 and 6301), that may result from both normal aerospace flight sequences and emergency escape. This includes the responsibility for establishing the design and development criterial for protecting man from such forces.

Task 722203, bioinstrumentation.—The following separate objectives are necessary to meet the requirements referenced above: (1) Determine and stabilize Air Force interests in bioinstrumentation; (2) advance the state of the art in support of these Air Force interests; and (3) produce prototype instrumentation for special application to experimental aircraft, balloon, and space flights and experimental research leading to the flight mission.

Task No. 722204, human thermal stress.—To determine the physiological changes that occur in man when exposed to the varying thermal environments anticipated during advanced aerospace explorations, establish human limits of tolerance and performance and devise means of protecting against thermal stresses.

Task 723101, effects of vibration and impact.—To study the physical, physiological, and psychological properties and responses of the human body to mechanical vibrations, buffetings, and impacts as are predicted in space vehicle environments during normal and emergency operation; to provide data necessary for formulating criteria and tolerance limits to these stresses; to develop principles, methods, procedures and devices for providing protection and maintaining performance capability.

Task 723102, response of the nervous system to external dynamic forces.—Air Force future objectives place man in new dynamic environments. The purpose of this task is to define the effects of these environments on the nervous system.

Task 723103, biological acoustics in aerospace environments.—Major objective is to assure no impairment of performance, health and safety among aerospace ground and flight crews resulting from acoustical stress and to provide adequate communications capability despite acoustical and other environmental conditions peculiar to the missions. Secondary objective is to determine community responses to aerospace vehicle noise sources and develop tolerance criteria.

Task 723104, biodynamic environment of aerospace flight operations.—To define and quantitate the biodynamic environment of aerospace vehicles during static firing, launch, inflight operations, reentry, and recovery phases; to investigate and evaluate methods, procedures, and devices used to simulate,

modify and/or control the biodynamic environment generated by aerospace vehicles and their auxiliary equipment.

Task 723105, theory of interaction of men and mechanical energy.—To develop mathematical methods, models, and procedures for predicting new biodynamic aerospace flight environments and the responses of biological systems to biodynamic environmental factors.

Task 723301, biological mechanisms for signal analysis.—The task is to analyze and study the principles and methods by which living organisms are so successful in the recognition and the processing of signals received through the receptors.

Task 723302, biological servomechanisms.—This task is to study the techniques employed by living servomechanisms and to compare them with those currently employed in manufactured servomechanisms. The study of the living systems will stimulate the development of new theoretical and mathematical methods for the treatment of servomechanical problems. These techniques will then provide the design engineer with new concepts and methods for the solution of his design problems.

Task 723303, biological components.—This task is to extract from the study and the analysis of biological components those principles, techniques, and theories which are suitable to the design of technical components for engineering applications.

Task 723304, neural networks.—The objective of this task is to provide knowledge necessary for the design of information-processing networks. The solution of this task has three phases: analysis, theory, and synthesis. Analysis includes direct observation of the biological structures and functions to provide data to be ordered and integrated by theory and tested by synthesis.

Task 723305, theory of information handling.—The purpose of this task is to develop and formulate theories of the higher functions of the nervous system, covering such features as perception, learning, associative memory, thinking, and recognition of categories or patterns in a sufficiently clear manner to permit testing and model construction. It is the ultimate goal of these theories to aid in the development of highly advanced information-processing devices.

Task 775801, fundamental mechanisms and tolerance limits in aerospace physiology.—The objective of this task is to determine tolerance limits in order to define optimal environmental conditions for aerospace crews. Associated with this is an objective to develop methods whereby the range of acceptable environmental conditions can be extended, either by preventing adverse physiological conditions from prevailing, or by counteracting them through artificial devices, both mechanical and chemical.

Task 775802, development of statistical methods, mathematical models, and computing procedures for analysis of aerospace physiological data.—The objective of this task is to develop more optimal statistical procedures for statistically analyzing dynamic physiological data, when usual assumption of normality and independence are not valid, to develop more realistic mathematical models to describe biological processes, and to develop faster and more objective ways of handling continuous curves (analog data).

Task 793001, biological regenerative systems for space applications.—The purpose of this task is the selection and evaluation of compatible biological species which can be integrated into a reliable steady-state ecology in extraterrestrial environments. Involved will be the selection, evaluation, and stabilization of biological species and subsystems and development of equipment and instrumentation to maintain the ecological environment within predetermined limits of steady-state regenerative performance.

Task 793002, investigation of parameters essential for manned space flight operations.—The objectives of this task are to define the optimum space vehicle atmosphere consistent with mission duration and profile; to investigate the physiological and psychological effects of simulated space flight experiments on man; to determine man's metabolic requirements and investigate techniques for fulfilling these requirements; to develop techniques of atmospheric monitoring and to investigate the physiological effects of chronic exposure to various gaseous environments at reduced pressures.

Task 793003, biodynamics/biomedical aspects of manned space flight operation.—The specific objective of this task is to investigate the physiological responses of both animals and man when unusual environments are imposed on them in a controlled or uncontrolled manner. In order to accomplish this objective, unknown or untried bioinstrumentation must be developed and evaluated in both the laboratory and in the near-space environment.

II. AEROSPACE MEDICINE

Task 630201, toxicology.—The specific objective of this task is to screen new materials used by Air Force personnel engaged in the development, test, and operational phases of new aircraft missile and orbital weapon systems for toxic properties. Tolerance criteria must be established for these materials to adequately protect the health of Air Force personnel.

Task 630202, pharmacology-biochemistry.—The specific objective of this task is to investigate absorption, metabolism, excretion, and site and mechanism of action of the toxic chemicals that are approaching large-scale system application and present exposure hazards. Once this knowledge has been gained, suitable methods of diagnosis and adequate therapeutic techniques will be developed.

Task 630203, identification of toxic materials.—The specific objective of this task is to develop and evaluate analytical techniques and instrumentation principles for the detection and measurement of new toxic materials for the evaluation of their toxic hazards. This will expedite all phases of R. & D. efforts by reducing the fear of unknown toxic materials, and the use of unnecessarily cumbersome overprotection, in addition to providing criteria for protecting Air Force personnel from undue exposure to toxic materials.

Task 630204, environmental pollution.—The specific objective of this task is to determine the exact environmental pollution profile of propellants approaching large-scale use, and to establish safe distances as they apply to the toxic properties and quantities used. Further, specific emphasis is placed upon the pollution effects of toxic combustion products, which in some instances are as hazardous as the propellants.

Task 630205, toxic hazards evaluation.—The specific objective of this task is to make certain that no pertinent medical information is lost during any contractual R. & D. Air Force effort. Further, it is necessary to stimulate industry to develop and sustain an occupational medicine program commensurate with the state of the art in toxicology. The ultimate objective is to bring into focus all pertinent health hazard experience as it applies to a particular system.

Task 630206, toxicological support.—The primary objective of this task is to provide medical consultation as well as facilities in histology, histochemistry, hematology, clinical chemistry, and other usual diagnostic laboratory areas as they apply to toxicological research.

Task 775001, physiological responses to protective equipment.—This task will analyze the effectivenes of personal protective equipment under simulated aerospace conditions, using as an endpoint the physiological response of human subjects.

The protection conferred by items of personal equipment as well as stresses inherent in the equipment itself require definition.

Task 775101, visual problems in Air Force operations.—The objective of this task is to conduct research programs that will enable the analysis and evaluation of biological phenomena which influence visual perception in aerospace operations. This will include electromyographic evaluation of neuromuscular ocular mechanisms, development of methods for properly integrating headgear eyewear in problem situations, evaluation of ophthalmic filters under laboratory and field conditions, evaluation of oxygen toxicity on ocular structures, evaluation of visual perception following dazzling flashes of light, development of a repository to study ocular problems of aging, including vascular changes, refractive changes, and changes in aqueous physiology.

Task 775102, mechanisms of operational stress.—The objectives of this task are to apply the physiological monitoring techniques which have been developed to measure in-flights stress in normal individuals to those aerospace crewmen who have been diagnosed as having or suspected of having a condition which is considered incompatible with flying safety. It is expected to identify those aberrations in physiological response which characterize their disease or illness. Ultimately, comparison of the responses of the normal and abnormal populations may lead to improved selection and maintenance procedures.

Task 775103, adverse effects of variations in oxygen partial pressure.—The objective of this task is to clearly define the hazardous effects, if any, of human exposure to atmospheres containing varying percentages of oxygen, under those partial pressures deemed feasible for utilization in space vehicles. Chronic studies are indicated, to elucidate the long-term effects with the task goal to establish the ideal space cabin atmosphere in terms of prevention of hypoxia and any adverse effects induced by breathing oxygen under conditions different from those at sea level.

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Task 775104, identification, measurement, and control of aerospace crew fatigue.—The objective of this task is to obtain information on the basic performance characteristics of man as an operator of complex systems, to identify task and environmental variables which interact significantly with these performance modes, to develop procedures for assessing man's functional states in these complex systems environments, and to develop procedures to mitigate or otherwise control potential performance and functional degradation.

Task 775105, the pathophysiology, prevention, and treatment of neurocirculatory dysbarism.—The objective of this task is to investigate the pathophysiologic aspects of neurocirculatory shock as seen in decompression sickness so that a rational mode of prevention and therapy can be outlined.

Task 775201, disturbances of consciousness.—The objective of this task is to obtain a better understanding of syncope and other disturbances of consciousness as they occur in a healthy population. Primary aims will be to learn means by which these disturbances can be prevented and to improve the ability to predict their occurrence. Decrements of performance brought about by impaired consciousness, in contrast to complete loss of consciousness, will also be studied.

Task 775202, drug effects in aerospace personnel.—The purpose of this task is to investigate the effects of various drugs upon the physiological and psychological capabilities required in the operation of Air Force systems.

Task 775203, pathophysiology of spatial disorientation.—The primary objective of this research is the understanding and control of spatial disorientation. This research will contribute to the efficacy of present and proposed weapons systems and to the safety of conventional and space flight, and to the diagnosis of complaints of labyrinthine origin.

Task 775204, human reliability in personnel having access to nuclear weapons, weapons systems, or nuclear devices.—The purpose of this task is to utilize every medical, psychiatric, statistical, and investigative method possible to characterize the individual who may, in any manner, effect unwarranted use of a nuclear weapon or nuclear device.

Task 775301, prevention of noninfectious and degenerative disease.—The objectives of this task are to explore fundamental biochemical processes involved in noninfectious and degenerative diseases, to determine the standard values for these processes and the significance of individual variation, to determine the reliability of changes in these physiological systems as indcators of development of specific noninfectious or degenerative diseases, and to assist in evaluation of proposed measures for preventing these diseases.

Task 775302, control of infectious diseases.—The objective of this task is to ascertain the effects of the aerospace environment on man's response to microbial infection. This will be accomplished by studying the effect of selected environment factors, both alone and in combination, on all aspects of the host-parasite relationship.

Task 775303, control of chemically induced biomedical disorders.—This task is concerned with those chemically induced biomedical disturbances which are unique to the Air Force operational environment but do not fall within the classical definition of "disease." Information and principles derive from this task are essential for the development of practical occupational and preventive medicine principles.

It is directed toward investigation of the fundamental biochemical, biophysical, cytological, and biodynamical mechanisms and changes induced by these chemical environmental factors.

Task 775501, evaluation of cardiovascular status.—The objective of this task is to search for, investigate and validate new techniques and refinements of established techniques of cardiovascular evalution. Emphasis will be directed to methods of functional evaluation under dynamic situations which are adaptable to and useful in the selection of candidates best qualified physically for advanced aerospace missions. Validation of methods for their diagnostic or prognostic utility will necessarily involve longitudinal studies.

Task 775502, maintenance of physical fitness of Air Force personnel.—The objective of this task is to evaluate current physical conditioning programs in respect to Air Force requirements and investigate new approaches to the maintenance of physical fitness. One aspect of the effort is to investigate obesity and its relationship to physical fitness.

Task 775503, auditory function of Air Force personnel.—The objectives are to develop improved procedures for determining existing and potential hearing pathology and to assess the effects of noise exposure. Those procedures will be applied to identify individuals evidencing adverse effects. Research will aim at

establishing improved criteria and standards that will assure maximum safety and performance in the aerospace environment.

Task 775504, neuropsychiatric assessment techniques.—The objective of this task is to develop and evaluate methods, techniques and devices which will enable interested personnel such as flight surgeons, psychiatrists, psychologists, and neurologists to identify those individuals who should not participate in aerospace crew duties, to identify such duties. It is further desired to be able to assess any changes in such capabilities that may occur with the passage of time. The primary problem is to be able to identify individuals who, throughout their career, will have minimum impairment in functioning from mental factors whether such factors are organic, intrapsychic or environmental.

Task 775601, improved medical surgical techniques and procedures.—The objective of this task is to establish methods for the diagnosis of incipient disease and to determine the most effective therapeutic regimens to prevent or mitigate the effects of a variety of medical and surgical conditions.

The development of new techniques in the early diagnosis and more effective therapy of a variety of medical and surgical diseases will continue to be essential to meet the goals of applied research and for the continued medical care of aerospace crew members.

Task 775602, dental problem studies of the USAF.—The objective of this task is to conduct research programs, the product of which must provide the USAF Dental Service with the best possible means for a desirable operational posture and to support the medical programs of space flight.

Task 775910, casualty evacuation in aerospace flight.—The object of this task is to anticipate and evaluate new problems in patient evacuation with association with engineering advances in aircraft resulting in higher performance and greater physiologicstresses. Extension of the currently accepted air evacuation techniques and reorientation of our ideas will be necessary in the planned evacuation of ill or injured space crewmen. In this area evacuation capabilities, operational requirements and the design of specialized medical equipment consistent with the space-imposed weight limitation will be a continuing, combined, medical-engineering effort for this task.

Task 775902, emergency care of the incapacitated aerospace crewman.—It is assumed that the crews of early space exploration and vehicles will not include medical professional personnel. Therefore, the objective of this task is to provide means, equipment and methods for self-aid.

Task 7996, medical equipment development laboratory.—This project will continue to support the research and development of medical equipment required by the Army, Navy, and Air Force. The program will include research of new approaches and techniques leading to the standardization and adoption of medical, dental and veterinarian equipment and supplies required by the three services. Items proposed for development will be coordinated with the three military Departments by the Armed Forces Medical Materiel Coordination Committee.

Task 823701, physiological effects and psychological effects of acute exposure to the arctic environment.—The objectives of the research accomplished under this task are to describe the general as well as the specific physiological and psychological alterations that accompany acute exposure to an arctic environment, to define those areas of bodily and mental function where impairment or failure is likely to occur, and to point up the nature of the protective or other measures that must be taken to assure that maximum performance of the individual is achieved.

Task 823702, physiological and psychological effects of chronic exposure in an arctic environment.—It is the objective of this task to delineate those arctic environmental factors that produce semipermanent changes in the physiology and mental state of the individual; to describe in detail the nature of these changes and to develop procedures and techniques to minimize the deleterious effects of the environment and to promote those physiological alterations and psychological adjustments that would be beneficial.

Task 823703, physical, chemical, and physiological effects of tissue cooling.—The research effort of this task falls in three general subject areas: the physiological effects of local or general body cooling; the chemical and physical alterations that accompany such cooling and the relationship of these alterations to tissue dysfunction at low temperatures; and the comparative physiology and physicochemistry of certain species (i.e., hibernators) that are able to maintain effective tissue function at extremely low, but above freezing, temperatures.

Task 823704, evaluation of research in arctic biology and medicine.—The purpose of this task to compile information on the current status of knowledge in selected areas of arctic biology and medicine, pointing up those areas where existing knowledge may be applied to the improvement of the Air Force capability in the Arctic as well as those areas requiring future research efforts.

Task 823801, development and evaluation of clothing for use in the Arctic.—The objectives of this task are the development of clothing which will permit the wearer to perform the normal duties of his Air Force job in an effective manner for an indefinite period of time in an arctic environment, and the development of clothing which will permit the physically active but otherwise unprotected wearer to work indefinitely out of doors under the most extreme weather conditions.

Task 823802, development and evaluation of personal and survival equipment and procedures for use in the arctic.—The objectives of this task are: the development of personal protective equipment and procedures which will permit the properly clothed but otherwise unprotected individual to survive and to continue to perform necessary duties effectively while exposed to the natural arctic environment following destruction of his living quarters, duty station, or vehicle; and the development or improvement of items of personal equipment which will enhance the quality of job performance in the normal Air Force arctic environment.

Task 823803, nutritional interactions during subsistance in the arctic environment.—The objective of this task is to define the effects of nutritional stress, both quantitative and qualitative, upon the performance and physiological status of men in the Arctic, and to determine what, if any, dietary manipulations can be recommended for increased efficiency of aircrews and support personnel during arctic operations.

Task 824101, relationship of the arctic environment to the infectious disease state.—The objective of this task is to determine the relationship of the arctic environment to the etiology, epidemiology, pathogenesis, prevention and treatment of infectious disease. To accomplish this, all of the many facets of the host-parasite relationship must be identified and evaluated.

Task 824102, relationship of the arctic environment to the noninfectious disease state.—Studies in this area are directed toward the investigation of the relationship of the arctic environment either alone or in combination with other factors to the etiology, pathogenesis, prevention, and treatment of noninfectious disease states such as frostbite, trenchfoot, snow blindness, hypersensitivities (allergies, asthma, etc.), shock due to trauma, drug action, and others.

Task 824103, toxic chemical and radioactive substances in the arctic environment.—The objectives of this task are to survey existing problems and to evaluate and/or develop methods of handling, controlling, and protecting personnel against toxic chemical agents and radiation in the arctic environment.

Task 824104, arctic sanitation.—The objective of this task will be identify, define, evaluate, and solve those problems which, when grouped together, are categorized in the general study area of arctic sanitary problems. Examples of the problem to be considered can be grouped as water and food sanitation, waste disposal, and internal and external esthetic sanitation.

III. RADIOBIOLOGY

Task 554501, studies of biological effects of electronic radiating equipment (radar).—The investigation of modifying influences of microwave energy on mammalian responses to ionizing radiation; the identification of mechanisms contributing to such effects and the specification of optimal microwave fields for exploiting enhancement of recovery possibilities.

To determine the effect of frequency, power density, waveform characteristics and relevant environmental conditions on biological responses to microwave radiation.

To meet these objectives, it is necessary to investigate the nature and mechanisms of the biological effects by means of controlled exposures of animals to the various fields produced by electronic generators.

Task 554502, studies of microwave induced lenticular opacities.—To make quantitative determinations of the cataractogenic effects of microwave energy. This study includes the investigation of isolated and combined influences of such microwave parameters as power density, frequency and waveform characteristics including cw if indicated. Special emphasis will be placed on the

determination of lenticular damage potentials of power densities in the range of 10 mw/cm² to 100 mw/cm².

Task 5877, Investigations of ionizing space radiations.—The following measurements must be accurately accomplished in natural and artificial radiation belts and in solar flare radiation environments:

Spectral measurement of ambient environment outside and within the space capsule or space capsule simulant.

Surface dose and depth dose distribution through the use of manikins or other configurations of simulated tissue. These measurements should be accomplished both within the space capsule simulant and without capsular shielding.

Linear energy transfer spectral measurements in simulated tissue. These measurements will be made at depths corresponding to the depth dose determination. It is hoped that present studies will result in development of a single sensor which will provide both measurements (LET spectra and depth dose).

Specific vehicles are now designated for (*a*) the outer Van Allen belt; (*b*) a long duration subsatellite package with a polar highly eccentric orbit with apogee approximately 2,500 nautical miles; (*c*) a passive solar flare satellite in a 300-nautical-mile circular polar orbit; and (d) two highly eccentric orbital satellites, one polar and one equatorial.

Task 7757, definition of potentially hazardous sources of radiation in Air Force operations.—Research is being, and will continue to be, conducted in the interactions of radiation with matter and the physical parameters of radiation sources which may modify the type, flux or energy spectra of the emanating radiation. Instruments and methods are being devised to measure more accurately and quickly these physical parameters of radiation, to record and transmit the data and, finally, to analyze the results in a manner amenable to extrapolation to biomedical parameters of interest. To accomplish this, many radiation sources are used in this laboratory utilizing various dose schedules. In addition, cooperative research is done with many university laboratories and with the national laboratories of the AEC, where unique radiation sources (cyclotrons and linear accelerations) may be available. Contractual research supplements the in-hous capabilities of this laboratory.

The study of radiation-induced radicals in chemical and biological systems.

A compressive map of space radiations.

Research on triplet states and photochronism.

Investigations of physical response of various types of detectors.

Development of an apparatus for localized bombardment of specific areas of living biological cells with high-energy protons.

Development of special lithium drift detectors for medical applications.

Dosimetry for laboratory irradiations of primates.

Procedures for whole-body exposure of primates to proton beams.

Whole-body counting of radioactivity in primates exposed to protons.

Neutron detection and dosimetry.

Task No. 775702, biological effects of radiation exposure.—Suitable research programs will include evaluation of damage by various types of ionizing radiations to biochemical systems, subcellular structures, cells, tissues and organs in human and suitable laboratory animals. Changes and damage by ionizing radiations at many levels will be tested and reevaluated for correlation with available human data in order that recommendations for human application can be made. This laboratory is in a unique position in that it has several groups of primates that have been irradiated chronically and some acutely as long ago as 10 years. This provides an unusual opportunity to study late effects of radiation in a suitable laboratory animal and logically will be applied to the study of late developments in the human.

Biological and medical aspects of ionizing radiation.

Radiation breakage of human chromosomes in vivo and in vitro.

The effect of radiation on the DNA binding capacity of hemoglobin.

Effects of radiation on neurons and glial cells by tissue culture methods.

To study in man the effect of 250–300 r total body irradiation.

Chronic exposure to gamma irradiation and its effects on serum isoenzymes systems.

In vitro studies on the human cell's physiology under proton bombardment.

The effect of radiation on cytoplasmic regeneration in acetabularis.

Studies on the effect of radiation on the submicroscopic structure of the sympathetic neurone.

Normative values and observations on the laboratory primate.

Metabolic pathways and the fate of isotopes in man.

Biochemical assays of irradiated eye lens hemogenates.

Effects of radiation on trace metals in the serum of irradiated animals.

The effects of radiation and radioactive compounds on erythropoiesis.

Effect of radiation on various transport systems of the intestine.

Microbiological radiation dosimetry.

Cytokinetic responses to ionizing radiation.

Task 775703, modification of radiation effects.—The study of potential chemical protective agents involves utilization of those methods common to the disciplines of chemistry, pharmacology, and biology. The general approach is as follows: A screening program designed to rapidly evaluate agents which may afford protection based on known chemical structure and/or pharmacologic actions is established. Us. rodents first, agents are screened by employing various drug dosages and radiation patterns. The toxic side effects of the administered agents are simultaneously evaluated. The effects of irradiation on these agents also aids in the isolation of more active fractions and to remove those with undesirable side effects. By this means mechanisms of action may be studied.

Chemical protection against chronic, sublethal, and fractionated doses of radiation.

Studies of the effect of radiation on the gastrointestinal tract and modification by protective agents and postirradiation therapy.

Studies of the effect of radiation on hematopoiesis and modification by chemical protection and postirradiation therapy.

Modification of biological effects by postirradiation therapy.

Long-term latent or chronic effects of ionizing radiation.

Effects of ionizing radiation upon physiological and psychological functions of various species.

The mechanism of action of the thiouronium class of radiation protective agents.

Radiation immunology in the pygmy marmoset.

Antibody formation by the hymphocytes and its role in the homograft reaction.

Task 7757, significance of radiation hazards in aerospace operations.—For almost 11 years the USAF School of Aerospace Medicine has been engaged in research which has characterized the acute radiation syndrome in the Macaca mulatta primate. The use of a full range of ionizing radiations such as bomb spectrum radiation (both low and high neutron to gamma ratios), Co^{60} gamma, high energy X-rays, Po-Be neutrons, fast and slow neutrons, and mixed reactor radiation has facilitated the establishment of RBE's for many endpoints. In addition, some aspects of the acute radiation syndrome in the primate have been compared with that in man under similar conditions. Much of these data have been utilized in estimating hazards to crew members of nuclear-propelled aircraft and in establishing training and combat mission schedules for such aircraft. It is a logical extension to expose animals to whole-body irradiation of very high energy protons in an effort to establish RBE's for such protons. It is felt that the data accrued from such a study would enable one to more accurately predict the dose-effect relationships resulting from exposure to the very high energy protons of space, especially those trapped in the Van Allen radiation belts and those associated with solar flares. Serious consideration must also be given to the biological hazards of existing electron belts.

Ocular effects resulting from exposure to high energy protons.

Biological effects of whole body exposure to high energy protons in primates.

Biological effects of chronic whole-body neutron exposure in the primate.

Task 780102, radiobiological aspects of reactor hazards —Hazards analysis followed by operational safety studies must precede USAF employment of any nuclear power system. The hazard may exist in the form of direct radiation from the system or distribution of radioactivity through accidental destruction of the system, e.g., reactor effluent and/or reentry burnup products. In any event and for each specific system, the hazard must be defined and the radiobiological consequences of personnel exposure determined. The research performed under this task is designed to provide this information with data to be obtained through field release tests which simulate accidental situations, the use of sampling and

measuring grids during AF) testing of reactors and the exposure of biological specimens to the operational environment of operating systems. This research is supplemented by exposure of large animals to radiation environments produced in the laboratory. The effort is primarily in-house; however, portions of it which are beyond the capability of the AFWL to perform are contracted for.

Task 780104, health and safety.—The ever-increasing use of isotopes for civilian and military purposes increases the chances of accidental ingestion and/or inhalation of radioactivities. While the amounts may be relatively low, medicolegal implications are such that the isotope must be identified, if possible, and an estimate of body burden determined. This will be accomplished by use of the whole body counter and gamma ray spectrometer. In evaluating certain ingestion or inhalation hazards by use of experimental animals, whole body counting is required to relate effect to dose. The whole body counting facility of this laboratory supports Lovelace Foundation, Sandia Corp., AFWL, and other DOD and NASA agencies. In vivo dosimetry will increase in importance as techniques are refined. Animals will be instrumented with appropriate detectors for all exposures done by this laboratory. Depth dose measurements are very significant if the damage produced by various forms of radiation is to be properly evaluated and protective measures are to be established.

IV. HUMAN PERFORMANCE

Task 171001, design of behavioral measurement instrumentation for aerospace vehicles.—The specific objective of this task is to accomplish all developmental efforts necessary to provide a battery of psychological bioinstrumentation devices capable of measuring and evaluating human operator performance and psychological response during aerospace missions. The end result of this task will be a prototype model and a complete set of engineering specifications for the design of a standard battery of psychological measurement devices of demonstrated feasibility and high reliability.

Task 171002, performance effects of environmental stress.—The types and extents of individual and crew performance effects of environmental stresses (such as temperature extremes, unsual g-forces and vibration) and prolonged confinement will be determined. Possible procedures for counteracting performance decrements will be developed and specified. The end results will be design and procedural recommendations with respect to aerospace vehicles.

Task 171003, human factors in the design of systems for operator training and evaluation.—The objective of this task is the development of an improved technology for the design of operator training systems with special attention to critical problems in training for manned space operations, the design and utilization of training equipment, and the automation of training. Application of the principles formulated under this task by weapon system contractors, human factors engineers in AFSC, and training groups and planners throughout the Air Force will facilitate the development of training equipment and facilities which are optimally efficient, valid, and economical.

Task 171004, techniques for training, aiding, and evaluating the performance of technical tasks.—The objects of this task is to generate, interpret, and organize human factors information pertinent to the development of devices and techniques for developing, sustaining, and evaluating proficiency of personnel in the performance of technical tasks. Such devices and techniques will be applicable to both present and future Air Force problems of providing skilled technical personnel.

Task 171006, personnel, training, and manning factors in the conception and design of aerospace systems.—The objective of this task is to develop the technical basis for efficient and timely consideration and effective handling of personnel, training, and manning factors in the conception, design, and development of aerospace systems. Systems must be designed with greater systematic consideration of these factors or it will be increasingly difficult or impossible for the Air Force to develop the human resources posture required to support the future technological force structure. The end result of efforts under this task will be techniques and data for use in the integration and/or trade-off of human factors related to personnel, training, and manpower with engineering and operational factors during the conceptual, design and development phases of weapon systems.

Task 171007, automated training and programed instruction.—The objective of this task is to develop principles for the design of highly effective and eco-

nomical systems of automated training and programed instruction. Such principles can be widely applied to Air Force training efforts for conventional operations, advanced aerospace operations, and activities associated with limited war and counterinsurgency.

Task 557701, advanced system displays.—The objective of this task is to: determine methods of presenting data which will satisfy advanced system requirements; provide detailed performance specifications for displays for advanced systems; determine principles for efficiently determining the roles and informational requirements of personnel in advanced systems; and developing techniques for satisfying these identical display requirements.

Task 557704, display standards.—This task has been established to consolidate and direct the conduct of research designed to: provide verification of the visual display standards which are currently accepted and applied in the field of human engineering; determine, measure, and specify the contrast and brightness levels required for adequate performance in displays of colored symbols on color backgrounds; and effects of display update rates on the perception of information. The visual display standards in current use are based on threshold determinations, and, as such, may not be completely appropriate as criteria in the design of complex visual displays.

Task 557708, information transfer.—Recent developments in the application of probability theory to both detection and decisionmaking problems appear to have value for inclusion into an approach designed to identify criteria and develop a measure for evaluating the potential information transfer capability of large-scale displays.

Task 557709, display decision interaction.—Displays are a management decision tool and, as such, should represent an optimal transducer between man and machine in the command-control system. To achieve this, the display must be utilized under conditions in which the data are presented, in the best possible manner, to allow quick meaningful perception on the part of the human observer.

Task 611402, energy management simulation.—The objectives of this task are to develop equations to simulate the energy management computation in full mission simulation of hypervelocity boost glide, rendezvous, orbital, and reentry vehicles, and to develop techniques which can implement these equations into practical hardware capable of simulating control of vehicle energy.

Task 611405, visual simulation techniques for manned space vehicles.—The specific objective of the task is to provide techniques to simulate the visual environment under the following conditions: fully unprogramed orbital flight with the Earth, star field, other vehicles, and the Sun in view singly or in combination; the landing maneuver from post-reentry to touchdown; the takeoff covering the same general boundaries as the landing. The technique will be extended to visual reconnaissance problems and to fully computer activated landing simulation upon completion of the orbital flight problem.

Task 611407, mathematical models.—The objective of this task is to develop techniques for writing equations, analyzing variables, and developing data for simulating conventional aircraft, hypervelocity, rendezvous, orbital, and reentry vehicles.

Task 611408, simulation computers.—The objective of this task is to develop or adapt as appropriate the techniques required for the development of computers for flight simulators for advanced weapon systems.

Task 611409, systems synthesis.—The objective of the task is to develop techniques for representing systems in a language which consists of mathematic, flow charts, logical expressions, and others typical of operations research; and mechanize these systems representation with computers. The systems considered will be typical subsystems such as propulsion, electrical systems, radar, infrared, fuel management, and man-machine systems.

Task 611410, display synthesis.—The objectives of this task are to develop techniques for: instrumentation which is modular and operates directly from computer signals; and generation and displaying of information on cathode ray tubes.

Task 611412, monitoring and scoring.—The objectives of this task are to: develop or identify principles by which student performance in training devices can be measured and evaluated; and develop design techniques to implement these principles in practical hardware.

Task 675501, the effect of personnel policies upon officer career plans.—Air Force policies pertaining to career management procedures have a strong effect upon the capabilities, motivation and retainability of Air Force officers. The purpose of this task is to obtain information and to develop methods by which insights can be gained into the reactions toward such policies. Information about how officers perceive and interpret policies in terms of their own careers will be obtained.

Task 675502, education as an indicator of officer effectiveness.—This task is directed at study of the relationships between education and measures of officer effectiveness. The goal is an evaluation of educational requirements as a necessary prerequisite of success as an Air Force officer.

Task 675504, identification of officers with scientific and engineering potential.—The Air Force needs officers trained in engineering or scientific areas. However, many officers hesitate to apply for such training because they are unaware of, or are doubtful of, their ability to succeed in such endeavors. Because of this the Air Force would benefit by having procedures which will identify individuals who possess the capabilities of succeeding in science and engineering career fields. The purpose of the study will be to try out aptitude tests, biographical information, and measures of interest as possible indicators of potential for scientific and engineering training.

Task 675505, prediction of retirement trends.—An increasingly larger proportion of officers will become eligible to retire within the next few years. Because of this, a major consideration of the Systems Command personnel planning is having enough replacements for officers who retire. To meet this requirement, it is necessary to have prior information as to how many and what types of officers will be leaving the Air Force. The purpose of this task is to try out one possible means of estimating trends in retirement of Systems Command officers. It will develop procedures to identify officers who are likely to retire as soon as they become eligible as compared to those who will remain in service.

Task 675506, application of automated procedures in the assignment of scientific and engineering personnel.—The purpose of this task is to apply a computerized mathematical model which will determine the factors relevant to assignment policymaking and then reproduce this policy as closely as possible, and, having decided upon a specific assignment policy, will maximize the goodness of allocations of individuals to jobs. Such procedures should be applicable to AFSC assignment activities provided that the necessary information about people and jobs is available and the program is refined to handle a larger amount of information.

Task 689301, animal performance equipment development.—The work on this task is required to provide a capability for psychological measurements on animals participating in experiments conducted under standard laboratory conditions and simulated and actual space-flight conditions. To do this standard commercial laboratory apparatus will be used along with nonstandard apparatus which will be designed, developed, and tested.

Task 689302, animal behavior research in space environments.—Work on this task will be directed toward developing research techniques and methodology of manipulating and controlling behavior which will enhance the general area of animal training and the ability to evaluate the effects of space environment, psychopharmacological reactions, acceleration, reduced sensory input, and other stressful situations that may be encountered in the aerospace environment.

Task 718401, criteria for the design and arrangement of displays.—The objective of this task is to specify the design requirements for visual, tactual, and auditory displays so that the information required by operator and support personnel associated with advanced weapon systems is readily perceived, correctly interpreted, and acted upon with maximum efficiency. Research on man's visual and perceptual capabilities in space will provide information concerning his performance capabilities and limitations, and will lead to design criteria for future systems which have requirements for rendezvous in space.

Task 718402, criteria for the design and arrangement of controls and control systems.—The objective of this task is to establish human factors criteria for the design of controls, control systems, and crew stations for aeronautical and astronautical weapon systems. More compatible control system designs and control linkages between the operator and the system he controls will result from this task.

Task 718403, man-machine systems research.—Fundamentally, this task focuses upon human behavior that is complexly integrated with machines and/or with other humans. Thus, the task is simultaneously concerned with the behavior of humans in men-machine systems, and with the behavior of systems of which major components are men.

Task 718404, advanced systems human engineering design criteria.—The objectives of this task are to provide a fast reaction, applied research capability for the solution of human performance problems associated with the development of a wide variety of Air Force systems. In addition, a more general research program is conducted to develop human engineering design criteria and procedures to facilitate systems design.

Task 718405, design criteria for crew stations in advanced systems.—The primary purpose of this task is to provide human engineering design criteria for orbital systems ranging from boost-glide vehicles to personal propulsion units for extra-vehicular operations. The specific area of interest is the assessment of human performance and tolerances under conditions of weightlessness, partial gravity, and the Coriolis forces present in rotating space vehicles.

Task 718406, the development of human engineering maintainability design criteria.—The immediate objective of this task is to provide human engineering information, principles, and criteria for design of advanced vehicle systems and associated equipment for easy, efficient, and effective maintenance. The ultimate objective is improvement in operational efficiency and utility of such equipment.

Task 718407, design criteria for nuclear systems support equipment.—The objective of this task is to establish human engineering design criteria for support equipment associated with nuclear systems. Such criteria will make possible more efficient and less hazardous operation and maintenance of nuclear systems.

Task 718408, anthropology for design.—The objective of this task is to provide the anthropological data necessary to insure the safety, efficiency, and comfort of man operating existing and advanced Air Force systems.

Task 768201, data presentation and human data processing.—Displays for future command and control systems must provide optimally relevant information to users with a minimum delay and confusion. As the complexity of display features is increased, as what the operator must monitor and perceive becomes more dense, a significant decrement in performance becomes apparent. It is a major objective of the research planned under this task to isolate those variables influencing the operator, so that reliable human performance may be realized.

Task 768202, communication.—The object of this task is to identify and describe the features of auditory and vibrotactile signals which can be utilized for rapid, efficient, and unambiguous communication among operators and decision makers in Air Force systems. Two end products are anticipated: in voice communication, knowledge about and prediction capability for the effects of language and system variables on speech transmission, and the value of extra-intelligibility information contained in the human voice: in communication through the sense of touch, knowledge about the characteristics of vibrotactile signals most suitable for communication in system operations.

Task 768203, decision making in computer environments.—The objective of this task is to provide the Air Force with design information and methodology to assist the development of superior man-computer decision-making environments.

Task 768204, automated training for information systems.—The overall objective of this task is to develop and test specifications for automated, programed instruction subsystems for Information Systems. Generalized techniques and programed instruction principles are required which have across-systems applicability to the class of complex intellectual and perceptual skills called for in these systems.

Task 771702, specialty knowledge tests.—The objective of this task is to develop and/or revise specialty knowledge tests; to develop USAF study reference lists to assist airmen to prepare for specialty knowledge tests; to revise the USAF supervisory examination on an annual basis; and to score specialty knowledge tests (five- and seven-level) and supervisory examinations.

"Adaptability" covers the areas of emotional adjustment to the military life and motivation to perform effectively in military jobs and activities. Specific objectives of adaptability research include the development of general procedures for screening in career fields where the reliability and emotional stability of personnel is of particular importance; for example, personnel assigned to high-risk jobs in special weapons maintenance and assembly.

Task 771903, development of procedures for the selective retention of Air Force personnel.—The objective of this task is to provide standardized procedures for the selective retention of Air Force personnel. The procedures and techniques will aid in the identification of Air Force personnel who are successful in the career field in which they have been trained, adaptable to future skill requirements, and morally and socially acceptable in the Air Force environment.

Task 771904, development, analysis, and improvement of tools and techniques for officer performance, evaluation, and measurement.—This task requires the study of existing criteria of performance and expansion of data on empirical criteria, development of new performance measures, and techniques for predicting various measures of officer performance. The goal is: the objective, quantitative and reliable evaluation of how well individual officers perform assigned tasks and duties; the effective prediction of job performance; and defining through research the potential influence of officer performance measures on aspects of Air Force personnel policies.

Task 771905, development, analysis, and improvement of tools and techniques for airman performance evaluation and measurement.—This task is directed at the study of existing criteria of performance and the development of new performance measures for airmen. The goal is: the objective, quantitative, and reliable evaluation of how well individuals perform assigned tasks and duties; and the effective prediction of job performance.

Task 771704, Armed Forces operational selection tests.—The goal of this task is to revise and improve Armed Forces women's selection test (AFWST) and women's enlistment screening test (WEST), and provide spatial items for Armed Forces qualification test (AFQT).

Task 771705, selection and classification instruments for airman personnel programs.—The purpose of this task is to provide on a timely basis tests and measurement devices having maximum efficiency as required for the various Air Force enlisted personnel procurement and screening programs.

Task 771706, selection and classification instruments for officer personnel programs.—The objective of this task is to provide on a timely basis tests and measurement devices having maximum efficiency as required for the various Air Force officer personnel procurement and screening programs.

Task 771707, psychological screening of USAF special projects candidates.—The objective of this task is to select those individuals from available candidates who have personality characteristics required for adequate performance in a special assignment.

Task 771901, development of mathematical models and techniques to facilitate research in the selection, classification, and utilization of Air Force personnel.—The objective of this task is to provide mathematical models and more powerful statistical and computer techniques which will enable the advancement of personnel selection, classification, planning, and utilization.

Task 771902, research on prediction and assessment of adaptability to Air Force life.—The objective of this task is to develop procedures for predicting and assessing adaptability to Air Force life.

Task 771906, improvement of present, and development of new, selection and classification procedures.—The objective of this task is continual improvement of selection and assignment procedures by revising existing practices and developing new ones.

Task 771907, relation of aptitude tests to programed learning outcomes.—The objective of this task is to determine the relationship of aptitude and other tests of individual differences to the results of programed learning.

Task 773401, development of methods for collecting, analyzing, and reporting information describing Air Force specialties.—The objective of this task is to develop procedures for collecting occupational information for all Air Force specialties so as to provide reliable, accurate, and current data in quantitative forms of maximum utility to using agencies.

Task 773402, development and appraisal of methods for job evaluation.—The primary objectives of this task are: to identify and define job requirement factors which discriminate among officer and airman jobs or specialties in terms of merited compensation, which possess face validity, and which can be used as a basis for evaluating jobs; to develop techniques of determining suitable factor weights; to develop appropriate methods for combining weighted factor values into job- and specialty-evaluation scores; and to develop operationally feasible plans for obtaining reliable and meaningful evaluations of officer and airman jobs or specialties.

Task 773403, development and evaluation of methods for grouping work activities into positions, specialties, and career fields.—The objective of this task is to develop and evaluate methods of grouping work activities into positions, specialties, and larger management units such as career fields. The goal is to develop methods to determine the most appropriate number and type of Air Force specialties and to provide flexible procedures for modifying personnel structures to allow for the integration of new jobs or for changes in existing jobs.

Task 773404, development of methods for establishing job-oriented criteria.—The purpose of this task is to develop and evaluate job-oriented criterion measures which are suitable for use in validating personnel qualifications requirements such as selection and classification test scores, training grades, specialty knowledge test scores, education, and experience data.

APPENDIX H

MISCELLANEOUS LETTERS TO THE SUBCOMMITTEE ON MANNED SPACE FLIGHT

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION,
OFFICE OF THE ADMINISTRATOR,
Washington, D.C., May 29, 1963.

Hon. OLIN E. TEAGUE,
House of Representatives,
Washington, D.C.

DEAR MR. TEAGUE: This letter is in response to your recent inquiry concerning NASA's nuclear program.

The work on nuclear systems for space application is contained in two categories in the NASA budget. These are the nuclear rocket and the nuclear electric systems programs. Much of this work is conducted jointly with the Atomic Energy Commission. The AEC is responsible for the development of the nuclear reactors that are used in all of these systems. NASA is responsible for development of nonnuclear components such as pumps, turbines, nozzles, heat exchangers, radiators, and for the integration and assembly of the nuclear reactors and nonnuclear components into operational systems. NASA is also responsible for applying these systems in space missions. The overall budget for nuclear systems is borne by both NASA and the AEC with each agency budgeting for and justifying to the Congress work falling within its area of responsibility.

We have adopted an organization and management structure which we believe leads to an absolute minimum possibility of any duplication in funding and effort. In the nuclear rocket program, Rover, NASA and the AEC have established a single office called the Space Nuclear Propulsion Office to manage all aspects of the development of nuclear rocket propulsion regardless of agency responsibility. The manager of this Office reports to NASA and the AEC. He exercises the responsibilities, spends the funds, and directs the work of both agencies in nuclear rocket propulsion development. The program is planned and operated as a single program even though NASA and AEC have distinct responsibilities and funds in it.

The manager of the Space Nuclear Propulsion Office is also NASA's Director of Nuclear Systems. In this capacity he manages and directs all of NASA's work on nuclear system development for space application. This assures a single line of coordination from NASA to the AEC on system research and development. We have assured ourselves that this organizational approach is, in fact, effecting good coordination and cooperation between NASA and the AEC on nuclear system developments. In addition, in those areas where the Department of Defense has related work, this organizational structure provides a single, clearly defined point of communication.

Our work on the nuclear rocket recognizes that it is the next logical type of rocket propulsion system capable of providing higher specific impulse and higher performance than is possible with any of our chemical rocket systems. The nuclear rocket systems rely heavily on the nonnuclear technology being developed and used in chemical rockets. Therefore, although it is necessary to learn how to extend the operating range of the components such as turbopumps, nozzles, controls, gimbal bearings, etc., to new environmental conditions including nuclear radiation, much of the basic technology and design information is available from chemical rocket practice. In addition, it is necessary to develop a suitable nuclear reactor which does require new research, technology, and hardware. This is a difficult development since it is necessary to operate materials close to their temperature limits in order to achieve the full potential of the system. The responsibility for this reactor work rests with the AEC. NASA funds for and manages the development of the necessary nonnuclear components and provides the hydrogen for the reactor tests. In addition, NASA is conducting some conceptual studies and materials and physics work in the reactor area under SNPO review and management.

As you are aware, there have been many problems to be overcome in the mechanical design of the Kiwi graphite reactors. Changes have been initiated in the program so as to emphasize more extensive component subassembly development and simulated testing of all parts that will go into the reactor in order to solve the problems that have been encountered. The results that have been obtained to date on this new approach are leading to a better understanding and more assured development of the nuclear rocket system.

We believe these nuclear rocket systems will be required and will be used extensively in missions to be performed beyond the first manned lunar landing mission. They offer potential payload improvements for both unmanned and manned flight into deep space, as well as for transport of heavy payloads between the Earth and the Moon. Because they involve logical extension of much of the technology of chemical ssytems and, when suitable reactors are available, will provide high impulse, we are convinced that these systems are the logical follow-on propulsion systems for use in extensive space missions. We believe that vehicles beyond the all chemical Saturn V (now being developed for Apollo) will utilize these stages as soon as they are available.

Turning to our Nuclear Electric Systems, our work is aimed at providing power for two applications. First, we recognize that it will be necessary to provide large amounts of power in the many kilowatts, and perhaps in the megawatt range, for on-board services to provide power for communications, data collection, data transmission, life support, etc. In addition, we recognize the performance potential that could be realized from electric propulsion if high power (megawatt range), light weight systems were available. It is apparent that both of these applications requiring high power levels operating for long periods of time must rely on the use of nuclear energy as the source of this electric power.

The SNAP–8 is the only nuclear reactor system development that NASA is now conducting. This project is a joint one with the Atomic Energy Commission. This system will provide 30 kilowatts of electric power and will be used for on-board power applications. Other on-board power applications that are of interest to NASA are those low values of power (hundreds of watts) that may be provided with isotope power supplies. Requests have been submitted to the AEC to initiate the first phase of analysis and development of isotope power supplies for such applications as Surveyor, the Interplanetary Monitoring Probe, the Orbiting Astronomical Observatory.

With regard to nuclear systems for high powers, NASA is conducting an extensive research and nonnuclear technology development program aimed at assuring that the light weight that is necessary to fully realize the potential of electric propulsion for transporting high payloads on different space missions can, in fact, be achieved. At the present time, it is not known whether it is feasible to operate liquid metal systems at 2,000° F. with over a year of reliable life. Such conditions are necessary in order to achieve the system weights of 10 to 20 pounds per kilowatt that are required for efficient, competitive electric propulsion systems. Electric propulsion is, therefore, a longer range and more advanced development that offers potential performance advantages if the performance requirements can, in fact, be achieved.

In conclusion, it is our strong opinion that this country must conduct research and advanced technology on those systems which appear to offer the kind of feasible performance potential that will be required for advanced missions that are not yet firmly programed. Only through such advanced research and technology programs will this country develop the capability to explore and operate in space in any manner and on any mission that our national interest may require.

Sincerely yours,

ROBERT C. SEAMANS, Jr.,
Associate Administrator.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION,
OFFICE OF THE ADMINISTRATOR,
Washington, D.C., June 26, 1963.

Mr. PHILIP B. YEAGER,
Counsel, Committee on Science and Astronautics,
House of Representatives, Washington, D.C.

DEAR MR. YEAGER: The accompanying tabulation provides information on the current status of major items proposed for funding in the Office of Manned Space Flight R. & D. program.

At the time the fiscal year 1964 budget estimate was finalized, we were still negotiating the McDonnell contract for the Gemini bid proposal from the contractor. This proposal, however, was modified before the contract was definitized in March 1963 to encompass results of studies to assure that the Gemini program was configured to provide the best possible testing and training base for the Apollo program.

The Grumman contract for the lunar excursion module was not definitized. However, the bid proposal that was used as the basis for the estimated requirements was essentially in line with the work agreed to under the definitized contract.

The NAA contract for the Apollo spacecraft is not yet definitized. In October 1962, the NAA Co. submitted a definitive cost proposal for the scope of work as definied prior to that time. The NASA fiscal year 1964 budget estimate was based on Government assessment of this definitive cost proposal with provisions for engineering changes and additions which were not yet defined to the contractor or provided for in his proposal.

The Chrysler and Douglas effort on the Saturn I–B has not been definitized. The Douglas Corp. is proceeding on a letter of intent and negotiations with the Chrysler Corp. are now underway. The estimated requirements were based on an extrapolation of existing contracts with both companies for the S–I stage and for the S–IV and S–IVB stages of the Saturn I and Saturn V vehicles.

The Boeing contract was not definitized. However, the bid proposal furnished August 1962, and the negotiated position of late November 1962, were used to develop the estimate. This contract was definitized in February 1963.

The Bellcomm contract was not definitized until December 1962. However, since the level of effort was understood by both parties, the range of negotiation was not broad.

NASA is operating under a letter contract with General Electric. However, the scope of work has been established. This planned scope was used as the basis for developing the fiscal year 1964 dollar requirements.

Sincerely yours,

J. S. BROWN,
Assistant Director, Office of Legislative Affairs.

Project	Contractor	Item	Proposal	Date of	
				Letter contract	Definitized contract
Gemini	McDonnell Aircraft Corp	Gemini Spacecraft	April 1962		March 1963.
Apollo	Grumman Aircraft Engineering Corp	Lunar excursion module	September 1962		
	North American Aviation Inc	Command and service module		December 1961	
	MIT	Navigation guidance system			June 1962.
Saturn	Chrysler Corp	S-I			July 1962.
	Douglas Aircraft Co	S-IV			July 1960.
Saturn I-B	Chrysler Corp	S-IB			
	Douglas Aircraft Co	S-IVB		September 1962	
Saturn V	Boeing Co	S-IC	August 1962		February 1963.
	North American Aviation Co	S-II			October 1962.
	Douglas Aircraft Co	S-IVB			August 1962.
RL-10	Pratt & Whitney				January 1961.
F-1	North American Aviation, Rocketdyne				January 1959.
J-2	do				September 1960.
M-1	Aerojet-General Corp			April 1962	
System Engineering	Bellcomm, Inc				December 1962.
Integration and C/O	General Electric Co			February 1962	

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1964 NASA AUTHORIZATION

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HEARINGS

BEFORE THE

SUBCOMMITTEE ON SPACE SCIENCES AND ADVANCED RESEARCH AND TECHNOLOGY

OF THE

COMMITTEE ON SCIENCE AND ASTRONAUTICS

U.S. HOUSE OF REPRESENTATIVES

EIGHTY-EIGHTH CONGRESS

FIRST SESSION

ON

H.R. 5466

(Superseded by H.R. 7500)

MARCH 6, 7, 8, 11, 12, 13, 14, 19, 20, 21, 27, 28; APRIL 1, 2, 3, 4, 5, 8, 9, 10, 11, 24, 25, 29, 30; MAY 1, 8, 1963

[No. 3]

Part 3(a)

Printed for the use of the Committee on Science and Astronautics

1964 NASA AUTHORIZATION

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BEFORE THE

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NOTE.—The chairman of the full committee and the ranking minority member, Hon. Joseph W. Martin, Jr., are ex officio members of all subcommittees.

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WEDNESDAY, MARCH 6, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SPACE SCIENCES,
AND ADVANCED RESEARCH AND TECHNOLOGY,
Washington, D.C.

The committee met at 10 a.m., pursuant to call, in room 214–B, New House Office Building, Hon. Joseph E. Karth presiding.

The CHAIRMAN. The meeting will be in order.

Our witnesses this morning are Dr. Homer Newell and Mr. Edgar Cortright of NASA's Office of Space Sciences. We want to welcome you to the subcommittee. This, of course, is the first day of our subcommittee hearings on the budget request of the Office of Space Sciences for fiscal year 1964.

I see that you have a long prepared statement, Dr. Newell. If you don't mind, I think I shall ask the members to interrupt whenever they might have a question. With a long prepared statement such as this, if they hold their questions until completion of the statement, I think it is possible they may forget what they had in mind.

If this is all right with you, we will proceed on that basis.

Dr. NEWELL. It's quite acceptable.

The CHAIRMAN. I don't know how long these hearings are going to take. From my own personal standpoint, I feel the subcommittee members must be as well informed as they can possibly be, in order to defend this budget on the floor of the House.

How well we do depends on how much information we get from the people who represent the NASA. So, it could well be we will be calling you back again and again to answer questions that members of the subcommittee may have.

Dr. NEWELL. It will be our pleasure.

The CHAIRMAN. Would you want to start now, Dr. Newell?

STATEMENT OF DR. HOMER E. NEWELL, DIRECTOR, OFFICE OF SPACE SCIENCES, NASA, ACCOMPANIED BY EDGAR M. CORTRIGHT, DEPUTY DIRECTOR

Dr. NEWELL. Thank you, Mr. Chairman, and members of the subcommittee.

The NASA space sciences program encompasses the total national effort to explore the solar system and beyond with unmanned instrumented spacecraft. There is nothing esoteric about it. It is an exploration in the most understandable and romantic sense. It makes use of men, rockets, and spacecraft. The men remain on earth and reach out

throughout the solar system with their instrument eyes, ears, and hands. They reach spots now inaccessible to them, but some of which someday man himself will visit.

This past year has been an important one for our program. We launched 6 scientific satellites, 5 lunar and planetary probes, and 78 sounding rockets. We are in high gear. We are setting a pace designed to insure the preeminence of this country in unmanned space exploration in the face of a very determined Soviet effort to capture the initiative in this area. Russia launched at least 15 unmanned satellites and space probes last year, which were identified as scientific in nature.

I would like to begin this year's testimony with a filmed history of our Mariner II project. I ask your indulgence if the film seems a little melodramatic in spots. It was made for popular consumption. I assure you, however, that it accurately reflects the feeling and emotion of those connected with the project. It conveys the spirit, the motives, and the complexities of this fantastic challenge of space exploration.

With your permission, Mr. Chairman, I'd like to show this film.

The CHAIRMAN. Of course, Doctor. Proceed.

[Film, 30 minutes.]

The CHAIRMAN. Thank you very much Dr. Newell. That was very interesting. You are the most photogenic of the group that appeared in the film.

Dr. NEWELL. Thank you, Mr. Chairman.

The CHAIRMAN. Are there any questions on the part of the members of the committee?

If not, Dr. Newell, will you proceed, please.

PART I

SCIENTIFIC RESULTS AND OBJECTIVES

Dr. NEWELL. Space science embraces a broad range of important problems. Because of the range and significance of these problems, it is essential that the United States have a vigorous space science program if it intends to maintain world leadership in today's most important areas of science.

The tremendous sweep of space science shows on the first chart (fig. 1, Space Science Areas) in which various space science areas of research are listed. The program presented which the committee endorsed last year included projects to attack a large number of important problems in these areas. In our presentation this year, we wish to report on progress during the past year and to describe important problems that remain to be solved.

One of the most remarkable features of the space science program is the great number of disciplines that are called into play in attacking the problems that confront us. Some of these are listed in the next chart (fig. 2, Space Science Disciplines). The drawing together of astronomers, geophysicists, and physicists in a great multidisciplinary attack on solar system problems is one of the most valuable benefits of the space science program. In space science, as in all science, advancing knowledge in one area sheds light in unexpected ways on entirely different areas. For example, as we shall see in more

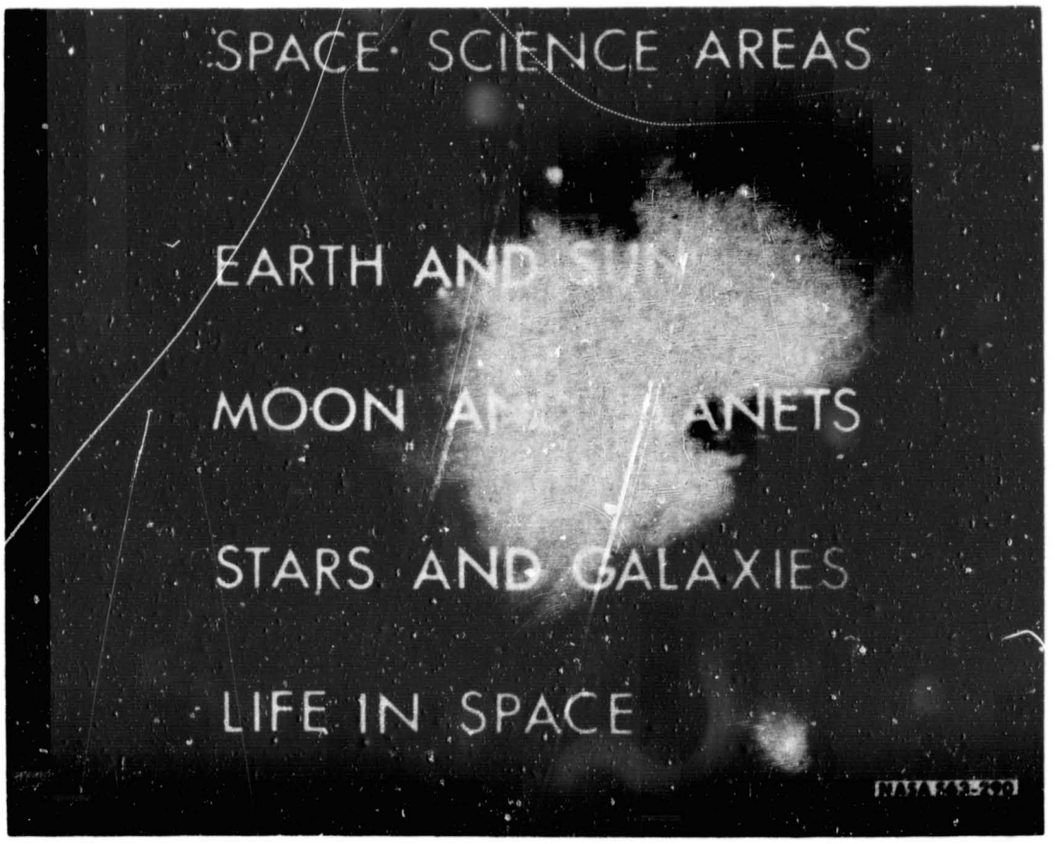

FIGURE 1

SPACE SCIENCE DISCIPLINES

PHYSICS	GEOPHYSICS
CHEMISTRY	GEOCHEMISTRY
ASTRONOMY	MATHEMATICS
ASTROPHYSICS	BIOLOGY
GEODESY	BIOPHYSICS
METEOROLOGY	BIOCHEMISTRY
GEOLOGY	SEISMOLOGY

NASA 563-291

FIGURE 2

detail later, the investigation of activity on the surface of the sun provides clues as to the causes of atmospheric, auroral, magnetic, and communications disturbances on Earth. The investigation of the Moon bids fair to shed light on the origin of the solar system, hence of the Earth. There are strong indications that the influence of the Moon on dust particles and fields in space may somehow be connected with periodic weather effects at the surface of the Earth.

It is, therefore, important to move ahead with a broad space science program such as the one that NASA has established with your support, and for which we seek your continuing support.

The program that we present to you today represents a careful selection of important problems to attack from among the many more that could be tackled. Our aim is to move ahead in an orderly fashion, focusing upon the most important problems that our present state of advancement in both science and technology permits us to attack, while at the same time maintaining a satisfactory breadth to the program.

In the second part of this presentation, we shall review for you in a systematic way our progress in launchings of satellites and space probes, the development of launch vehicles, and relating supporting activities, as well as the plans for which we ask your support. Before that, however, I should like to dwell on some of the scientific results obtained from our past efforts, and on some of the intriguing problems that face us today.

We shall begin with the Sun, which is our primary source of energy, and also a major source of hazard to manned space flight because of the cosmic rays it generates. Then we shall discuss the medium of interplanetary space, and thereafter the Earth's magnetosphere and atmosphere. We shall see that the Sun exerts a controlling influence on all three of these regions. After discussing the Earth, we shall move outward again to the Moon, Venus, and Mars. Lastly, we shall touch briefly on the important subject of galactic space.

THE SUN

The next chart (fig. 3, Diagram of Sun) shows a schematic diagram of the Sun. The picture presented here is that which the theorists now believe to be correct. Our investigations of the Sun are designed to acquire as much factual information about solar activity as we can. Whether the experimental results will substantiate our present concepts or call for revising them remains to be seen.

As shown in the picture, it is believed that in the central core of the Sun hydrogen is converted into helium by a series of nuclear reactions. This burning of hydrogen to form helium generates very large amounts of energy in the form of gamma rays which are similar to X-rays, but much more energetic. This radiant energy moves outward from the solar interior—escaping through the surface largely in the form of the visible light that we see coming from the Sun.

Near the outer surface of the Sun, solar gases become turbulent, boiling and churning constantly. It is this region that we now think produces the solar storms that have important effects on the Earth and its environment, and on manned space flight and space applications.

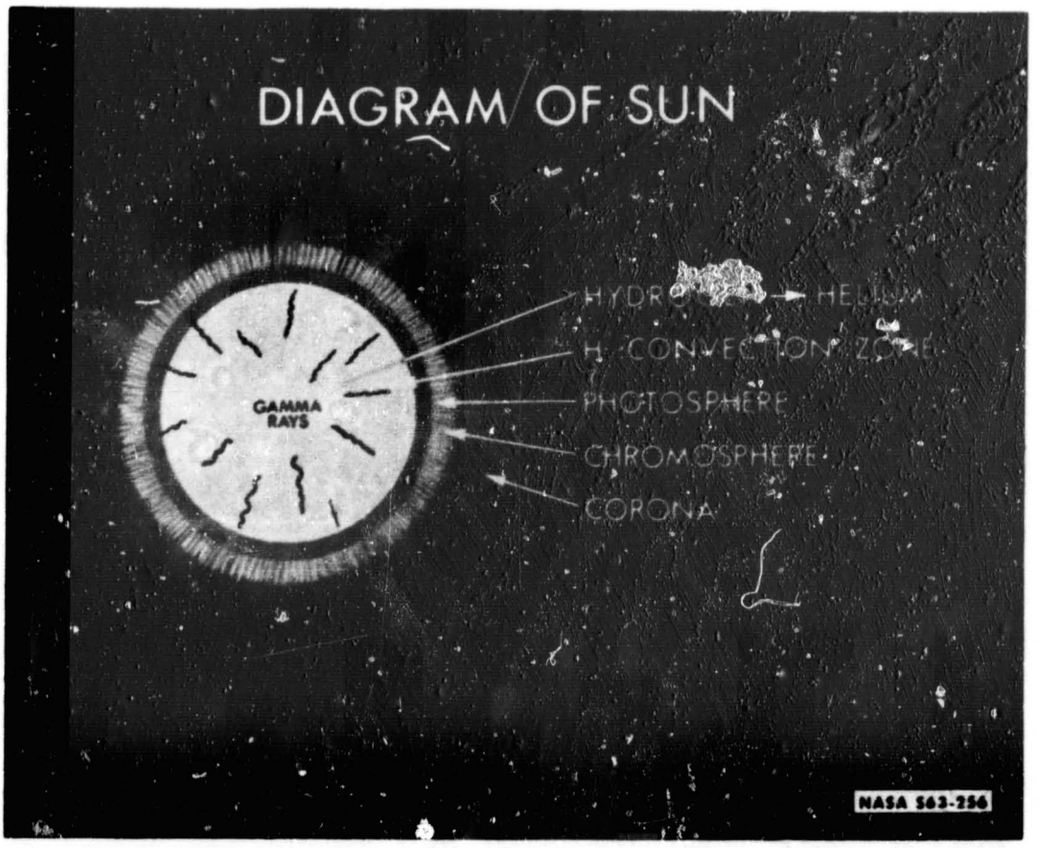

FIGURE 3

It would be natural to suppose that temperature would decrease steadily the farther one moved away from the center of the Sun. Surprisingly, this is not the case. The region labeled "chromosphere" on the diagram turns out to be the coolest part of the Sun. The corona lying above it and extending far out into the space around the Sun is a thousand times hotter than the chromosphere. Here is a real puzzle to which we are trying to find the answer in the space science program. The riddle is important in that it is thought to be related to the question of what happens in solar flares, some of which produce great quantities of high energy particles.

Sunspots are of great importance in the study of the Sun. They have been investigated for about two centuries, while solar flares which occur in the vicinity of sunspots have been under investigation for several decades. Nevertheless, the causes of these forms of solar activity have so far defied theoretical interpretation. This is unfortunate as far as manned space flight is concerned, because much of the radiation hazard in space is associated with the occurrence of solar flares. It would be extremely valuable to the manned space flight program to be able to predict when hazardous flares will occur.

The accompanying chart (fig. 4, Solar Activity) shows a graph of the number of sunspot groups appearing on the face of the Sun over the interval from 1900 to the present time together with a predicted extension of the curve to 1971. At the bottom of the graph is shown schematically a quiet Sun which is associated with the valleys of the sunspot graph, as indicated, for example, by the arrow point-

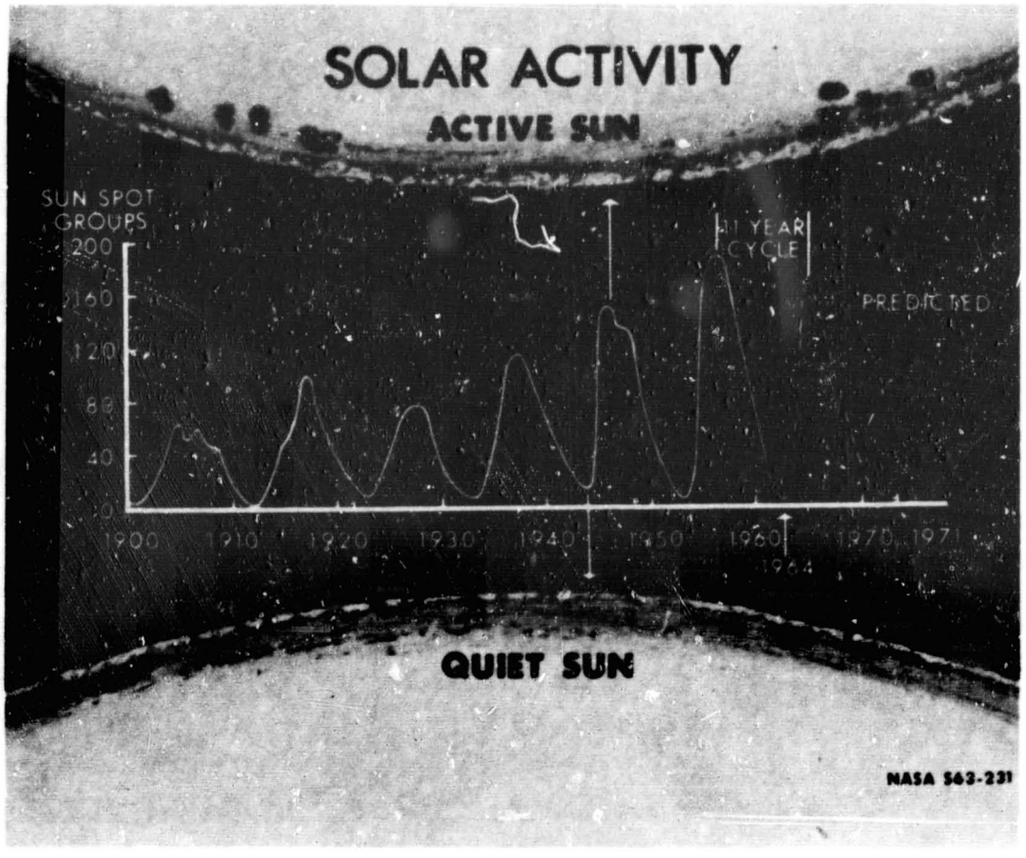

FIGURE 4

ing downward from the minimum in the sunspot curve in the 1943 time period.

Mr. STAEBLER. Let me ask one question off the record.

(Discussion off the record.)

The CHAIRMAN. I think all questions involved in the subject we are here to explore, Mr. Staebler, should be on the record. Don't worry about expressing your ignorance; these are highly technical matters, and we are all faced with the same problem.

Please, let's be on the record.

Mr. STAEBLER. The surface phenomena then are in the nature of some reflections of these recurrent stages of contraction and expansion?

Dr. NEWELL. That is correct. The surface phenomena we see are in some way a product of the tremendous energies produced by the nuclear burning processes in the interior.

The CHAIRMAN. Mr. Randall?

Mr. RANDALL. Mr. Chairman, I would hope that Dr. Newell could repeat that, or provide us with that for the record, because I've certainly never heard anything as compact and complete and as informative as his explanation. I hope it will be put on the record in very much the same terminology.

The CHAIRMAN. If you would do that, Doctor, we will insert it at this point in the record.

(The information is as follows:)

This is an answer to Mr. Staebler's question posed during the hearings on March 6, 1963. Mr. Staebler's question was, "What is the burning process inside the sun?" My answer goes as follows: The burning inside the Sun, to which I referred earlier, is a nuclear process in which hydrogen fuses with hydrogen to form helium. It is not the usual chemical process in which, for example, wood or coal burns in air.

There is a fascinating story associated with these processes inside stars. It is now believed generally by scientists that stars are formed out of dust, gases, and materials strewn throughout space. In such a cloud of dust, extending over gigantic dimensions, there occurs by accident an eddy, or whirlpool, which amounts to a somewhat denser accumulation of material than in the rest of the cloud. This slight accumulation of dust has a gravitational attraction for other material in the surrounding regions, and that other material tends to fall in toward the initial region of increased density.

At first this process is quite slow, since gravitational forces are intrinsically very weak. However, as the size of the accumulating material grows, its gravitational attraction grows and the process becomes more and more rapid. Eventually, out of the gases and dust spread throughout the surrounding region, a huge ball of material has assembled which is the newly born star. At first the star is cool and dark. But as the material of the star is pulled in under gravitational attraction, tremendous pressure is built up in the interior, and the heat generated by these pressures builds up the temperature in the interior of the growing star. These temperatures increase steadily until eventually they become so high, about 20,000,000° C., that the hydrogen, which is the predominant constituent in the star, begins to fuse to form helium.

During this process of fusion, great amounts of energy are emitted in the form of gamma rays. The radiation pressure from this gamma radiation balances the gravitational attraction which was causing the star to contract. The contraction under gravitational forces then stops for the time being, and a state of equilibrium is reached in which hydrogen goes on fusing to form helium.

After some long period of time, amounting to billions of years, the fusing of the hydrogen causes a helium core to build up in the star. Eventually, when most of the hydrogen has burned up to form this helium, the fusion process declines, and the radiation pressure of the gamma rays created by the fusion is no longer able to counterbalance the gravitational forces. The star then begins to contract again under gravity. Once again the temperatures in the interior of the star increase until they become so great that the helium begins to burn. In this burning process, which it must be reemphasized is a nuclear process and not a chemical one, the helium fuses to form carbon.

Once again the radiation emitted during this fusion process balances the gravitational forces and the contraction of the star again comes to an end. For a period then, there is once more equilibrium in the star with the helium fusing to form carbon.

Eventually, the helium is used up and the star has acquired a core of gaseous high-temperature carbon. At this point, the process repeats itself. Under gravitational attraction the star again begins to contract, again raising the temperatures in the center of the star. As these temperatures rise, they approach a point where carbon begins to burn—this time forming oxygen.

Such a process goes on repeatedly with elements of higher and higher atomic weight being formed until the star has become basically a star of iron. At this point, the process comes to a halt because iron cannot be burned to form either elements of lighter atomic weight or of heavier atomic weight. In a sense, then, iron is a dead ash of this stellar burning.

At this stage the gravitational forces take over and the star suddenly collapses. Although the process described in the preceding paragraphs has taken many, many billions of years, the collapse of the star is a matter of seconds. In this very brief time, the star collapses to a very tight, dense ball of material. This pulling together of the material then results in a rebound which amounts to a tremendous explosion of the star, giving rise to what astronomers call a supernova. In exploding, the star then casts all of its material, the elements that were formed during its previous history, out into space. In addition, the very high temperatures that are created during this process cause the creation of elements of higher atomic weight than iron.

Thus, it is that all the materials that we know of in the universe are formed inside a star. This is true of the materials that comprise our Earth and every-

thing we see in this room including our own bodies. Thus, if this theory of the birth, evolution, and demise of a star is correct, each of us may say that, at one time, he was part of a star.

Mr. CHENOWETH. When we see falling stars and particles coming to Earth, is that the result of stars disintegrating?

Dr. NEWELL. No, falling stars are meteors in our Earth's atmosphere. When the star disintegrates in this tremendous explosion, that's when we see in the sky what is called a nova or supernova, suddenly a great flareup, a bright star.

These occur at about the rate of three per 100 years in a galaxy the size of ours.

Mr. CHENOWETH. They are visible from the Earth, are they?

Dr. NEWELL. They are visible from the Earth. There was an extremely bright one back in the year 1054, which is now observed as the crab nebula by astronomers. The crab nebula just appears to be a constantly expanding glob of gas. It's the exploded remnants of what was once a star.

The CHAIRMAN. And we see these things at a date substantially later than when the explosions actually occur, Doctor?

Dr. NEWELL. That is correct.

The CHAIRMAN. How far away are these stars?

For example, this occurrence in 1910?

Dr. NEWELL. The one in 1910 was in our galaxy. Now, the distance across our galaxy is about 100,000 light years. A light year is the distance traveled by light in 1 year and that is——

The CHAIRMAN. Doesn't light travel at 186,000 miles a second?

Dr. NEWELL. At 186,000 miles a second, that is 6 trillion miles. So the distance across our galaxy is 100,000 times 6 trillion miles.

Our sun is at 30,000 light years from the center of our galaxy, so any of the supernovas that occur in our galaxy will be within this region 100,000 light years across.

The supernovas that we see in other galaxies, however, may be millions of light years away, depending on how far the galaxy is away from us.

The CHAIRMAN. Excuse me, Dr. Newell, Chairman Miller just joined us. Mr. Chairman, we are very happy to have you with us.

Chairman MILLER. Thank you, I just dropped in to hear Dr. Newell. I'm very happy to see you again, Dr. Newell.

Dr. NEWELL. Thank you, Mr. Chairman.

The CHAIRMAN. Dr. Newell, if you'd like to proceed.

Dr. NEWELL. Thank you.

The peaks of the sunspot curve, like the one occurring in the 1946 time period, are associated with a highly active Sun exhibiting many sunspot groups, as shown diagrammatically at the top of the chart. You can see that periods of high solar activity are associated with large numbers of sunspots, and they occur at intervals of about 11 years.

The Sun has just passed through its most active period on record and is now rapidly approaching a period of quiet in 1964. Even during the quiet periods, however, the Sun is not completely free of the signs of solar activity. For only a few days during any solar cycle is the face of the Sun completely free of spots. Moreover, the amount of activity in the Sun can change quite rapidly. In April of last year,

while OSO I—the first Orbiting Solar Observatory—was trained on the Sun, there was a short period when no sunspots were visible. Nevertheless, within a few weeks, a very intense solar flare occurred. Since flares occur only in regions where sunspots are present, and usually only near large spots with complex magnetic fields, the absence of such spots appears to be a reliable guarantee that a solar flare will not occur within a period of at least a few days. However, as already indicated, such periods are too rare to be of much use for long-term prediction purposes.

We cannot, as yet, predict which active regions on the Sun are likely to produce flares emitting solar protons. Even worse, after having observed a solar flare in a visible wavelength region, we are not yet able to state whether or not a strong flux of solar protons, proton being a hydrogen nucleus, was produced at the same time as the flare.

The latter ability would give us a few hours at least in which to warn any astronauts who might be outside of a protected area.

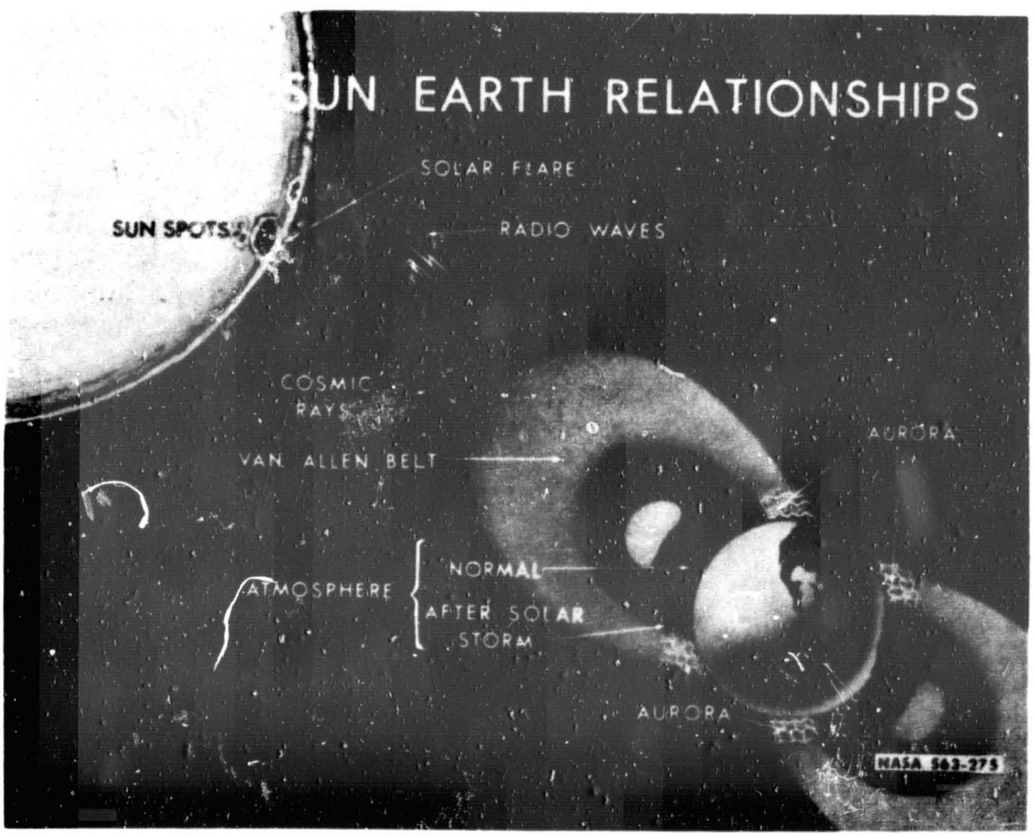

FIGURE 5

The next chart (fig. 5, Sun Earth Relationships) summarizes the major aspects of our present knowledge of such flares and particle fluxes. At the time of a flare we observe that a small region of the solar disk emits light more brightly, the red light characteristic of hydrogen. At the same time the Sun increases its outpouring of radiation in the radio wavelengths. These are called "radio bursts." Great geysers of brilliantly illuminated gases erupt from the surface of the Sun. Most of this gas falls back into the Sun. However, we

have learned from such space probes as Pioneer V and Mariner II and from Earth-orbiting satellites that a portion of this gas leaves the Sun. It is projected through interplanetary space, often reaching the Earth, and sometimes beyond the Earth. This triggers a number of changes in the environment of the Earth. The number of particles striking a satellite may increase by several factors of 10. The enhanced radiation sometimes lasts several days, and is sufficiently intense to cause the death of any unprotected astronaut.

The Van Allen belts are affected by the new particles reaching the Earth, and appear to dip farther than usual into the atmosphere to cause aurorae.

At times of solar flares, our satellites have reported the presence of intense and high energy ultraviolet and X-ray radiation. Little of this reaches the Earth's surface; yet, at these times, the Earth's ionosphere is considerably disturbed and our radio communications frequently are disrupted. Uppermost regions of the atmosphere become warmer and more dense and this increases their drag on satellites. An accompanying disturbance of the Earth's magnetic field sometimes is so severe that it leads magnetic compasses astray, while northern transatlantic telecommunications via cable are suddenly interrupted.

Our first Orbiting Solar Observatory has given us new and valuable information about the Sun (fig. 6, Orbiting Solar Observatory Results). Since its launch last March it accumulated at least 1,200 hours of data on solar X-ray and ultraviolet radiation, which is about 1,000 times the amount of this type of information gleaned from previous rocket and satellite experiments. Excellent spectrograms of the Sun's

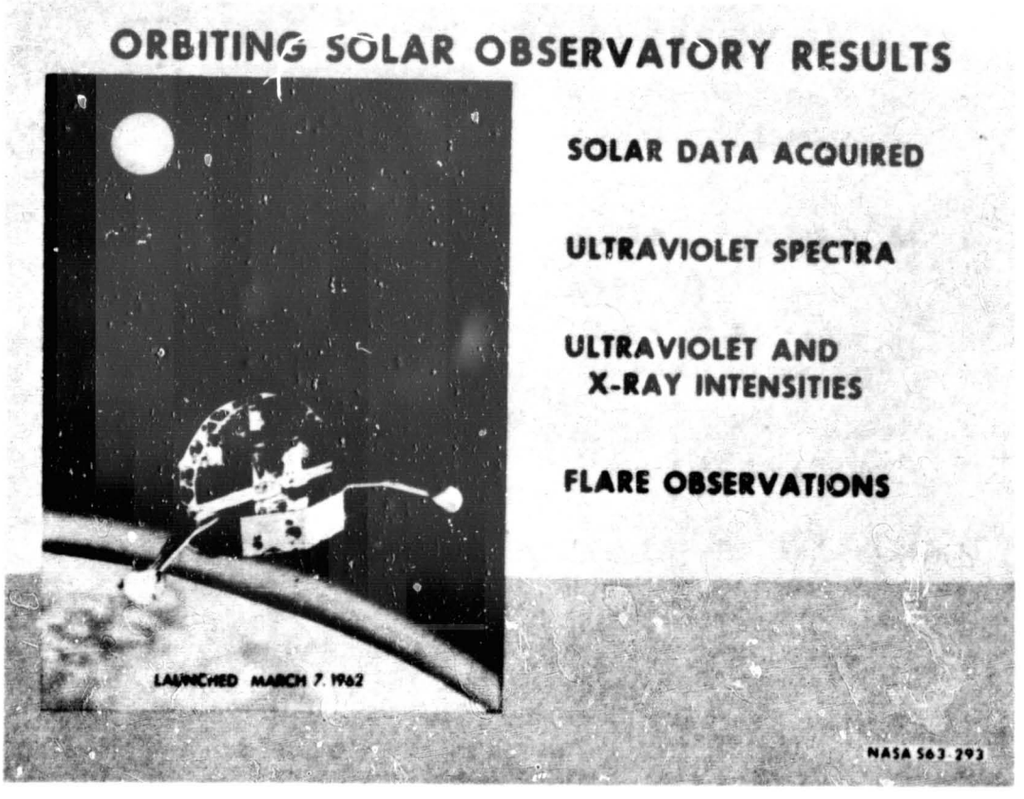

FIGURE 6

radiation in the far ultraviolet region have been obtained. The spectral lines—which are the fingerprints of chemical elements—are of bewildering complexity and most have not yet been identified. However, the presence of ionized helium and of highly ionized iron is clearly indicated. A sound knowledge of the variety, distribution, amounts, and state of the gases that constitute the Sun's turbulent exterior would bring the day when we can predict solar events much closer at hand.

Mr. STAEBLER. Dr. Newell, does this suggest that there are elements in the Sun that are not present in the Earth?

Dr. NEWELL. There have been no elements discovered in the Sun that are not present in the Earth.

Mr. STAEBLER. These lines—the spectrogram lines, what do these mean?

Dr. NEWELL. What that means is that they observe iron, for example, in a high state of excitation, a highly energetic state or to put it another way, in a very high temperature state, and similarly with the helium.

Mr. STAEBLER. It's in new forms. That doesn't extend the table elements then.

Dr. NEWELL. No, it's the same element, but in a different physical state.

I wish to stress once more that intensive research in solar phenomena is vital to many scientific inquiries.

It is also of crucial importance to the manned space flight program.

It is in this area that our future unmanned orbiting solar observatories will be set to work. The next chart (fig. 7, Solar Detail) il-

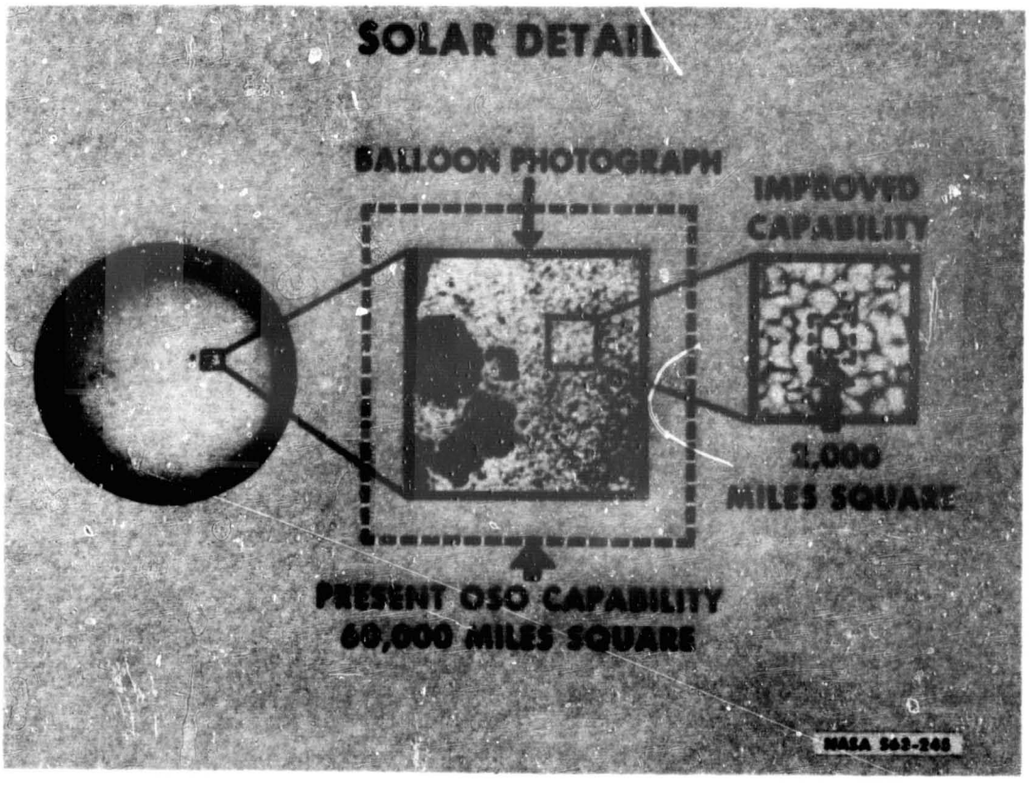

FIGURE 7

lustrates why we must develop an improved pointing accuracy for future orbiting solar observatories. The left side of the diagram shows the Sun with several large sunspot groups. You recall that these are the active regions that produce solar flares. One of these sunspot groups is enlarged in the middle diagram. This is an actual photograph. It was taken by a telescope designed by Prof. Martin Schwarzschild, of Princeton University. The telescope was raised above most of the Earth's atmosphere by a giant balloon. Pictures thus obtained provided us with a much improved view of the solar surface. Note the structure of the sunspot group and the cellular structure over the rest of the solar surface. We believe that these structures are related and that somehow an understanding of the cellular structure will hold important clues to the beginnings of solar flares. The dashed line square around the stratoscope photograph represents the present limit within which we can keep our present orbiting solar observatories pointed. Within this limit our instruments are free to wander over an area which you see that is even larger than the area covered by the stratoscope photograph. The principal advantage then of the present OSO is that it does orbit in space, thus raising our telescopes above that portion of the upper atmosphere that must always remain between any balloon-borne observation device and the Sun, stars, or planets. While this is a very slight layer of atmospheric gases, it is sufficient to deprive us of valuable information carried by ultraviolet and X-ray radiation.

A more precise study of the details of sunspots and of the cellular structure of the solar surface is essential to our understanding of the occurrence of solar flares. We surmise that the cellular structure is caused by the motions of the gas in the solar atmosphere and that similar mechanisms underlie the solar flares. In order to concentrate our study upon the small region of the cellular structure we must considerably improve the precision with which we can point our orbiting solar observatories and the instruments that they hold. The right side of the chart illustrates this. Here, a section of Professor Schwarzschild's photograph has been enlarged. The small dashed line square defines the limits within which we must be to study this cellular structure and to observe the birth of a flare.

We have had design studies conducted for these improvements during the past year, and are requesting money this year to start the necessary developments.

Our studies show that the present state-of-the-art just permits us to achieve the 200-mile-square pointing accuracy required.

Not only must future Orbiting Solar Observatories have a high pointing accuracy but also they must be able to store great amounts of information, in order that we may be able to study in detail rapid changes on the surface of the Sun and the distribution of radiation intensities over the solar surface.

Since it is necessary to investigate solar radiations in a large number of wavelengths, the future observatories must be able to point a number of instruments at the Sun continuously. At the present, Orbiting Solar Observatory is able to direct only two instruments at the Sun at a given time.

INTERPLANETARY SPACE

By far the greater distance traversed by men going to the Moon or to the planets will be through interplanetary space. This interplanetary space in the vicinity of our Earth and other inner planets is dominated by the Sun. We have already referred to the clouds of charged particles that are emitted from the Sun. At times of solar activity, such clouds of particles moving away from the Sun pull with them magnetic field lines which, however, remain rooted in the Sun (fig. 8, Solar Magnetic Effects). This process generates a huge tongue of expanding gas and magnetic field as shown in the diagram on the left side of the picture. Although it does not look much like one, the region of space enveloped by these solar magnetic field lines

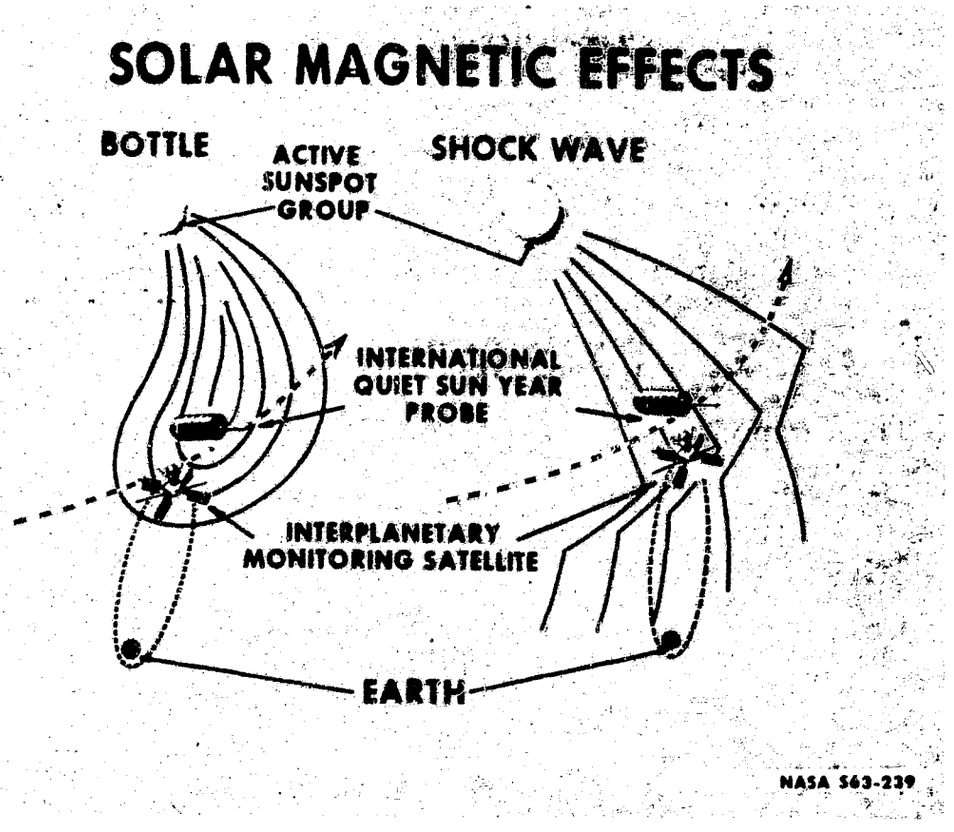

FIGURE 8

has come to be referred to as a magnetic bottle. The reason for the term "bottle" stems from the fact that the magnetic field lines serve to trap the clouds of charged particles from the Sun that find themselves in the interior of this region of space. Such particles, are therefore, confined as though they were indeed in a bottle.

Particles from the solar regions where the magnetic field lines of the bottle have their roots in the solar surface have relatively easy access to the interior of the bottle. As a consequence, the bottle may be expected to contain a high density of particle radiations. Thus, when such a magnetic bottle has reached out to envelop the Earth, the regions of space surrounding the Earth are more exposed to

solar particle radiations than at other times. In particular, at this time solar proton beams injected into the bottle will quickly make their presence felt at the Earth. Since these solar proton beams constitute the principal radiation hazard in interplanetary space, it becomes of importance to manned space flight to be able to determine when the Earth is enveloped in a magnetic bottle and to be able to predict the occurrence of solar proton events.

During the past year, Explorer XII provided valuable information on solar proton events, while the highly successful flight of Mariner II yielded valuable data on the interplanetary medium. Explorer XII showed that the radiation level in solar proton events is lower than earlier estimates had indicated, opening up the possibility of designing enough shielding into the Apollo spacecraft to protect an astronaut during a solar event. The exact amount of the shielding required is yet to be determined.

I would like to interpolate here, Mr. Chairman, one must keep in mind these observations are functions of time and these Explorer XII observations were made during the decline of solar activity so this is not an absolute statement that the solar proton events are necessarily always of lower intensity than had been previously thought. It's just in this period of time they turned out to be lower than had been previously thought.

It will be important for us in the next solar maximum to double check this to see whether in the period of solar maximum——

The CHAIRMAN. Even at this time the information we received from Mariner was rather startling, was it not?

Dr. NEWELL. That is correct.

The CHAIRMAN. We did suspect it would be substantially higher than it was.

Dr. NEWELL. We thought it might well be, and you know we found the radiation in interplanetary space is in the nature of a solar wind, rather than a solar storm.

The Mariner II measurements of the wind of charged particles, or plasma, blowing outward from the Sun show that the wind always exists, although it was found to be quite variable in density and velocity. This spacecraft also measured the interplanetary magnetic field. While this field turned out to be a small fraction of the Earth's field intensity, the measurement did give numerical values of the strength and time variations of some of the forces that affect interplanetary particles.

These data permit the theorist to make some additional advances in understanding the normal medium of interplanetary space, and the influences of solar activity. There remain, however, numerous unanswered questions. How large a region of space does the proton beam from a solar event fill? How large a region of space does a magnetic bottle eventually cover? What happens to a magnetic bottle with the passage of time? Does it become separated from the Sun? Do shock waves produced by plasma clouds from the Sun introduce kinks in the magnetic field lines of these magnetic bottles, as shown in the diagram on the right side of the picture? If so, then particles spiraling along these field lines of the bottle will be reflected when they strike the kink. For a period, then, there will not be a direct path from the Sun to the Earth, and the Earth will be, in effect,

shielded from many of the solar particles until after the shock wave has passed beyond the earth.

In order to answer some of these problems, we are developing an interplanetary monitor satellite, which will be described in the latter half of this presentation. Also, to conduct similar measurements in far-distant interplanetary space, we are instrumenting Pioneer-type spacecraft to be launched during the International Year of the Quiet Sun. This spacecraft, and the experiments to be carried on it, will also be described later. The interplanetary monitor satellite and the deep space Pioneer will provide us with a powerful double-punch attack on these very important problems of interplanetary radiations and fields. They will permit us to obtain some of the answers to the questions put forth in the previous paragraph.

Mr. STAEBLER. Doctor, may I ask now a question which you may answer in your statement later; and if so, stop me.

The relevance now as to future operations here is that we could not go much beyond the Moon without having answers to these questions. Is that right?

Dr. NEWELL. That is one of the relevances, Mr. Staebler.

The importance of some of these questions is to determine how large a region such a magnetic bottle covers so as to know when we start out, let's say from the Earth, how long we will be in a region of high particle activity and on this, of course, will depend the amount of shielding you must introduce into the spacecraft, the amount of protection you must provide for equipment or crews.

Mr. STAEBLER. This is important, even on the Moon probe.

Dr. NEWELL. This is important even in the case of the Moon probe.

The CHAIRMAN. Doctor, was this interplanetary monitor satellite a project that came up as an afterthought? Why is it that although no request for funds was made during the last fiscal year, substantial funds were spent on the project?

Dr. NEWELL. The interplanetary satellite came up in the course of our learning about the conditions of outer space. As a matter of fact, in the next couple slides we will illustrate why it was important to introduce this into the program.

Our previously described collection of satellites was directed toward studying the Earth's magnetic field as scientists then thought it was.

Now, it has turned out in the course of our investigations that the shape of the Earth's magnetic field is quite different from what had been thought; it extends in some directions much farther from the surface of the Earth than had been thought.

It was therefore necessary to introduce a satellite with a more eccentric orbit even than the Eccentric Geophysical Observatory which was described last year.

The CHAIRMAN. What are you asking, $11.4 million?

Dr. NEWELL. $11.4 million.

The CHAIRMAN. What will be the magnitude of the program, let's say, over the remainder of the decade? What are we talking about in terms of total dollars for this program?

Dr. NEWELL. In the interplanetary monitoring satellite program we are thinking of one every 6 months for the next several years and—do you have the cost?

Mr. CORTRIGHT. No, I don't.

Dr. NEWELL. I don't have at my fingertips, the cost per shot of this device.

The CHAIRMAN. What do you plan to use as a booster?

Dr. NEWELL. This will be launched with the Delta rocket.

The CHAIRMAN. I wonder if you could give us a pretty good estimate of the cost of this total program for the record?

Dr. NEWELL. We will be glad to.

Mr. RANDALL. Mr. Chairman, one question.

Following the line of questioning of Mr. Staebler—isn't it important that since we have found that this magnetic field creates a possible shielding problem—shouldn't we get on with that as soon as possible?

I mean, you talk about 11 years here. You didn't say the number of shots, did you? One every 6 months for how many years?

Dr. NEWELL. We plan to use this satellite for the next several years through the interval of the quiet Sun and into the interval of the active Sun.

I may say that in this area of fields and particles in space, I believe we are in a very strong position to move ahead and get the needed measurements.

Our earliest measurements in space were made by Van Allen on the radiation belts and these have been continued by him, Simpson, Winckler, MacDonald, and others, so that we are in pretty good shape here. We are continuing our measurements with flights like the Pioneer I mentioned and with flights on the interplanetary monitoring satellite right through this period of the quiet Sun and into the next sunspot maximum period.

Mr. RANDALL. I'd just like to observe, it seems to me it's vitally important. You say the findings of Mariner and some of the others show that the intensity of the magnetic and interplanetary forces is not as great as maybe we believe, but, I think, you also said it is a question of timing and there may be further experiments.

It seems to me we should have that information as early as possible for a lunar flight to determine shielding and design and all these things.

Dr. NEWELL. I agree with you, Congressman Randall.

Mr. MOSHER. Mr. Chairman, just a question concerning procedure—do I assume correctly that what we are doing now is sort of a general survey, and that we will get back in dollars and cents terms to some of the details of this?

The CHAIRMAN. Each one of the budget items.

Mr. MOSHER. In the yellow books, later?

The CHAIRMAN. Yes.

Dr. NEWELL. Mr. Chairman, with regard to the question you asked earlier, the cost for seven flights of the interplanetary monitoring satellite, which is our present projection, will be $30 million total, approximately.

The CHAIRMAN. Thank you, Doctor. How much information do you get from one of these interplanetary monitor satellites that you do not get from the Pioneer?

Dr. NEWELL. The purpose of the interplanetary monitor satellite is to remain within the Earth-Moon system. The purpose of the Pioneer type spacecraft is to go out from the Earth to distances of up to 50 million miles. Between the two types of spacecraft, we can measure

conditions at different points in space, so that one can time the passage of, let's say, an event by Pioneer and then time its arrival in the vicinity of the Earth on the interplanetary satellite.

So, they do different jobs. The one does one thing. The other, another.

The CHAIRMAN. When do you plan the first flight, Doctor?

Dr. NEWELL. The first interplanetary monitoring satellite is scheduled for late this year.

Mr. CORTRIGHT. Pioneer starts at least a year later which is one of the differences. They are staggered.

Dr. NEWELL. The Earth's magnetic field both affects and is affected by these magnetic bottles just discussed. The general shape of the field is shown in this chart (fig. 9, Earth's Magnetic Field).

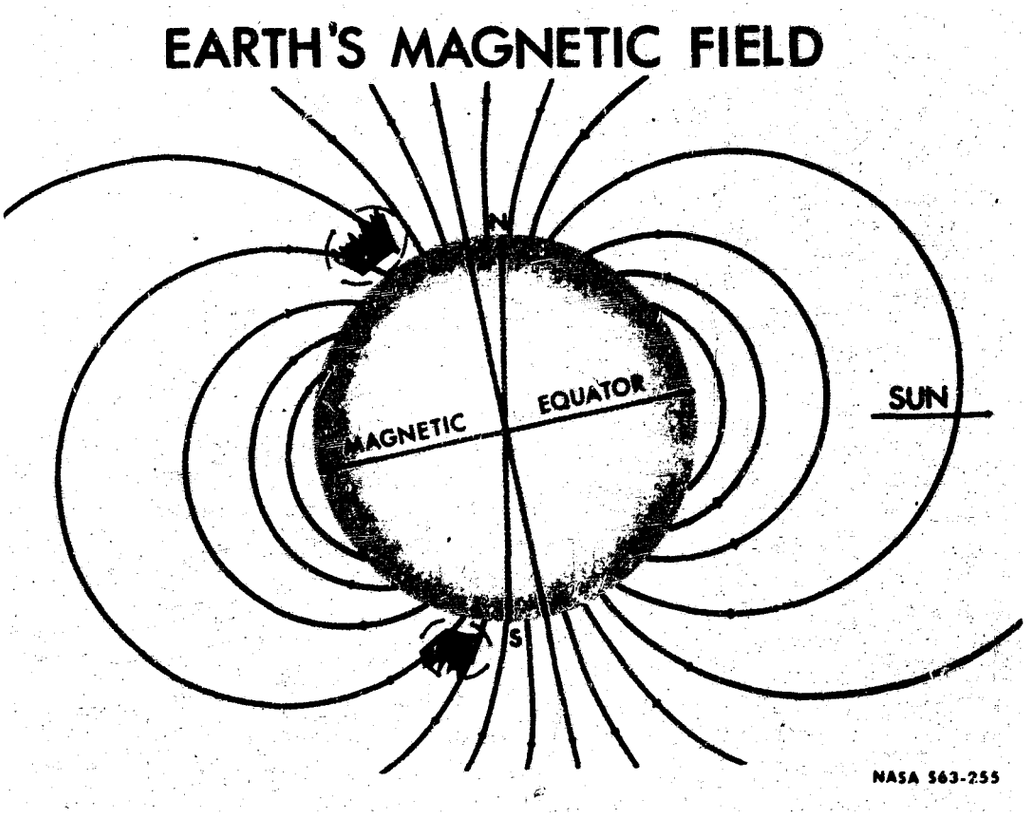

FIGURE 9

I should interpolate, this is the general shape one should expect if nothing were happening to it. It's the shape that a bar magnet has and is theoretically the shape to be expected of the Earth's magnetic field.

However, the solar wind mentioned earlier compresses the field lines on the sunlit side of the Earth and passes in a long wake on the dark side as shown in this chart here (fig. 10, Shape of Magnetosphere). This cavity formed in the solar wind by the Earth's magnetic field is called the magnetosphere. As the solar wind fluctuates, occasionally erupting in great gusts from solar flares, the magnetosphere boundary moves in and out on the sunlit side of the Earth.

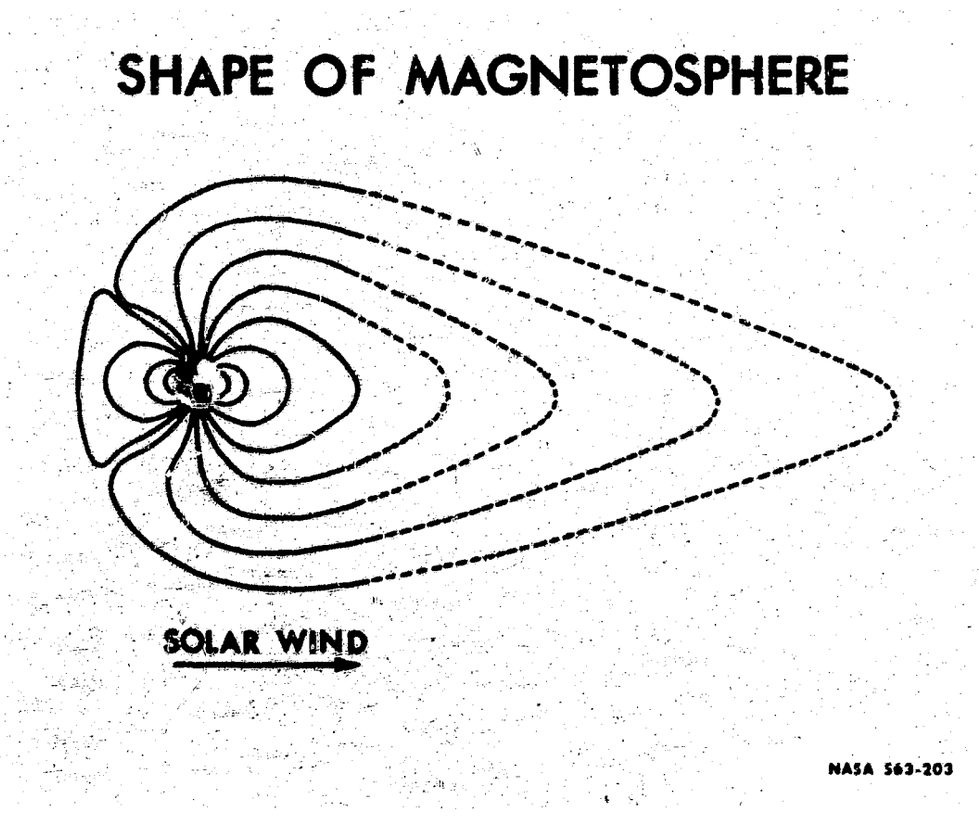

FIGURE 10

Results obtained during 1962 from Explorer X, XII, and XIV have been consistent with this shape. However, we have not been able to map out the boundary of the magnetosphere over large regions of space. Two of the satellites scheduled for launch during 1963 will contribute materially to the mapping of this boundary. First, the Eccentric Geophysical Observatory (EGO) will be making a large number of coordinated measurements of the magnetic field and the energetic particle population from a highly eccentric orbit extending some 60,000 miles from the center of the Earth.

The CHAIRMAN. Doctor, may I interrupt you right there. What is the importance of completely mapping the magnetosphere?

Dr. NEWELL. The magnetosphere contains the trapped particles that have been put in there by various solar activities and constitute a radiation belt around the Earth.

The mechanisms of how these particles get trapped in the region—in the magnetosphere, of how they arrive at the energies that we observe them to have, particularly during auroral disturbances and magnetic storms, and how they are lost into the Earth's atmosphere or wherever they go, are not understood.

These are important to understand because they have a bearing on what happens to the magnetosphere when you introduce such particles through nuclear explosions, for example.

They will have a bearing on how long such artificial radiation belts last and, therefore, on what effects such belts have on space stations

or spacecraft put into these regions, and on how long these effects will endure.

The CHAIRMAN. What you are saying, really, is that to get all the answers we want, we will need a continuous mapping program. Isn't that correct?

Dr. NEWELL. That is correct.

The CHAIRMAN. And it amounts to more than just scientific curiosity?

Dr. NEWELL. It amounts to more than just scientific curiosity. It's a practical matter of being able to operate and do what one may want to do in this region of space.

Mr. STAEBLER. Dr. Newell, is the effect of the magnetosphere felt only in communications or are there other effects?

Dr. NEWELL. There are other effects, Congressman Staebler, than just communications.

There are effects on sensitive materials—for example, solar cells used in power supplies or possibly on transistors used in the electronics of spacecraft in this region.

Also the radiation belt is sufficiently intense that as of the present time we know of no way to shield a manned space station adequately to permit it to orbit through this region continually without damage to the crew. In a very short time, in a matter of a few days or so, crews of any sort of space station we see how to build at the present time, would have been overexposed to harmful radiations.

Mr. STAEBLER. So this is a rather crucial point?

Dr. NEWELL. It is, indeed.

Since the angular position of the EGO orbit is fixed in inertial space, penetration of different portions of the magnetosphere will be accomplished as the Earth revolves around the Sun.

By "inertial space," for practical purposes, I mean "fixed relative to the stars."

The interplanetary monitor satellite will carry out a more compact group of measurements, carrying a considerably smaller payload to the much greater distances required to plot out the shape of the boundary of the magnetosphere on the dark side of the Earth. Here, if the theoretical picture is correct, these outermost contours extend out at least to 150,000 miles, which is 2½ times the apogee of EGO.

Perhaps I ought to explain that there is a little intricate geometry here.

My fist designates the Earth and the Sun is over in the direction of the wall to my left and we think of the orbit of the geophysical observatory as lying in this plane [indicating around wrist].

What I have said is that the plane of that orbit remains essentially fixed in space.

However, as the Earth moves around the Sun, the EGO orbit will in effect have drifted through the magnetosphere and in that way the Earth helps us to explore the magnetosphere.

To say this again, if the orbit were like this [indicating slanting position] as the Earth goes around the Sun, this, in effect, pulls the magnetosphere around through the plane of the orbit of the satellite so the satellite gets a chance to scan through the magnetic field.

The CHAIRMAN. It has the same effect as if the satellite orbit were changing constantly?

Dr. NEWELL. For all practical purposes that is the same effect. And, which, Mr. Chairman, is the reason why we felt we had to introduce the interplanetary monitoring satellite into the program.

Within the boundary of the magnetosphere lie the trapped particle belts (fig. 11, Magnetosphere). Protons and electrons populate the belt in equal numbers but with large spatial variations of energy. In some regions electrons are more energetic, and more easily detected; in others the protons are more energetic. Closest to the Earth lies a belt characterized by energetic protons. Superimposed on this belt is a decaying belt of energetic electrons contributed by a high-altitude nuclear blast last summer. Beyond this is a belt of protons of mod-

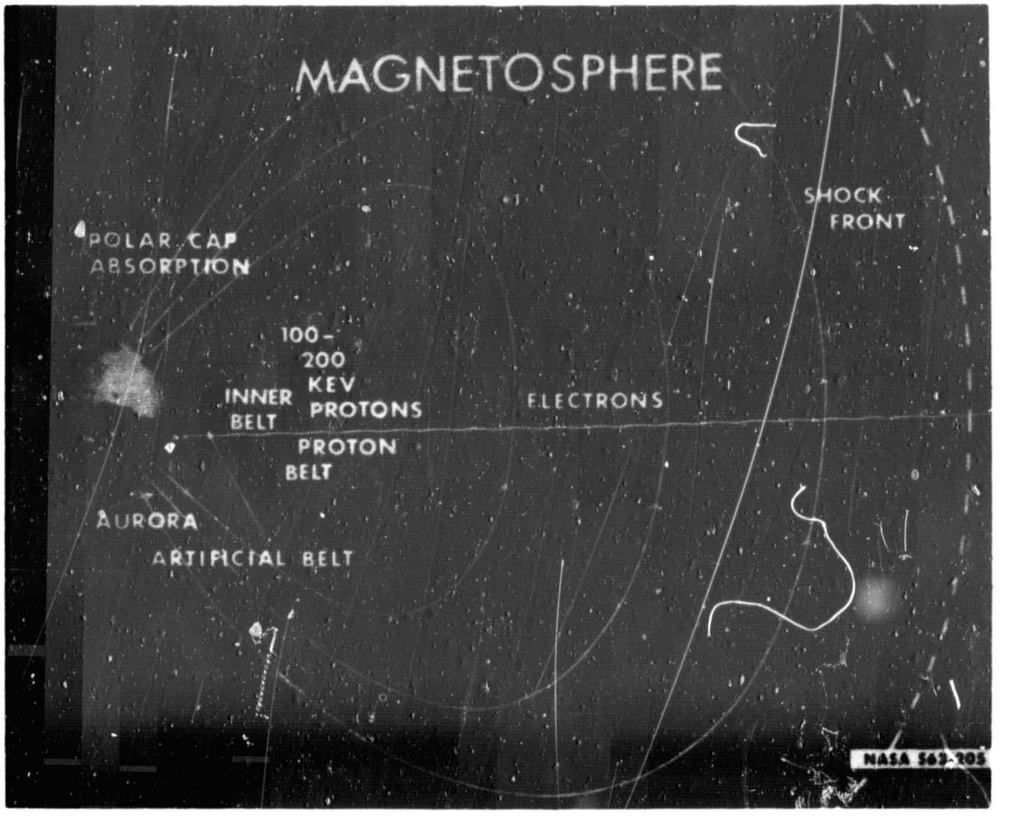

FIGURE 11

erate energy that exhibits considerable changes in intensity with time. The outermost belt is characterized by energetic electrons. This belt fluctuates by many factors of 10 with solar activity. Auroral activity and precipitation of electrons into the atmosphere at high altitudes are thought to be related to these fluctuations.

Mr. Chairman, this slide we have drawn to as nearly correct scale as we could, so that you do get a feeling for the size and extent of these belts with respect to the size of the Earth.

The CHAIRMAN. Doctor, where did we find the $5 million that we channeled into the interplanetary monitoring probe satellite? Where did we get that $5 million?

Dr. NEWELL. We will look this up for you.

To complete my last remark, this is the side facing the Sun so this is to correct scale, the size of the magneto section that is in the direction toward the Sun.

Would you like me to wait for this or continue?

The CHAIRMAN. You can insert it in the record any time you find it.

Dr. NEWELL. In our total reprograming of the Geophysics and Astronomy Program, we wound up with a net reduction.

In this reprograming, we were able to cover the $5 million about which you have inquired.

The CHAIRMAN. You mean you ended up with a net reduction? A net reduction from what?

Dr. NEWELL. A net reduction of funding applied to geophysics and astronomy over what we had discussed——

The CHAIRMAN. You spent less than you got, Doctor? Is that what you are saying?

Dr. NEWELL. In geophysics and astronomy we spent less than we had asked for last year.

The CHAIRMAN. Where did you put what you had left? Where did you program it to?

Dr. NEWELL. Mr. Chairman, this goes into an involved set of figures in detail. We have a piece of paper here which describes these changes and where the moneys went. We will be glad to furnish this to the committee for its study.

The CHAIRMAN. Well, we are very interested, Doctor, in finding out where moneys were reprogramed to and where they came from, and how much moneys are involved in dollars and cents value.

Dr. NEWELL. Well, may I suggest that we supply this outline of these figures and give the committee an opportunity to study these and then we'll be glad to answer questions on them.

The CHAIRMAN. OK, I had previously made a request for this information. I am not sure I can understand the information I received, and as a result, I again make the request, so it becomes a part of the record.

Dr. NEWELL. Fine.

Mr. RANDALL. We all know that every member of the committee receives, every week and sometimes daily, the mimeographed or the reproduced letters to the speaker.

Now, I know that this subcommittee couldn't follow through on all of the manned space flight program, or applications, or tracking and data acquisition, but I think the subcommittee should have a compilation of those requests as to the area of its inquiry; that is, space sciences and advanced research and technology. I assume that is what you were requesting, Mr. Chairman.

The CHAIRMAN. Yes, sir; that is correct.

Mr. CORTRIGHT. Mr. Chairman, I'd like to comment on that.

Your staff did ask NASA to submit a history or summation of our reprograming actions, not only within Geophysics and Astronomy, but all the Office of Space Sciences.

This list has been submitted and it will identify, for example, the fact there was a net reduction of $7.4 million in what we had initially intended to expend in geophysics and astronomy although the total expenditure within the Office of Space Sciences is up.

In other words, the various reprogramings throughout the course of the year to meet contingencies and other problems, resulted in numbers being allocated which are slightly different from what was in the budget book last year.

We have submitted these data to your staff.

The CHAIRMAN. Let me just pass this over to you, Mr. Cortright, and ask you to identify this as the submission you are talking about.

If it is, I think it deserves an explanation.

Mr. CORTRIGHT. That is the information.

The CHAIRMAN. Perhaps it's because it was just submitted to the staff late yesterday afternoon and I didn't have a chance to look at it until this morning a few brief minutes before the committee meeting started, but it doesn't really tell me how funds were reprogramed; that is, from what project to what project, from what area to what area.

Mr. CORTRIGHT. We are prepared to discuss that.

Dr. NEWELL. Perhaps I could run through a brief summary of the overall reprograming to give an overall picture of what has happened.

The total R. & D. budget for space sciences to be the sum of $479,493,000 for fiscal 1963.

The CHAIRMAN. This was your budget request?

Dr. NEWELL. That was the budget request.

Mr. MOSHER. What was that total?

Dr. NEWELL. That was $479,493,000 for the research and development portion of our budget.

The CHAIRMAN. Doctor, may I interrupt to ask if you have some more of these?

Dr. NEWELL. I am sure I do.

The CHAIRMAN. Could we have one for each member of the subcommittee, and put it in the record, too, please?

Dr. NEWELL. Certainly.

(The information requested follows:)

Office of Space Sciences, fiscal year 1963 reprograming status of OSS research and development funding through January 1963

[Thousands of dollars]

Program/project	Fiscal year 1963 budget	Fiscal year 1963 column, fiscal year 1964 budget	Commitments	Obligations
Total, Office of Space Sciences	$479,493	$525,279	$361,556	$269,119
Geophysics and astronomy	151,900	144,500	98,646	79,377
S.R. & T	16,500	13,700	9,600	5,658
Energetic particles	200	10,500	8,067	7,547
Interplanetary monitor		5,000	4,714	3,983
Atmospheric structure	200	4,000	3,072	2,909
Topside sounder (S-48)	200	1,000	514	436
Ionosphere monitor	2,000			
OGO	55,100	38,500	23,238	19,590
OSO	13,600	11,350	7,028	4,942
OAO	42,700	36,100	29,317	27,311
International	5,400	12,850	6,876	4,644
Sounding rockets and geoprobes	16,000	11,500	6,220	2,357
Lunar and planetary	246,300	221,179	156,198	148,529
S.R. & T	10,760	20,244	13,409	10,895
Ranger	42,022	78,970	59,481	59,408
Surveyor	95,678	61,696	42,100	39,800
Prospector	10,000			
Mariner (Venus flyby)	9,240	9,096	9,096	9,096
Mariner (Mars flyby)		29,400	24,320	24,320
Mariner (lander)	72,100	18,273	5,000	5,000
Voyager	6,500			
Pioneer		3,500	2,792	10
Bioscience	7,093	21,000	6,161	2,911
S.R. & T	3,000	10,050	5,861	2,890
Flight program	4,093	10,950	300	21
Launch vehicle development	64,200	108,000	81,776	38,134
S.R. & T		2,000	600	
Scout	4,200	4,200	2,821	1,251
Centaur	60,000	92,900	78,355	36,883
Operational support		8,900		
Sustaining university program	10,000	30,600	18,775	168

Dr. NEWELL. If you look at the yellow books in our budget submissions this year, you will observe we are actually operating in the fiscal year 1963 on the budget of $525,279,000, which is an increase of $45,786,000.

Now, this comes about as follows:

We initiated a flight program in biosciences and began developing experiments to support this at an increase of $13,907,000.

This is a program that was in its very formative stages as a result of the reorganization of NASA at the time we appeared before the committee last year.

The CHAIRMAN. That was in biosciences, Doctor?

Dr. NEWELL. That is in fundamental biosciences, that is correct.

We increased our effort on Centaur, in order to hold an operational date of 1964. Including an increase in operational ground support to the Centaur program this added up to $43,800,000.

The CHAIRMAN. I thought it was $32 million here, according to the chart I have.

Mr. CORTRIGHT. That is $32 million, plus the operational support item.

Dr. NEWELL. My figure said, "including an increase in operational ground support," this increased the budget by $43,800,000.

The CHAIRMAN. Then you see what we have is only part of the picture, don't we? What does $92,900,000, for example, represent? If it doesn't include operational support, what does it include? Salaries and expenses, hardware?

Mr. CORTWRIGHT. It includes research and development costs—yes, sir; all of that.

The CHAIRMAN. Everything but operational support?

Mr. CORTRIGHT. The operational support brings it up to the full $101 million.

Dr. NEWELL. You have the operational support figure there? It is the eight point something——

The CHAIRMAN. Eight—nine——

Dr. NEWELL. Below there. If you add those.

The CHAIRMAN. That is operational support vehicle program.

I don't know if that is applied specifically and entirely to Centaur or whether it's scattered around.

Mr. CORTRIGHT. Almost entirely to Centaur. One thing that we would be happy to do, Mr. Chairman, because we recognize that a simple listing of numbers like this cannot be entirely meaningful, is to have our people meet with your staff and fully brief them on how these numbers were arrived at.

The CHAIRMAN. Well, no reflection on the staff, Mr. Cortright, but I'm not sure that necessarily benefits the members of the subcommittee to the extent I'd like to have it.

On many occasions this information doesn't get from the staff to all of the members of the subcommittee. Might get to me, for example, or some other members of the subcommittee; but I would prefer each member of the subcommittee would be as completely informed as he can be.

So if you could—maybe as we go along these things will be explained and, if so, we'll need no further information.

Mr. MOSHER. This reference to an increase of $49 million; is that fiscal year 1963 or fiscal year 1964? Which are you talking about?

Dr. NEWELL. I beg your pardon?

Mr. MOSHER. You referred to an increase of $49 million plus. Were you talking about fiscal year 1963 or fiscal year 1964?

Dr. NEWELL. We are talking about fiscal year 1963 in the figures I have been giving out.

Mr. MOSHER. This $49 million was in addition to your original R. & D., in the space sciences?

Dr. NEWELL. The increase of $45,786,000 was an increase in our budget for space sciences.

Mr. MOSHER. Over and above the original 479?

Dr. NEWELL. That is correct; yes. Perhaps I should continue with this overall summary.

I should like to emphasize we will be pleased to speak to each individual item as it comes up, but it may be worth while to have this summary to integrate it at this time.

The CHAIRMAN. Yes, I think so, Doctor.

Dr. NEWELL. We also increased our sustaining university program by $20,600,000 from its original $10 million figure. Now, these major increases totaled $78,307,000.

Mr. MOSHER. What was that again?

Dr. NEWELL. The sum of the major increases, the biosciences, Centaur, and the sustaining university program increases is $78,307,000.

Now, in order to partially offset these increases, we reprogramed within the Office of Space Sciences in the geophysics and astronomy area, decreasing the total by $7.4 million and in the lunar and planetary area, decreasing the total by $25.121 million.

The CHAIRMAN. And how did you effectuate this decrease in the lunar and planetary programs? What items, Doctor? Could you be more specific?

Dr. NEWELL. I'll be glad to go into that.

You will note the sum of these decreases when subtracted from the $78,307 million figure gives the net reduction of $45,876,000, the figure that I quoted earlier.

Now in the geophysics and astronomy area we had a number of things that influenced our programing and resulted in reprograming.

First, there were the high-altitude nuclear tests. Immediately following the detection of the increased trapped radiation surrounding the earth, we initiated a project to investigate it. This was an opportunity that could not have been anticipated.

By using existing parts and technology and rescheduling a Delta launch vehicle, we were ready to launch about 2 months after "go ahead."

The cost was about $10 million. This was a cost we had to cover that had not been planned on.

Also during the past year it was determined that we needed more data on solar radiation, to prepare for manned flight to the Moon. We thus initiated a series of three small Delta launched spacecraft called interplanetary monitor. This is the interplanetary monitoring satellite we have already mentioned. This project, which will have its first flight this year, required $5 million in fiscal 1963. It also was a project not covered in our planning at the beginning of last year.

In addition, there was an opportunity to cooperate with the Italian Government on atmospheric research by means of equatorially launched satellites and our part in this program required $6 million in fiscal year 1963.

Now these constitute increases required in the area of geophysics and astronomy.

Decreases, in order to take care of this, and to help counterbalance the total Office of Space Sciences increases, went as follows:

The supporting research and technology effort was reduced by $2.8 million.

We saved $2 million on an ionosphere satellite by virtue of the fact the Canadians have indicated they will build this satellite and pay for it.

We reduced the orbiting geophysical observatory costs by rescheduling the follow-on launches after the first launch for a slower rate at a rate of three per year, rather than four per year.

This resulted in a reduction of fiscal 1963 fund requirements of $16.6 million.

Because of the success of the Orbiting Solar Observatory No. 1, we were able to defer the second launch, thus reducing the fiscal 1963 requirements by another $2.2 million. OSO I is still operating, as

the committee may know, although at the present time it's just limping along.

The Orbiting Astronomical Observatory has slipped due to technical difficulties and we have rescheduled the follow-on launches so as to have one every 9 months instead of one every 6 months as we told the committee last year, hoping therefore, to obtain a reduction of $6.6 million in the fiscal 1963 requirements.

Lastly, we reduced the sounding rocket and geoprobe costs by $4½ million by eliminating Scout-sized rockets.

The CHAIRMAN. Eliminating what?

Dr. NEWELL. Scout-sized rockets. Scout, you see, gets to be a rather large sounding rocket; it is costly, and is the "tail that wags the dog" in the sounding rocket and geoprobe program, so we have pulled that out of this area for this year.

Also, the Office of Applications is conducting a meteorological sounding rocket program, so that we in OSS do not have to.

In the lunar and planetary area, as I mentioned, the net reduction was $25,121,000. We have had to increase supporting research and technology by $9,484,000 to permit additional study effort on advanced programs before we plunge into hardware funding on such programs.

The CHAIRMAN. What programs, specifically, Doctor?

Dr. NEWELL. Voyager would be an example of one such.

The CHAIRMAN. How about the Ranger?

Dr. NEWELL. Operating funds for JPL also constitute a function of this money, because their general supporting funds support all of their programs for Ranger, Surveyor, and others.

Project Ranger was increased by $36,948,000 to provide initial funding for 5 additional flights bringing the total of approved flights to 14, with 5 of them already complete.

The CHAIRMAN. Let me ask you, Doctor.

Why did we decide we needed five additional Ranger flights, because the first five weren't very successful?

Is that the reason?

Dr. NEWELL. Well, we feel we must get data on the lunar surface as soon as possible and in order to do this, we wish to make full use of the Ranger vehicle.

The Surveyor, as you know, is designed to initiate our first really all-out attack on this problem, but the Ranger is capable, when it gets to operating—of giving us very valuable initial information.

We feel that we must make full use of this approach while we are developing the Surveyor approach.

The CHAIRMAN. How much of this additional $37 million for the Ranger program is going into redesigning the spacecraft? Is this just for the five additional Rangers, or is a certain percentage of this money going into redesigning?

Dr. NEWELL. This is primarily for the five additional flights.

Much of the redesign involved in these funds is to do different things with the Ranger spacecraft—to make different measurements, rather than redesigning the basic spacecraft.

For example, the Ranger can be used for taking television pictures. We plan to do that in the next block of Rangers.

It can be used for making measurements of the radioactivity of the planet, and the magnetic field of the Moon.

It can be used for implanting such things as seismographs on the planetary surface.

We even have a scheme in mind that has been proposed to us for taking very high resolution pictures of the Moon from a landed capsule.

The Ranger, you see, can be used for all of these.

The CHAIRMAN. We are not saying we don't have this program set in concrete, are we, Doctor?

Dr. NEWELL. No, we are not.

The CHAIRMAN. You said we "could" use this kind of experiment, or there is a "possibility" we may have this kind of experiment.

We are not floating around here, very loosely, just attempting to settle on the experiments we should fly on these Rangers, are we?

Dr. NEWELL. No, the situation is as follows:

With respect to the next block of Rangers, this is already set in concrete.

The instrumentation is designed and built.

The hardware is ready, and a prototype is undergoing a series of tests to validate it for flight.

The next block of Rangers will carry a set of experiments to be selected in the near future.

The CHAIRMAN. That is the five additional ones you are talking about?

Dr. NEWELL. No, that's preceding the five additional.

The CHAIRMAN. Preceding or——

Dr. NEWELL. That is the five additional.

The CHAIRMAN. That is the five additional?

Dr. Newell, when you talk about this next block, what does that mean on the calendar?

Dr. NEWELL. The next block of Rangers consists of a group starting toward the end of 1963.

Mr. MOSHER. Of this year?

Dr. NEWELL. Of this year.

Mr. MOSHER. It's in fiscal year 1964 then?

Dr. NEWELL. Yes.

The CHAIRMAN. For which we are now funding because of the lead-time involved, right, Doctor?

Dr. NEWELL. Yes.

Mr. MOSHER. You are satisfied with the Ranger; it is a basic, useful vehicle, even though you have had some problems?

Dr. NEWELL. We are satisfied the basic design is valid and that it will be a useful vehicle.

The problem that faces us is to do the right things to make it work and these things can be done and we intend to.

The CHAIRMAN. OK, do you want to go to Surveyor, now?

Dr. NEWELL. Project Surveyor was decreased $33,982,000.

Mr. RANDALL. Would you repeat that again?

Dr. NEWELL. Project Surveyor was decreased by $33,982,000.

However, it does continue as a high priority project.

About two-thirds of this decrease resulted from deferral to fiscal year 1964 of the lunar orbiter.

The balance resulted from the fact that Centaur slipped which postponed the date on which Surveyor operational projects would buy their own launch vehicles and be charged for them.

The CHAIRMAN. Doctor, I wonder if we could bring our hearing for today to a conclusion at this point.

Dr. NEWELL. Surely.

The CHAIRMAN. We do not have permission to sit during a session of the Congress, and I notice that some of our members have had to leave for various reasons.

Could we continue this at 10 o'clock tomorrow morning, and then we can get on with your prepared statement.

Dr. NEWELL. Be glad to do it.

Mr. RANDALL. Before we adjourn, one question.

I think what I am going to say is probably true of some of the other members.

I don't know whether it is possible to have a transcript of the testimony; I'm sort of lost, without any back-up figures, unless we can get them from the record here.

I have tried to follow, as best I could, these pluses and minuses, but I am considerably far behind. I would like Mr. Chairman, either permission to have the record or something to proceed on tomorrow.

The CHAIRMAN. I have asked Dr. Newell for additional copies, and I understand we will be supplied with them and have them on your desk tomorrow morning.

Mr. RANDALL. All right, thank you.

The CHAIRMAN. Thank you very much, Dr. Newell.

Dr. NEWELL. You are welcome, Mr. Chairman.

The CHAIRMAN. The meeting is adjourned until 10 a.m. tomorrow.

(Whereupon, at 12:02 p.m., the subcommittee adjourned until 10 a.m., Thursday, March 7, 1963.)

1964 NASA AUTHORIZATION

THURSDAY, MARCH 7, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SPACE SCIENCES
AND ADVANCED RESEARCH AND TECHNOLOGY,
Washington, D.C.

The committee met at 10 a.m., pursuant to call, in room 214–B, New House Office Building, the Hon. Joseph E. Karth presiding.

The CHAIRMAN. The meeting will come to order.

Dr. Newell, yesterday, if I recall correctly at the time we adjourned, you were explaining to us the reprograming of funds on Project Surveyor. Would you like to continue with that, and then we can go back to your statement.

FURTHER STATEMENT OF DR. HOMER E. NEWELL, DIRECTOR, OFFICE OF SPACE SCIENCES, NASA, ACCOMPANIED BY EDGAR M. CORTRIGHT, DEPUTY DIRECTOR

Dr. NEWELL. Thank you, Mr. Chairman.

I believe all members of the subcommittee now have a copy of the summary portion of my posture hearing testimony with numbers inserted into it.

I thought before I continued, I might explain the meaning of those numbers.

It was this piece of paper that I was looking at when I was discussing the numbers on the other piece of paper, that doesn't have the text. You will note that wherever there is a number such as in the second line on the first page, $479,493,000 that there is also another number in parentheses.

I was giving you the first number which is research and development. The second number, for the sake of completeness, is research, development, and operations, the expenses of salaries, operating centers, and so on.

We had gotten down to page three, the bottom of the first paragraph in Lunar and Planetary, and I was about to say, as the committee recommended last year, we eliminated Project Prospector which saves $10 million in R. & D.

Then in the area of planetary projects, the total funds were decreased about $27½ million in R. & D. and this came about as follows:

Centaur delays forced us to rely on the Atlas-Agena for the 1964 flybys rather than using Centaur for landers. We therefore deferred Centaur launched landers until 1965. Also, Mariner II was so successful that the 1964 Venus flyby was canceled. The purpose here

was to prepare for more sophisticated Venus experiments before we go ahead with another Venus attempt. But, we are continuing with the Mars flyby in 1964 under high priority.

Also, the Voyager project did not go into hardware stage. This has been deferred, at least another year, to continue with a study phase in fiscal 1964.

We have one new start in the Lunar and Planetary area; one that I mentioned in my prepared testimony yesterday. This is to use Pioneer type deep space probes during the International Year of the Quiet Sun. This costs $3½ million in R. & D. in fiscal year 1963, and is to provide radiation and field measurements from distances up to 50 million miles from the Earth throughout the International Year of the Quiet Sun.

Mr. RANDALL. What calendar year is that, Doctor?

Dr. NEWELL. That covers 1964 and 1965.

Mr. RANDALL. Thank you.

Dr. NEWELL. Although they call it the Year of the Quiet Sun, it's really a several-year time period spanning the minimum of the sunspot cycle.

Mr. RANDALL. I see, thank you.

The CHAIRMAN. Doctor, I think unless there are specific questions the members have in mind they would like to ask at this time, we will just defer on becoming more specific in this dollar and cent area. So, finish your prepared statement.

Would you like to do it that way?

Dr. NEWELL. Surely.

Then should I submit this for the record?

The CHAIRMAN. Yes, please.

Dr. NEWELL. I believe I've already pointed out that this is the same as the summary portion of my posture hearing but with the numbers inserted.

The CHAIRMAN. Correct. I think it might be a good idea to insert this summary sheet at this point in the record.

(The information referred to is as follows:)

SUMMARY

To first summarize the reprograming, the total R. & D. budget for OSS was submitted as $479,493,000 ($535,427,000) for fiscal year 1963. Our budget submission this year shows that we are actually operating in fiscal year 1963 on a budget of $525,279,000 ($578,874,000), an increase of $45,786,000 ($43,447,000). What caused this increase? We initiated a flight program in Biosciences and began developing the experiments to support it at a new increase of $13,907,000 ($18,019,000). We increased our effort on the Centaur in order to hold an operational date of 1964. Including an increase in operational ground support this increased our budget by $43,800,000 ($45,616,000). Lastly, we increased our Sustaining University Program by $20,600,000 ($21,666,000) from its original $10 million figure. These major increases totaled $78,307,000 ($85,301,000).

To partially offset these increases, the Geophysics and Astronomy Program was decreased by $7,400,000 ($15,691,000) and the Lunar and Planetary program by $25,121,000 ($26,163,000). These reductions left a new requirement of $45,786,000 ($43,447,000) which was added to the Space Science program.

Within the individual elements of our programs, other reprograming actions were required and they fall within these gross changes.

***Geophysics and Astronomy.*—A significant event which influenced our programing this year was the high altitude nuclear tests. Immedicately following the detection of significantly increased trapped radiation surrounding the Earth, we initiated a project to investigate it. By using existing parts and technology and rescheduling the Delta launch vehicle, we were able to launch about 2 months**

after go-ahead. The flight was highly successful in determining the nature, extent, and probable lifetime of the artificial belt. Its cost was about $10 million ($11,975,000) for two flights, the second of which has now been deferred.

During the past year, it was determined that we needed more data on solar radiation to prepare for manned flight to the Moon. Solar monitoring should be nearly continuous until we understand the Sun and its disturbances much better than we do now. We thus instituted a series of three small Delta-launched spacecraft called Interplanetary Monitors, which will orbit the Earth in highly eccentric orbits. This project, which will have its first flight this year, required $5 million ($7,410,000) in fiscal year 1963.

In addition we have completed negotiations with the Italian Government and are underway with a cooperative program which will culminate in an equatorial launch by a Scout of an Italian satellite. The launch will take place from a platform in the Indian Ocean off the east coast of Africa in 1964. Our part of this program is $6 million ($6,712,000) in fiscal year 1963.

These constitute most of the increases within Geophysics and Astronomy in fiscal year 1963. Decreases in other projects have more than counterbalanced this. The S. R. & T. effort has been reduced thereby permitting a reprograming of $2.8 million ($11,768,000). $2 million ($2,983,000) was saved on the Ionosphere Monitor by the decision of the Canadians to develop this satellite as they did the highly successful Alouette. We will again provide the launch services. It was possible to reduce the OGO project costs by rescheduling the follow-on launches for a later start and a launch rate of three per year rather than four. This resulted in a reduction of fiscal year 1963 fund requirements of $16.6 million ($15,428,000). The success of OSO–I permitted us to defer the second launch while making some improvements, thus reducing fiscal year 1963 requirements by $2.2 million ($2,671,000). OAO has slipped due to technical difficulties. We also rescheduled the follow-on launch and reduced the rate from every 6 months to every 9 months, thus hoping to operate at $6.6 million ($6,288,000) less in 1963. The last saving in G. & A. is the $4.5 million ($8,413,000) in sounding rockets and geoprobes. This was made possible by eliminating Scout-sized rockets, and by the fact that meteorological sounding rockets were funded by the Office of Applications.

Lunar and Planetary.—A number of important changes accompanied the net reduction of $25,121,000 ($26,163,000) in the L. & P. program. The increase in S. R. & T. was necessary to permit additional study effort on advanced programs such as Voyager in lieu of hardware funding. Operating funds for JPL research constitute a major function of this money. Project Ranger was increased $36,948,000 ($35,797,000) to provide initial funding for five additional flights, bringing the total of approved flights to 14, with 5 already complete. This increase reflects the urgency of getting some early information about the lunar surface in support of Apollo. Project Surveyor was decreased by $33,982,000 ($34,746,000) although it continues as a high priority project. About two-thirds of this resulted from deferral to fiscal year 1964 of the lunar orbiter. The balance resulted from the Centaur slippage which postponed the date on which operational projects, such as Surveyor, will be charged for developed launch vehicles. Project Prospector was eliminated with a saving of $10 million ($10,400,000).

In the area of planetary projects, the total funds were decreased about $27.5 million ($27,265,000). This occurred as follows. Delays in the Centaur forced us to rely on the Atlas-Agena in 1964 for fly-bys rather than landers. The Centaur-launched lander was thus deferred to 1965. Mariner II was so successful that the 1964 Venus fly-by was canceled. The Mars fly-by in 1964 is proceeding under high priority. The Voyager project has been deferred at least another year and will continue with additional studies in fiscal year 1964.

We did have one new start in the L. & P. area. Project Pioneer, costing $3.5 million ($4,070,000) in fiscal year 1963, will provide radiation and field measurements from distances up to 50 million miles throughout the International Year of the Quiet Sun. These measurements will support our national participation in the worldwide program as well as support our own efforts to understand the Sun and its disturbances.

Biosciences.—For several years we have been carefully studying the need to conduct fundamental experiments in the biological sciences in the radiation and weightless environment of space. The Soviets decided early and have conducted short duration flights. We have now determined that the need is for flights of very long duration, i.e., 2 weeks up to a year or more. These tests will initially be exploratory and will serve to determine the most promising areas for

future studies. The longest duration flights will answer questions posed by manned planetary flights which will exceed 1 year. This program will cost an additional $13,907,000 ($18,019,000) in fiscal year 1963, equally divided between the flight programs and the supporting experiments.

Sustaining University Program.—This program is designed to enable our universities to develop their full potential in support of the national space program. Where outstanding research teams exist and can help if funded, or where such teams can be built up with funds, such supporting research funds are provided. Where these groups are in dire need for facilities, they are provided. And where outstanding faculty groups are available to train more young men in graduate work, fellowships are provided to encourage such advanced study. The increase of $20.6 million ($21,666,000) in fiscal year 1963 over that amount programed in our first submission provides for a total of $15 million for training grants, $5.6 million for multidisciplinary research in support of our total program, and $10 million for needed facilities.

Launch Vehicle Development.—The need to increase our launch vehicle development funds was known and discussed with you last year. Nearly all of this $43.8 million ($45,616,000) increase was required to rectify technical problems in the Centaur development. These steps, which I will discuss with you at a later hearing, are well underway and we now feel that we are coming out of the woods on this project—although much remains to be done. Among the major requirements for these additional funds were increased ground testing of the total system and its major subsystems; structural improvements; insulation panel improvements; and stage separation improvements. In general we are ruggedizing this vehicle and simplifying its mission profile to reach operational status late next year.

Dr. NEWELL. I believe we had arrived at page 23, the top of the page in my prepared testimony. We had been talking about the Earth's magnetosphere and I was about to point out that in the magnetosphere some of the electrons can be stopped by a few thousandths of an inch of glass; others more energetic will penetrate one-half inch of aluminum. Some electrons arising from the nuclear blasts can penetrate several inches of aluminum. Further, they are damaging to unprotected solar cells which have only thin shielding.

There are many questions about both the natural and artificial radiation belts still to be answered. What are the sources of the trapped particles in the magnetosphere? How do the particles acquire their tremendous energies? What are their lifetimes in the magnetosphere? What is the role, if any, of hydromagnetic waves or shock fronts, and radio waves, in accelerating the trapped particles to their energies? What is the relationship between the magnetosphere and such phenomena as magnetic storms, the aurora, and communications blackouts?

We are attacking these and other similar problems by flying a coordinated set of experiments on the Orbiting Geophysical Observatory later this year. One hundred and fifty pounds of experiments, including magnetometers, plasma detectors, and very low frequency radio propagation experiments, are being flown in the highly eccentric orbit that will range from well below the trapped radiation out through the boundary of the magnetosphere and into interplanetary space in the sunward direction.

THE IONOSPHERE

The Earth's ionosphere, which ranges from 30 to several hundred miles in altitude, is produced by the ionizing action of solar electromagnetic and particle radiations (fig. 12, Ionosphere) that is, light and particles. These electrified regions of the upper atmosphere act as mirrors to radio waves shorter than 15 meters in wavelength, thus

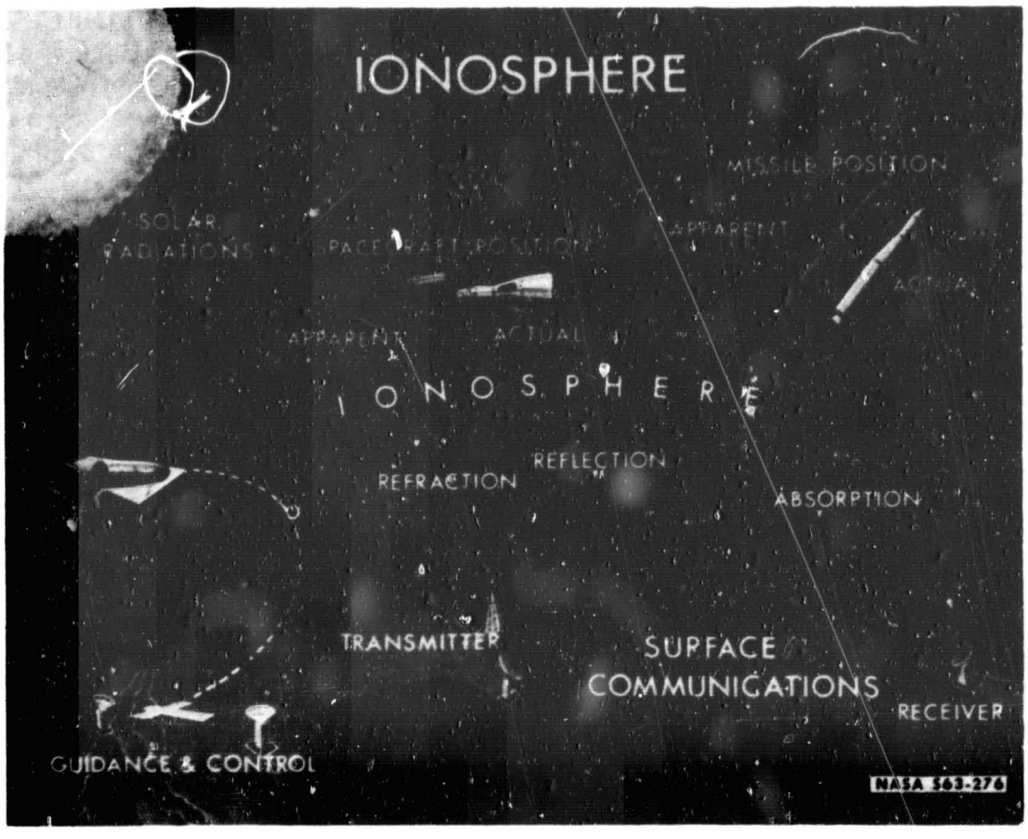

FIGURE 12

making possible shortwave radio communications beyond the horizon as indicated on the chart. Because of the high variability of the ionosphere with solar and magnetic activity, however, the mirror is not a very reliable one.

Radio waves that are not reflected or perhaps absorbed by the ionosphere may be bent in passing through this region. As shown in the lower left-hand corner of the slide, radio waves used to guide and control a flying vehicle are bent, thus affecting the accuracy with which such an operation can be carried out.

Similarly, as shown in the upper middle of the slide, the tracking of a spacecraft to determine its position is affected by the influence of the ionosphere on the tracking signals. One of the first steps required in making the transit satellite useful as a navigational device was to remove ionospheric refraction errors from the determination of the satellite's position. Likewise, the determination of the position of an outgoing space vehicle or perhaps an incoming enemy missile can be made with accuracy only if the ionospheric refraction errors are taken into account and corrected.

The lower portions of the ionosphere below 150 to 200 miles can be investigated by means of radio signals from the ground, but the uppermost regions are inaccessible to ground-based probing. For this reason they must be studied by means of rocket-borne or satellite instruments. One of the most interesting and successful satellites to be launched during 1962 was the Alouette swept-frequency topside sounder satellite. This was launched in a cooperative program, in

which the satellite was built by Canada, while the United States furnished the launch vehicle and conducted the launching operation. This satellite, which has worked perfectly, uses radio signals to look down on the ionosphere from above, thereby measuring the electron content of the ionosphere above the altitudes that can be examined with ground-based techniques.

Alouette has produced excellent data, some of which has already been analyzed. As so often happens, these measurements have revealed an unexpected structure in the ionosphere, particularly in the equatorial regions. Other satellites are now required to study these new features. In association with sounding rockets measuring properties of the ionosphere below 120 miles, such satellites are advancing our understanding of this important region to a degree absolutely impossible when man and instrument were both confined to the surface of the Earth.

THE EARTH'S ATMOSPHERE

Contrary to supposition of half a century ago, the Earth's upper atmosphere is an exceedingly complex system. The next chart (fig. 13, Characteristics of the Earth's Atmosphere), which I do not intend to discuss in detail, presents schematically only a small fraction of the tremendous body of information that has been acquired about the upper atmosphere, much of it from sounding rockets and Earth satellites. Involved in a study of the Earth's upper atmosphere are its pressure, temperature, density, composition, motions, the ionosphere,

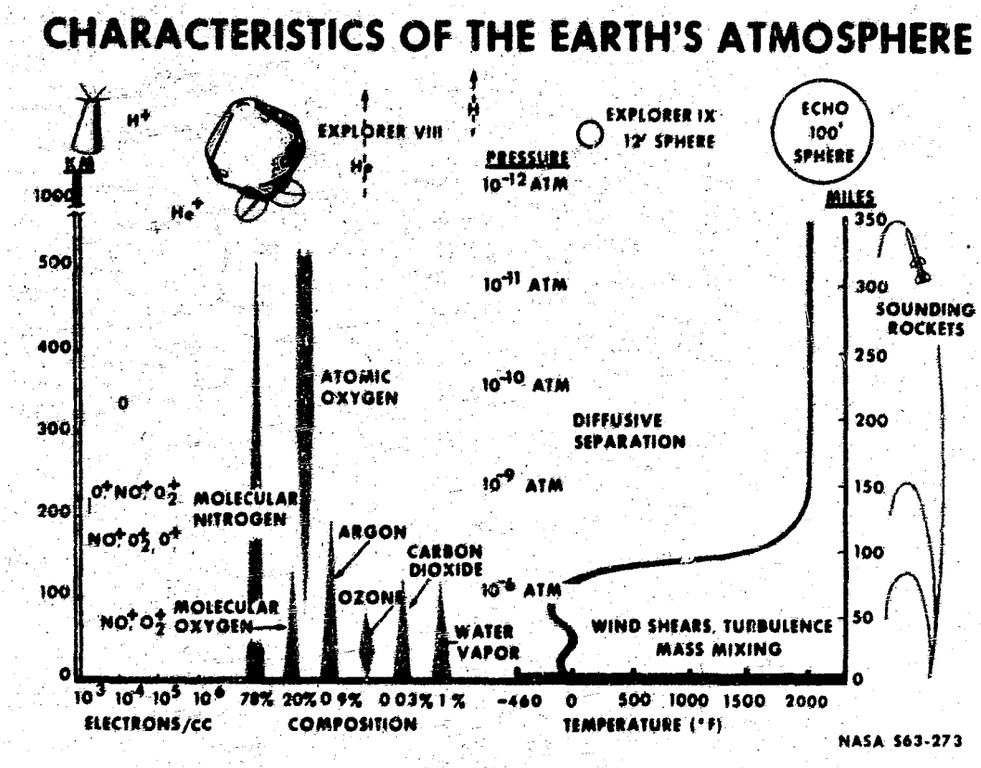

FIGURE 13

the aurora, airglow, the magnetic field, separation processes, absorptions of solar radiations, micrometeors, and solar and lunar tides. The student of the atmosphere very quickly finds himself concerned with the very complicated subject of solar terrestrial relationships.

I wish to present now a few of the more recent important results of atmospheric research, and to indicate to you our plans for further investigation of this important subject.

Satellite observations have now demonstrated clearly that there exists a distinct helium layer in the upper atmosphere beginning at about 600 miles. At still higher altitudes this helium gives way to a region in which hydrogen predominates.

The average temperature during the past 2 years in these uppermost portions of the atmosphere has been found to be 2,000° F. There is, however, a diurnal variation in temperature. During the 1959 time period this variation ran from about 2,800° F. in midafternoon, down to about 1,350° F. in the hours just before dawn. Moreover, all three of these temperature values—minimum, maximum, and average—have been shown by Dr. Priester, who recently spent some time with the Goddard Institute for Space Studies in New York, to have a definite correlation with solar activity. For example, Dr. Priester predicts that at the low point of the present solar cycle in 1964, the predawn temperatures in the upper atmosphere will be 440° F., as compared to almost 2,250° F. for times near the solar maximum.

Temperature variations in the upper atmosphere have an important and substantial effect on the orbits of artificial satellites. With increasing temperature, the height of the atmosphere also increases, raising the atmospheric density at the higher altitudes. This thickening of the Earth's atmosphere increases the atmospheric drag on artificial satellites, markedly affecting their velocity below about 620 miles altitude and decreasing their lifetime in orbit. Such effects would, of course, be felt by any object falling through these regions, as for example, manned spacecraft, reentry vehicles, and winged vehicles.

The winds and turbulence in the atmosphere also are of importance to the design engineer because of their pronounced affect upon aircraft, rockets, and missiles, particularly at the lower altitude levels.

A considerable amount of information has been obtained in the space science program concerning motions of the atmosphere from about 50 miles to 110 miles altitude. These data come from observation of meteors and from sounding rocket experiments. Strong turbulence is usually found in the region below 65 miles. Wind shears, that is, regions in which winds of very different velocities and directions are found very close together, appear in the altitude range from 62 to 67 miles. The strength of these wind shears is sometimes amazingly great, being equivalent on occasions to a change in wind speed of 220 miles per hour in less than a 1-mile change in altitude.

In the latter portion of this presentation we shall describe an atmospheric structure satellite especially designed to continue and extend these atmospheric researches. This satellite, in conjunction with sounding rocket investigations, will provide a powerful double-pronged attack on problems of importance both to the atmospheric scientist and to the design engineer.

THE EARTH

Detailed study of the orbits of artificial satellites has yielded a considerable amoun of information about the internal structure of the Earth. Let us assume that the satellite shown on the accompanying chart (fig. 14, Gravitational Effects on Orbital Computation) has been in orbit 1 week since its position was last determined. One of the positions shown is that that would be computed on the basis of gravitational field data existing before the launching of Vanguard I. The other position is that that would be computed using the better gravitational data that have been obtained from artificial satellites. As indi-

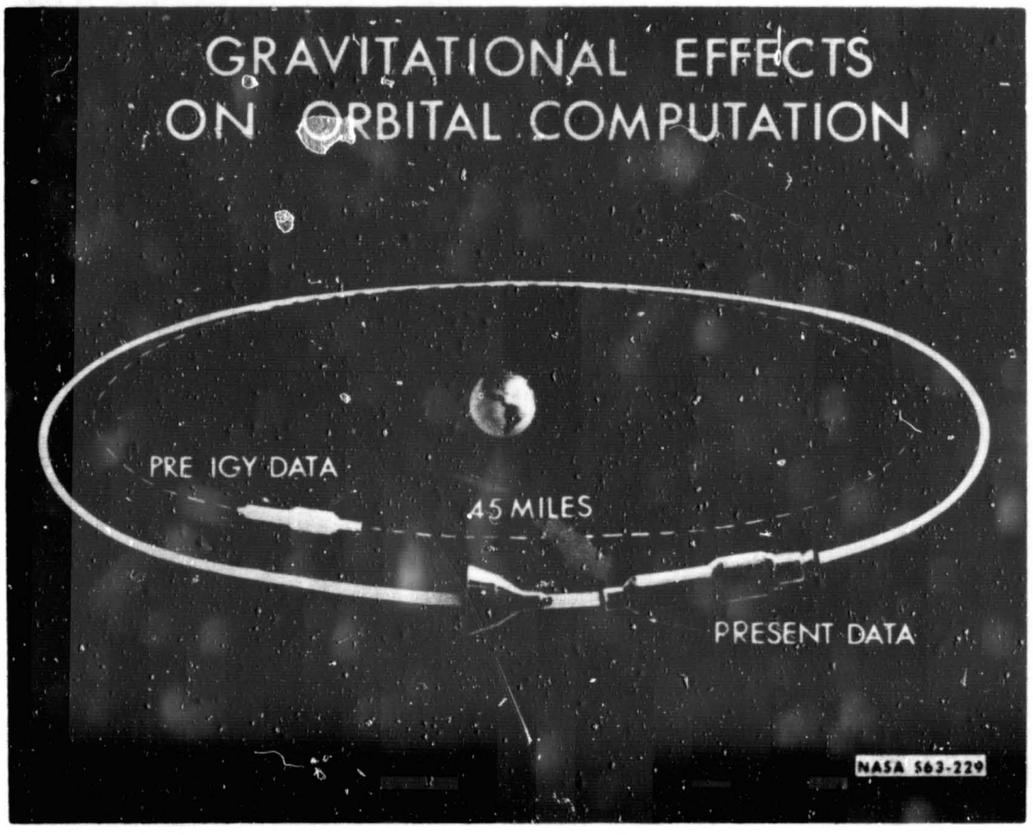

FIGURE 14

cated, the uncertainty in position using data available before the International Geophysical Year amounts to at least 45 miles.

It is clear that the availability of more accurate gravitational data has removed an appreciable constraint from tracking, or even rendezvous operations that one might wish to carry out in the vicinity of the Earth.

The present inaccuracies in determining the precise trajectories of space probes such as Mariner and the miss distances of such space probes from their targets are the result of a lack of sufficiently accurate knowledge of the mass of the Earth and of the position of the tracking stations. It would be desirable to know the mass of the Earth approximately 10 times better than it is known at present, and the positions of the space tracking stations at Goldstone, Woomera, and Johannesburg,

to an accuracy of perhaps 5 times that with which they are known at present.

Mr. STAEBLER. Pardon me. Would you give me some notion of the order of uncertainty?

Dr. NEWELL. In the mass of the Earth?

Mr. STAEBLER. Yes. Oh—just rough.

Dr. NEWELL. I really don't have it in hand, but I'd be glad to get that for you.

Mr. STAEBLER. Any kind of approximation now, if you——

Mr. RANDALL. Percentage, perhaps, Doctor.

What are we off in decimal points?

Is that what you are speaking of?

Mr. STAEBLER. Yes, and is it 100 to 1 or——

Dr. NEWELL. It's on the order of 1 part in 10,000, as I recall it.

Mr. STAEBLER. So this is a very great refinement that needs to be made?

Dr. NEWELL. Yes.

The CHAIRMAN. Doctor, we might accomplish part of this refinement with Project Anna.

Dr. NEWELL. We hope to do so.

The CHAIRMAN. Is not that one of the purposes?

Dr. NEWELL. That is one of the purposes of Project Anna.

The CHAIRMAN. How well can we expect to get that, 10 times this factor of 10?

Dr. NEWELL. Ten times this factor of ten, yes.

The CHAIRMAN. I think it's very important that the record include mention of Project Anna at this point.

While we are at it, what do you plan for Project Anna during fiscal year 1964?

Dr. NEWELL. We are getting underway for the preparation of the first firing of a Project Anna satellite. There have already been firings by the Department of Defense, you know, and we hope to have a satellite prepared for launching in the first part of the next calendar year.

The CHAIRMAN. Johns Hopkins Research Laboratory is making this for NASA?

Dr. NEWELL. They will work with us, yes.

We will continue to use the people who have been working on the project in the past. We also——

The CHAIRMAN. NASA people working on Project Anna are at Goddard?

Dr. NEWELL. Goddard Space Flight Center has been assigned the management responsibility for this project and a policy board is being established with membership from NASA, the Department of Defense, and the Department of Commerce—because of the Coast and Geodetic Survey's interest.

This policy board will determine what are the important things to measure and give policy guidance to the Project Manager, Goddard Space Flight Center. They will carry out the project using a working group with membership from the interested agencies.

The CHAIRMAN. Is NASA funding this project in total?

Dr. NEWELL. NASA will budget for the portion of the project that pertains to NASA, but the other agencies may be putting in budgets

of their own for their own peculiar interests and applications of the satellite.

The CHAIRMAN. In the total Anna program, how many satellites do we have planned, Doctor?

Dr. NEWELL. On our present planned schedule, we have three indicated, but part of the task of this policy group will be to determine whether that is adequate.

The CHAIRMAN. And what is the average cost of each satellite?

Mr. CORTRIGHT. The requirement is $6.2 million in fiscal 1964.

I think I can get the average cost.

Dr. NEWELL. We will consult our notes on this and get that for you.

The CHAIRMAN. Are we still getting data from the Anna satellite that's now in operation?

Mr. CORTRIGHT. Mr. Chairman, the cost you inquired about is a little more than $5 million per launch of an Anna-type satellite including the launch vehicle.

Dr. NEWELL. I don't know the answer to your question as to whether we are still getting data from the previous Anna satellite.

The CHAIRMAN. Well, if data is being accumulated, what agency of Government is receiving this information?

NASA or the Department of Defense?

Dr. NEWELL. The data being accumulated, is being accumulated by the Department of Defense and its contractors, but the information is being made available to NASA and to other agencies who are interested.

The CHAIRMAN. But you are not aware of whether we are getting any data from it?

Dr. NEWELL. I am not aware of whether we are continuing to get data.

The CHAIRMAN. There was some testimony before our committee last year, Doctor, when the Panel on Science and Technology met with the committee, to the effect that we would probably need six Anna type satellites to properly do the job; but you said something about "three."

Has there been a change in NASA's thinking on the magnitude of the program that's necessary?

Dr. NEWELL. What I say is there are three in our planned schedule, and the policy board has as one of its first tasks, to determine the extent of the program that is required.

The CHAIRMAN. Mr. Randall?

Mr. RANDALL. I thought I heard you say in connection with Dr. Priester, that the temperature studies—there was some kind of an office or unit in New York?

Dr. NEWELL. The Goddard Space Flight Center has an Institute for Space Studies which is located in New York City.

Mr. RANDALL. It's a subdivision of Goddard?

Dr. NEWELL. A subdivision of Goddard. Dr. Robert Jastrow is Director of this Institute—reports directly to Dr. Harry Goett, the Director of Goddard Space Flight Center.

Mr. RANDALL. It has to do with space sciences?

Dr. NEWELL. Yes, it's a theoretical group.

The CHAIRMAN. Do we budget for this group, Dr. Newell?

Dr. NEWELL. We do, in support of the Goddard Space Flight Center. It's a civil service group.

The CHAIRMAN. Mr. Mosher?

Mr. MOSHER. Could we go back a second to Alouette.

How do these arrangements come about? Do we go to Canada and suggest here's something we'd like to have your support on or do they come to us asking for help because they are interested in this, or how does this arrangement come about?

Dr. NEWELL. The arrangements for such cooperative programs grow up in several ways. In the case of the Canadian satellite Alouette, the Canadians came to us with an interest in working in the ionospheric area.

We had, as a matter of fact, indicated a general interest to the scientific community in having satellites prepared for exploring the ionosphere and we received proposals from a number of agencies around the country, including the Central Radio Propagation Laboratory of the Bureau of Standards, and others.

Among these proposals was one from the Canadians. The Canadian proposal was excellent technically and also afforded an opportunity for the United States to benefit in that the Canadians offered to pay for preparing the satellite.

This meant we would not have to pay for it. Because of its excellence and because of its additional features, we were pleased to accept the proposal.

Mr. MOSHER. Do the Canadians have the equivalent of NASA up there in any form at all?

Dr. NEWELL. They have a space committee and this space committee draws together the activities of a number of agencies, the National Research Council and their Defence Research Establishment.

Alouette was actually carried out by a laboratory of the Defence Research Establishment.

Mr. MOSHER. Proportionally what share did we pay to that whole project, would you guess?

Dr. NEWELL. I think we can pin that down for you.

I'd rather check my notes on that.

Mr. MOSHER. We can get that later, if it's not convenient for you now.

Mr. CORTRIGHT. We paid approximately $184,000 in support of their spacecraft work, which was very nominal on our part, and $13,100,000 for the launch vehicles.

Mr. MOSHER. What would be their part in dollars and cents?

Mr. CORTRIGHT. I don't know.

Dr. NEWELL. We don't know, but it must have been many millions of dollars.

Mr. MOSHER. In other words—this was an example of very useful and very effective cooperation between the two nations?

Dr. NEWELL. Extremely so.

Mr. MOSHER. You invited support in this area; but then they initiated their project.

It was their plan?

Dr. NEWELL. That is correct.

The CHAIRMAN. Mr. Hammill?

Mr. HAMMILL. I wonder, Doctor, if you would put something in the record regarding the present status of the first Anna satellite; whether any of the three systems are working and, if not, when they discontinued operation.

Dr. NEWELL. Be glad to do so.

The CHAIRMAN. Might give us some kind of a wrap-up for the record, Doctor; what general information or specific information that has been of value that we have been able to get from Anna I.

Dr. NEWELL. From Project Anna?

The CHAIRMAN. Yes.

Dr. NEWELL. We'll be glad to do that also.

(The information referred to follows:)

STATUS OF ANNA I

In response to your questions concerning the status of Anna I, the Department of Defense geodetic satellite, the following information is provided:

Are any of the three systems working? At the present time both the optical beacon and the Transit electronic tracking system are still operating. The satellite is now operating at 60 percent of its previous level. Due to a failure in the capacitor bank the light output has been reduced to approximately one-fourth to one-half of its full output. There has also been a degradation of the solar cells which reduces the available power to the satellite experiments. This degradation had been predicted the SECOR electronic tracking system remained in operation from October 31, 1962, when the satellite was launched, until November 23, 1962. It appears that the SECOR system did not respond to commands given from the ground and therefore, the batteries were exhausted.

Are we still getting any kind of data from Anna I? Yes, Doppler information is still being received on the Transit electronic tracking system. The light flashes from the optical beacon are so weak that very little information is being obtained at the present time.

What data of value has been obtained from Anna I? Approximately 400 observations have been made of the light flashes, and 60 to 80 days of good doppler data have been received and reduced from the Transit electronic tracking system. Both the photographic plates and the doppler data will be analyzed. Their value is expected to consist primarily as a means to calibrate the Anna satellite system. However, not enough data has yet been analyzed to determine whether the calibration phase has been completed.

Dr. NEWELL. Similarly, there are uncertainties about the shape, mass, and mass distribution of the Moon that will appreciably affect the precise determination of orbits of objects about the Moon. Removal of these uncertainties is one objective of our program to investigate the Moon.

THE MOON

The Moon will play a special role in the investigation of the origin of the solar system, hence also the origin of the Earth, because it is a body whose surface has preserved the record of its history for a much longer period than the Earth, and probably much longer than Mars and Venus as well. Until we land instruments, and later men, on the Moon, however, our investigations of that body must continue to be conducted from the distance of 238,000 miles lying between us.

Mr. STAEBLER. Pardon me. Could you give a simple explanation of why this is so? Why the Moon has preserved a record of its history?

Dr. NEWELL. This is another fascinating story that space science has an opportunity to try to unravel.

There was, a number of centuries ago, put forth the hypothesis that the planets of the solar system were formed when a star came near to collision with our Sun; and in passing by our Sun, the tides that were raised on the Sun, pulled out great globs of material and these globs of material circling around the Sun eventually cooled to form the planets.

This is a hypothesis put forth by the Philosopher Kant, and has been espoused by scientists at various times since then.

However, more recently it has been felt that this is not the most plausible explanation of how the solar system was formed.

It has been felt that the planets might well be formed out of condensations of the gaseous material that existed in space at the time the Sun was forming in much the same way the Sun was formed, as I explained yesterday.

As the material from some giant cloud condensed to form the Sun, leftover material condensed in little pockets around the Sun to form the planets.

Now, if the collision theory were correct, then, you see, the planets, when they were originally formed, would have been molten right at the start of their careers. Well, the molten material would include molten iron and the iron being heavier than the other material of the planets, settles to the center to form an iron core and this would be true of all the bodies of the solar system including the Moon, Mercury, the small bodies, as well as the large bodies.

However, if the other hypothesis were correct, and the bodies of the solar system were formed by the accumulation of material from a cold gas and dust of the universe; then these bodies were originally cool.

That means that the lumps of iron and rock and other material were just scattered in random fashion throughout these bodies.

The larger bodies, however, have enough radioactivity in them as they accumulate, so that the combination of gravitational pressures and the heating from the radioactivity, is sufficient to melt them so that even though they started as cool bodies with a random distribution of iron and rocks and so forth, at some point in their careers they became molten and, again, acquired central cores of the heavier iron.

So that by looking at a body like the Earth or Mars or Venus, you could not tell whether the one origin or the other was the true one.

The CHAIRMAN. Does it really make much difference, Doctor, which hypothesis is correct?

Dr. NEWELL. Well, it does, and I'd like to wind up this story with that difference.

The CHAIRMAN. Yes, surely.

Dr. NEWELL. In the case of the Moon which is a small body, the ratio of the surface of the Moon to the total volume is much larger than in the case of the Earth.

The surface of the Moon is the area out of which heat is radiated away from the Moon as it is built up in the interior.

That means that even though the Moon did generate heat from the gravitational compression and radioactivity, presumably, in the Moon, the temperatures never rose high enough to melt the body and therefore the Moon may not have ever built up an iron core.

It may still be in this "gingerbread" form with materials scattered throughout it.

So, when we get to the Moon, we will look to determine the structure of the Moon by drilling, by using seismometers and so on, to decide which of these origins is the correct one.

Now all of this has tremendous philosophical import. The collision hypothesis requires a very rare event.

To give you some idea of the emptiness of our galaxy, if the Sun is an orange, to borrow an analogy put forth by someone else, then the nearest star to our Sun is another orange in Chicago.

Well, with such emptiness in space, the collision hypothesis requires an event to occur that has probability of appearing, maybe, a few times in many billions of years.

On the other hand, if the cold gas accumulation hypothesis is correct, this is a very probable event and has happened in the case of almost every star in the galaxy.

There are a hundred billion stars in our galaxy, so there must be billions or tens of billions of stars that have formed planetary systems around them and there must be billions or at least millions of them in which one of these planets is located at a proper distance from its star to have just the right conditions for the formation of life and; therefore, the probability of life existing elsewhere in the universe, is very great in this case, and we are probably not alone in the universe. In the near collision case, however, the probability that there is another planetary system is almost zero and we are probably alone in the universe.

This, I think, is one of the most exciting reasons why we'd like to find out.

The CHAIRMAN. Which one of those two have the greatest number of supporters?

Dr. NEWELL. The second one. The formation from the cold gaseous clouds is now the generally accepted one.

The CHAIRMAN. By a ratio of what? Four or five to one, Doctor?

Dr. NEWELL. I would say almost all scientists now believe that is the true one simply because of the low probability of the other. Nevertheless, they can't exlude the other until they have some way of checking it.

The CHAIRMAN. And when we get to the Moon, we will prove one or the other is correct. Is that my understanding?

Dr. NEWELL. We hope to, yes.

The CHAIRMAN. That's good enough reason for getting there, wouldn't you say, so, Mr. Staebler?

Mr. STAEBLER. Particularly since it throws a little light on that figure that people are bandying around about the possibility of there being a hundred billion other places where life may exist.

Dr. NEWELL. Yes.

The CHAIRMAN. I thought it was a hundred million, but I won't argue with you.

Mr. RANDALL. Hundred billion.

Dr. NEWELL. There are a hundred billion stars and some large fraction of these stars in our galaxy must have planetary systems at which there is a planet just at the right distance.

The CHAIRMAN. So the speculation of the number that could support life, is what?

Dr. NEWELL. Some tens of millions to maybe a billion.

Mr. HAMMILL. In our galaxy?

Mr. CORTRIGHT. In our galaxy.

Dr. NEWELL. Just the one galaxy, yes, sir.

The CHAIRMAN. How many galaxies are there?

Mr. NEWELL. Unknown numbers, but there are billions of those already known.

Mr. STAEBLER. I can't help being impressed with what a big question our research is nibbling at here.

Mr. CORTRIGHT. I think there are a billion trillion stars within the range of our telescopes.

Mr. STAEBLER. Say that again?

Mr. CORTRIGHT. A billion trillion stars within the range of our telescopes, and our telescopes are of limited capability, of course.

Dr. NEWELL. Our telescopes can see out to about—well, I was going to put it in light years—10 billion trillion miles.

That's about right, yes.

Mr. STAEBLER. Don't put the next point down.

(Off the record.)

The CHAIRMAN. Go ahead, Doctor. It's very interesting.

Mr. RANDALL. I thought maybe after that, we ought to rest a little while.

Dr. NEWELL. Our lunar program so far has been one of preparation for the time when Rangers and Surveyors will have come into successful operation. Available data from groundbased observation and researches are being assembled and put to use in both current engineering design for Apollo and in the planning of scientific observations in support of the manned lunar mission. In addition, the NASA space science program is supporting both laboratory and theoretical investigations into lunar mapping, the chemical properties of the Moon's surface, radio and radar reflection characteristics of the Moon's surface, and properties of lunar-type materials under simulated lunar conditions. I should like now to review some of the results obtained in these ground-based activities.

As you know, we try to get all the information we can about the Moon by photographing it from ground-based observatories. These pictures are taken with telescopes in various locations because viewing conditions vary from time to time.

The limits of accuracy obtainable from photographs with present telescopes are approximately two-thirds of a mile on the lunar surface, both in horizontal and vertical directions. It is believed that improvements in methods of photography can reduce this limit to 800 feet. This improvement is deemed necessary for mission planning, for inflight navigation, and approach to landing for the manned lunar program, Apollo. Obviously, any improvement gained here will be useful also for scientific data. We are expediting this phase of work by supporting additional telescopic work and are considering whether additional telescope installations are required.

The CHAIRMAN. Doctor, if I may interrupt there—if our photography can reduce this limit to 800 feet and from that we are able to establish pretty well what the surface of the Moon is like, do we need all of the programs that we've planned for assisting the manned lunar-landing program?

I mean, we have so many now. We have the Ranger and we've got the Surveyor Orbiter and the Surveyor Soft Lander and so on.

Are all these programs necessary?

Dr. NEWELL. I believe the programs are necessary.

Reducing the limit to 800 feet will not tell us what the lunar surface is like. It will not tell us the physical characteristics of the lunar surface to an accuracy sufficient for insuring a safe landing on the surface or sufficient for picking out the actual landing area.

The CHAIRMAN. Any one of the three programs I mentioned would give us a better resolution than the 800 feet, will it not?

Dr. NEWELL. That is true; any one of the other programs will give you resolution down to numbers of feet, rather than hundreds of feet, as indicated here, and this is what is required in order to be able to get a feeling for what areas are acceptable as landing areas and what are not.

But by the combination of the ground-based observations, where you have a limited resolution on the ground and high resolution in your Ranger and Surveyor programs, you will be able to do the job less expensively than if you try to do it all with the Rangers and Surveyors. With the combination, the high resolution pictures will develop a feeling for what you are seeing with the lower resolution, and you will be better able to pick areas to go to, to look at.

You will say—well, we looked with Surveyor at this one area, and from Earth with a lower resolution you can now attempt to identify similar spots to be rejected if Surveyor data indicated they were forbidding, or to be investigated further if Surveyor showed such spots to have promise for landings.

By the combination, you do the job much more cheaply than if you try to do it all with space probes that land in a limited number of spots.

The CHAIRMAN. Well, the only thought that occurred to me, was if we are going to land a man on the Moon, how much of this information do we need before we actually do it.

Dr. NEWELL. Well, I feel you need quite——

The CHAIRMAN. And must we have generally surveyed the surface of the Moon or a substantial portion of it, prior to that landing?

Dr. NEWELL. I think perhaps it might be of interest to the subcommittee to review some of the discussions that have been going on at NASA headquarters on this very subject.

One interest in making these observations on the Moon is to be as effective as we can with the Ranger and Surveyor spacecraft in solving the scientific problems and providing the data needed for the manned lunar landing project.

In order to sharpen our thinking, the thinking of the scientists and engineers working on these problems, this very week, we have had at NASA headquarters, the leading experts in the world on the characteristics of the lunar surface. We have had Professor Gold of Cornell; Professor Whitaker, of the University of Arizona; Dr. Pettengill, of Massachusetts Institute of Technology; Dr. Shoemaker, of the U.S. Geological Survey, who is working with NASA for the current year; Prof. Audouin Dollfus, who is the professor of astronomy with the University of Paris Observatory; and a number of other experts who have met with NASA scientists and engineers to review what they thought the lunar surface looked like.

Professor Gold, with NASA support, has been performing experiments in the laboratory to try and determine what type of surface gives exactly the same type of reflections of electromagnetic radiation as we observe from the Moon here at the surface of the Earth. He has found that the only type of material that he can invent theoretically or construct in the laboratory, is a material that is built up in the random fashion by just dropping finely powdered material in a vacuum so

that it builds up "tree like," but very underdense materials that he and his coworkers have come to call fairy castles.

Looked at through microscopes this material is just filled with caverns, with intricate branches. The empty spaces in these caverns is most of the volume of the material.

Now, he theorizes from the fact that this type of material gives exactly the same type of reflection of light as does the Moon; that the Moon must be covered with this sort of material, and considering the tremendous times that have been available to the Moon to accumulate this sort of material from meteor impacts, and from wearing away of craters and so forth under bombardment of solar radiations and meteors, that the Moon must be just covered with this sort of material.

The CHAIRMAN. I thought the Moon was pretty much in its original state; that it hadn't been disturbed by atmosphere and rain or wind and what have you.

Dr. NEWELL. It hasn't been disturbed by atmosphere or rain or wind, but Dr. Gold has proposed there is another type of erosion that's going on that we don't experience here on the surface of the Earth, and, therefore, he says you may find in areas like the maria of the Moon many meters, perhaps 30 meters of this underdense material.

So, he says you may be in for surprises. Spacecraft may come in for landing and may just sink right out of sight in this underdense material.

Well, Dr. Gold tells a very convincing story, and he backs it up with laboratory measurements and with good theory.

At the same time the geologists look at the Moon from their point of view, and people like Dr. Gene Shoemaker say that in looking at the Moon they see that the very oldest craters that they can observe there, don't appear to have been worn away, and they wonder how Gold's theory can stand up, and yet the very oldest craters seem to look just about the same as the very newest craters.

What you arrive at here is a conflict—a very reputable and competent group of scientists differing with another reputable and competent group of scientists, and both of them having convincing arguments.

If you sit in the room with one group, you go away convinced they are right, until you have an opportunity to sit in the room with the other group, and then you go away convinced they are right.

The CHAIRMAN. That is the trouble with me and you, Doctor. You convince me you need every penny.

Dr. NEWELL. Well, I am about to put in my sales pitch.

This means we just have to go there and find out.

The CHAIRMAN. My question would be, Doctor: Which one of the experiments we have planned would prove or disprove either of these two theories?

Dr. NEWELL. The collection of experiments.

The CHAIRMAN. Neither one would prove or disprove either one of the two theories?

Dr. NEWELL. You can't build up a sound scientific theory in general on just one observation.

You have to have an integrated series of observations and this is what we have built up in our program.

The CHAIRMAN. Won't Ranger tell us whether or not the Moon surface actually is an accumulation of this "talcum powder," if I may put it in those terms, or is a hard surface as the geologists say it may be?

Dr. NEWELL. They may not. At least, the early Rangers.

The CHAIRMAN. Will the Surveyor Lander tell us?

Dr. NEWELL. Now we are getting to it.

The Surveyor Lander will be instrumented to get to this information.

The CHAIRMAN. The Surveyor Orbiter might not tell us?

Dr. NEWELL. The Surveyor Orbiter alone might not tell us, but there again, the combination of Surveyor Orbiter and Surveyor Lander, we think will be the most efficient way and the least expensive way of getting to the problem.

The CHAIRMAN. You are not suggesting that Ranger is no longer very important, are you?

Dr. NEWELL. No; I'm not, because Ranger will give us some initial information in advance of going ahead with the Surveyor Lander and we will be doing our best to get our answer from what we see from the Ranger pictures. We will be doing our best with the Rangers to glean some information on these layers of the lunar surface and hope that with the advance information from the Ranger we will have sharpened up the Surveyor instruments so as to get the most complete and most satisfactory answers possible.

Mr. CORTRIGHT. Mr. Chairman, just one comment on that.

One of the major questions remaining to be answered is, How rough is the lunar surface? What is the Apollo going to have to cope with in terms of protuberances?

The Ranger flights which are coming up are designed to get at that answer in an early time frame so that the knowledge can be cranked into both our scientific planning as to where to put Surveyors down and not have them topple over; and how to design the landing gear on the Apollo.

Most of the scientists at the meeting Dr. Newell was referring to, seem to believe the Moon is not apt to be a very nice place to land; that if it isn't covered by dust that will support very low pressures only, it will at least have a rugged surface. We can only design so much flexibility into our Apollo spacecraft to cope with contingencies.

The CHAIRMAN. Now, in that regard, Mr. Cortright, when do we expect to have the design of Apollo well on down the road in the development of hardware in relation to when we'll get this information from any one of the three programs we are talking about—Ranger, Surveyor Lander, or Surveyor Orbiter?

Mr. CORTRIGHT. The landing gear design on the lunar excursion module being built by Grumman, if my memory serves me correctly, will be firmed up next year—say late in the year.

The CHAIRMAN. What do we have between now and then in terms of Rangers and Surveyors that will give us the information we need to properly design the module?

Mr. CORTRIGHT. Seven Ranger flights and——

The CHAIRMAN. Are these all past flights?

Mr. CORTRIGHT. They are impact flights with the high resolution television. Also the Surveyors will just be beginning late in 1964 to make their landings which will determine such parameters as surface bearing strength and the detail structure of the protuberances.

The CHAIRMAN. Can't we get this information from Ranger impact shots?

Mr. CORTRIGHT. No, sir, we can't.

The CHAIRMAN. We absolutely cannot?

Mr. CORTRIGHT. We have wrestled with that problem for 2 to 3 years and have not come up with a good way to get that information until recently.

I should have qualified my remark.

We now have in the mill a backup program of capsules which can be flown on the Rangers in 1965, in the same time period that we will be trying to wring the bugs out of our Surveyors.

These capsules would be capable of taking one or two very high resolution pictures in the immediate vicinity of where the capsule lands.

Now, from what you see of the lunar surface and the imprint of the capsule on the surface, you could draw some conclusions as to what that surface is like, provided the capsule doesn't bury itself.

The CHAIRMAN. Now, what is the Surveyor impact shot going to give us that Ranger won't give us?

Mr. CORTRIGHT. The Surveyor has a higher probability of landing. It lands at a low velocity—5 feet per second instead of 200 feet per second.

It gathers not only better television data of the surroundings, but much other information as well, including the bearing strength of the surface as measured by instruments which press down on the surface and determine how much the surface compacts under various loadings.

The CHAIRMAN. Then why do we need Ranger?

Mr. CORTRIGHT. The Ranger at the moment, is our "bird in the hand."

We have some flight experience with the Ranger spacecraft. We have learned some things about it and are working as hard as we can to get it to work.

We'd like to be in a position to extract everything out of it that we can in the way of lunar surface intelligence.

We are providing an overlapping program where we do not rely on a new spacecraft working immediately; but rather carry on with the old one for about a year's overlap, and perhaps even more if we are getting very good information from it.

The CHAIRMAN. Any other questions?

Mr. RANDALL. Yes, Mr. Chairman.

The CHAIRMAN. Mr. Randall?

Mr. RANDALL. Our objective is, of course, a question of costs or money—the possible elimination of some of the Ranger shots; but last year we had an extended discussion of Prospector, and, you recall, we put it out of the program.

Is it possible that a good Prospector project, and I don't know where we are so far as the state-of-the-art is concerned, or how far advanced it is or whether we could pick it up; but might it not be a saving of money to go back to Prospector?

In other words, you are talking about a capsule buried in the dust on the Moon's surface, and you are talking about impacting the lunar surface at 200 feet a second for Ranger, and 5 feet a second for Surveyor.

Now, is it possible that Prospector, which will move about on the surface of the Moon, while expensive in the first instance, may be an economy in the long run?

Would you explore that?

Dr. NEWELL. Well, I think it's our feeling, our judgment based on experience and studies of these problems; that if you attempt to take too big a jump from where you are now to where you want to be that you don't save money in the long run. You lose. In our approach to the Moon we felt that a Ranger step was a reasonable step to take in order to gain the experience of all the operations that go on in getting something onto the Moon which involves not only the launching into orbit about the Earth, but then the progress from the Earth to the Moon with midcourse corrections and with terminal maneuvers, with the landing, with telemetry from the spacecraft in approaching the Moon, telemetry after landing, and a first look at what happens to these things after they land—that this was the wise and efficient and economical way of going about this first step before we committed a tremendously expensive Surveyor to the study of the Moon.

What we will have learned from Ranger will constantly be fed over into what we are doing and will do with Surveyor.

Likewise, we feel that we have to go through the process of a soft landing on the Moon which Surveyor is designed to do, and conduct operations after that soft landing with equipment which has not been damaged, and functions properly, and use a fixed piece of equipment like the Surveyor by remote command before we go to the much more difficult matter of trying to run a remotely controlled vehicle about the lunar surface.

Mr. RANDALL. One more question. You say we are not ready for Prospector yet. Is that it?

Dr. NEWELL. We are saying Surveyor is a sensible step to take before you go after Prospector.

Mr. RANDALL. I don't know whether all of you remember it; we were invited over to the Congressional Hotel one time last summer for a briefing on a poor man's version of Prospector—Project Green Cheese.

Have you explored that? That was a fraction of the cost of Prospector.

Have you gone into that?

Dr. NEWELL. We have looked at all schemes that have come to our attention that show promise or even a hint of being cheaper, more economical, a quicker, better way of getting at these things.

I would like to ask Mr. Cortright to carry on with the answer to your question here.

Mr. CORTRIGHT. The only point I would wish to add is, we are examining more carefully or more thoroughly now, the utilization of the Surveyor to land a mobile craft which would travel around on the lunar surface.

We think that it's feasible that an uprated Surveyor on a slightly uprated Centaur can do this job; perhaps in the 1966 time period.

It would not be as elaborate as the original Prospector which we talked to you about, but it looks as though it could extend the survey capability of the Surveyor quite a bit.

Mr. RANDALL. In other words, a Surveyor that will have some mobility?

Mr. CORTRIGHT. A Surveyor which would carry a device on it which would have mobility, but a small lightweight device rather than the heavier one we talked about earlier.

Mr. RANDALL. Thank you.

Mr. MOSHER. Mr. Chairman?

The CHAIRMAN. Mr. Mosher.

Mr. MOSHER. Thinking in terms of cutting the cost as much as possible, I judge you are arguing Ranger is your "bird in the hand" and you might as well make as much use of it as possible. Making good use of it, you are going to cut the costs of Surveyor; that is, you are going to gain enough knowledge so that you will materially lower the costs of Surveyor.

Dr. NEWELL. That our experience will pay off in a more economical Surveyor program, yes.

Mr. CORTRIGHT. In a major way that would help in the utilization of the Surveyor.

One wasted Surveyor by landing it in an impossible terrain is a large waste.

We want to use them effectively.

The CHAIRMAN. You'll probably convince us again, Doctor. I'm not sure. Go ahead. Proceed.

Dr. NEWELL. The information obtained is also used for geological mapping of the Moon. This picture (fig. 15, Lunar Geology) shows a small portion of the Moon's surface, with an indication of its actual location on the Moon. In the chart at the lower left is a topographic

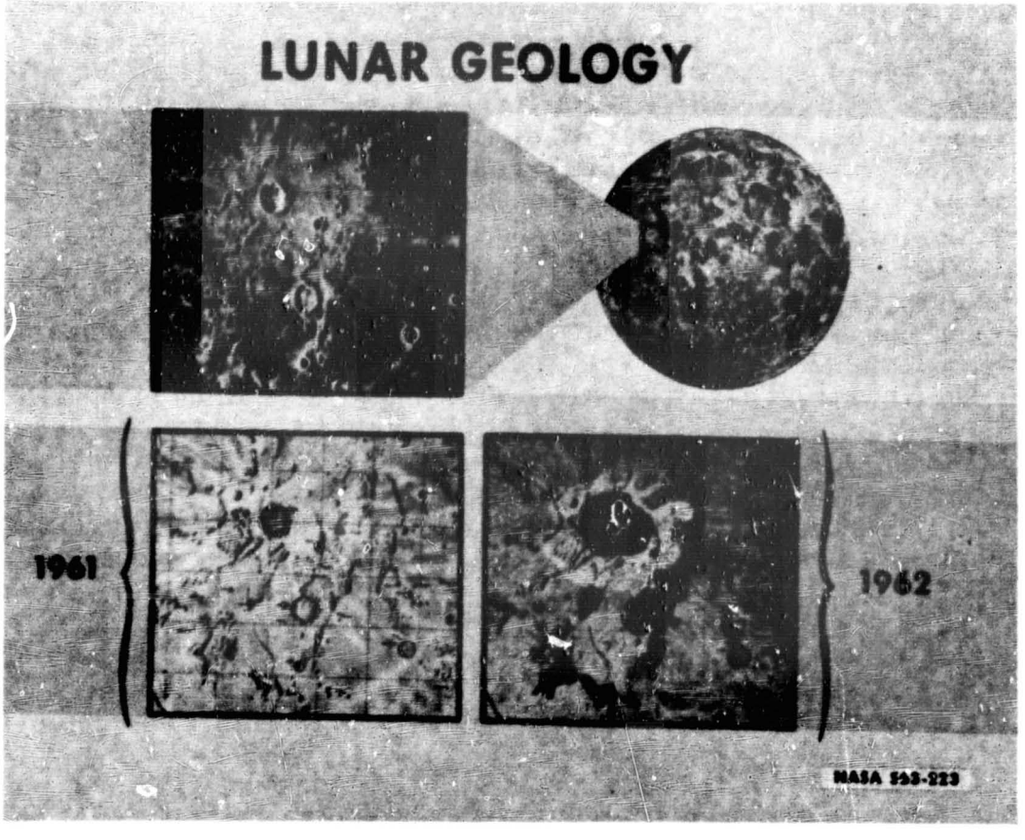

FIGURE 15.

map which shows the location and shape of the major land forms by means of contours. On the right side is an example of a geological map giving not only contour information, but also using colors to classify the lunar surface into different types of terrain.

Mr. Chairman, these maps are most fascinating, particularly to people like me who like maps anyway. I thought perhaps the members of the committee might like to have copies of the actual map from which this chart was made. They make good decorations, they are interesting to look at, and this particular one is highly informative about the characteristics of the moon's surface as we see it from the Earth.

The CHAIRMAN. Thank you very much, Doctor.

Dr. NEWELL. The initial Apollo program requires that this mapping program be extended to cover the equatorial region of the Moon to at least 300 miles on both sides of the lunar equator. This is a tremendous amount of work, and to complete the job in time, we are considering the use of automatic computing facilities.

The above information, particularly if the improvements of current resolutions by a factor of four is realized, is adequate for the present engineering design and mission planning. For the final stages of preparation, however, it is deemed necessary to improve the resolution by another factor of ten. Such an improvement can be obtained only by means of the Surveyor spacecraft orbiting the Moon at an altitude of approximately 60 miles.

The CHAIRMAN. Doctor, am I correct in recalling that during our posture hearings you said a decision would be made about the middle of this week on whether or not the Surveyor Orbiter will be necessary?

Dr. NEWELL. That is correct, and the decision has been made.

We feel on the basis of our very careful review that the Surveyor Orbiter, combined with the Surveyor Lander, will give us the most economical and efficient way of meeting these various requirements.

The Surveyor Orbiter will also assist us in greatly improving the probability of success with each Surveyor landing as we go along. So, on the basis of these considerations, we are asking the committee for its support of the Surveyor Orbiter program as well as the Surveyor Lander program.

The CHAIRMAN. What's the time schedule on the Orbiter, compared to the Lander?

Dr. NEWELL. The first Surveyor missions will be Landers, but after the first several, we will introduce Orbiter into the program.

The CHAIRMAN. Orbiter won't save much money by providing much information for the Lander missions if the Lander is first, Doctor.

Dr. NEWELL. Well, it will, in that when it has been introduced into the program, it will greatly increase the probability of choosing acceptable landing sites.

We estimate improvements by factors of four or five or more, being able to choose, for the next Surveyor Lander, an acceptable landing site.

The CHAIRMAN. Your first Lander should do that for you, shouldn't it?

Dr. NEWELL. No, the first Lander will have picked on only one site. The advantage of the Orbiter is that you survey large areas of the whole lunar surface.

The CHAIRMAN. Shouldn't that come before any Landers? I mean, if the Orbiter really will produce what you say it's going to, it should be first.

Dr. NEWELL. It would be desirable, and we would like to do it that way, but from the point of view of the engineering constraints and the project as it's now developing, we can't do it without delaying the first Surveyor.

The CHAIRMAN. You see, it almost looks as though it's a squeezed-in project which we thought of a little late, and decided somewhere along the way it might have some value, so we are therefore going ahead with it.

Dr. NEWELL. The project is squeezed in, to the extent we are attempting to do a job with the technology of Surveyor, rather than do it with some other rather costly approach.

The CHAIRMAN. Did I understand you to say there would be two Landers before the first Orbiter shot?

Dr. NEWELL. I believe I said a "few."

Mr. CORTRIGHT. It's not that well pinned down, but a "few" is a good answer.

The Orbiter could fly and is planned to fly in the first half of 1965.

The CHAIRMAN. How many Surveyors do you have planned in the whole program, Mr. Cortright?

Mr. CORTRIGHT. There is a rate of approximately 5 to 7 per year planned, until they cease to pay off.

That could be quite a few years.

Mr. STAEBLER. Mr. Chairman, how much money are we talking about for the Orbiter program?

The CHAIRMAN. Well, how much?

Dr. NEWELL. For this year it's about $30 million

Mr. CORTRIGHT. I looked that up the other day.

The CHAIRMAN. I think there are several figures you would be interested in having, Mr. Staebler.

No. 1, what is the budget request for 1964 and then how much are we talking about as a total program?

Mr. CORTRIGHT. It's $28.4 million in the fiscal 1964 budget, and if we ran a six-shot program, which would give us a very high probability of getting several successes, at least two successes, the cost would run in the neighborhood of $150 million.

Mr. RANDALL. Overall?

Mr. CORTRIGHT. Overall.

Mr. MOSHER. Mr. Chairman, do I understand that if you had thought of it in time, your preference would be to have some Orbiter flights first and then Lander flights? If that is true, how much time lag would there be? How much postponement would there be in waiting until you could do Orbiter first?

Dr. NEWELL. It isn't a question of if we had thought of it in time.

We have thought about this ever since the very early stages of NASA. It is a question of tradeoffs in total cost of the program of one way of doing this to other ways of doing it.

Our efforts have been to keep the number of different spacecrafts in our program to a minimum, although sometimes it may not appear that we are doing that.

In the present case, we could have introduced into the program another type of spacecraft, and just gone ahead with this and gotten the pictures of the moon or, at least, scheduled the beginning of photographing the moon in an earlier Orbiter effort.

The way the tradeoffs have worked out, however, is we are trying to make use of as much of the Surveyor technology as we can to do this, and in order to use the Surveyor technology, we have to wait until we have gone a certain distance down the road with Surveyor.

In this way the cost of the Orbiter program will be considerably less than the cost of another entirely separate Orbiter program would have been.

Mr. MOSHER. Is Orbiter farther down the road than Lander?

Dr. NEWELL. Orbiter goes down the road together with the Lander, inasmuch as they are both Surveyors.

Mr. MOSHER. Mr. Chairman, just another question.

Is the first Lander shot to be sort of a random shot?

Will you have any selectivity at all as to where you land?

Dr. NEWELL. We will select the spot on the basis of our best estimates of a good landing site from the information we will have had from Ranger and from continued observations from the surface of the Earth.

Mr. MOSHER. And having an Orbiter flight first, wouldn't give you much greater selectivity?

Dr. NEWELL. It would be better, yes, but if you are suggesting an entirely separate Orbiter program, in order to do this it is not clear that the cost wouldn't be greater than the possible losses by this approach.

Mr. MOSHER. When you select a site, how large an area is this?

How close do you come to hitting the spot, the exact spot?

Dr. NEWELL. The estimate is about a 50-mile diameter circle.

Mr. STAEBLER. Mr. Chairman, may I pursue this line of thought a little further?

You have told us that the cost of the Orbiter program will total about $150 million.

What will be the cost of the Surveyor Lander program?

Dr. NEWELL. We will look this up for you.

Mr. CORTWRIGHT. If we were to carry that program through a full 17 missions, the total cost would be about $500 million, including launch vehicles.

Mr. STAEBLER. Each one, therefore, would be something like $30 million. The first one will be, as Mr. Mosher has indicated and you have somewhat verified, more or less at random, a shot not in the dark—but kind of a rough approximation of what you'd like to do?

Then after that, the Orbiter program will help to make the Surveyor landings more carefully approximate what you feel is a good location.

Is that a fair statement?

Mr. CORTRIGHT. Yes, sir.

Mr. STAEBLER. So that $150 million is kind of insurance on the $500 million program?

Mr. CORTRIGHT. It is an insurance and it's a technique of extending the information we get from the $500 million program to cover vast areas of the Moon, rather than the specific selected points.

Mr. STAEBLER. You have both improved the Lander program and you gain a lot of independent information that will add to your knowledge of the Moon?

Mr. CORTRIGHT. Yes, sir.

Dr. NEWELL. It might be of interest, Mr. Chairman, to go through some of the statistics that we have asked some of our lunar experts to go through on the gains to be expected from having an Orbiter in the program.

If you assume that the Surveyor spacecraft and the launching will be 100 percent reliable, just as a starting assumption, and that 80 percent of the Moon's surface is sufficiently smooth and firm to permit a successful landing of the spacecraft; then the expected number of Surveyors required for getting one successful landing would be two flights, with a 90 percent confidence.

This would be very greatly modified if only 50 percent of the Moon was smooth enough, in which case four flights would be required.

If only 10 percent of the lunar surface was good enough for Surveyor landing, then 22 flights of Surveyor would be required to expect one real success.

Well, these probabilities are getting so poor that you simply don't want to operate on that basis, so you then try to estimate what an Orbiter will do for you in attempting to reduce these probabilities to something that you'd like to live with. We have had our geologists estimating how well they feel they could use Orbiter photographs of the Moon in order to pick out acceptable landing sites and their estimate is, for example, that if only 20 percent of the lunar surface is smooth enough for Surveyor landing, the number of flights required for one success—now using the Orbiter pictures, could be reduced from 11 to 1 or 2.

The CHAIRMAN. Our chance for success is becoming so far reduced, I'm not sure it's worth the effort, Doctor.

Dr. NEWELL. No, but with the Orbiter, you bring the chances of success right back to the point where it makes good sense.

The CHAIRMAN. Well, we are going to have a circumlunar Apollo flight in 1966.

Dr. NEWELL. You guarantee that?

The CHAIRMAN. Well, I can guarantee it just about as well as you can guarantee your flight, I think.

It's only the information we have from people like you who are active in the program.

Mr. STAEBLER. Mr. Chairman, I note the word "if" preceding these.

"If" the chances of the Moon surface being 10 percent or 20 percent favorable.

This is what we don't know at the moment and that's why the ratio becomes so forbidding. But then I notice that as the hypothesis for a bad area increases, the need for the Orbiter rises.

The worse the situation, the more we need the information.

Do I interpret this correctly?

Dr. NEWELL. That is correct.

Mr. CORTRIGHT. This is, of course, a simplified analysis. It defines a bad area, I believe, as one where the spacecraft will certainly fail.

The CHAIRMAN. Of course, this is assuming we are getting no information from any other source, and I hesitate to forget about all the Rangers that we are sending up there.

Dr. NEWELL. But you recognize when we send up the Ranger we will get information on a limited number of spots and what we need to do is to tie together that information so you get as much of a picture of the total lunar area as possible for the Apollo people to consider for landing sites.

The Orbiter not only permits us to make advance surveys to be used in the landing of Surveyor, but to tie together the Ranger information and the Surveyor information so as to give the Apollo people a broad picture of what the Moon is like.

Mr. MOSHER. How limited is the information from a Ranger flight? I suppose it depends on what instruments you have on.

Dr. NEWELL. It's limited in the number of instruments that can be carried. It's also limited in the size of the region that can be viewed.

Mr. MOSHER. Tell me again, what a Ranger is? What do we expect to do with the Ranger?

Dr. NEWELL. This will be covered in detail in the next slide, actually—shows the size of the Ranger picture. Can we have the next slide? (Fig. 16, Ranger TV Photos, p. 1514.)

The first Ranger picture will show you a region 125 miles on the side, but at a distance at which the resolution won't be much better than what we get from the Earth. The last picture will actually be the same size as the first picture but will cover a very much smaller area of the lunar surface so that it will be 60 feet on a side and will have 3-foot resolution and we will be able to see whether there are boulders there or not.

The CHAIRMAN. This is the impact?

Dr. NEWELL. This is the impact of the next Ranger to go.

The CHAIRMAN. How many Ranger impact shots do we have planned in the overall schedule?

Dr. NEWELL. We have right now——

Mr. CORTRIGHT. Seven.

Dr. NEWELL. Seven more.

Mr. CORTRIGHT. Plus the option of using the 1965 Rangers that way, should it appear desirable.

The CHAIRMAN. I'm not sure I understand that answer.

Dr. NEWELL. Well, the next seven have planned for them television pictures.

Whether or not television is the best thing to put into any Rangers after the next seven, is something we will wait on to see what our results from these Rangers tell us.

The CHAIRMAN. Oh, my question was not how many shots do we have planned for fiscal year 1964, but how many Ranger shots do we have planned "period," for this whole program, or don't we have any such plans?

Dr. NEWELL. We have a total of 14 approved including the 5 that have gone and a total of 10 more "planned."

By "approved," I mean the NASA Administration has given the go-ahead to proceed with hardware development and launches.

By "planned," I mean the NASA Administration has indicated willingness to consider as tentatively in the program, depending how the currently approved part works out.

The CHAIRMAN. If the on-going Rangers didn't have television what would be their most valuable experiment?

Dr. NEWELL. The experiments that are being prepared for the Ranger program include seismometers, and landing-type television which Mr. Cortright referred to, in which you take pictures after landing instead of just pictures taken while approaching landing. Penetrometer measurements are being considered, although no work is going on on them as yet.

Radioactivity measurements are being worked on, and there is instrumentation available.

There are other experiments for studying the interplanetary medium on the way to the Moon.

The radioactivity measurements, as you may guess, are extremely important because of the fact that if the lunar surface is highly radioactive, something has to be done to protect the people and equipment from that. They are also important in determining the composition of the lunar surface because the radioactivity will be characteristic of the material of the lunar surface.

We are also looking into the measurements of the micrometeor problem on the lunar surface. If the surface is being constantly bombarded by exceedingly high-speed meteoritic particles, this means they are producing splashes and laboratory observations indicate the numbers of particles in the splashes are tremendously great—that the phenomena at the very high meteoritic speed is entirely different from the impact, say, of high-speed rifle bullets.

This could mean then that the surface environment of the Moon is one in which you have got very high-speed particles moving around in all directions—particles that would penetrate suits of the astronauts, for example.

This sort of experiment is definitely included in our Surveyor program, but might be one type of experiment to include in the Ranger program and we are keeping this in mind.

The CHAIRMAN. Doctor, last week it seemed to me you were somewhat doubtful about the value of the Surveyor Orbiter because it would become available very close to the time we would have the Apollo circumlunar flight. It is your opinion we are not going to have that shot quite as soon as we had anticipated; or is it your feeling this Orbiter shot can be made sooner than you felt it could be made last week?

Dr. NEWELL. Experience has shown that your very difficult programs take longer than you expect them to take. The Orbiter can contribute much of value.

On the schedule that we have indicated for Orbiter, we will get information that will be of value both to our Surveyor program and to the manned lunar effort.

It is our judgment, after considering all these factors, that it is not wise to delay the Orbiter program simply by saying, that a year or so later you will be able to get these data from Apollo, because the Apollo program is going to be subject to the same difficulties that any other program of this type is subject to.

The wise approach is to cover your bets here.

The CHAIRMAN. Any further questions? Mr. Randall?

Mr. RANDALL. This Ranger starts out, of course, with the TV photographs. I understand the shell is made out of balsa wood. I'd like to know what sort of survival possibility does it have?

It comes into the lunar surface at 200 feet a second, and you are hoping that Surveyor can come in at 5 feet a second.

Isn't that true? What is Ranger's possibility of survival?

Dr. NEWELL. These television pictures will be taken as the spacecraft approaches the lunar surface, so it doesn't have to survive. Your pictures will be taken and transmitted back to Earth before the impact.

The CHAIRMAN. In other words, you expect nothing from Ranger on the surface of the Moon?

Dr. NEWELL. Not from the series we are illustrating here.

Mr. RANDALL. What is the difference of the cost between Ranger and Surveyor?

Mr. CORTRIGHT. The Rangers will cost, with the improvements we are having to put into them now, approximately $18 million per shot including the launch vehicle.

The Surveyors will cost closer to $30 million per shot, all development cost prorated over that series I mentioned.

Now, if I'm a little off on those numbers, with your permission I'll correct it in the record.

Mr. RANDALL. Not quite twice as much.

Mr. CORTRIGHT. That is right.

Mr. RANDALL. But we are not ready for Surveyor. Isn't that the answer?

That's why you used the expression "cover our bets"?

Mr. CORTRIGHT. We won't start our first Surveyor test flights until late 1964 and we hope to have an operational Surveyor launch designed to do the full touchdown and gather data by mid-1965.

Mr. RANDALL. Now, I thought I heard, back here a moment ago that we are going ahead with one, or at least contemplating one, Surveyor Lander before we do the Orbiters.

Dr. NEWELL. My phrase was "there would be a few."

The CHAIRMAN. A "few."

Mr. RANDALL. A "few."

The CHAIRMAN. Can you define that a little more specifically, Doctor? What would you say in this case a "few" is?

Dr. NEWELL. I always use "few" in a situation of this case to mean something around three—two to six.

Mr. RANDALL. Two to six?

Dr. NEWELL. Yes.

Mr. RANDALL. There is some suggestion to the effect that some of the Surveyor flights can be dispensed with by the Apollo circumlunar flight.

In all due respect to our chairman, I don't know that I agree with him. How can we get the same information? We are talking about Surveyor here orbiting at 60 miles down close to the surface of the Moon. Isn't that true?

Dr. NEWELL. That is correct.

Mr. RANDALL. This manned circumlunar orbit will not be anywhere near that distance, will it?

Mr. CORTRIGHT. I don't know what mission the manned space people described. I didn't hear their testimony.

Mr. RANDALL. In order to provide for the safety of astronauts I understood it would be a much greater distance than that.

The CHAIRMAN. I am going to arrange a private conference for Mr. Randall and some of the manned lunar people and I think they can give you that idea.

Mr. RANDALL. All right. I have several other questions. We will let it go at this time.

Mr. MOSHER. As a matter of curiosity, do you folks assume, or do you have better information than just an assumption, that the Russians are going through somewhat the same series or are planning a somewhat similar series of flights?

Dr. NEWELL. Well, we know that they have already launched spacecraft to the Moon. They have taken pictures on the other side of the Moon and they have had a successful impactor. We assume that they are continuing with this program. Having made a good start, and gotten some good early results, it wouldn't make sense for them not to continue with it.

Mr. MOSHER. This impactor that they have, can we assume it is somewhat similar to the Ranger?

Dr. NEWELL. The mission was similar to Ranger, although it did not carry television; but it was not designed to operate after impact.

It was designed to make measurements on the way to the Moon and during the approach——

Mr. MOSHER. What results of this have they published?

Dr. NEWELL. As far as we know, they have published all those results.

Mr. MOSHER. From those results, have you found any useful information?

Dr. NEWELL. Yes, scientifically, they have been very useful. They didn't tell very much about the lunar surface, but they did tell about the Moon's magnetic field and a bit about the particle radiations in the vicinity of the Moon.

Mr. MOSHER. Is there any expectation that over the next few years, some of our cost can be cut and some of their costs cut by the mutual publication of information?

Dr. NEWELL. I don't expect that in the next several years, no.

Mr. MOSHER. In other words, you don't think they are going to make any flights that will do away with the necessity of our series of flights?

Dr. NEWELL. I don't feel the Russians are going to publish information that we are not in the position to get.

I think they will play the game that way.

Mr. MOSHER. Is that the way we are playing the game?

Dr. NEWELL. No, we are playing it open.

Mr. MOSHER. In other words, a series of seven Ranger shots may result in public information which will save them some cost perhaps by not having to do this?

Dr. NEWELL. Well, it can be played so that it may save them some costs.

Our interest, however, is in relations with the rest of the world.

Mr. MOSHER. Yes, it is.

I am not objecting to this. I am just curious.

Dr. NEWELL. Yes. I think the Soviets have an advantage from this point of view.

Mr. STAEBLER. Mr. Chairman, guessing that the Russian strategy on the Moon may be like some of their others where they disregard human safety a bit and take more chances than we are inclined to

take; Dr. Newell, do you visualize the possibility of their short circuiting some of these steps we are taking and putting a man on the Moon several years earlier, several stages earlier, taking a chance on having their craft buried in this quicksand or however you would describe the possible surface of the Moon?

Dr. NEWELL. I don't really have all the information on the Russian program, but everything that I have seen indicates that they are being just as careful with their astronauts as we are with ours.

I don't visualize their flying people to the Moon and landing them there and leaving them deserted or taking the very high risk on a mission when they could reduce the risk.

But I'm not the expert in this area and I could be wrong.

Mr. STAEBLER. At least, we are contemplating these possibilities, I presume?

The CHAIRMAN. Doctor, would you like to proceed?

Dr. NEWELL. This chart shown here (fig. 16, Ranger TV Photos) shows the manner in which we expect the photographs to be nested, or arranged, as the spacecraft approaches the Moon. The first picture will encompass an area of approximately 125 miles on a side. As the spacecraft gets closer to the surface, the pictures will necessarily cover a smaller area; however, the resolution will be steadily increased.

This is because the size of the actual photograph you get is the same.

The last picture to be taken will enable us to obtain a resolution of approximately 3 feet; that is to say, we would be able to see rocks larger than 3 feet in diameter that are separated by that distance.

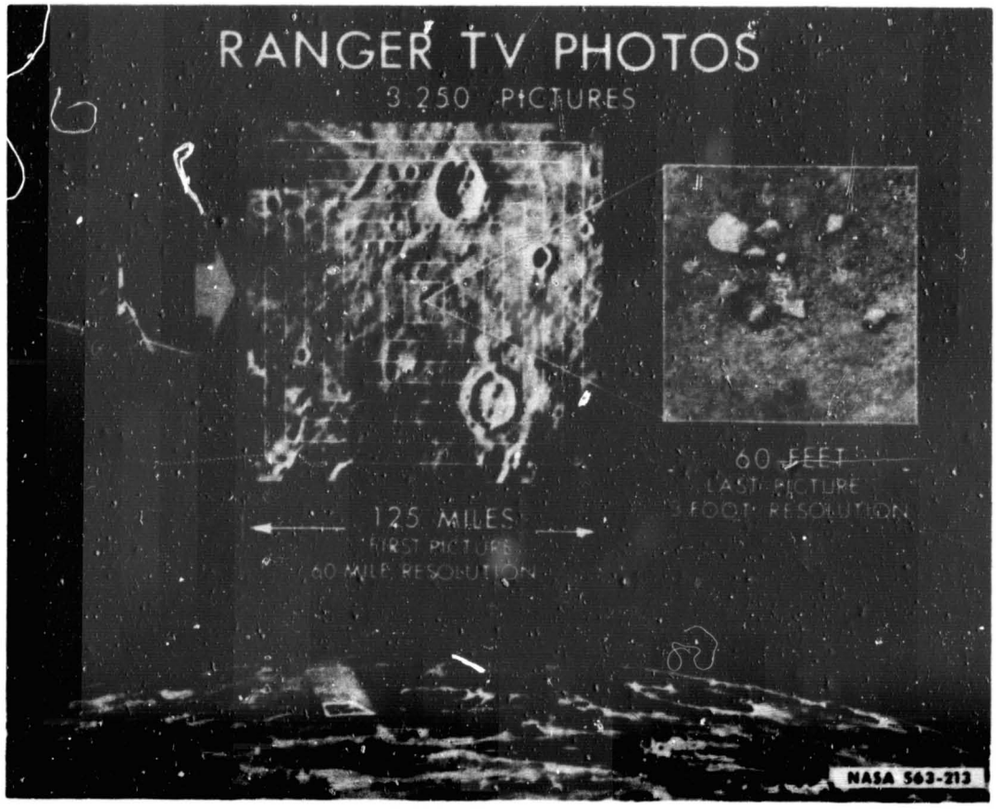

FIGURE 16

The Surveyor Lander will also obtain some TV pictures during its final descent to the Moon; however, its greatest contribution from the standpoint of pictures will come after Surveyor is safely down on the lunar surface. Its television system will provide eye-level viewing of the local lunar landscape, the topography in the vicinity of the spacecraft, and the visual examination of the texture and form of the material comprising the lunar surface. These missions will be discussed later in more detail.

At the present time, radio, radar, and infrared observations of the lunar surface provide the best information available. Considerable controversy rages over the interpretation of these data. One interpretation, espoused by Professor Gold of Cornell under contract to NASA, indicates that the lunar surface may be covered by deep layers of underdense material into which any landing vehicle might well sink out of sight.

Because it is so difficult to learn about the surface of the Moon directly, NASA is supporting measurements of simulated lunar surfaces in the laboratory. There, experiments are underway to determine the effect of radiation and fast-moving meteoroids impacting on layers of loose particles. Dust particles disturbed in this manner settle down into rough, highly diffuse surfaces. Rock or mineral surfaces exposed to intense radiation break down into fine particles of dust which may coagulate into larger dense clumps. Charges accumulated on these particles may act so as to transport the dust along the surface of the Moon. This same effect would serve to cause lunar dust to envelop any spacecraft that landed on the lunar surface. Studies show that intense proton bombardment may cause cementing of these particles so as to give layers of them some bearing strength.

Professor Gold has examined a large number of materials and compared these with the observed reflection coefficient of the lunar surface. It turns out that the material shown in the next chart (fig. 17, Artificial Lunar Surface) matches the observed characteristics of the Moon. The material has a cobweb-like structure and is composed of cement powder which has a chemical composition similar to that which might be expected on the lunar surface. The two graphs at the bottom of the chart show the similarity of the reflection properties of the substance with the observed reflection characteristics of the Moon's surface at two angles of observation. If the Moon's surface is covered by a deep layer of this cobweb-like material, the worst fears expressed by Dr. Gold may indeed be realized when the first lunar spacecraft attempts a landing. It is clear that the capabilities of Ranger and Surveyor must be brought to bear upon this problem at the earliest possible date.

It has been known for some time that the surface of the Moon is hot when illuminated by the Sun and cold when it is not. This past year with an infrared telescope, Dr. Murray of the California Institute of Technology, under NASA contract, has been examining the cooling characteristics of a portion of the Moon's surface as it passes from daytime to nighttime. He has observed that four areas shown in the next picture (fig. 18, Hot Spots on the Moon) have a markedly slower cooling rate than the general lunar surface. The curve at the right illustrates the temperatures observed in scanning across an area of the crater Copernicus.

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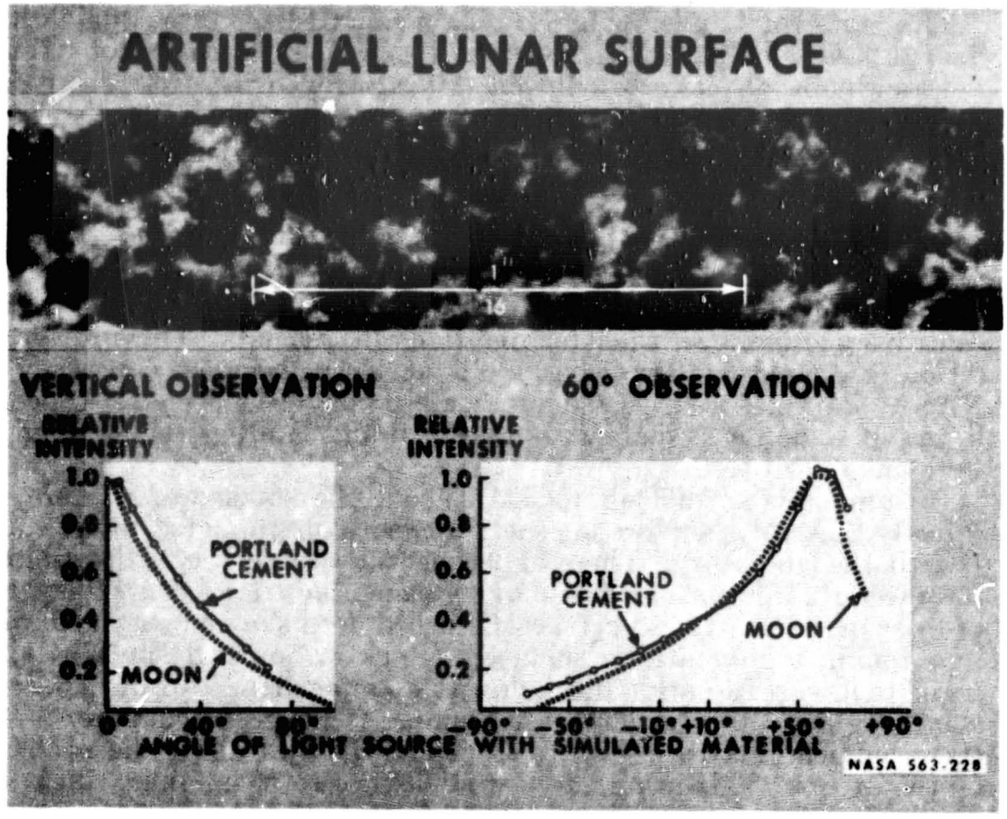

FIGURE 17

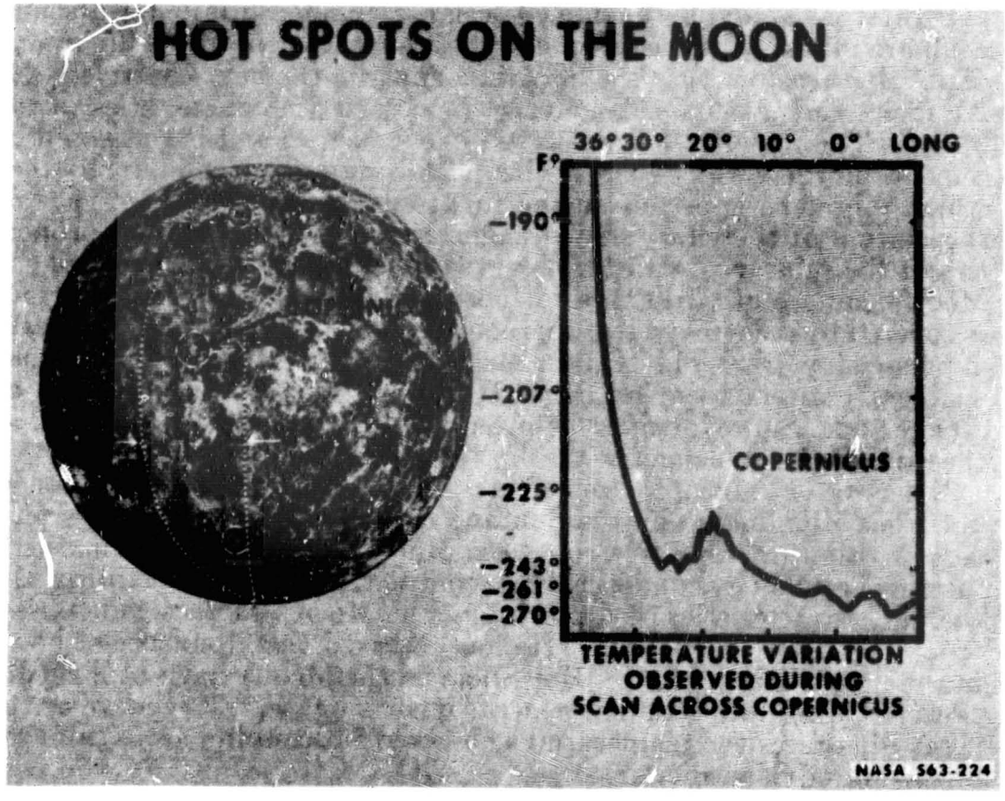

FIGURE 18

As can be seen from the curve, the temperatures are considerably hotter in some spots than in others, indicating that the hotter areas must be composed of either rock formations with a high heat capacity so that they cool slowly, or of some other unusual material we don't know about, which emits heat at a much lower rate than the other lunar material.

VENUS

Our nearest planetary neighbor, Venus, continues to arouse a great deal of curiosity, satisfied only in part by the recent spectacular flight of Mariner II. Most of our information about this planet has been obtained from the ground using optical and radio telescopes and radar. The effort to glean information from these ground-based techniques is a struggle against great odds, because of the great distance of the planet from us, because of the fact that while it is nearest to us, most of the surface toward us is not illuminated by the Sun, and because of the mysterious cloud cover enveloping the entire planet. Nevertheless, a sizable amount of information has been assembled on our twin planet, all of it intriguing but much of it ambiguous.

This chart (fig. 19, Venus by Telescope) shows you how Venus appears to us as observed through a telescope with the same degree of magnification, but at different distances. You see that when it is nearest to the Earth, and hence, largest, we can "see" only the dark portion of the planet. When the illuminated side is facing us, it is more than 150 million miles away.

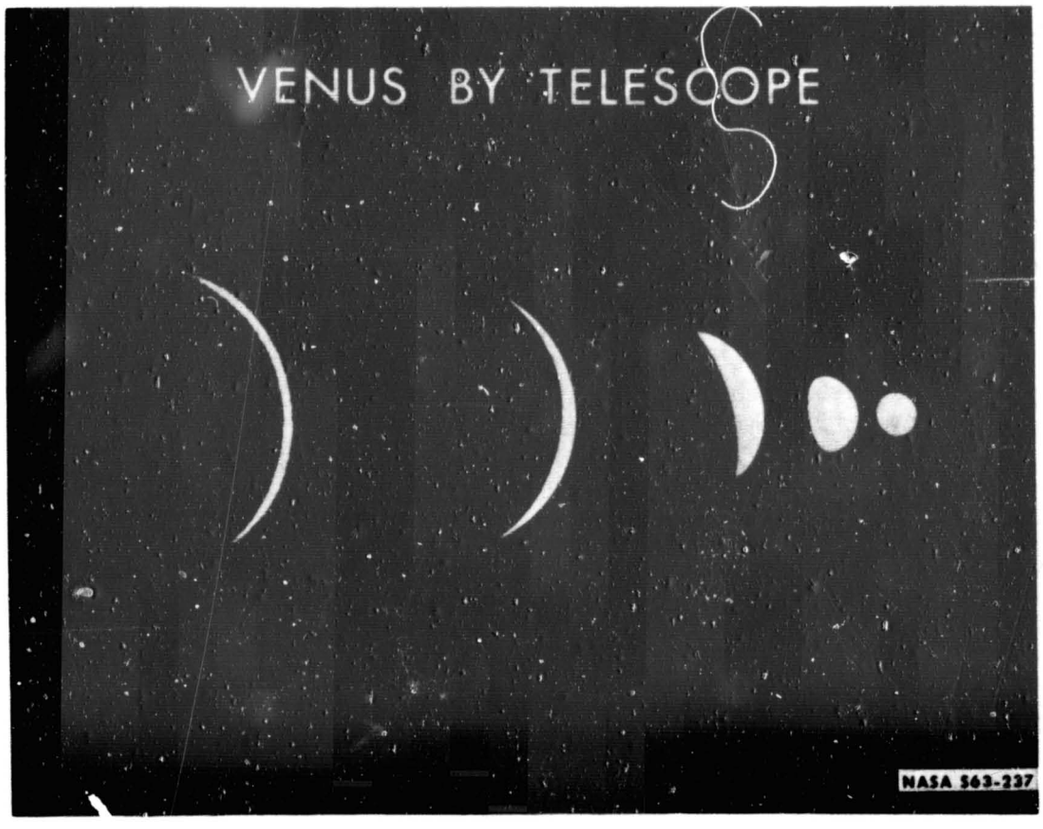

FIGURE 19

Because of this unfavorable illumination, together with the clouds which perpetually envelop the planet's surface, it has not been possible to determine for sure whether the planet rotates about its own axis. The use of ground-based radar measurements has offered the most promise for resolving this question but has not yet provided a specific answer.

The composition of the Venus clouds remains a mystery, although they may be composed largely of ice crystals. Large amounts of carbon dioxide have been detected in the Venus atmosphere. Professor Kuiper of Arizona has shown spectroscopically that the ratio of the isotopes of oxygen and of carbon in the carbon dioxide in the Venus atmosphere is identical to the ratios found in the Earth's atmosphere within the limits of experimental error. This strongly suggests that the materials in Venus and Earth had identical origins.

Infrared measurements of the Venus atmosphere indicates that its temperature is approximately −35° F. Microwave radar measurements indicate that the planet's temperature is approximately 600° F. It is obvious that these two techniques are measuring temperatures of two different portions of Venus. In fact, it is believed that the 600° temperature may correspond to the surface of the planet.

I should interpolate here, Mr. Chairman, this portion was written before the final data from Mariner was in, so now the next paragraphs bring this up to date.

The CHAIRMAN. Doctor, these microwave measurements were taken from where?

Dr. NEWELL. They were taken from the surface of the Earth and were obtained by the Naval Research Laboratory, Harvard, and others.

The CHAIRMAN. Doctor, I wonder if we can close on this note inasmuch as the House is going into session and we do not have permission to sit during the session this afternoon.

Dr. NEWELL. Very well.

The CHAIRMAN. I wonder—off the record——

(Discussion off the record.)

The CHAIRMAN. Unless you receive notification to the contrary we would meet here at 9 o'clock Monday morning. Depending on what kind of response I get from the membership of the subcommittee, Doctor, we may also meet here at 9 a.m. tomorrow. I'll make sure you are contacted sometime this afternoon.

Dr. NEWELL. Thank you. Very good.

(Whereupon, at 12:02 p.m., the subcommittee adjourned until a time to be determined.)

1964 NASA AUTHORIZATION

FRIDAY, MARCH 8, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SPACE SCIENCES
AND ADVANCED RESEARCH AND TECHNOLOGY,
Washington, D.C.

The subcommittee met at 9 a.m., pursuant to call, in room 214–B, New House Office Building, Hon. Joseph E. Karth (chairman of the subcommittee) presiding.

The CHAIRMAN. The meeting will come to order.

Dr. Newell, we were on page 41, I believe, when we adjourned yesterday. You may proceed.

Dr. NEWELL. Thank you, Mr. Chairman.

FURTHER STATEMENT OF DR. HOMER E. NEWELL, DIRECTOR, OFFICE OF SPACE SCIENCES, NASA, ACCOMPANIED BY EDGAR M. CORTRIGHT, DEPUTY DIRECTOR

Instruments were carried aboard Mariner II to resolve the question of temperature and obtain accurate measurements of the surface temperature of the planet and information concerning its atmospheric composition (fig. 20, Mariner Results). These measurements showed that the atmospheric temperature of Venus, presumably in the vicinity of the clouds, is about −33° to −70°. The microwave radiometer measurements gave temperatures of 700° to 800°, confirming those deduced by radar measurements from the Earth. It is now up to the theorist to explain this high temperature.

The Mariner instruments detected no radiation belt, nor any planetary magnetic field. From the data it is estimated that the Venus magnetic field must be less than one-twentieth to one-tenth that of the Earth (fig. 21, Exploring Mars).

At this point in time, it seems obvious that it will be considerably longer than another decade before we can be as successful as was Edgar Rice Burroughs in getting man on the surface of Mars. We do, however, know quite a few things about this fourth planet of the Sun. For observations from the Earth's surface, the favorable illumination from the Sun and the absence of a cloud cover more than compensate for the somewhat greater distance to this planet as compared to Venus. Consequently, the surface features of Mars are known in a gross fashion. Some of these features vary as a function of the time of year, the most notable such variation being that of the appearance and disappearance of the polar ice caps.

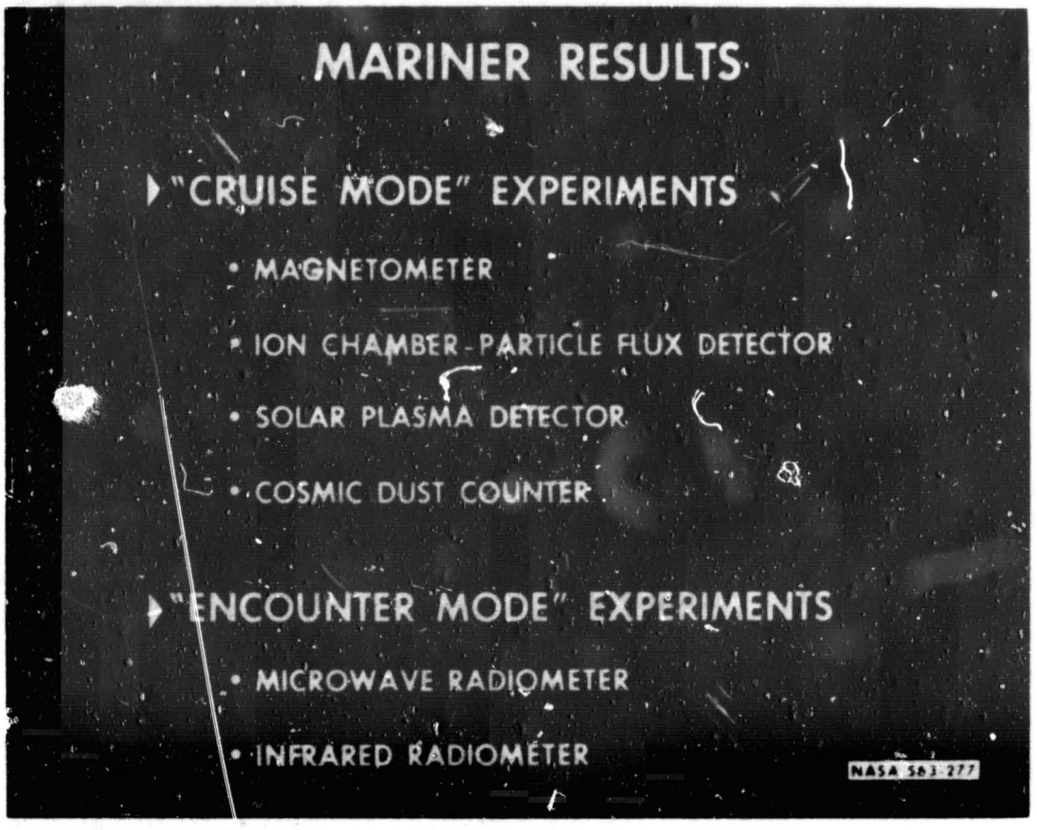

FIGURE 20

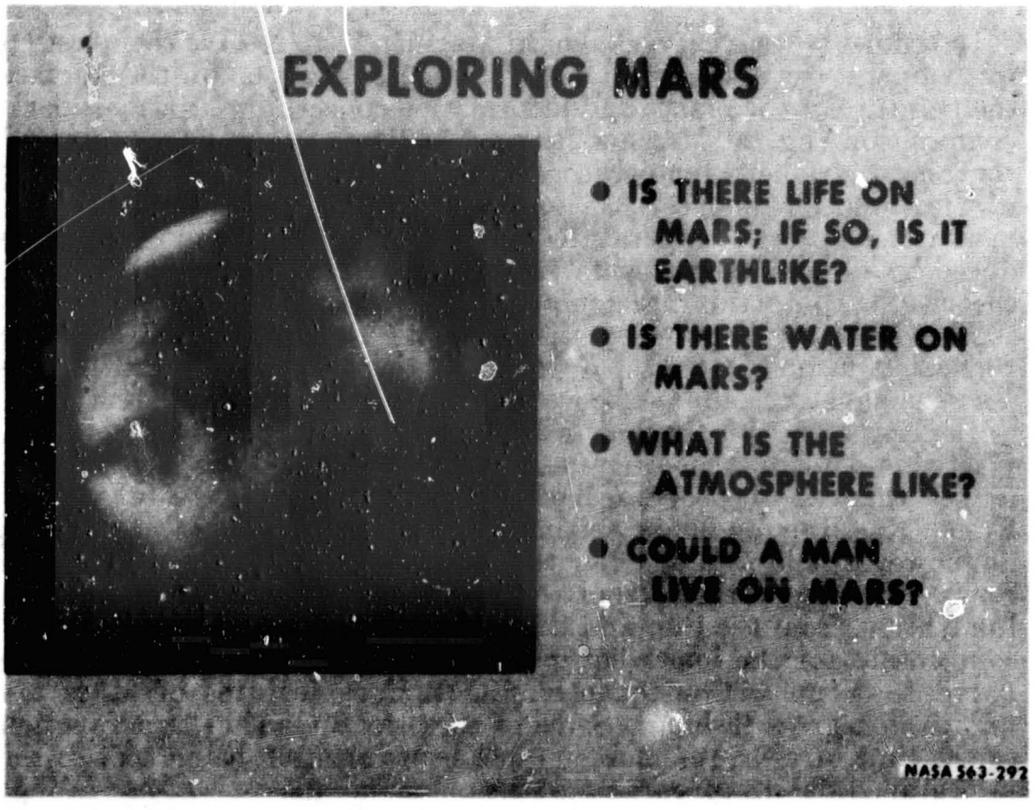

FIGURE 21

The best value we have for the atmospheric pressure on the surface of Mars is that it is about the same as that at 55,000 feet above the Earth. While this atmosphere could not sustain the mammalian life as we know it on the Earth's surface, it is quite conceivable that some other forms of life can exist, particularly lower forms.

Bioscientists are virtually unanimous in their feeling that the question of whether or not indigenous life exists on Mars is the most important question that space science can answer, and considerable ingenuity is being demonstrated to glean every scrap of information possible from the surface of the Earth, and from experiments carried out on rockets, to learn all that we can prior to actually penetrating the Martian atmosphere and touching its surface.

Without question, spectroscopic and television techniques from spacecraft flying by the planet will provide a very large increment indeed in existing knowledge of the surface features of the Red Planet.

The next opportunity for a flight to Mars will occur slightly less than 2 years from now. The time between now and then will be used for a careful selection and preparation of experiments to make the most valuable use of this exciting opportunity.

During the same interval, we are planning to have a closer look at ourselves as others see us. By this I mean that if we are to understand and interpret the data we obtain about other planets, we need to look at the Earth from a distance of a few thousand or a few hundred miles to assist us in interpreting the more difficult measurements from the other planets.

DUST IN SPACE

The large bodies in the solar system hold a special interest for us because we live on one of them. But the tiny bodies of dust particles, often called micrometeors, also have their importance.

There is a group of scientists who contend that meteoroid dust falling on the Earth has appreciable effect on the Earth's weather, providing nuclei for the condensation of water vapor in the lower atmosphere, and thus influencing the formation of rain. If further studies confirm this, then measurements of these particles in space will add to our understanding of the conditions that create our weather.

Of more direct concern in the space program is the effect of these particles on objects sent out into space. Because of their extremely high velocity, they may be very damaging to exposed surfaces and thin structures, such as large radiator systems for solar or nuclear power supplies, and large antenna systems.

To assess the seriousness of this problem, one needs to know about the numbers, sizes, velocities, and distribution in space of these particles.

The next chart (fig. 22, Micrometeorite Spatial Distribution) gives a plot of micrometeor counting rate as a function of increasing distance from the Earth. These data were obtained from observations made in near-Earth satellites and deep space probes, including Mariner II.

Mariner carried an acoustical-type detector capable of responding to particles as small as one hundred billionth of an ounce in mass. As may be seen from the curve, the flux rate of small particles in deep

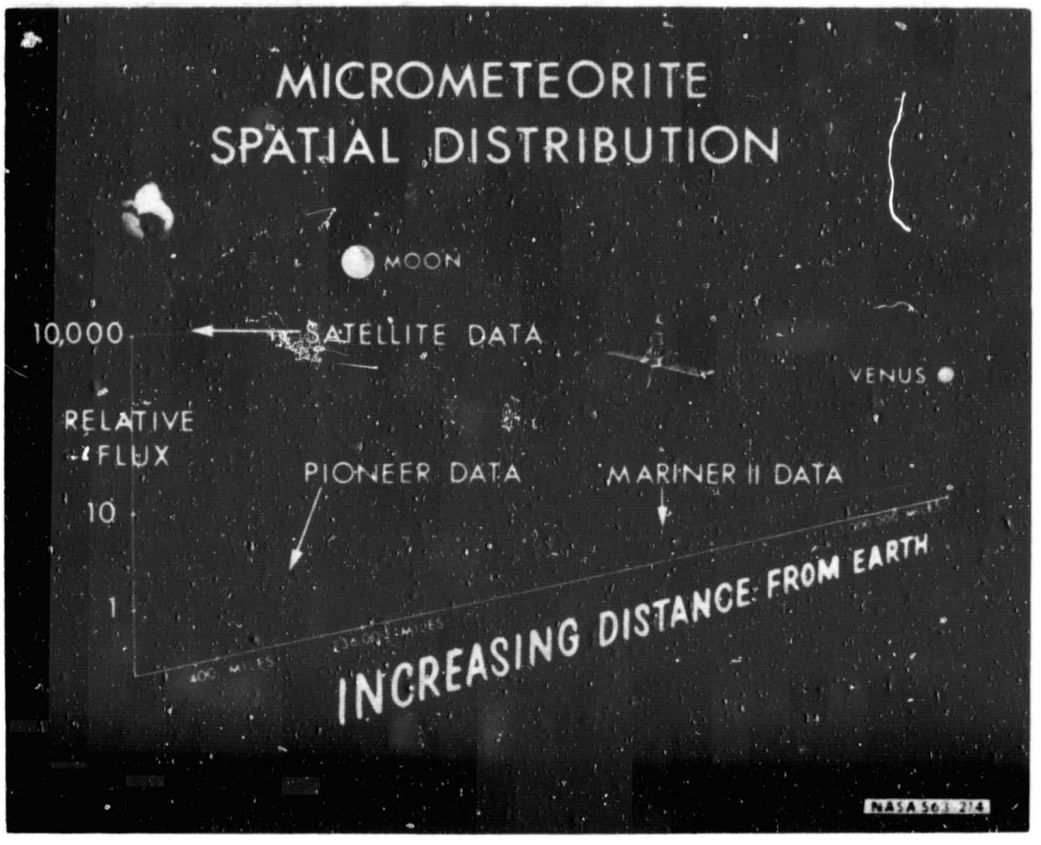

FIGURE 22

space is approximately 10,000 times smaller than that found in the vicinity of the Earth.

While these observations in space are underway, there are numerous laboratory investigations going on to develop an understanding of the penetration capabilities of fast-moving small particles into materials used in constructing spacecraft (fig. 23, Hypervelocity Impact Craters).

The craters shown in the chart were created by particles only a surprisingly small fraction of the size of the craters they dug. Such studies enable the designer to determine more accurately the weight of material needed to provide protection of spacecraft against micrometeors, which is very important since weight is at a premium in the design and construction of both manned and unmanned spacecraft.

We plan to continue these measurements, and to carry micrometeor counters on a number of the satellites and deep space probes that will be described in the latter half of this presentation.

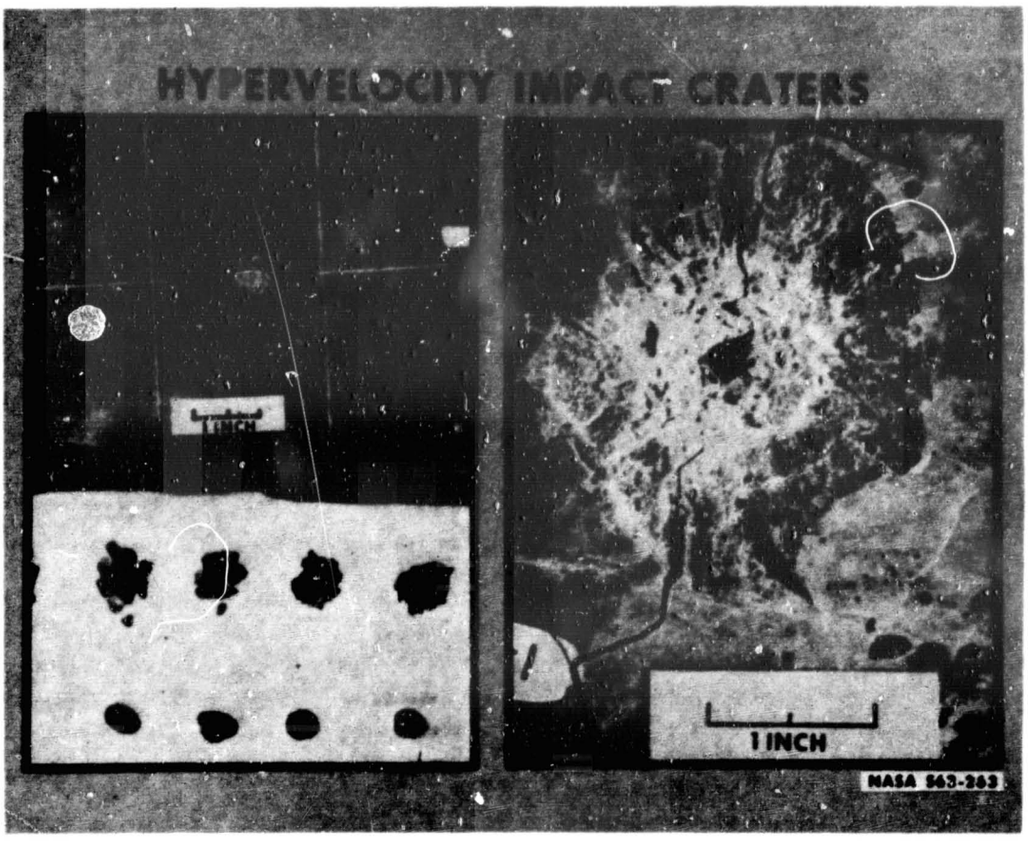

FIGURE 23

STARS AND GALAXIES

As you know, our solar system is part of a much larger stellar system called the Galaxy. Astronomers tell us that our own Milky Way galactic system must look very much like the Andromeda Nebula when seen from the outside, as shown on this picture (fig. 24, Andromeda).

The chemical composition of stars seems to vary markedly from our own, having different ratios of isotopes of the chemical elements. Some galaxies appear to be surrounded by very large and very thin halos of rapidly moving electrons, which give rise to the radiation studied by radio astronomy.

These observations have led us to a number of questions which astronomers are anxious to answer. Why does the Galaxy have a halo of fast electrons? What supplies the energy? Is this as it seems to be related to the problem of the origin of cosmic ray particles? How are the elements formed? Why do they occur with different abundances in different stars? Do galaxies age? If so, how can we find sequences of galaxies at different ages? Does the universe as a whole age?

The theorists have propounded answers to many of these questions. However, the theorists often do not agree with each other. Moreover, no single theory simultaneously answers all the questions and remains consistent with all known observational data.

FIGURE 24

Indeed, last year we presented to the committee some sounding rocket results obtained by the Goddard Space Flight Center which showed that the amount of ultraviolet light emitted by very hot stars is very different from what theory had predicted. It is clear that theory built only on observations taken in the visible wavelengths is built on a very unsure foundation.

For example, the Orion Nebula shown in the next chart (fig. 25, Orion Nebula) poses a wealth of problems that can be investigated adequately only by means of observations in the ultraviolet and infrared wavelengths.

In the Orion region, there are very hot stars illuminating very dense gaseous nebulae and dense interstellar dust. We have already seen that the very hot stars must be investigated in the ultraviolet wavelengths if we are to obtain a full understanding of them.

But, in the dust near the hot stars there are objects which are believed to be young stars that have just been born. Much of their radiation lies far in the infrared, which also can be observed only above the Earth's atmosphere. These new stars are highly variable. Already there is evidence in this spectrum of the presence of elements such as lithium, which normally cannot survive in stellar interiors. Investigation of these objects should yield some very fundamental results.

Mr. STAEBLER. Mr. Chairman, may I inject a question?

The CHAIRMAN. Surely.

Mr. STAEBLER. Can you relate the significance of findings regarding other galactic systems? Will it have any significance for travel to

FIGURE 25

the Moon? Will it have significance in interplanetary travel? Where do these other findings begin to have significance for us?

Dr. NEWELL. The findings in the studies of the galaxies will not have particular significance in our lunar landing project or even in future planetary expeditions, say to Venus or Mars. These findings will be of great importance in studies of the fundamental laws of our universe, the fundamental behavior of matter, and how the different elements are created.

You recall the other day I described one theory as to how all our different elements are created and how objects such as our Sun are originated and then go through an evolutionary process to their final destruction.

The study of the galaxy and these fundamental laws, which include relativity matters, will be of concern if some day man thinks about travel from here perhaps to another star. This is where they would come in as far as space travel is concerned, but for travel in our own solar system these do not have any special bearing.

Mr. STAEBLER. If then we are planning any expenditures just for the purpose of obtaining information of this more fundamental sort, it could be postponed without any impact on our immediate programs?

Dr. NEWELL. It depends on what your immediate program should be. The study of the stars and galaxies, as I said, is an investigation into the very fundamentals of our universe, the physics of the materials and energy with which we deal at all times.

If your program is to further this sort of understanding of the universe, then one wants to continue with this on a broad front. If,

on the other hand, you say that your program is going to be confined just to, let us say, the lunar-landing project, then the answer to your question is that these could be postponed.

Mr. STAEBLER. The committee then needs to adopt some conclusion about the strategy of research here.

Dr. NEWELL. Yes.

Mr. STAEBLER. In connection with the research of these fundamental questions is there a point about their traveling piggyback on other items of research? Are we conducting the thing you are now going to refer to here—well, you are going to talk about the astronomical observatories, and as I remember they were going to tell us other things about our galactic system and indeed about the Sun and the Sun spots, and so forth.

What you are now talking about, this fundamental research in other galactic systems would come as another part of the Orbiting Astronomical Observatories, right?

Dr. NEWELL. This would be part of the satellite observatory program, that is right.

Mr. STAEBLER. So that this is not the only reason you are having the observatory program, am I correct in this?

Dr. NEWELL. That is correct, the observatory program as you will see in Mr. Cortright's part of this presentation, involves three types of spacecraft: the geophysical observatory, the solar observatory, and the astronomical observatory.

The one I am about to mention is the astronomical observatory designed to carry large telescopes to above the Earth's atmosphere and, as I have indicated, it is only from above the Earth's atmosphere that you can obtain the fundamental information on stellar processes, on their birth, evolution, and related processes because that information is contained in the ultraviolet, X-ray, and infrared wavelengths that just don't get through our atmosphere to the ground.

The astronomer has built up his tremendously remarkable theory of the universe on the basis of a very small window in the total spectrum, the visible region, and more recently a portion of the radio region. It is remarkable that his theory has been able to go as far as it has, but it also turns out that his theory is not completely correct, because the observing in the ultraviolet that we have been able to do with sounding rockets has shown that in very important respects the theory is not correct.

Mr. STAEBLER. Would it be possible, as you describe the next project, to indicate whether any part of it is attributable just to research in the galaxies so that as we are considering the cost of these projects it would be possible to determine whether any part of it could be deferred?

I am not saying that it is desirable to defer it, but whether it could be deferred without an impact on the shorter range projects, the lunar landing, the interplanetary travel.

Dr. NEWELL. I would be glad to do that.

The Orbiting Astronomical Observatories, to be described to you later, are designed to carry telescopes to a vantage point above the Earth's atmosphere where improved measurements can be made in the optical wavelengths, and where observations can be carried out in the X-ray, ultraviolet, infrared, and radio wavelengths that do not reach the astronomer on the ground because of the Earth's atmosphere.

We solicit your strong support of these very fundamental researches.

Now with regard to the question which Mr. Staebler has just asked, the Orbiting Astronomical Observatory will be used to observe stars, galaxies, and to make some observations from the vicinity of the Earth on the planets of our own solar system.

As far as the observations of the stars and galaxies are concerned, these at the present time are in the nature of fundamental researches. They could proceed more slowly without having a delaying effect on our lunar landing and interplanetary travel projects.

However, the observations of the planets will have importance to the later flights to the planets and these observations taken in conjunction with those made by spacecraft that are sent to the planets will be of value to us.

In order to do both of these you do have to construct the orbiting observatory. You can't get the one without being able to do the other and as you may know, we are well into the project of building the Orbiting Astronomical Observatory, the prototype model is in existence, and we are well down the road toward getting it.

Mr. STAEBLER. May I raise another question, Mr. Chairman?

Since the Orbiting Astronomical Observatories are being constructed in any event to take a look at the planets, does the additional work that they will be doing on the galaxies add anything to their cost of operation or cost of construction?

Dr. NEWELL. I think I had better make clear that the Orbiting Astronomical Observatories are being built primarily to observe the stars and galaxies and secondarily, the planets. The major requirements on them, the major specifications, come from the need to observe the stars and galaxies.

These are the high pointing accuracies, the capability of carrying large telescopes, 36-inch mirrors, and the capability of being slewed around to observe any part of the sky that the astronomer may wish to observe.

Mr. STAEBLER. Then we should face up to the question right away of whether the appropriation for them is postponable or whether we ought to think of it now.

Am I right in saying that you are asking for $52 million this coming year?

Dr. NEWELL. That sounds about right.

Let us check that.

Mr. CORTRIGHT. 52.9; yes, sir.

Dr. NEWELL. $52.9 million.

Now you recognize that the question of how much you can save in a project that is so far along as this one is a difficult one to answer.

You do in effect generate a larger total cost if you delay something of this sort.

Your saving comes primarily in a reduced cost rate, but it is offset by a larger total cost.

Mr. DOWNING. Would the gentleman yield?

Mr. STAEBLER. Surely.

Mr. DOWNING. Doctor, how important is that in relation to our attempts to make a lunar landing?

Dr. NEWELL. The Orbiting Astronomical Observatory has very little bearing on our attempts to make a lunar landing.

I think I ought to point out that the space science program has as its main objective the advancement of knowledge in a number of very important areas and it would be very unfortunate indeed if we thought of the space science program only in terms of whether or not it contributed to the lunar landing.

There is much more to be gained from it than just the support of lunar landing.

Mr. DOWNING. I agree. I was thinking in terms of postponable items in the budget.

Is that an important program?

Dr. NEWELL. The Orbital Astronomical Observatory from the scientific point of view is one of the most important that we have.

As Mr. Webb mentioned in his introductory remarks, the space science program has already been reviewed from the point of view of the optimum pace considering costs, needs to support other programs, and so on, and the funding requests are geared to moving it ahead at the sort of pace that is consistent with the same pace in other research programs in other agencies.

In other words, the space science budget we have presented is not constructed on the same ground rules as that of the lunar landing project. It is the program that we feel the country should have in order to maintain preeminence across the board in important areas of science.

Mr. DOWNING. I won't say anything further about that.

Thank you very much, Doctor.

The CHAIRMAN. Mr. Hammill?

Mr. HAMMILL. Dr. Newell, you may recall that when Dr. Seamans was before the full committee we told him that a couple of members of our Panel on Science and Technology, which as you know is comprised of some of the most distinguished men in the country representing many of the scientific disciplines, had said that they were concerned about the emphasis that had been placed on the manned lunar landing program; they felt that there was a real danger that programs such as space sciences might suffer, that sufficient emphasis would not be placed upon them, and that too great a portion of the available funds would be shifted over to support manned space flight, a very expensive undertaking. I am sure that their concern was genuine.

Their comments were unsolicited. They brought this matter up quite voluntarily and spontaneously.

I wonder if you would comment on that.

Dr. NEWELL. I think that this is an ever-present danger. It is the sort of difficulty one runs into when one has an urgent program that has engineering deadlines to meet, that is extremely difficult, and in which, when you do run into difficulties you have to bear down on them and do everything possible to resolve them in order to go ahead with the total program.

I would say eternal vigilance is therefore required in order that the national program not be skewed so as to lose the benefits of other aspects of the program such as advanced research and technology, applications, and space science.

As I mentioned a little earlier, Mr. Webb, and Dr. Dryden, and Dr. Seamans have all been very much concerned with maintaining this balance in our program.

The budget that has been put forth for the space science effort is one which is designed to maintain a proper balance, the objective being to preserve the preeminence of the United States in this very important field.

I might point out that many of the scientists who were on the Panel you referred to, participated in a summer study for the Academy of Science at the request of NASA, and they conducted a review of space research. Copies of their report have been made available to the committee.

This review of space research was designed to look into what are the important things to do in the space science area and we have used this material in our deliberations to doublecheck what we have put into our program and what we are trying to achieve.

Mr. HAMMILL. Is your program consistent with the recommendations which appear in that report, would you say?

Dr. NEWELL. Our program is consistent with the recommendations in this report.

Mr. HAMMILL. In his answer to a similar question, Dr. Seamans said he supposed that some of the directors of the other NASA offices, other than manned space flight, may not be entirely satisfied with their budgets.

Was he talking about you, by any chance?

Dr. NEWELL. Well, it is eternally true that we could always use more money, but the program that is represented by the budget that is being presented to you, is a sound program, it is one with which we are very much satisfied.

We think it is a worthwhile program and we feel that if we get the funds that are requested in this budget, we will produce for the committee a program of which it can be proud.

The CHAIRMAN. But you are not sure that Dr. Seamans was referring to the Office of Space Sciences, Dr. Newell, is that correct?

Dr. NEWELL. No; I would suspect that that was just a general remark.

The CHAIRMAN. In the report that you briefly referred to just a moment ago, do those recommendations go beyond the program that has been adopted by the Office of Space Sciences or do they stop short of the program which has been adopted by the Office?

Dr. NEWELL. These recommendations go beyond the program we have developed. We have felt that we would like to do all of the things that are represented here but that we have to establish a list of priorities.

The CHAIRMAN. Well, is it a reasonable program, in the same time frame that the Office of Space Sciences is making proposals?

Dr. NEWELL. I beg your pardon?

The CHAIRMAN. Are the proposals that you find in that report in the same time frame as the proposals that the Office of Space Sciences is today making to the Congress?

Dr. NEWELL. In general, yes.

The CHAIRMAN. I assume that you have a composite of proposals there for an on-going program that the Office of Space Sciences should continue to conduct, perhaps for the next 20 years, and this is what my question is intended to ascertain.

Are we pretty much in line with what they are suggesting we do, or does the report make suggestions above and beyond what our pro-

gram now involves, or does it stop short of what our program now involves in the present time frame?

Dr. NEWELL. This review looks ahead, in some areas up to as much as 10 years ahead, and reviews the NASA program as we described it to this group so they would have that background information, makes suggestions as to where there are additional problems to work on, valuable areas in which to work, and recommendations as to how to go about it.

Our program is in general consistent with these recommendations.

The CHAIRMAN. Dr. Newell, I suppose you have noticed that there is greater interest in the manned lunar flight program than there is in the space sciences program and as a result of that often the question occurs, does this problem in the Office of Space Sciences, for example, tend to answer questions we need answered for the manned lunar flight program or doesn't it. While I feel that this is a reasonably good question, I do feel that on occasion we may overemphasize the one road that so many people look at and look at only in the overall space program. Maybe it might be worth while if you would just take 5 or 10 minutes or whatever amount of time you think you need to call this committee's attention to reasons why we need a program, at least a space sciences program.

As I understand it, this is basic, this activity in space sciences is the beginning of future space programs.

Here is where we determine which direction we will go in the future. It might be well worth while for this committee to have it in the record, for the benefit of the full committee and for the Congress, so will you address yourself to why we must have programs in addition to those that have a direct effect upon the manned flight program?

Dr. NEWELL. I would be delighted to speak to that point.

The CHAIRMAN. I thought you would, Doctor.

Dr. NEWELL. The space science program is part of our total national effort in what may be called fundamental science.

It is this effort that brings forth new ideas, new facts, new principles, new laws, that are used in furthering science, in applications in the development of technology, in supporting operations that one may wish to undertake.

These new laws and new facts are, one might say, the basis, the foundation on which our technology and engineering and applications accomplishments rest.

It is important to have a broad program of fundamental research going on because the tendency to try to direct such a program along the lines where you think the best applications will come from may very well lead you away from the best.

The best applications very often are completely unanticipated and come from corners of this research that you never expected they would come from.

I can bring this very close to home, for example, in the area of space flight, since one always comes back to this by pointing out that in 1956 and early 1957, before satellites had been put into orbit, some of our leading scientists when questioned as to what were the real radiation hazards out in space, would say there are not any very great radiation hazards; the primary difficulty would be with galactic cosmic rays, and the radiation from galactic cosmic rays is simply not serious.

In fact, I have heard some of our leading scientists say this in answer to questions posed to them during scientific meetings.

Well, now, in the very earliest satellites in our space program the radiation belt was discovered and this radiation belt turns out to be a region of very intense radiation.

If we had gone ahead with a manned orbiting satellite program in which the satellite was put through the region occupied by this radiation belt, we would have killed the man, because even now we don't know how to shield such a satellite against these radiations for periods of many days or a week.

We would have run into, therefore, a very nasty surprise.

Well, now following the discovery of the radiation belt one was then inclined to say: Well, this is the major radiation hazard, but if we fly objects below the radiation belt or beyond the radiation belt then we would have no trouble.

But again nature had a surprise in store because it was not too long after the discovery of the radiation belt that people began to observe very intense cosmic ray beams coming from the Sun, beams of solar protons, and these beams which are ejected at the time of solar flares are sometimes so intense as to be lethal to anyone exposed to them who is not properly shielded.

Here again is a surprise, something that was not anticipated and if one had gone along blithely under the assumption that the only radiation hazard that existed out in space was confined to the radiation belts of the Earth, he could have killed someone by sending a crew out during a period when these solar beams were in interplanetary space.

So again I say that in addition to moving ahead in the collection of scientific facts, new ideas, learning of new fundamental laws, and so on, one must be exploring to uncover the surprises that may be in store for us.

The CHAIRMAN. Doctor, what has the Office of Space Sciences program contributed to the national security as a result of its programs? Has valuable information been made available to the military services? Could you address yourself to any programs that have offered this kind of information that has been very valuable?

Dr. NEWELL. I think in order to answer this question one must first recognize that the rapidity with which information and data feed into actual applications is perhaps less than one would desire because these ideas and new knowledge have to sort of be molded; a general understanding has to grow for what they really mean before they really get into applications.

The CHAIRMAN. But the discovery of the Van Allen radiation belt, for example, has a tremendous effect upon satellite communications systems, doesn't it? As I understand it, the radiation does affect the very heart of a satellite communications system, including the electronic equipment inside, is that correct?

Dr. NEWELL. That is correct.

The CHAIRMAN. So doesn't this provide us with valuable information to make better the instrumentation that goes into a package, for example?

Dr. NEWELL. It certainly does.

The CHAIRMAN. Well, this was the thought that I had in mind.

Are there any other such areas?

Dr. NEWELL. Well, there are other areas and this is what I was leading up to in my first examples.

Our space program actually extends back to the end of World War II at the time when sounding rockets were first put to use to explore the upper atmosphere.

As a result of measurements and observations with these sounding rockets then followed on by measurements with satellites in the NASA program, we have learned a tremendous amount about the upper atmosphere, about its pressures, its temperatures, its density, and variations with solar behavior.

Now all of these enter into the designing of high-speed, high-altitude craft.

This will include the supersonic transport that one is considering right now. It has included airplanes that are now flying, both civilian and military. It certainly includes the launching vehicles that are used to put our spacecraft into orbit.

It certainly includes the missiles that we use, affecting the accuracies with which they can be fired, influencing their design so that they will be able to withstand the high pressures and temperatures that are generated in their high-speed flight.

So although this accumulation of information and later application to vehicles is a slow and gentle process, nevertheless, it is a very real one.

In addition, there is a steady hacking away at our ignorance about the meteorology of the Earth's atmosphere that comes from a joint attack on problems of the lower atmosphere and the upper atmosphere. I think that it is quite plain that the more we know about the prediction of weather, the better off we are in matters of national security.

Military operations are certainly dependent on this, but so also are matters of commerce and industry, marine activity, mining operations, agriculture, and so on.

So here again is an area in which advances are being made because of the basic scientific research.

Again this is a gentle, slow process that is apt to be missed, if you really are not looking for it, but nevertheless it is real.

Then there is the more immediate application that you have mentioned, Mr. Chairman, of the impact of our knowledge about radiation belts on things that we want to do in space. If we don't protect our spacecraft against the radiations in the radiation belt, then we find that their lifetimes are limited.

Solar power supplies are affected and destroyed. But with knowledge of the radiation belts they can be adequately protected and long lifetimes can be achieved.

The CHAIRMAN. By what means have we gained most of our information about the radiation belts, Doctor, sounding rockets, satellites, or what specific program?

Dr. NEWELL. We have gained most of our information about the radiation belts from artificial Earth satellites.

Another area in which our general program of research on the atmosphere has very great and very valuable practical application is in the study of the Earth's ionosphere.

The ionosphere is that portion of the upper atmosphere which contains large numbers of charged particles, electrons and charged atoms of oxygen, nitrogen oxide, and so on.

The ionosphere acts as a mirror to radio waves that are sent up toward the ionosphere and thus permits us to send radio waves around the Earth.

The investigations of the ionosphere that began back in the late forties and have continued have steadily improved our knowledge of this region to the point where we know enough about it to predict fairly accurately what its conditions will be like.

Now this is important practically because communications schedules, both military and commercial, are based on the prediction of when one can use the ionosphere with given frequencies, sometimes to to choose a frequency that can be a security frequency.

I have heard the estimate that the improvement in this prediction accuracy amounts now to a saving of a couple of million dollars a year in schedules that were actually carried through instead of being scrapped because the ionosphere started to do something that had been unanticipated.

If this value is true, and I know of no reason why it should not be accurate, the saving more than pays for that particular set of researches.

Mr. DOWNING. Mr. Chairman?

The CHAIRMAN. Mr. Downing.

Mr. DOWNING. Doctor, I don't want you to think that I am critical of the program, I am not; I probably am your most vigorous supporter, but we have got to look at this thing in relation to a reasonable budget and what the general public is willing to bear and the results that you obtain from this program.

Now did we discover the effects of the radiation belt by the Orbiting Astronomical Observatory?

Dr. NEWELL. No; the Orbiting Astronomical Observatory has not yet been flown. It is being constructed. We discovered the radiation belt by means of the early satellites, the early Explorers and here again is an interesting story: Professor Van Allen was intending to study galactic cosmic rays with the instruments that he had in that satellite.

He was not looking for the radiation belt, so his observations of a very fundamental nature led him to a very important discovery.

Now if you had constrained him to looking for something of this sort, something that you vaguely might have had in mind as being important, he might never have done the right thing to make this discovery.

There is a classical example that has often been quoted that I think brings out this point very emphatically.

If back in the days when Roentgen was playing around with his evacuated tubes and electrical discharges someone had come around and said now I want you to work on something that will be of great value to medical science, it is almost certain that he would have put aside these tubes and have started to work on some other thing. But his work with these tubes led to the discovery of X-rays which has been very important to medical science, and not only to medical science but to industry and to many other applications.

Mr. DOWNING. You come upon those things by accident. I know Mr. Edison accidently invented the Victrola when he was working toward some other end.

Is this the first time we have funded the OAO program?

Dr. NEWELL. No, sir; this has been funded for a number of years.

Mr. DOWNING. How much in total has been appropriated for that?

Dr. NEWELL. Let us check our notes on that.

I think as you say you come upon these things by accident but you come upon them accidentally only if you are carrying on the type of activity which permits you to come upon them by accident, and this type of activity is a broad scientific program.

Mr. DOWNING. Is it necessary?

Dr. NEWELL. In order to come upon such discoveries it is necessary to have such a broad scientific program.

Mr. STAEBLER. Will the gentleman yield?

Isn't the situation something like this, Doctor: In order to have a flow of practical findings that keep us protected and in line with what other people know in the practical fields we have to have an advancing front of what appears to be a kind of pure and unrelated research going off in some more or less selected direction but nevertheless with the assurance that we are going in all of the directions we ought to be going in.

Is this the kind of thing you are suggesting here? This is the advancing front of pure research and the findings from it will guide us into taking more specific inquiries into practical directions in the years to come?

Dr. NEWELL. That is a precisely correct statement of the situation.

Mr. STAEBLER. Then the question arises: Is this the only field of pure research—let me put all of my questions together—the only field of pure research in the galaxies and interstellar field?

Second, is this a rate of spending in that research which we need to maintain in order to keep us consistent with the rate at which we need practical findings to follow up?

Dr. NEWELL. I believe that this is a reasonable rate, a rate that is paced for us to move ahead in a reasonable fashion in this particular area of fundamental research.

Mr. STAEBLER. How can you get nonscientific people like us to understand that need? What will make it intelligible?

The CHAIRMAN. Lengthy hearings like this?

Mr. DOWNING. That is a good question.

We are entirely—not entirely, but we are at your mercy. You say that this is necessary now. It may be that we don't need to do this until 10 years from now.

Dr. NEWELL. I take the following approach to this problem, which is a very difficult one, and is just as difficult for us as it is for you, one with which we struggle constantly. The approach that I have devised which I think is a reasonable one is the following:

In the Office of Space Sciences we constantly survey the entire area that we are concerned with, which is a broad area, as you have seen. It covers the Earth's atmosphere, and the solar system and the galaxy and biosciences. In this survey we attempt to isolate the problems of major scientific importance.

Now you may ask how do we determine when they are of major scientific importance. The best set of criteria I think is to get a concensus of the leading experts in the business. They have a feeling for

which areas are about to produce some of the most fundamental discoveries, and it is their educated intuition, their experience, the evaluations derived from working in the area that we apply to determining what are the most important areas and the most important problems to tackle.

We then build up a program in which we attack, not all of these problems, because we can't afford it, we understand this, but enough in each area so that we do have a broad enough approach along this frontier to permit these valuable discoveries, to permit an interaction among the areas.

The CHAIRMAN. Dr. Newell, perhaps you should tell us sometime about the total program you would like to follow as a scientist, or that the scientists would like to follow.

Now quite frankly I agree with my colleague that we are completely at the mercy of the people who are expert in these scientific fields. We are laymen attempting to do the best possible job under very trying circumstances, quite frankly. I hope that you appreciate our position.

Dr. NEWELL. I do understand this.

The CHAIRMAN. And I do feel that on occasion it might be that those of you who are interested in science and scientific exploration are somewhat overzealous. You are very enthusiastic about your program. If you weren't, you wouldn't be what you are. And as a result of that, lengthy meetings such as this committee hearing could tend to make us brainwashed—if I may use that term, rather than, as I put it a little while ago, being informed.

We have the responsibility of picking the right niche that we hope we can find for the benefit of all mankind, and that includes the taxpayer at present, as well as the man who is going to follow us in the next generation or two.

I do agree, of course, that scientific investigation, and the technological advancement which is normally brought about as a result of scientific investigation of one sort or another, is the real reason that we live the good life today that we live.

This is why we have the highest standard of living ever known to mankind. There is no question about it. This didn't just happen by accident. This happened because we were willing to spend money to do scientific and technological research, similar to what we are doing now.

So I understand that, too, and I am sure that my colleagues do. On occasion the witness may even feel that we are abusive. We don't intend to be that way. On the other hand, we must try to prevent being brainwashed; rather we must try to get as much information as we can so that we can be rational enough to make the proper decision.

Dr. NEWELL. I understand this problem thoroughly, Mr. Chairman, and the problem weighs heavily on our consciences, too. We could, for example, present to the committee a scientific program that would cost many times the budget that is being presented.

In fact, when we put together all of the things that we can regard as important and very valuable to do, they do add up to many times the present budget; yet we have gone through the process of cutting this down and whittling it down to the present budget.

We feel in good conscience that the present budget will support what the country should regard as a minimum program in the space

science area to move ahead on the necessary broad front, and to meet the competition in today's world in which we are not alone, and in which our preeminence in science is an important factor in maintaining our strength.

Mr. DOWNING. That is certainly true. Of course the biggest challenge I guess we have before us is the preservation of peace, but the preservation of peace is completely and entirely dependent upon the economy, because if we go broke you just give up. The reason we are at peace is we have tremendous armies and nuclear potentials and things like that. We have to keep it in balance.

Dr. NEWELL. This program, however, is in the nature of an investment. It isn't a program into which you put your money and nothing comes out.

Mr. DOWNING. Well, now I was asking about the total cost of the OAO program.

Dr. NEWELL. Through 1963 the total cost is $81 million.

Mr. DOWNING. Now what have we gotten from that, what results?

Dr. NEWELL. This will be described in Mr. Cortright's presentation. He will show you the present status of the Orbiting Solar Observatory.

Mr. DOWNING. All right. Thank you, Doctor.

The CHAIRMAN. At this point, would you insert in the record how much we have spent on the three observatory programs, the OGO, the OSO, and the OAO?

Dr. NEWELL. I would be glad to.

Mr. CORTRIGHT. Do you want it right now, or do you want it supplied for the record?

The CHAIRMAN. If we could just have it now; I think it is well to find out what our total commitment is up to this point and how far down the road we are.

Dr. NEWELL. I think, Mr. Chairman, it might be of interest to reemphasize the fact that the Orbiting Solar Observatory, and the Orbiting Geophysical Observatory, in addition to pressing forward with the fundamental research as we have just been discussing, provide basic information on solar activity in the interplanetary medium, on the radiations there that are important to anything we do in manned flight in space, including the lunar landing project.

It is because we have had a broad program in this solar and particles area that we are in such a good position right now to continue with the researches that are needed for this particular application.

They also have bearing, as the Chairman has brought out, on such things as communications satellites and any other satellites that use transistors and solar cells for power supplies.

Mr. CORTRIGHT. Through 1963 we have expended, in addition to the $81 million on the Orbiting Astronomical Observatory, $69 million on the Orbiting Geophysical Observatory, which covers both the versions to fly in low-altitude polar orbits and highly elliptical-inclined orbits. These are the same spacecraft instrumented slightly differently. On the Orbiting Solar Observatory, one of which we have flown successfully, and are still operating, we have spent $23 million.

Mr. DOWNING. Is there any possibility of combining them into one operation at lesser expense?

Dr. NEWELL. We looked at that very carefully, and it turned out not to be possible when considered from all points of view. The Orbiting Geophysical Observatory does not require the accuracy of

the Orbiting Solar Observatory and carries a different set of experiments, different types of experiments, with different requirements.

Therefore it turned out that if you attempted to make a spacecraft that would satisfy both groups, it would be too costly. Each set of experiments that you would be flying you would be paying more for than you ought to, you would be using too costly a vehicle for it.

Mr. STAEBLER. Mr. Chairman, I suppose most questions ought to be deferred until after we have heard Dr. Cortright's information, but one more question seems in order here.

Prior to this time I suppose our pure research has been done by educational institutions through ground observatories, foundations and so forth. I presume now that we have gone beyond the point where this is anywhere near sufficient to answer our questions, and fortunately we have many more new devices through rockets and these orbiting observatories to get at information above our atmosphere, I suppose there is no other agency except the Federal Government, through NASA that can do this.

Is this a fair statement of the situation?

Dr. NEWELL. That is a fair statement.

Mr. STAEBLER. So what has come to us heretofore through many sources, from research in many institutions, much of which we have taken for granted, isn't adequate any more to supply us with this advancing front of pure research; is that right?

Dr. NEWELL. That is correct.

It also ought to be added that even many of the ground-based researches are becoming very costly, those, for example, that use the high-energy accelerators that cost a hundred million dollars or so, and those that use the most advanced ground-based upper-atmosphere ground stations, ionosphere ground stations, cost $10 to $20 million per station, and the scientists tell us in order to make use of these they have to have networks of them.

If a network involves, say, six of these ground stations, you are talking about $60 million for doing this from the ground. On the other hand, a satellite to do some of these ionospheric researches would cost you $5 million or so, so it turns out that sometimes these space researches are not more costly than the ground-based researches to do the same thing. In many other cases the research just cannot be done from the ground, and the satellite and space probe approach is the only way to do it.

Mr. STAEBLER. It sounds as though we were at one of those great turning points in knowledge where we are moving from one kind or order of inquiry into another, sort of a change from Ben Franklin and the kite to a totally different kind of research.

Dr. NEWELL. That is correct.

The truly exciting phase of the space biology program, when we shall place instruments on Mars in search of life on the Red Planet, is yet to come. Up to now our activity has been largely one of preparation. Nevertheless, many fascinating, and some fundamental, results have been obtained.

As of a year ago, it was not known whether micro-organisms existed in the Earth's upper atmosphere. In July and October, NASA carried large sterile sampling devices to altitudes between 65,000 and 90,000 feet, using the 128-foot-diameter balloon shown on the next slide (fig. 26, Balloon Observatory).

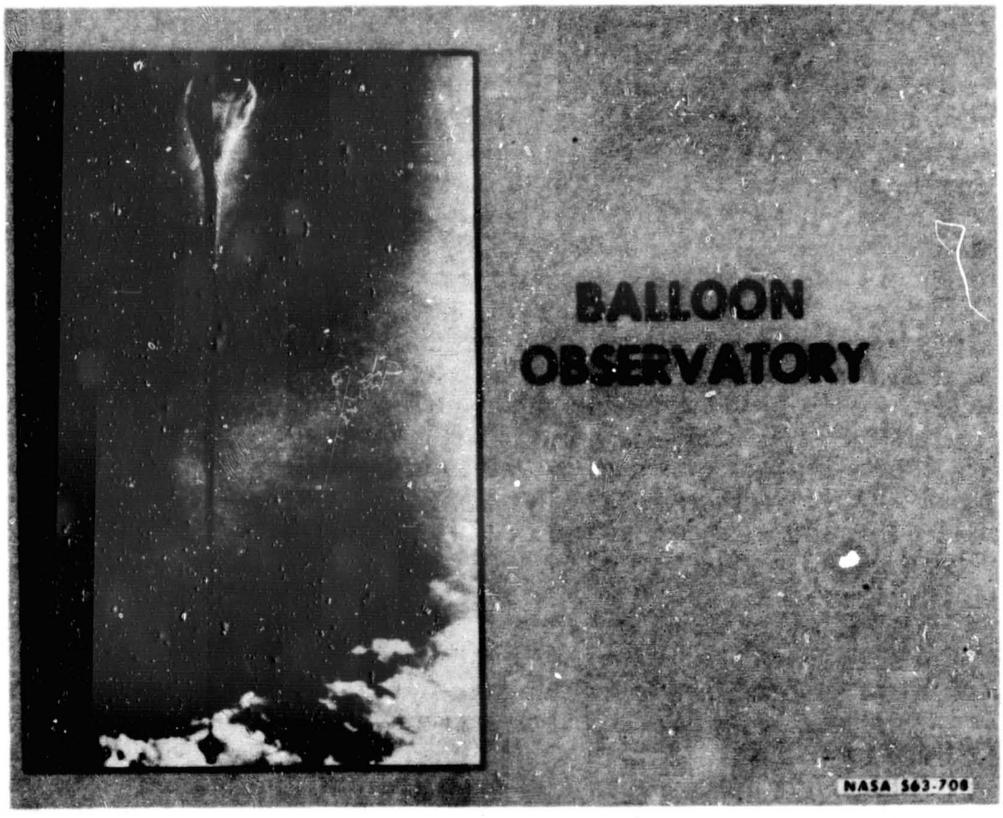

FIGURE 26

Samples of as much as 140,000 cubic feet of ambient air were processed to determine whether the upper air did contain micro-organisms. It was learned that at times the stratosphere does contain large numbers of micro-organisms, while at other times it appears to be relatively free of them, perhaps depending on meteorological conditions.

Investigations such as these may have a number of important consequences. First, if it is found that there are micro-organisms that can live out their entire life cycle at high altitude, one may then conclude that the question of whether life exists on Venus is not necessarily settled by the very high surface temperatures that appear to exist there.

Secondly, we may learn quite a bit about the migration of living matter from one place to another.

Thirdly, it is of great value to compile a list of micro-organisms that have high endurance capabilities. Such organisms would be likely candidates to look for under the hostile conditions known to exist on other bodies of the solar system.

Not long ago a report from industry indicated that bacterial spores would be destroyed in space within 5 days of exposure to a hard vacuum. Subsequent studies by NASA showed that life in this relatively simple form can survive exposure to vacuum up to 32 days at least.

More recent preliminary results suggest, however, that 90 to 100 days of space vacuum may be too much for these forms of life. If

this is confirmed, our immense problem of keeping terrestrial organisms off from Mars during its biological exploration may be greatly simplified.

In early 1962 the possibility of synthesizing living matter seemed at a standstill. Suddenly, however, unexpected breakthroughs have emerged (fig. 27, Laboratory Experiments With Lifelike Cells).

Prof. Sidney Fox, a NASA grantee, has shown that protein synthesized from amino acids has catalytic activity typical of living cells. In the picture you see some of Professor Fox's synthesized protein spheres. The similarity to actual cells is obvious. One even sees some of these cells in various stages of dividing in two.

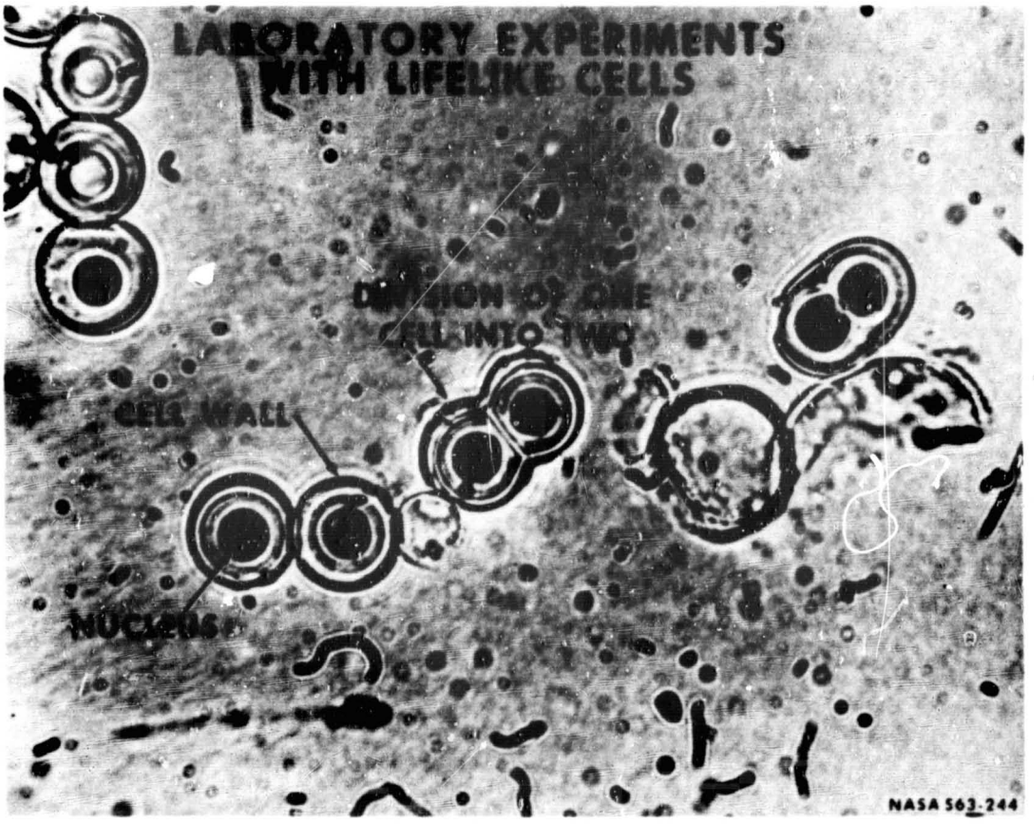

FIGURE 27

The NASA Ames Research Center has synthesized fundamental biological materials from mixtures of gases that may have characterized the primitive Earth atmosphere. One biochemist has recently gone through a series of steps leading all the way to the polynucleotides that are the structural units of the hereditary genes.

Does life actually exist elsewhere than on Earth? Speculation about this exciting and fundamental question is a common pastime. We hope in the near future to gather additional facts to shed light on this question.

NASA contributed to the support of the flight of a high-altitude balloon in February 1963 to conduct spectroscopic analyses of radiations from Mars, looking for those radiations that are characteristic of biological materials. In 1964, a deep space probe flying by Mars, and in 1966 a capsule landing on Mars, may provide definitive answers.

A life detecting device ready to go on a Martian mission was developed to a high degree of reliability in 1962 by a NASA grantee (fig. 28, A Planetary Life Detector). Named "Gulliver," a preliminary version of this device was described to the committee last year. It is designed to detect radioactive carbon dioxide produced by biological activities of living material pulled into the device by means of a sticky string drawn over the Martian surface.

Still another instrument, called the multivator, has been built, using as a principle the fact that the phosphatase enzyme, a fundamental

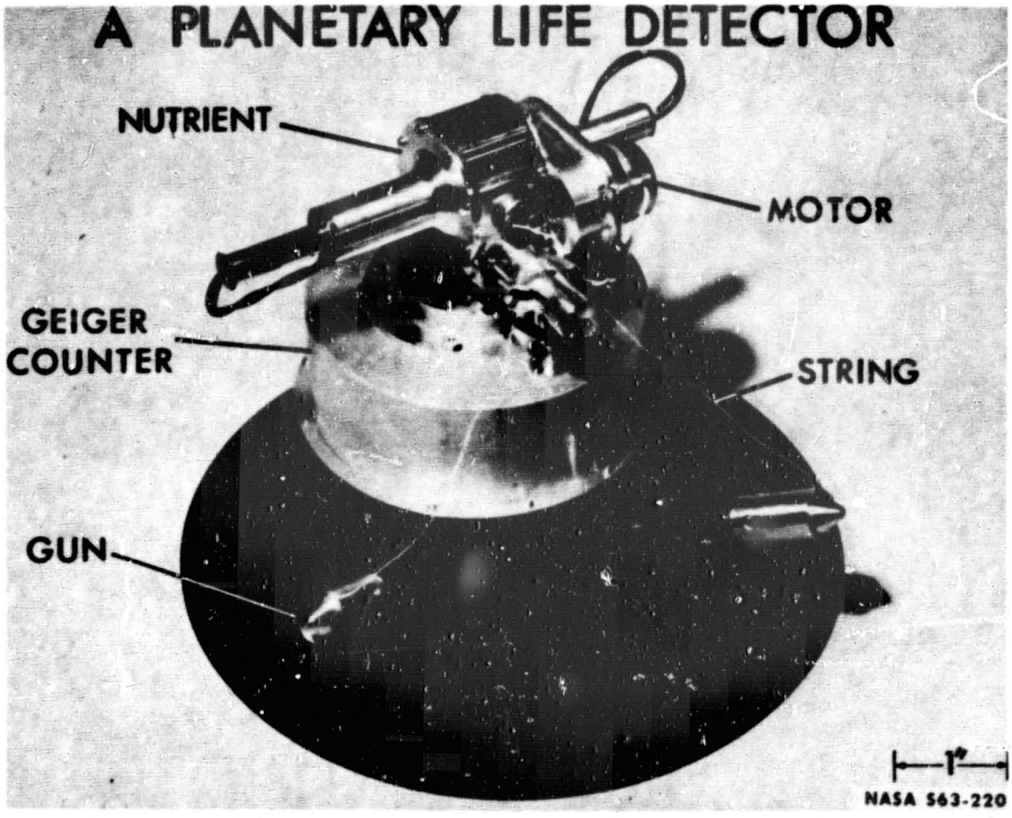

FIGURE 28

component of all known living systems, exists virtually everywhere. This multivator has been miniaturized, and fabricated, and is ready for field tests. Six other remote life-detecting instruments are under laboratory feasibility study.

The CHAIRMAN. Doctor, under what program were these funded?

Dr. NEWELL. These were funded under the Office of Space Sciences program. In the budgeting last year the funding for them was not drawn out into a separate line item, but they were included under various items throughout the space science program.

In the next part of this presentation, we shall describe to you the supporting research and flight missions necessary to move forward in this important area of space science. We ask your endorsement of these space bioscience investigations that may eventually produce some

of the most fundamental discoveries and breakthroughs of the space science program.

At this point, Mr. Chairman, I would like to ask Mr. Cortright to present a review of our present program status.

The CHAIRMAN. Thank you very much, Doctor.

Mr. DOWNING. May I ask one question?

The CHAIRMAN. Yes, Mr. Downing.

Mr. DOWNING. Did I understand you to say that they had synthesized living matter? Was that synthetic protein I saw on the screen?

Dr. NEWELL. The figure that you saw showed little protein spheres. The protein spheres were not living matter——

Mr. DOWNING. But if bifurcated they would be?

Dr. NEWELL. Except that they bifurcated under specially applied conditions of heat and temperature and chemical material that brought about this bifurcation. But one hasn't got quite to the point where living matter has been synthesized, rather to the point where the activity under special conditions is similar to the enzymatic activity of living material. One is tantalizingly close but not there.

Mr. DOWNING. Was that program funded under the Office of Space Sciences?

Dr. NEWELL. Yes.

Mr. DOWNING. Well, there is not a specific funding for synthesizing living matter?

Dr. NEWELL. No, there is not. The funding of this research is to give us a firmer background for our searches for biological materials and living matter on Mars and the other planets.

Mr. DOWNING. Thank you.

The CHAIRMAN. Mr. Cortright.

Mr. CORTRIGHT. During 1962, the NASA space exploration program has entered a new phase of its evolution. We have passed beyond the relatively simple satellites and probes which characterized our early years and are heavily engaged in the development of advanced spacecraft and launch vehicles to accomplish the more rewarding, but more difficult missions. In doing so, we have met with both dramatic successes as well as some temporary delays.

In general, however, the year has been one of intense activity and excellent progress. The following discussion will attempt to present a concise statement of the program and the progress which has been made during the past year.

MISSIONS ACCOMPLISHED

As a prelude, let us review the record of missions accomplished since the beginning of the national space program. The next chart (fig. 29, Scientific Satellites) illustrates the scientific satellite flights from 1950 through 1962.

Several important observations may be drawn from this chart. In 1962, we have had 100 percent successes with our scientific satellites, whereas prior to 1962, the successes did not exceed 50 percent in any year.

This dramatic improvement is due to two factors: first, we have learned how to design and develop reliable spin-stabilized satellites;

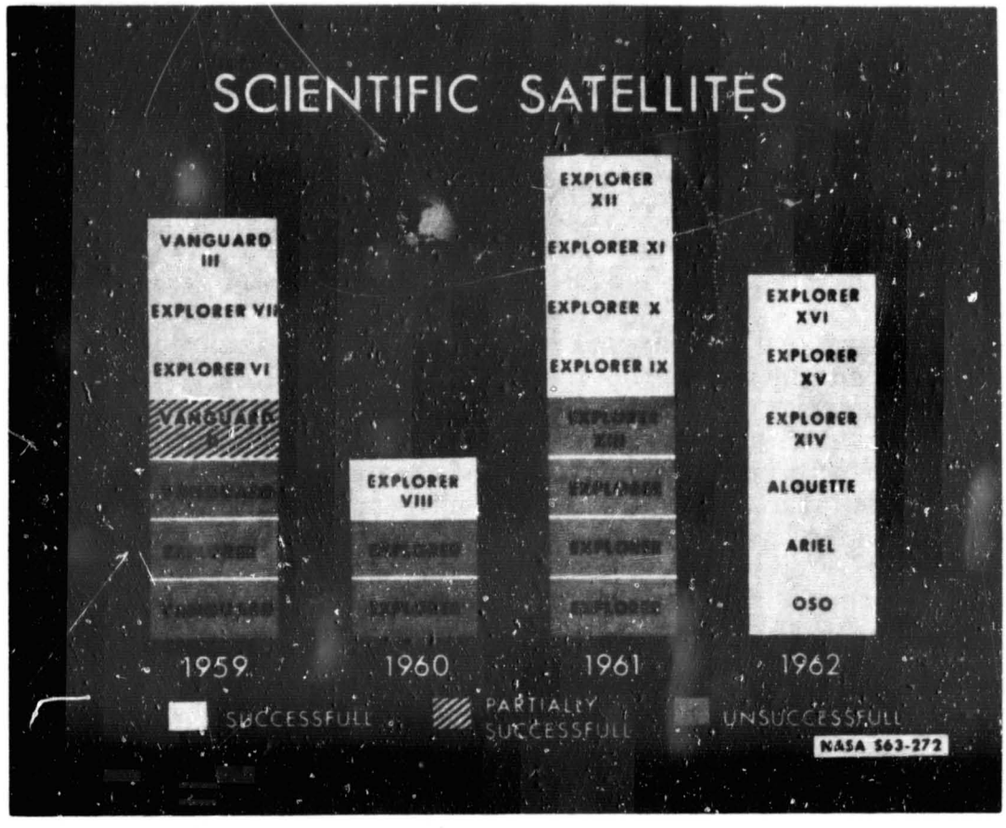

FIGURE 29

second, we have capitalized on launch vehicles for satellite injection which are highly reliable, such as the Thor-Delta.

Another observation to be made is that the nature of our satellite missions has changed. In 1962, we flew our first solar observatory, which heralded a new era of astronomical observation. In addition, 1962 saw the successful commencement of a cooperative flight program for space exploration with Canada and England. The Ariel satellite was instrumented by British scientists, and the Alouette satellite was developed entirely by the Canadians.

In the area of space probes, we are at a development stage comparable with that of scientific satellites in previous years. As indicated in the next chart (fig. 30, Deep Space Probes), we attempted five lunar and planetary missions in 1962.

Of these five, only one mission can be counted a complete scientific success. This was the Mariner II which, on December 14, 1962, made history by flying on a predetermined trajectory close by the planet Venus.

The CHAIRMAN. May I interrupt briefly, Mr. Cortright, to welcome the chairman of the full committee who has just joined us.

If you have any questions, Mr. Chairman, as we go, feel free to interrupt at will.

Chairman MILLER. Thank you.

Mr. CORTRIGHT. Shall I proceed?

The CHAIRMAN. Yes, please.

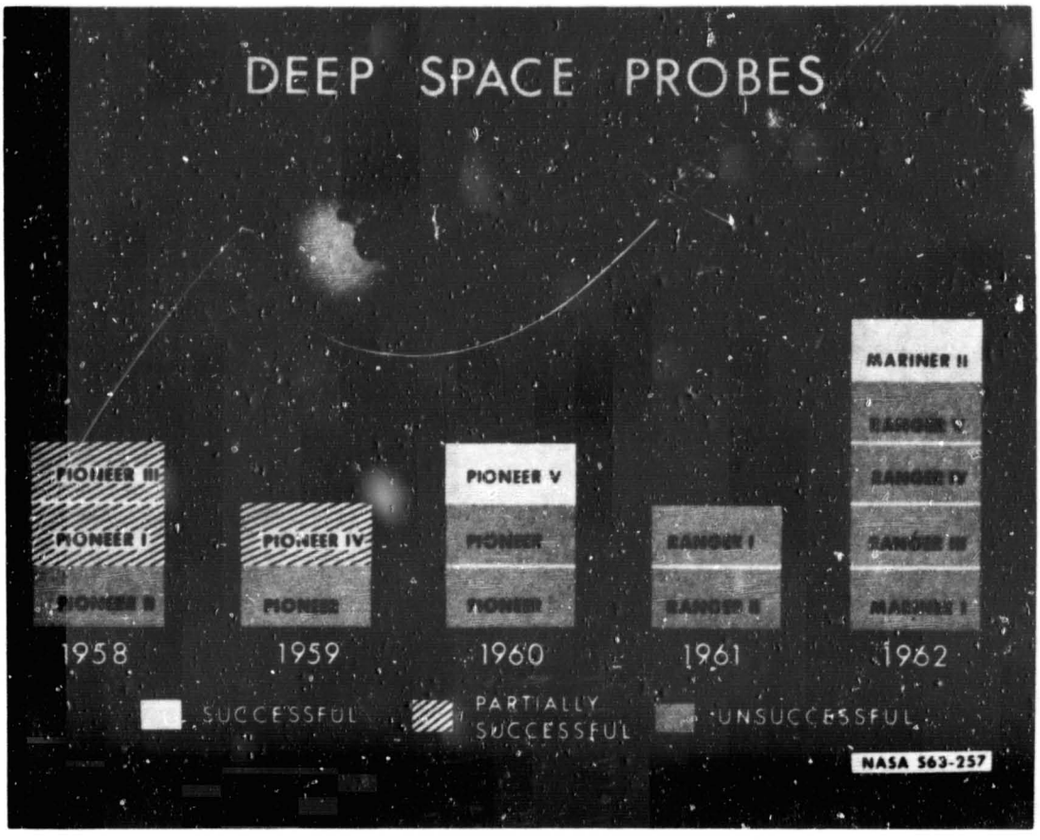

FIGURE 30

Mr. CORTRIGHT. Suffice it to point out here that these space probes have called upon the most advanced technology in launch vehicles and unmanned spacecraft which the country has yet attempted. Initial development problems have been encountered, both with the launch vehicles and the spacecraft, and strenuous efforts are underway to solve these problems. These will be the subject of further discussion herein.

The next chart (fig. 31, Sounding Rockets) summarizes the history of sounding rocket launches in this country since 1956. As can be seen, the activity was very high during the period of the International Geophysical Year; that is, 1957–58, following which launchings dropped off markedly. Since 1959, however, the activity has built up steadily and it is important that this build up continue.

One of the prime reasons for the dramatic success and high reliability which we enjoy in the scientific satellite field is the fact that as many instruments and components of our satellites as can be accommodated are tested on sounding rockets before they are committed to the more expensive satellite programs.

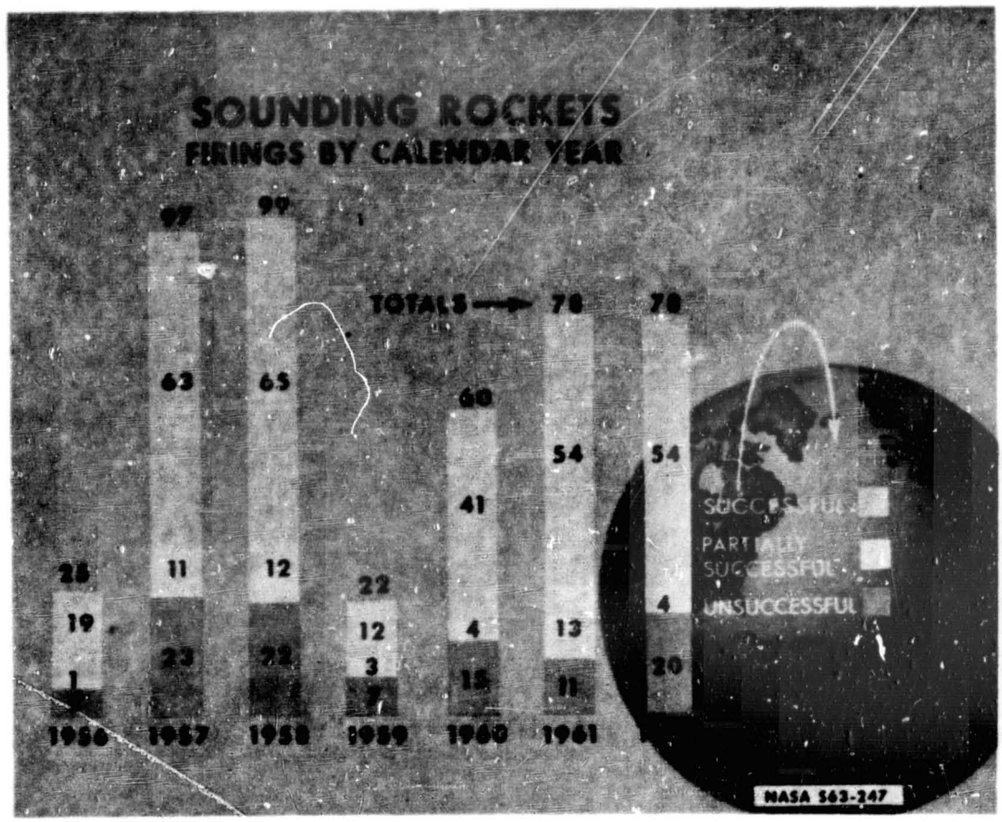

FIGURE 31

PROGRAM SUMMARY

I will next summarize our current program and our plans for the future. Consider first the Geophysics and Astronomy Program shown in the next chart (fig. 32, Geophysics and Astronomy Programs). The explorers and monitors, and the international satellites, which programs have been very active in 1962, are planned to continue at about the same rate throughout the time period shown in this chart.

Sounding rocket activity will increase somewhat. In addition, it is planned to continue our launchings of the highly successful orbiting solar observatories at two a year until 1966 or 1967, at which time the rate should increase to about four a year.

Significantly this increased launching rate in the 1967 time period coincides with the advent of maximum solar activity. The first use of an OSO with increased observational capability will occur at this time.

Much of our effort during the past year in the area of geophysics and astronomy has been directed toward the development of two large observatories—the orbiting geophysical observatory and the orbiting astronomical observatory.

The geophysical observatory will make its first flight in 1963. It is planned for launch rates of approximately 3 per year thereafter, covering 2 important orbits with well-integrated payloads of 20 or more advanced experiments.

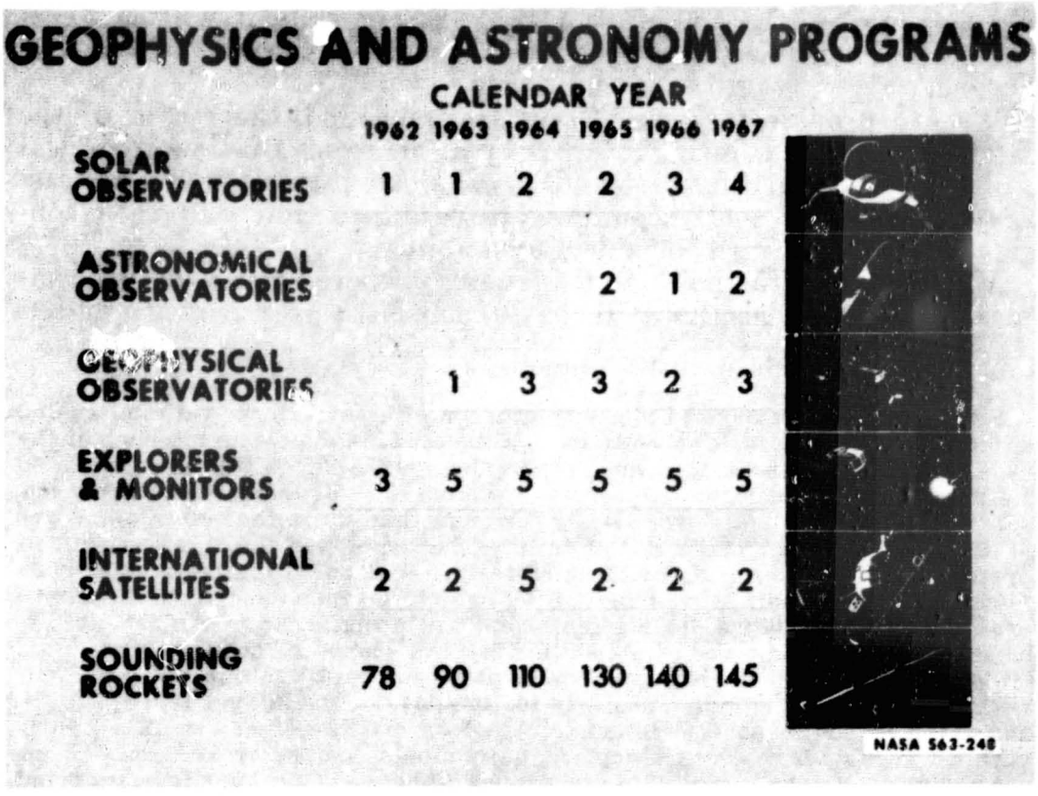

FIGURE 32

The CHAIRMAN. If I may interrupt, what is the lifetime of the geophysical observatory, or for that matter any one of them? Does it mean, for example, if they have a 2- or 3-year lifetime that we may have as high as eight or nine in orbit at one time?

Mr. CORTRIGHT. No, we would be very happy to reach a reliability which would permit us to reduce the launch rate. We are initially shooting at about a 6-month life, and later striving for a 1-year life. Assuming reliability of launch vehicles to go up somewhat, but allowing for the initial problems we will probably have with these spacecraft because they are complicated, we have scheduled enough observatories to keep approximately two in the air all of the time, one in the polar orbit and one in the inclined-elliptical orbit. We have allocated only three per year to keep two up virtually all of the time, so we are counting on getting high reliability early.

The CHAIRMAN. What are the components in the observatory that cause them to have only a 6-month lifetime? Is it electronic equipment failure that causes the limited lifetime, or what is it?

Mr. CORTRIGHT. Primarily our electronic equipment and possibly some electromechanical equipment will probably fail in this order of time.

The CHAIRMAN. These all get their power supply from solar cells, is that correct?

Mr. CORTRIGHT. That is correct.

The CHAIRMAN. And is this one of the components where deterioration takes place fairly rapidly?

Mr. CORTRIGHT. We are protecting the solar cells with a film covering to permit the length of operation that we are designing for.

That should not be a limitation, no. Statistically it will be something else in the electronic systems that won't last beyond those time periods.

We can provide for you, if you are interested, the record of the satellites launched during the past year in terms of time to initial failure and useful life. By and large, all of them operated at least 2 months before they encountered any failure, and they then continued to operate with some degraded ability.

We are not at the point in this country where we can design complex satellite systems that will consistently last a year from the outset.

RELIABILITY

Enclosed is a summary of the past year's operating experience with automated spacecraft and the vehicles used to launch them. It is limited to missions of the Office of Space Sciences, the Office of Applications, and the Office of Advanced Research and Technology. A cursory examination will indicate that only one satellite failed to operate successfully for more than 2 months before some type of failure occurred. These initial failures have not put the satellites out of operation, and all but 1 of the 11 satellites are still operating. The most complicated of the satellites was the OSO–I which has now completed 1 year of operation, fully stabilized to one-tenth of 1° pointing accuracy. This satellite must reacquire the Sun and establish this pointing once each orbit.

Four Ranger and Mariner spacecraft were successfully launched last year with the Mariner functioning properly for 129 days. One Ranger functioned for about the 66 hours required to get to the Moon and the other two failed early within the first day. Thus Mariner was our only completely successful deep-space flight last year. It might be worth recalling, however, that Rangers I and II appeared to operate properly for the several days they were in orbit and that the earlier Pioneer V operated quite well to a distance of 22½ million miles and for a time period of several months. The increased difficulty with our lunar and planetary series undoubtedly reflects the second generation nature of these relatively complex systems. All in all, we did achieve about 80 percent reliability with our unmanned spacecraft last year and our reliability analyses indicate that the advanced systems should reach reliabilities of 80 percent fairly early in their flight history.

The launch vehicle performance is summarized and indicates excellent performance with the Scout and Delta and Thor-Agena.

This listing for 1962 does not include military flights with the Scout and Thor-Agena which were quite successful. Scout, although only 15 have been launched, has been successful in its last 4 attempts to orbit satellites. The Atlas-Agena is a real headache, however, having less than 50 percent reliability to date. Our overall launch vehicle reliability was over 80 percent last year.

This memorandum has no particular purpose other than to generally acquaint you with the state of the art in automated spacecraft. We will be happy to elaborate on any specific area or to provide on-site briefings to members of your staff interested in this equipment. I think there is a lot to be learned from the experience we and our contractors have had which may materially help a program such as yours wherein you are planning for nearly 100 percent reliability at the outset, something which has really never been done by our aerospace industry.

Performance record—Spacecraft

I. SATELLITES

A. Office of Space Sciences

Name	1962 launch date	Weight in pounds	Days to first failure	Useful life, days	Remarks and major cause of failure
OSO I [1]	Mar. 7	440	69	(1) 69 (2) 290	(1) Loss of 2d tape recorder. (2) Real time operation only.
Ariel [2]	Apr. 26	132	77	(1, 2) 77 (3) 260	(1) Radiation damage from atomic tests. (2) Tape recorder. (3) Real time operation only.
Alouette [2]	Sept. 29	320	----------	----------	
Explorer XIV [2]	Oct. 2	89	----------	----------	
Explorer XV [2]	Oct. 27	100	(3) 0	(1) 0	(1) Despin.

B. Other Than OSS

Tiros IV	Feb. 8	285	84	(1) 120 (2) 266	(1) Useful TV days—tape recorder No. 1. (2) Last TV days—delay circuit (turns on camera) No. 2.
Tiros V [2]	Jan. 19	283	18	(1) 195	(1) Open filament in camera No. 2.
Telstar I [2]	July 10	170	129	(1) 129 (2) 170	(1) Command encoder. (2) Energetic particle experiments.
Tiros VI [2]	Sept. 18	285	72	(1) 105	(1) Vidicon filament and focus circuit No. 2.
Relay I [2]	Dec. 13	172	----------	----------	
Explorer XVI [2]	Dec. 16	169	----------	----------	

II. SPACE PROBES

Ranger III	Jan. 26	727	3	3	Computer failure during terminal maneuver.
Ranger IV	Apr. 23	730	>1	----------	Unknown, probably computer.
Mariner I	July	447	----------	----------	Launch failure.
Mariner II	Aug. 27	447	129	129	No malfunctions that SC was not designed to cope with.
Ranger V	Oct. 18	755	>1	----------	Power failure.

[1] Still operating with attitude control.
[2] Still operating.
[3] At launch.

Performance record—Launch vehicles

1. SCOUT

1962	Mission	Result	Remarks
March	Reentry	Success	Improved 3d stage performance.
March	Probe	Success	
August	Reentry	Failure	4th-stage ignition problem.
December	Orbit	Success	

2. DELTA

February	Tiros IV	Success	
March	OSO I	do	
April	Ariel I	do	
June	Tiros V	do	
July	Telstar I	do	
September	Tiros VI	do	
October	Explorer XIV	do	
October	Explorer XV	do	
December	Relay I	do	Improved performance capacity (+60 percent).
February (1963)	Syncom I	do	

3. THOR-AGENA

September	Alouette	Success	

4. ATLAS-AGENA

January	Ranger III	Failure	Atlas guidance failure (near miss).
April	Ranger IV	Success	
July	Mariner I	Failure	Atlas guidance, off course, safety destruct.
August	Mariner II	Success	Lucky launch, mission accomplished.
October	Ranger	do	

The CHAIRMAN. Is it due primarily to the fact that we are always pushing the state-of-the-art, that we really don't have the metals or other materials developed to a state where these can withstand the hostility of space, or is it a matter of little plumbing failures which occur as time goes on, which all goes back to quality control? Which one of those two areas are we talking about?

Mr. CORTRIGHT. We push the state-of-the-art in this equipment. We don't think that we push it excessively, but we are trying to get out of American industry what it is capable of doing.

The CHAIRMAN. So although the lifetimes of these observatories normally is from 6 to 9 months, let us say, it is because of the state-of-the-art rather than because of the lack of good quality control which contributes to some plumbing failure of an off-the-shelf piece, or something like that; is that right?

Mr. CORTRIGHT. Quality control is a part of the state-of-the-art in this country. I know what you are driving at, and I think that both factors enter into it. I think quality control is just as much state-of-the-art, however, as whether or not we know how to design a transistor to carry a certain electrical load and so forth. Quality control involves the organization and control of thousands of people making thousands of parts which go into this equipment. The accomplishment of high reliability early in the program is a major goal and a major challenge to this country.

We certainly hope that the space program will pace the country in this area and that we will all benefit, even beyond space systems.

Mr. STAEBLER. Mr. Chairman, I notice that the rate of development of the several different instruments is for the most part stationary except for sounding rockets. Does that mean that the present amount of expenditure is likely to continue, or do you anticipate if this rate of development is continued that there will be further increases?

Mr. CORTRIGHT. I am not certain I understand your question entirely.

Mr. STAEBLER. If this rate of development that you projected here is continued, do you anticipate the present budget level will be continued?

Mr. CORTRIGHT. We anticipate that a modest increase even beyond the budget of this year will be required to support this program.

Mr. STAEBLER. This goes back to the question we were raising with Dr. Newell, whether we have reached a kind of plateau for the pure science exploration. I take it we haven't quite reached a level of spending yet.

Mr. CORTRIGHT. We think we are within a year or two of it, based on the present economy and the competitive situation and the scientific needs, but not this year.

Mr. STAEBLER. Thank you.

Mr. DOWNING. Mr. Chairman.

The CHAIRMAN. Mr. Downing.

Mr. DOWNING. That is interesting. What do you mean by a plateau, is that where we stop?

Mr. STAEBLER. I am sure this is my term and not his.

Mr. CORTRIGHT. No, I recognize the term I hope, and that is the point at which the space sciences program may be expected to level off and run at that level, at least for some years.

Mr. DOWNING. It won't be a level of technology which we won't go beyond?

Mr. CORTRIGHT. No, sir.

Dr. NEWELL. It would be a funding level.

Mr. DOWNING. A funding level?

Dr. NEWELL. Yes.

Mr. DOWNING. That is what I wanted to know.

The CHAIRMAN. Mr. Cortright, one more question, if you don't mind, and then we will allow you to proceed with your prepared statement.

Are we desirous of having two or three a year of these observa ries injected into orbit because we have different scientific experiments aboard, or merely because those aboard wear out and we have got to replace them?

The reason I ask the question is that it would seem that if we increase reliability we might reduce the number of launches.

Obviously, if one satellite could stay up there for years, then we wouldn't need three in 1966 and four in 1967.

Mr. CORTRIGHT. That is a very good question.

The CHAIRMAN. So what is the purpose of your numbers here? Is it to get different experiments up, so that even if you had high relia-

bility and one satellite would last for a year, you would still have a need for three and four a year?

Mr. CORTRIGHT. I think that it is both. Yes, we learn from the experiments we conduct, and this stimulates thinking throughout all of our scientific community which then comes up with new ideas. This means we like to give them an opportunity to fly as part of an integrated payload within some reasonable period of time.

On the other hand, there are certain types of experiments which don't necessarily have to be changed for a period of years. We would like them up there and operating and monitoring the vicinity of the Earth for solar radiation and trapped radiation. So both of these motivations are present, and this particular satellite is designed to meet those needs.

It is designed to have the life, and it is also designed so that we can put one up with relatively short leadtimes and can accommodate completely new experiments, ones that we haven't thought of yet. We sometimes call this the streetcar satellite because it has a rack in it to accommodate experiments and a rather flexible data-conditioning system which can pick up various types of instruments.

The CHAIRMAN. Well, I wasn't sure that we were attempting to build into the satellite greater lifetime expectancy, and I am still not sure. I guess it depends upon the nature of the experiment. For some experiments you don't care to have them last more than 6 months, because you get all of the information that you need, and others you would like to have last for several years. Is this correct?

So really what you need is an on going program with additional observatories just because you have different experiments coming up.

Dr. NEWELL. If I may comment on this, Mr. Chairman, in the case of the solar observatory and the geophysical observatory, it is particularly true that there will be new experiments coming along because of the complexities of the studies and the variety of instrumentations needed to study the different things that are being measured.

In the case of the Orbiting Astronomical Observatory, we come to what may be compared to, say, a facility like Mount Palomar with its 200-inch telescope. Here it is our hope that we can arrive at a point where we will have put up a very versatile instrument that then can be used by different experimenters. When one experimenter has finished his observation, another one can move in and use this instrumentation to perform a different experiment.

At the present time we are using the first three observatories to develop our abilities to put a highly accurate astronomical observatory into orbit and at the same time to perform different experiments in the three.

Hopefully in this process we will learn how to construct a facility of useful applicability so that if we can get the lifetime we can continue to use it as long as it is there.

The CHAIRMAN. Thank you very much.

Mr. CORTRIGHT. Well, to continue, Mr. Chairman, and members of the committee, the astronomical observatory will not be flown until 1965 and will continue at approximately 9-month intervals. This satellite will constitute a major milestone in the science of astronomy.

Turning now to the Lunar and Planetary Programs (as illustrated in the next chart (fig. 33, Lunar and Planetary Programs), we see that our current active flight projects are Ranger and Mariner.

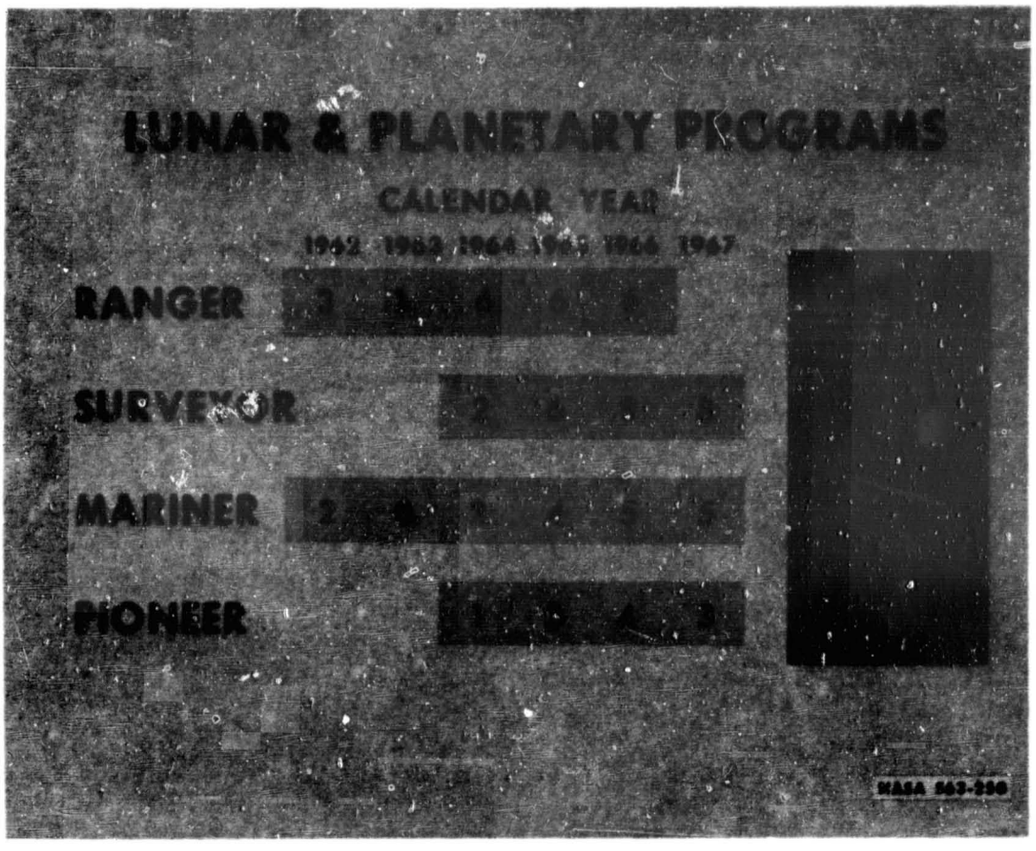

FIGURE 33

Ranger has had five launchings to date. This project, which is designed to obtain our first detailed information about the lunar surface by means of approach photography and landing capsules, has resulted in many technological developments and an impact on the lunar surface.

Following a series of improvements, Ranger will continue on into 1966. The Ranger will be followed by a considerably more advanced spacecraft, the Surveyor. The Surveyor will commence its test flights in 1964 and should result in an instrumented soft landing on the Moon in 1965.

In addition, an orbiting version of the Surveyor is planned for late 1965 or early 1966.

Current planning since this document was prepared indicates mid-1965. I should have corrected that.

This team of spacecraft, the Surveyor Lander and Orbiter, will provide us with our most extensive knowledge about the Moon prior to manned landing, and will probably be utilized well beyond the first manned mission.

The CHAIRMAN. Mr. Cortright, I wonder if you would give to us the pros and the cons for the Surveyor Orbiter?

Now there must be some cons as well as some pros because the Office of Space Sciences was debating the question as to whether or not to continue the program, and I understand only this week made the decision to go ahead with the Orbiter program.

Would you list for the record the reasons why we should have it, and then those reasons that were advanced which indicated we may not need it?

Mr. CORTRIGHT. Yes, Mr. Chairman, I will attempt to do that. The Surveyor Lander is technically capable of landing within approximately a 50-mile circle.

We plan to utilize this spacecraft by selecting, on the basis of Ranger photographs and Earth-based photographs, potential landing sites and directing the Surveyor to those sites.

In a sense we are taking a chance that these sites may or may not be suitable for landing a surveyor.

Now as you will see later, the Surveyor is designed to land under some pretty unfavorable conditions and survive and get the data it is supposed to get, but I would like to reemphasize the fact that we simply don't know what the surface of the Moon is like.

Now in order to make much better use of the Surveyors and direct them into areas that will pay off in terms of both data return and probability of a successful landing, we want to use an Orbiter to do area surveys, sort of photoreconnaissanc from an orbiting position.

The Orbiter will greatly extend the advanced knowledge which we will have from the Rangers which approach impact with a decreasing size picture.

In addition—and I am not sure we made this clear yesterday, but I would like to make it clear now—once we get to selected spots of the Moon with the Surveyor Lander, we would like to be able to say that the local surface characteristic is probably also present at other identifiable areas that are likely landing sites for man, for example.

Now we can extrapolate the point information on the basis of the orbiter which sees the Surveyor and the terrain itself and then goes on to look at other spots of the Moon.

The Moon is a big place and it is important that we look at more of it than just where the Surveyors can sit down.

Mr. CHENOWETH. May I ask a question, Mr. Chairman?

The CHAIRMAN. Yes, sir.

Mr. CHENOWETH. You are going to land a Surveyor on the Moon in 1965, you indicate.

Now is it possible that you might get such information from that landing that would cause us to take another look at this manned lunar flight? Is it possible that conditions might be so adverse and so difficult that you might want to reconsider whether or not you are going to put a man on the lunar surface at all?

Mr. CORTRIGHT. Insofar as that single sampling would be indicative of large areas, it is certainly possible.

Mr. CHENOWETH. That is possible?

Mr. CORTRIGHT. Yes, it is.

Mr. CHENOWETH. Then we would be spending all of the money on the manned lunar program later to find it is not feasible at all.

Is that a possibility?

Mr. CORTRIGHT. That is a possibility and that is the reason we are so anxious to pursue this unmanned program.

As a nation we simply do not want to arrive at some point in history, several years from now, having invested billions of dollars——

Mr. CHENOWETH. That is the point I am coming to: Would it be a part of wisdom to slow up on the manned lunar program until you

get this information and are sure just what conditions man is going to encounter there? Would that be a wise decision to make now? We are going full steam ahead on the Apollo as I get it. They are not waiting for what you will find out in your program. They are going ahead regardless.

Mr. CORTRIGHT. We don't think we should slow up Apollo for two reasons: First, we are designing the Apollo landing craft to cope with some reasonably bad situations and the pilot will be there to make final judgments, such as maneuvering a landing gear 20° to the left to avoid a boulder, which will be helpful.

In addition, the program for which we are asking support is designed to get the data which are required to give us this feeling of confidence that we are not risking too much in time.

Mr. CHENOWETH. Well, you feel you should have that data before we take the risk of sending him there?

Mr. CORTRIGHT. Yes, sir.

Mr. CHENOWETH. There is the possibility—it may be remote—but you may decide not to send him at all if it is too adverse.

Mr. CORTRIGHT. I think that there is no one in the world capable of answering that question until we get some data.

Mr. CHENOWETH. I appreciate that. Thank you very much.

Mr. CORTRIGHT. Continuing on, I think that I have really completed the arguments for why this is a valuable project, when I say that we can extrapolate to large areas the data that we get from small spot samples.

When I am through I will ask Dr. Newell to add his thoughts to this. In the con column, which you asked for, certainly the two items that come to mind are the additional technical effort and manpower required to do the job, and the money.

It is not a cheap project.

The CHAIRMAN. How much are we talking about in terms of dollars and cents, Mr. Cortright?

Mr. CORTRIGHT. We are talking about $150 million for a six-launch program.

The CHAIRMAN. Is this the normal estimate that we can assume would be off by 50 percent or maybe 75 percent, or is this a really good "set in concrete" type estimate?

It is difficult to make, I know.

Mr. CORTRIGHT. I am not certain that we are smart enough to tell you what a good "set in concrete" estimate is.

It is the best estimate that we can make at this time. It has been increased slightly from the contractor's estimate by about 25 percent to allow for the types of overruns and design changes that we frequently have to accommodate.

The CHAIRMAN. I suppose when this decision was being made or at least when it was being discussed or debated, you sat through most of the meetings; is that a fair assumption on my part?

Mr. CORTRIGHT. I sat through the major critical meetings.

The CHAIRMAN. Do you recall any other cons that were considered by those who expressed some concern as to why we should not have the Surveyor Orbiter, and if so, what were they?

Mr. CORTRIGHT. Yes, sir. We discussed the possibility that the manned system could be placed into orbit about the Moon and do photo reconnaissance in advance of the manned landing.

There are several factors to consider in evaluating the pros and cons of this approach. One is: When do you judge that this could be done?

The national commitment is to get man to the Moon by the end of this decade, and I don't think anyone is certain just when he is going to get there within this decade, but we feel confident we can do it within the decade. Now, it would be possible to develop a system, a photo-reconnaissance module to be attached to the Apollo spacecraft in lieu of the landing module, for example, with which man could go to the Moon and do large area photo reconnaissance and bring the film back with him without a lunar landing.

The present Apollo program is not designed to do that. That would delay the program. They are examining this possibility.

Now to go on a little bit more, the cons of that approach include the fact that it gives you the photography only a short time in advance of the manned landing and hence does not enable you to guide your Surveyor program with these films.

However, from a scientific point of view it would enable us to extrapolate the data as I have been discussing and project what other parts of the Moon are like without actually putting a Surveyor down in each area.

Another con is that it does complicate the manned program, it does delay it, it requires a development all of its own; namely, the photo-reconnaissance module to attach to the Apollo spacecraft.

The CHAIRMAN. Why do they need a photo-reconnaissance module attached to the Apollo spacecraft when the Surveyor Orbiter would apparently be nothing more than a capsule similar to Apollo but much smaller which orbits the Moon for the purpose of taking photographs?

Mr. CORTRIGHT. It would be to get more data.

You see, with the unmanned spacecraft we can select the orbit you need for photo-reconnaissance purposes and thus get by with limited film.

The CHAIRMAN. Do you mean the manned Orbiter cannot take photographs without building a new module that you referred to as a photo-reconnaissance module?

Mr. CORTRIGHT. That is being studied, but it is complicated by the space, weight, and volume requirements of the Apollo spacecraft itself and the need to return the film.

Well, we have to return the film anyway. Mr. Chairman, these studies are now underway. It is difficult for me to give you much additional information, but I think it is important to bring out the fact that should this be injected as part of the Apollo program it is phased several years later depending on how Apollo progresses, than the program we are proposing to do with automated equipment to complement our Surveyor Lander program.

Mr. HAMMILL. Would the photographs that a Surveyor Orbiter would take be of the same quality as those which a manned orbiter would make?

Mr. CORTRIGHT. Our current estimate of the resolution potential of the automated orbiter is between 1½ and 3-foot resolution on the lunar surface, comparable to the Ranger impacter.

It does this by virtue of using a developed film system with a photocell scan technique which is available in this country.

The photographs obtained with a manned system could be better than those obtained with the unmanned system because you are bringing the film back to Earth and you can examine it microscopically. It also depends on the optical system that you would put on board, but I think it is an honest statement to say that it could be better.

Mr. HAMMILL. It could be better than what?

Mr. CORTRIGHT. The film returned to Earth will be better than the pictures we can telemeter to Earth, but not by a tremendous margin.

The CHAIRMAN. But if we get pictures that gave us a resolution of 1½ to 3 feet, this certainly would be good enough, would it not?

Mr. CORTRIGHT. It is right on the border. Yes, it is good enough in this sense: the Apollo landing spacecraft, if I remember my number correctly, and if I don't I will correct the record—is designed to cope with a 2-foot boulder on the lunar surface.

It is not required to maneuver out of the way of that order of roughness.

The CHAIRMAN. Are there any more cons that you can think of that were expressed during the meetings or sessions held prior to the decision on the Surveyor Orbiter?

Mr. CORTRIGHT. We discussed the potential reliability of the system; that is, how many successful flights could we hope to get with the six-vehicle series.

The CHAIRMAN. What was the best judgment of the group on that?

Mr. CORTRIGHT. The best judgment was two to three.

The CHAIRMAN. Out of six?

What was the worst estimate?

Mr. CORTRIGHT. I can't give you the worst estimate, Mr. Chairman.

We have had programs in this country that have gone many launches without a success and it always can happen to you, no matter how good your intentions are. We analyzed the reliability on the basis not so much of theoretical considerations but of experience we have had with flight equipment. We took each subsystem within the spacecraft and compared it with similar subsystems that we are now building and for which we know the reliability. Putting that together, we were able to come up with spacecraft reliability in excess of 80 percent. Assuming launch vehicle reliabilities approaching 70 percent, you would get the 50-percent reliability for the total mission which would give you three out of six.

It could be better, it could be worse.

The CHAIRMAN. Mr. Cortright, the thing that really bothers me about the Surveyor Orbiter is that, first, we are going to fire it after we have had three Surveyor Landers, a minimum of three I think, probably from three to six.

Just looking at your chart, if the first Surveyor Orbiters would be launched the latter part of 1965 or early 1966, it means that possibly all of 1966 would go by before you would have a successful Surveyor Orbiter, isn't this correct?

Mr. CORTRIGHT. I would like to comment on that if I may, please.

One thing I would like to do is elaborate a little bit on the Surveyor program schedule.

The first two Surveyors which will be launched in 1964, if we hold our schedule, are test spacecraft. They are designed to test all systems through the midcourse maneuver and hence should impact on the

Moon at a preselected point. We will equip that spacecraft with engineering instrumentation to determine what goes wrong, if something goes wrong, and how to correct it.

The next two Surveyors are also test spacecraft and they are designed to go all the way to the lunar surface.

They will not carry the full complement of scientific equipment that the Surveyor is capable of and is planned to carry at a later phase.

They will be instrumented to determine the cause of potential malfunctions during the retro maneuver and radar-guided descent to the lunar surface.

Now this carries us through the first two launches in 1965.

The first Surveyor planned to do a complete mission with full complement of scientific instruments is, if I recall correctly, planned in mid-1965.

Now it is possible, we feel, to start flying the Orbiters at about this same time period, and that is why we feel that the timing is reasonable and it is not coming in too late.

It is a simpler spacecraft and a simpler mission than the landing mission and we have some technical justification for believing we can achieve good reliabilities early.

Dr. NEWELL. Mr. Chairman, if I may, I would like to add to the list of pros for the Orbiter.

The CHAIRMAN. Can you add something to both the pros and the cons for the record?

Dr. NEWELL. I think Mr. Cortright has done very well on the cons.

The CHAIRMAN. Proceed.

Dr. NEWELL. Mr. Cortright has mentioned the gross survey of the lunar surface which can be made which would tie together the observations made by Ranger and by Surveyor.

In addition to such measurements, one can measure the radioactivity of the lunar surface. Much of this radioactivity, it is expected, would be gamma ray activity and, therefore, would fill the region surrounding the Moon; it is, therefore, important practically to know this.

Also scientifically the gamma radiation will be characteristic of the materials on the lunar surface.

The orbiter will also provide us with an object to observe for obtaining the geodetic characteristics of the Moon. The geodetic characterictics are important to any maneuvers you make in the vicinity of the Moon, whether rendezvous maneuvers or landing maneuvers, because these geodetic characteristics pertain to the gravitational properties of the Moon.

In addition, if the Moon is being peppered by micrometeors, the splash particles from these micrometeor impacts will set up a field of fast-moving material particles in the vicinity of the Moon and it is important to make observations of these. One will be able to do this on an orbiting satellite.

The CHAIRMAN. You could do that with a Lander, too, couldn't you?

Dr. NEWELL. Well, with the lander you will find out what is in existence on the surface of the Moon but with the Orbiter you will find out if these splash particles are also existing in appreciable numbers far out from the Moon so that they have to be taken into account when you are making approaches to the Moon.

The CHAIRMAN. Well, the Lander will begin taking pictures from what point above the surface of the Moon?

Mr. CORTRIGHT. The Surveyor Lander?

The CHAIRMAN. Yes; didn't you say yesterday it would have a resolution of 125 miles down to——

Dr. NEWELL. That is the Ranger impactor.

The CHAIRMAN. Well, then, won't we get that information, Doctor, or a certain portion of it from Ranger?

Dr. NEWELL. On the micrometeor studies we will get some of that information from the Surveyor as it approaches, but again since the Surveyor Lander approaches one area, we will not get a picture of the total field around the Moon.

The Surveyor Lander gives you a measurement along an approach trajectory and at a single spot on the Moon, where it lands.

One advantage of the Surveyor Orbiter is that it then permits you to tie together these spot measurements, both the measurements along the trajectories and at the landing point.

The CHAIRMAN. What about all the Ranger flights?

It seems to me that we are going to take a lot of photographs and have use for a very few of them.

Maybe this is not an accurate statement, but I would think we will have use for substantially less than we take. Are we going to be taking pictures with the Ranger, are we going to be taking pictures with the Surveyor Lander and are we going to be taking pictures with the Surveyor Orbiter?

It just seems to me, Doctor, that we are going to have a lot of pictures that we don't need because we are going to get information from several that gives us about all I guess that we really do need.

Now can we do something with Ranger, for example, to eliminate a very, very costly project like Surveyor Orbiter?

Dr. NEWELL. Well, I think that you recognize that a picture of one region on the Earth's surface does not give you the whole story about the surface of the Earth.

The same thing is true about the Moon, a picture at one or even a few spots does not give you the whole story about the Moon.

The CHAIRMAN. Well, I appreciate that, but you are not going to get all of that information with all of your Rangers and all of your Surveyors, so I suppose what you are saying really is how far down the road should we go to getting a percentage of the total.

I don't know how much we add by Surveyor Orbiter.

I would say that if this is your argument, comparing Earth to the Moon, generally speaking if you can stay off the Rocky Mountains you could probably land almost any place in this United States, if you were not worried about the people who live here. If you had the capability of landing something, the situation may be the same on the Moon. I am not sure, but if we find out the composition of the surface of the Moon, then really we are not as hamstrung in selecting a landing site, are we, as we might be led to believe?

Dr. NEWELL. Well, if it turns out that much of the Moon's surface is like the very rugged areas of the craters of the Moon National Monument in Idaho or the very rugged terrain of parts of Utah, or is of a quicksand type, then we are in real trouble.

I think one of the major points about the Orbiter is that if we have had spot checks with the Surveyors and Rangers so that we know what certain spots are like and we can tie that information in with

other observations such as the optical appearance, reflection characteristics, and so forth, then with the Surveyor Orbiter pictures we can extrapolate and interpolate effectively from the spot checks made by Ranger and Surveyor Lander and determine whether we have a real problem or not.

Mr. CORTRIGHT. Although the Ranger takes many pictures, it takes them along a single axis, starting from the original hundred mile picture down to a very small one.

The Orbiter takes hundreds of square miles of pictures along selected strips, and we can select them while it is in orbit. Think of the Moon as a checkerboard with each square having something different in it, and assume that we can only sample maybe four or five of these before man goes to the Moon.

Orbital photographs will enable us to create the potential checkerboard in advance and then, on the basis of a few samples, make up a mosaic of probable lunar surface conditions over the whole desired landing area of the Moon.

Now we are not trying to map the whole Moon.

The CHAIRMAN. Even at that, it will be like putting postage stamps on that wall, won't it, Mr. Cortright?

Mr. CORTRIGHT. I think it is better than that but it is far from a complete lunar mapping job.

Mr. DOWNING. This present picture of the Moon that you have here, it looks like it may be composed of rocks 1,000 miles in length or something.

Is that a reasonable interpretation?

Dr. NEWELL. The photographs of the Moon show very little coloration. The Moon appears to be mostly gray which would indicate rocky type surface: the radio observations from the surface of the Earth show that the Moon looks relatively smooth which means that the boulders and materials strewn about the Moon would probably be less than, on the average, some yards in diameter.

We are therefore reduced to determining whether or not the Moon is strewn with boulders of many feet in diameter, as compared to many yards.

The CHAIRMAN. Dr. Newell, really the only thing that we must know about the surface of the Moon is whether or not it will sustain the weight of an LEM.

Isn't that right?

Dr. NEWELL. No; that is not quite correct.

The CHAIRMAN. Well, perhaps not quite, but this is the really important thing, isn't it?

I mean we want to make sure that we have ascertained before the manned landing that the surface will support the weight of the man in the module, isn't that right? We want to determine that it is not sponge-like substance such as you described yesterday.

Dr. NEWELL. It is not only a question of the weight, but also whether the Moon is so rough that the capsule could not find a level enough spot, or even enough space on which to land. It might be toppled over and damaged because of the fact that there are boulders and cracks and crevices, even though the material might support the weight.

The CHAIRMAN. Well, first of all we have to establish what the composition is, and then we'll try to pick out a fairly level spot, but how

accurately is the astronaut going to be able to maneuver this thing and with what kind of map are you going to be able to equip him? Will he be able to maneuver this thing to a precise point on the Moon the size of this room or the size of this building, or the size of Washington, D.C.

I am not sure you see that all of the information we are going to have is going to do him much good unless this thing is extremely maneuverable; and if it is extremely maneuverable, he can pick out his own landing spot, he does not need a map to guide him to a particular section of the Moon as indicated by our photographs.

Dr. NEWELL. Well, in order to go ahead with this project, he wants to know, as you say, whether or not there are areas in which he can set his landing module down and not be toppled over by the presence of boulders, or the existence of cracks, and know that he is not going to sink into a mass of dust.

The combination of the Surveyor Landers and the previous Rangers together with the Surveyor Orbiter is designed to map enough of the Moon so that with the scientists studying this they will be able to tell him whether or not such and such an area is an acceptable one for him to attempt a landing in.

These scientists will combine the optical appearance on the photographs with the physical characteristics actually measured by means of the Surveyor landing craft.

The CHAIRMAN. What you seem to be saying is that all of the Surveyor Landers may land in one spot, and so you just won't get a checkerboard effect like what you might need to ascertain the composition of the various sections of the Moon's surface; is that right?

Dr. NEWELL. What I am saying is all of the Surveyor Landers, even if they don't land in one spot, will give you only a sampling, and you have to have a further check to see whether that sampling is a good sampling.

The CHAIRMAN. Can we direct the Surveyor Lander to a precise spot on the Moon or within a certain small given area?

Dr. NEWELL. We can direct it to within about 50 miles on the lunar surface.

Mr. CORTRIGHT. Any 50 miles on the left-hand side of the Moon as you look at it.

The CHAIRMAN. Using this thing [indicating], as a somewhat accurate description of what the lunar surface looks like, we could undoubtedly hit this area [indicating], couldn't we, with a Surveyor Lander?

Dr. NEWELL. That is correct.

The CHAIRMAN. Or hit this area?

Dr. NEWELL. That is correct.

The CHAIRMAN. So if we hit any one of these areas I guess we could be pretty much of the opinion that what it is like here [indicating] it is like over here; isn't that right? And what it is like here it is probably like all over here; isn't that a fair statement?

Dr. NEWELL. To the extent that you are willing to rely on the limited observations from which that model was drawn.

That resolution, corresponding to telescope observations from the Earth, is something like three-fifths of a mile, and as that picture has been drawn the artist has said to himself where it all looks alike it is

alike. So he has covered one set of areas with blue, and he has drawn up another set with that structure that you see in the mountainous area.

Now we say in order to be sure that you are not committing somebody to a suicide mission we have to obtain this same information to a better resolution.

The CHAIRMAN. Our telescopic resolution today is what, sir?

Dr. NEWELL. Three-fifths of a mile.

The CHAIRMAN. What do you think this is, what would this be?

Dr. NEWELL. That is based on three-fifths-mile resolution, and hence hides just the questions that you need to know: Are there boulders of several feet to several meters? Is there this fairy castle dust layer on the Moon? Does this fairy castle layer cover not only the maria but the mountains, as Dr. Tom Gold thinks?

I for one would not like to go on such a mission without knowing the answers to these questions.

The CHAIRMAN. I am not sure that we are going to get anything more than we will already have by the Surveyor Lander; this is my point, Doctor.

I certainly agree we should have as much information as we can possibly get. Sophisticated redundancy does not necessarily appeal to me.

Dr. NEWELL. You look with our telescopes and you get a resolution of three-fifths of a mile, that is a pretty big distance actually, and you say within this resolution there are big areas that look as though they are all the same, over those whole areas of the maria, for example. But you don't know that they are really uniform, and in order to be sure about it you ought to get observations over that total area and with a resolution of a few feet as we are proposing to do.

Now, with our Surveyor Landers we will have spot checks in the various maria, and spot checks in other types of locality.

The CHAIRMAN. Yes, but we will have more than a spot check. When the Surveyor Lander is approaching the Moon it takes pictures at what distance from the surface?

Mr. CORTRIGHT. It is not really designed to get high resolution surface photography, it is designed to get a series of nested pictures so we can reconstruct where the Surveyor landed.

The CHAIRMAN. Except that you will get a pretty good idea of what a large area of the surface of the Moon appears to be like in that area in which it lands, isn't that correct?

Mr. CORTRIGHT. Not a high resolution.

The CHAIRMAN. No; except that you will be able to tell, won't you, from even its non-high-resolution pictures as it approaches whether or not that whole area is pretty generally the same as the area that it landed on. Won't you be able to tell that?

Dr. NEWELL. When it is at high altitude its resolution will be comparable to what we already get from Earthbound telescopes. When it gets low enough so that its improved resolution is giving you better information its area of view will have become limited so that again you are in the same bind that you are seeing only one restricted spot.

You know that with low resolution a total area looks very much like what that restricted spot did with that low resolution, but you do not know that with the high resolution that total area is all the

same. Prudence dictates that we know more about the Moon before we send some men there.

The CHAIRMAN. Yes, the only point that I want to make is, if we were so imprudent as to have waited until this time in our manned lunar landing effort to decide that we need a Surveyor Orbiter, then I am not so sure that we have as fine a program as we think we have, you see. I agree with you insofar as your opinion on prudence is concerned. I think that is true.

Dr. NEWELL. It is true, Mr. Chairman, that a basic science program of limited scope can very often get you into binds like this where you only wish you had done it earlier. This is why I keep pleading for the broadest possible program to keep us protected against the unexpected and to cover all our bets.

The CHAIRMAN. Now there is a program in the manned lunar landing program that actually sends some kind of a module to the Moon, isn't there, which lands on the Moon, or takes a look-see and makes some analyses and sends the information back to Earth? Isn't there some kind of program like this in the manned lunar landing program?

Mr. CORTRIGHT. As you recall, last year when this committee and the main committee recommended that Project Prospector not be carried forward, this was about the same time when we transferred responsibility for any large logistics vehicle which was one of the functions of the Prospector, to the Office of Manned Space Flight.

They have taken this past year as an opportunity to study a number of such systems, and these systems have varied all of the way from automating the lunar excursion module so that it can land remotely, to building a separate logistics vehicle.

These systems are still under study, and to the best of my knowledge none of them are approved by the NASA Administration.

The CHAIRMAN. Well, what if they decide to go ahead with one of those and then we decide to go ahead with the Orbiter and the Lander and the Ranger? Then how many programs too many will we have, would you say? We must have one too many.

Mr. CORTRIGHT. Well, Mr. Chairman, we are not uncoordinated in that sense. We work together on a weekly basis. In fact, we have set up a special group under Dr. Shoemaker just to insure that the programs that we start, which have both scientific value and value in support of the manned mission, are projects which are needed and are traded off against possible things that could be done as part of their program. This is reviewed by Dr. Seamans and Dr. Dryden and Mr. Webb, and they make the final judgments.

Now, in the case of a lunar logistics vehicle, an entirely new one of the C–5 size, this is an end-of-the-decade sort of operation designed to support extensive lunar exploration by man after the initial landing.

An automated lunar excursion module could come in earlier, but anything you put in earlier of that sort of nature may detract from the current Apollo schedule, which is tailored to get man on the Moon at the earliest possible date.

I am not sure that answers your question, but I am trying to give you the status of the total deliberation.

Mr. HAMMILL. If I recall Dr. Newell's testimony during the posture hearings when he was asked about the reevaluation of the Surveyor Orbiter which was then underway, he indicated that the Surveyor

Orbiter pictures would be available in the 1965–66 time frame, and that this would probably only be a year or so before the first manned flight to the Moon; referring not necessarily to a landing on the Moon, but a manned flight in the vicinity of the Moon. Presumably all of the objectives of the Orbiter could be carried out by a man in the vicinity of the Moon.

Is that a correct statement of your testimony or not?

Dr. NEWELL. Yes. The point was made that we wanted to consider all different approaches to getting this information.

Now, our decision to go ahead with the lunar Orbiter included the thought that we needed these data as early as possible and as far as possible in advance of the lunar landing, and that the chances of getting it with the lunar Orbiter at the planned time period were greater than the chances of getting them in the manned flight program in the designated time period, because again that program is going to be subject to the same difficulties that we all have in getting on with a very complicated and extremely difficult program, and there will be delays there.

So, on balance it seems to us a better way of covering our bets to go ahead with the lunar Orbiter.

The CHAIRMAN. Any other questions?

Mr. Chenoweth.

Mr. CHENOWETH. I would just like to ask one more question.

Following up the line of questioning of the chairman, do I get the impression now that the data which you are going to obtain from this Orbiter is essential and absolutely necessary to the manned lunar flight; in other words, the flight will depend upon the data which you get?

Dr. NEWELL. We feel that, yes.

Mr. CHENOWETH. Now, should we go ahead with other preparations for this manned flight program until you have completed your program? Suppose you come up with a very unfavorable or impossible situation there, what are we going to do with the manned flight then?

Dr. NEWELL. Well, our best estimate at the present time is that there will be found places where the landing can take place. Our problem is to find those areas. We don't know right now where they are.

Mr. CHENOWETH. You don't know whether there are any, do you, Doctor?

Dr. NEWELL. We do not.

Mr. CHENOWETH. Then the whole thing is a matter of conjecture.

Dr. NEWELL. Yes. It is not a matter of just guessing, however, it is a matter of educated conjecture.

Mr. CHENOWETH. You hope you can find a place?

Mr. CORTRIGHT. There are reasons to expect that there would be places, because gravity tends to pull everything to a uniform surface and is only resisted by materials which have structural strength in themselves, like boulders. Lava flows tend to flow flat, although rough, and from our experience on Earth the geologists feel that there will be places, but we don't know where.

Mr. CHENOWETH. It is possible that the decision will be made as to the lunar flight that man will make his flight and come back without landing because the conditions would be so adverse that he might not want to run that risk.

Mr. CORTRIGHT. He has that option all of the way up until the final instance before touchdown.

I might say that one such aborted mission saved, pays for a program like the lunar Orbiter.

Mr. CHENOWETH. Well, he would have the benefit from this before he leaves, and surely would be guided by that, I think.

The CHAIRMAN. I would like to have some answers for the record as to how maneuverable this capsule is going to be.

Now let us say that we get some really good pictures from the Surveyor Orbiter and putting them together with pictures that we receive from the Surveyor Lander and from the Ranger program and others that might be involved, we decide that man should land in a specific region on the Moon. Now, how possible is this going to be? Can we direct him to an area of the Moon the size of Washington, D.C., for example?

This is what we are going to have to do if the value of these pictures is to be anything at all. We are going to have to design this kind of capability into the craft; right?

Then it seems to me if we have this capability an astronaut would probably be a better judge of where he should land when he gets close to the surface than what the map which you have prepared would tell him about where he should land.

I don't know. I am just speculating here, but it seems to me that if I were that pilot I would probably want to take a look for myself if I had this kind of vehicle and I assume we are going to have that kind of vehicle.

This is going to be a pretty maneuverable piece of machinery, and if it looks like the surface of the Moon is made of putty, I assume that the astronaut is going to have the capability built into the vehicle so that he doesn't really land. He might just hover there for a minute over the surface and then go back to rendezvousing with the command module.

Isn't that correct, Dr. Newell?

Dr. NEWELL. Mr. Cortright has the information on the numbers that you have asked about, but before he gives them I would like to point out that what we are trying to do is to put the operator of that module into the best possible position to avoid a catastrophe.

Now, you think of this object as hovering over a spot and deciding whether or not that is a good spot to land in, but suppose that the lunar surface is covered with these tremendous layers of dust that Tom Gold speaks about, and that the jet from this hovering craft simply builds up clouds of these particles that then envelop the spacecraft and cover it with a layer of dust because of the fact that out there in a vacuum being electrostatically charged by solar radiations the dust sticks to the spacecraft. The man is then in trouble.

In other words, he gets in trouble in what on Earth would just be a normal type operation, but in the vicinity of the Moon is a dangerous thing to do.

So when we say we want to survey the Moon to pick out the best landing spot and so forth, we say that we are trying to study all of these pictures in perspective and that perspective relates to conditions on the Moon, the properties of lunar material, what it will do under blast by the lunar vehicle, and so forth.

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We are trying to guess what surprises may be in store for the man and to acquaint him with these and to give him the ability to detect danger.

With this introduction, Mr. Cortright I think has the answer that you asked for.

Mr. CORTRIGHT. I have only approximate numbers, but I think you might want them to have this whole thing considered in the proper context.

The lunar excursion module will have the option of maneuvering several hundred feet in any direction during the final descent, a current nominal translation range of 1,000 feet in 2 minutes while hovering just above the lunar surface.

You have to be directed to a pretty good spot to start with, and then you do have the man's judgment, which is a very vital and critical factor in the success of the mission, which can be applied at the final moments, and will be, no doubt.

Mr. RANDALL. Mr. Chairman.

The CHAIRMAN. Mr. Randall.

Mr. RANDALL. Just a suggestion, not detracting from anything Mr. Cortright has said, but I would suggest on this matter that at some time next week we have someone from the Office of Manned Space Flight as a witness to give us more detail on it.

The CHAIRMAN. This might be a possibility.

Mr. RANDALL. At some later time to tie in with the suggestion of the chairman and the others.

The CHAIRMAN. Just one more question, Mr. Cortright.

If geologists are correct and gravity has the effect that you alluded to some time ago, then the Moon would have a hard surface. Just by virtue of the fact that it is round, it must have a fairly hard surface, isn't this correct, or a fairly firm one?

Mr. CORTRIGHT. Not necessarily, if you believe Dr. Gold's hypothesis. You could have a large dust layer, for example, 20 feet. I believe that for one model that he built up in the laboratory, you could sink over 10 feet before you would reach a bearing strength of 1 pound per square inch, and this would be disastrous.

The CHAIRMAN. But he doesn't agree with the geologists, does he?

Dr. NEWELL. No, the geologists disagree with him.

On the other hand, the geologists present just as forbidding an area and they show us pictures of lava flows that have jagged and very sharp projections, and even though the bearing strength of this material is very high nobody would want to land in it because the spacecraft would be cut to pieces.

The CHAIRMAN. Any further questions?

Go ahead.

Mr. CORTRIGHT. In the planetary program—and by the way, I would like to introduce a remark here simply to tell you that I will be coming back to each of these areas in some detail, so that if you would like to defer detailed questions to when I get to the specific items, it might be appropriate.

The CHAIRMAN. Fine. Thank you very much.

Mr. CORTRIGHT. In the planetary program, our active flights began with the highly successful Mariner in 1962 and will pick up again in late 1964 with the next opportunities to fly to Mars.

Beyond 1964, it is planned to launch a minimum of two flights at each opportunity for the Mars and Venus missions. The Mariner series, which began with the capability of observing the planet during close flyby, will culminate with the landing of instrumented capsules on the planetary surfaces. Exploration of the planets constitutes what may be the next greatest national challenge in space beyond manned exploration of the Moon.

Accordingly, planning is continuing toward a large spacecraft to make use of the Saturn launch vehicle capabilities. This project, known as Project Voyager, will be continued into preliminary design studies in 1964.

The Pioneer series of flights shown at the bottom of the chart has been added since we last had an opportunity to describe our program to you. This project is designed to capitalize on the high reliability of the Thor-Delta launch vehicle and the simplicity of a light spinning spacecraft reminiscent of the successful Pioneer V.

The Pioneer program will provide a series of deep space probes in the 1964 through 1967 time period which will help us monitor solar radiations, both as a contribution to the International Quiet Sun Year and in preparation for solar flare prediction at the time of the manned lunar mission.

The bioscience flight program is shown in the next chart (fig. 34 Bioscience Programs). This program, which was in its formulative stages last year, is now beginning to accelerate.

In the upper part of the chart, our balloon-borne program is illustrated. This program is currently concentrating on two objectives.

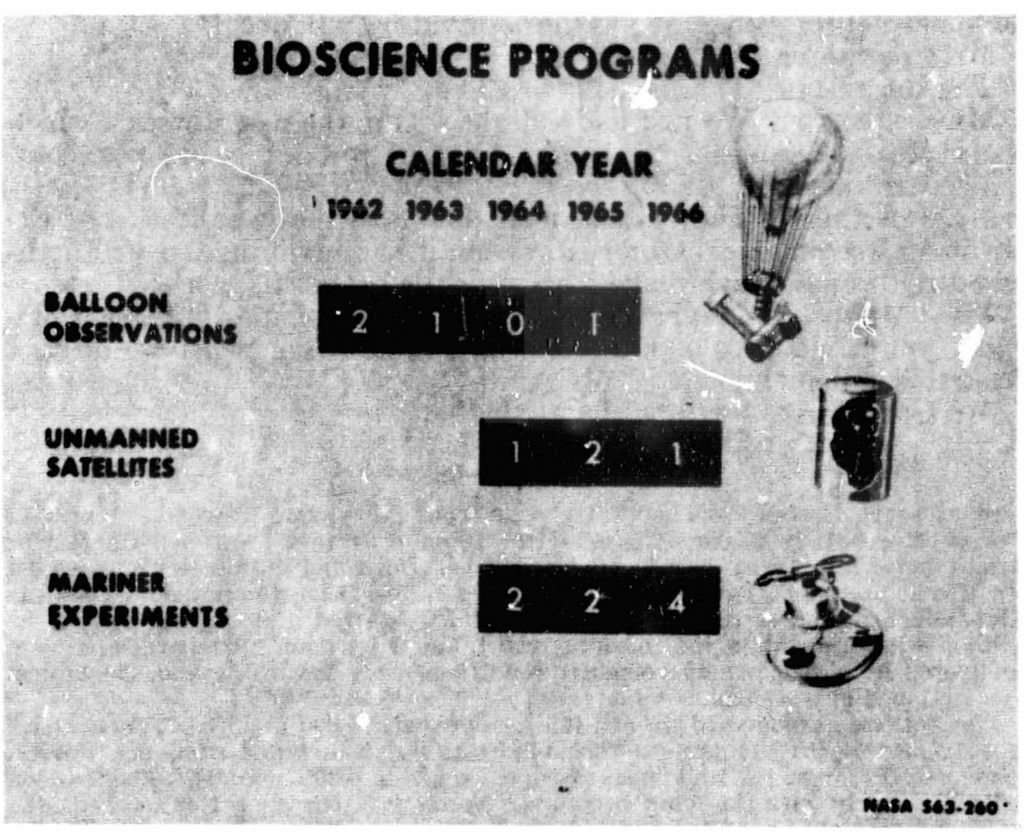

FIGURE 34

The first of these is to obtain biological samples from the upper stratosphere, and the second is to obtain infrared spectra of the planets by carrying a telescope to high altitudes for observations of Mars and Venus.

You will recall a successful flight to observe the planets was just made.

The CHAIRMAN. Is this going to be done by the observatories also?

Mr. CORTRIGHT. Yes, the observatories will get above all of the atmosphere whereas the stratoscope can get above most of it.

The CHAIRMAN. And what is the time frame for each of these?

Mr. CORTRIGHT. For the observatories?

The CHAIRMAN. How does that fit into the time schedule?

Mr. CORTRIGHT. The Orbiting Astronomical Observatory will fly for the first time in 1965. We are doing what we can with balloons, now.

The CHAIRMAN. The one that you are scheduling with the telescopic capability, when do you expect to launch that?

I see none for 1964, one for 1963. Does the one for 1963 have the telescope in it, or are you planning that for the 1965 observation?

Mr. CORTRIGHT. I think we may be mixed up here, Mr. Chairman. The Orbiting Astronomical Observatory carries large optical equipment and spectrographs to study stars and look at the planets. It is capable of looking at the planets.

This schedule does not show the flights of the Orbiting Astronomical Observatory. This shows at the top, our balloon flights both with atmospheric or stratospheric samplers and with telescopes.

The CHAIRMAN. That was the object of my question. When do you expect to launch the balloon that will carry the telescope that will do somewhat the same thing as the observatory will do?

Mr. CORTRIGHT. We just did it.

The CHAIRMAN. That is the 1963 shot?

Mr. CORTRIGHT. We just had a flight within the past 2 weeks, which was successful.

The CHAIRMAN. I see.

Mr. CORTRIGHT. The balloon does not have the capabilities of the Orbiting Astronomical Observatory but it has advantages over Earth-based telescopes which make it worthwhile to do this work.

The CHAIRMAN. Maybe when we get into these specifics, Mr. Cortright, you could give us kind of a nice rundown on what we did get from this balloon launch.

Mr. CORTRIGHT. I will be glad to do that.

RESULTS OF STRATOSCOPE II

Stratoscope II was launched (after numerous delays due to weather) at 5:41 p.m. on March 1, 1963, from the Scientific Balloon Station (National Center for Atmospheric Research), Palestine, Tex. Operations and guidance were carried out from a control van located about 200 miles from the launch site near Alexandria, La. Preparations for the launch started the night before; the balloon was laid out in the morning and inflated by noon. Preparations were completed by 4 p.m.; meteorological conditions were favorable and the launch accomplished at 5:41 p.m.

The balloon ascended to an altitude of between 78,000 and 79,000 feet, above most of the Earth's moisture. The payload, which included a 36-inch mirror, telescope, TV camera, and spectroscope, weighed 6,300 pounds. The balloon drifted easterly with the wind currents. At about 8 p.m. operations were begun to orient the telescope. A coarse vision TV camera "finder" was turned on to pick up guide points (stars, Moon, etc.). The telescope with its 18-foot tube

was balanced and pointed. Aiming the telescope was accomplished by determining the azimuth and elevations for required position. A compass on the telescope relayed information as to the direction in which it was pointing to the ground station. The coarse TV camera or "finder" relayed the telescopic picture and then a more sensitive TV camera took over by remote control.

The telescope was aimed carefully, centering on Mars. An automatic guiding device took over, locking the telescope on the planet. This remained fixed, despite the balloon's movements. The spectroscope measured the frequency spectra emitted from Mars in the infrared range. In this case the frequency spectra from 1 to 7 microns were scrutinized.

Five scans were made of Mars by the telescope, and data from the spectrometer were sent back via the TV camera and also recorded on board simultaneously. Two of the scans were slow, and the other three fast. Observations were made of CO_2 and water vapor on Mars. Tracings in the 1.8-micron region and in the 2.7-micron region indicated the presence of water and CO_2. This is the first time that a positive indication of the presence of water has been obtained on an object outside of the Earth.

The carbon dioxide and water tracings were quite definite, although the amount of water indicated was small. It was surprising that the water was so easily measurable. While the scientists at the University of California and Princeton University have data which clearly indicate the presence of these compounds, it must be emphasized that the exact quantities have not yet been determined. The analysis is still underway; the analysis of these data should be completed about mid-April.

The balloon drifted easterly for about 700 miles and descended just north of Huntsville, Ala., in an open field near Paluski, Tenn. The descent was made at about 6 a.m. by parachute from 40,000 feet. A local man saw the descent and notified the sheriff, who guarded the balloon until the crew of the chase planes arrived and took charge of the instrument. Very little damage occurred as a result of the descent.

At the beginning of the experiment there were some difficulties associated with an unexpected temperature of −70° C. Although a low temperature was anticipated, it was not expected to be at this low a level. The difficulty was corrected prior to the scientific determinations.

The CHAIRMAN. Fine. Thanks.

Mr. CORTRIGHT. In addition, the biosciences flight program is entering into the satellite flight phase. In late 1964, it is planned to launch the first of a series of recoverable satellites which will carry multiple experiments in fundamental biology.

Beyond these early exploratory flights, we are planning to eventually use manned spacecraft for the conduct of more complex biological experiments in space.

And I might inject here the information that we now have a request for proposals of this simple recoverable satellite capable of bringing biological samples back. The industry is now preparing its bids on that system.

In support of this space sciences flight program, we are continuing with the launch vehicles which were described to this committee last year, namely, the Scout, Delta, Thor-Agena, Atlas-Agena, and the Atlas-Centaur.

In addition, we are examining closely the use of the Saturn launch vehicle series in our advanced planetary program.

THE ORGANIZATIONAL BUILDUP

The breadth of the space sciences program has required an equally broad organization to carry it forward. This organization is illustrated in the next chart (fig. 35, The Organization To Do the Job).

The Office of Space Sciences contracts project management and project support to the eight NASA field organizations listed. These

THE ORGANIZATION TO DO THE JOB

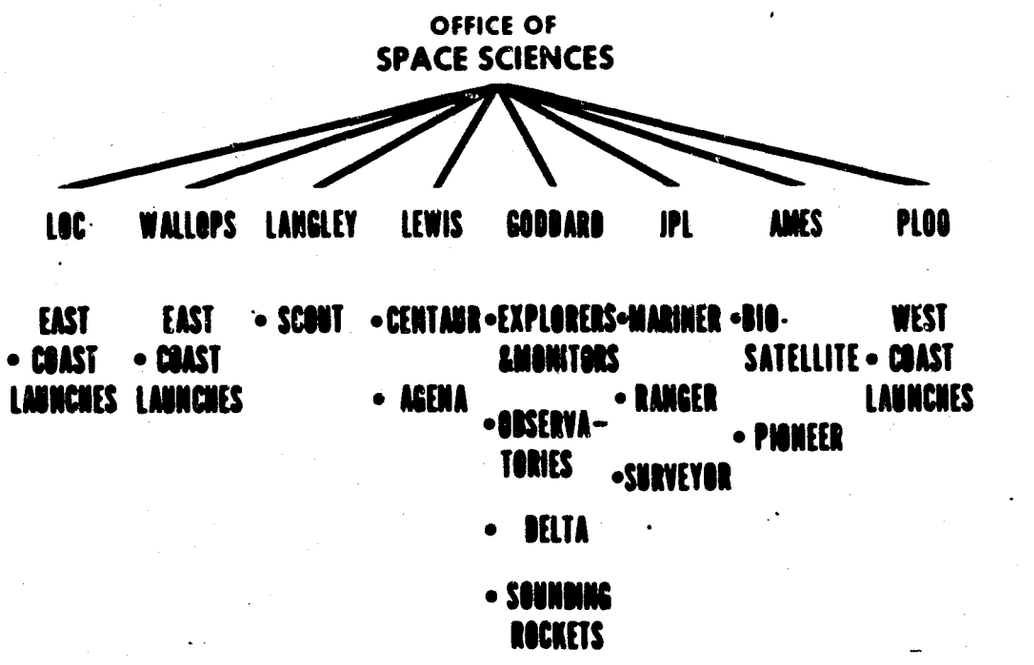

FIGURE 35

organizations, in turn, contract the major portion of the indicated project work to industry.

Scientific support is provided primarily by NASA Centers and by universities. This large Government, industry, university team has become well integrated into an efficient organization during the past few years, an organization which is capable of executing the complex tasks which have been laid upon it.

The key individuals responsible for the overall management of this effort are the Directors of the Office of Space Sciences and the Directors of the NASA field installations. I would like to identify them for you at this time.

NASA Headquarters, Office of Space Sciences

Dr. Homer E. Newell, Director.
Edgar M. Cortright, Deputy Director.
Dr. John F. Clark, Associate Director and Chief Scientist.
Dr. Richard B. Morrison, Director, Launch Vehicle and Propulsion Program.
Dr. John E. Naugle, Director, Geophysics and Astronomy Programs.
Oran W. Nicks, Director, Lunar and Planetary Programs.
John D. Nicolaides, Director, Program Review and Resources Management.
Dr. Orr Reynolds, Director, Biosciences Programs.
Dr. T. L. K. Smull, Director, Office of Research Grants and Contracts.

NASA Field Installations

Dr. Smith J. DeFrance, Director, Ames Research Center.
Dr. Harry J. Goett, Director, Goddard Space Flight Center.
Dr. Abe Silverstein, Director, Lewis Research Center.
Dr. Floyd Thompson, Director, Langley Research Center.
Dr. Kurt Debus, Director, Launch Operations Center.
Robert Krieger, Director, Wallops Station.
William H. Evans, Director, Pacific Launch Operations.

Jet Propulsion Laboratory

Dr. William H. Pickering, Director.

These key men gather bimonthly for 1 or 2 days at a senior council meeting at which we discuss our program planning, project progress, technical and management problems, new management tools, budgeting, contracting, coordination, and the host of other areas which must be dealt with.

This management technique brings to bear on our toughest problems the best collective thinking we can muster. It is but one of the techniques we employ to insure good management, without which a program of this magnitude would founder.

PROBLEMS WHICH HAVE BEEN ENCOUNTERED

As I mentioned earlier, the advance scientific missions which we have undertaken have pressed the state of the art in many areas. As a result, we have been confronted with a number of difficult problems which must be solved before we can count our program satisfactory in all respects.

These problems are summarized in the next chart (fig. 36, Problems We Have Encountered).

The first of these problems is that of reliability. The systems with which we work are, of necessity, highly complex. They require the ultimate in design concept, engineering, craftsmanship, and quality control. These qualities are not easy to achieve.

The difficulty in achieving early systems reliability is illustrated by the average curve of reliability versus flights for several major military flight systems.

And, incidentally, I would have been very happy to use NASA flight systems if we had enough experience with our systems to plot them to this curve. We don't in most cases.

On the average, it took about 20 flights to achieve 50 percent reliability. The more advanced civilian and military spacecraft are comparable in complexity to these illustrative systems. Some are showing signs of similar "bugs" early in their development cycles. We must radically improve this situation and strive for reliabilities approaching 100 percent at the outset.

We are working closely with the Department of Defense in this effort.

Another type of problem which we have encountered is that of maintaining schedules in the face of unforeseen technical problems

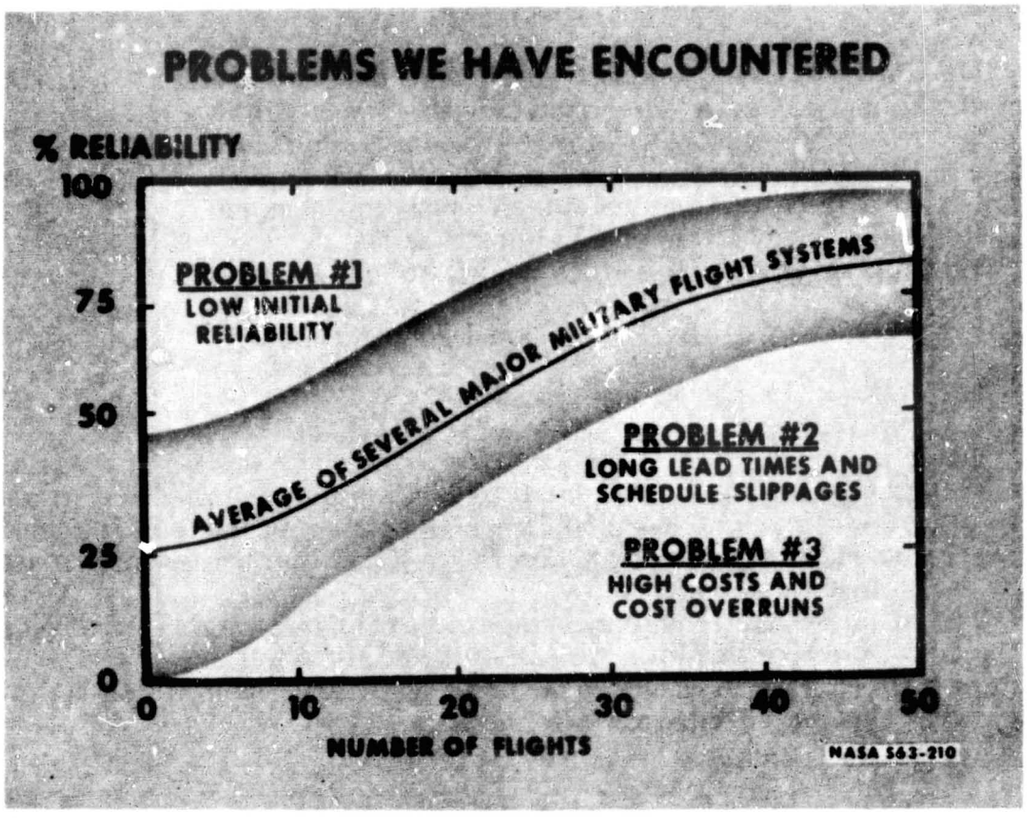

FIGURE 36

encountered in attempting to advance the state of the art in launch vehicles and spacecraft.

A third type of problem which confronts us is that of holding down costs. Overruns on contracts are a constant hazard in research and development projects and require continuous and diligent effort to keep to a minimum.

All of the problems which have been listed in this chart are being attacked with determination and imagination. Improved reliability is being sought by increased attention to basic design, by tighter specifications, by improved inspection and quality control procedures, and by more rigorous test and checkout procedures.

We are pressing this attack from the Government laboratories, through the prime contractors, and down to the smallest vendors of parts.

In addition, contractural techniques are being actively sought to provide incentives for those contractors who produce reliable equipment, on schedule, and within estimated costs. We are endeavoring to improve our initial specifications and to minimize changes within the course of the project which will alter schedules and increase costs.

Mr. RANDALL. May I interrupt, Mr. Chairman?

These incentives, I think, are important.

In the posture hearings of the full committee we discussed the displeasure of certain members that the percentage of failures had mounted up, and the question of penalties was brought up.

We did not go into penalties but we mentioned incentives.

What are some of those incentives, could you spell that out?

Mr. CORTRIGHT. I can submit a complete report to you later but for today I can say, for example, that with the Space Technology Laboratory on the Orbiting Geophysical Observatory we had incentives based on keeping overhead down on the contract. With the Grumman Aircraft Engineering Corp. on the Orbiting Astronomical Observatory we had incentives in our contract based on meeting schedules.

We are working with our contractors to provide incentives based on meeting schedules, costs, and reliabilities, and penalties based on not doing so.

These penalties are conceived of as loss of fee.

We don't have in our program at the moment to my knowledge actual penalty clauses but I am going to have to look into this for you a little bit more.

Mr. RANDALL. By your program you mean the Office of Space Sciences?

Mr. CORTRIGHT. Yes, the Office of Space Sciences.

Mr. RANDALL. Well, have you had any experience, if you put strict penalties in the contracts? Well, of course, you say you have not yet had that experience so you could not answer that question.

Mr. CORTRIGHT. I would really like to say I am not certain. There may have been a penalty clause in the Grumman contract which resulted in a cost sharing above a certain point but I am going to have to——

Mr. RANDALL. Well, that is back on the incentive side.

Mr. CORTRIGHT. No; because overruns then result in penalties, but with your permission I will beg off on that question today.

Mr. RANDALL. All right.

The CHAIRMAN. Would you submit it for the record?

Mr. CORTRIGHT. Yes, I will.

The CHAIRMAN. As much information as you can get on that?

Mr. CORTRIGHT. I will submit a statement for the record summarizing the Office of Space Sciences experiences with incentive contracts and whether or not penalty clauses were involved.

(The information requested is as follows:)

There are three incentive contracts currently being utilized for projects under the program management cognizance of the Office of Space Sciences.

They are:

I. Contractor, location: Space Technology Labs, Inc., Los Angeles, Calif.

Number and date executed: NAS 5-899, July 31, 1962.

Project: OGO Spacecraft Development.

Type: Cost plus fixed fee with incentive revision on indirect cost.

Incentive features and penalties involved: Contract and plantwide targets were established on indirect costs for calendar year 1962, based on labor overhead and related general and administrative expense. On the contract basis the difference between target and actuals at the end of the period calendar year 1962 was to be considered for sharing at a ratio of 50:50. On a plantwide basis, 10 percent of the difference between the established target and actuals would be considered for sharing at the same ratio. In other words, any savings effected by the contractor on indirect costs would be shared as outlined above. Conversely, the contractor assumes risk in the sharing of excessive indirect costs.

Remarks: It should be noted that the contractor has not submitted his formal report on this incentive arrangement but it is generally believed that it has resulted in some efficiencies at the contractor's plant.

II. Contractor, location: Aerojet-General Corp., Azusa, Calif.

Number and date executed: NAS 5-2252, June 30, 1962.

Project: Development and procurement of Aerobee 350 rocket systems.

Type: Fixed fee with incentive revision.

Incentive features and penalties involved: Target cost and profit amounts were established on this contract. Target profit represents 9.6 percent of target costs. Profit parameters range from 0- to 15-percent. A ceiling on costs was also established. A sharing ratio of 75:25, Goernment:contractor, was agreed upon. If the contractor effects savings against the target costs, he receives the benefit of 25 percent of the savings not to exceed 15 percent of target cost. If, however, he exceeds the target costs, he absorbs 25 percent of the excess up to the established ceiling on costs. Any costs above the ceiling are incurred exclusively by the contractor.

III. Contractor, location: Grumman Aircraft Engineering Corp., Bethpage, N.Y.
Number and date executed: NAS 5-814, January 8, 1963.
Project: OAO spacecraft.
Type: Cost, plus incentive fee.

Incentive features and penalties involved: A target cost was set on this contract and incentive fee for scheduled performance was provided for. The contractor must meet six technical milestones on schedule to receive a total of $300,000 in incentive fee. If the target cost is exceeded on the contract, the contractor will lose 8¾ percent of the increased costs from definitized fee. There is a ceiling of $3 million and floor of $2,300,000 on fee. Contractor could lose a total of $700,000 in fee.

NASA has not actively collaborated with DOD in the negotiation of incentive contracts for the procurement of launch vehicles under the management cognizance of the Office of Space Sciences. All NASA Atlas-D space boosters have been procured under incentive contracts with GD/A. However, these contracts were negotiated and administered exclusively by the Air Force. The incentive provisions of the Air Force negotiated contract with GD/A for the standard Atlas SLB3B are on cost and reliability. The target fee of 7½ percent is split as follows:

(*a*) Three percent based on meeting target costs.
(*b*) Four and a half percent for meeting target reliability.

Penalties are that if contract is overrun 25 percent or more, all fee relative to cost is eliminated. Loss of fee is also incurred if contractor fails to perform within the reliability target of 65 to 90 percent. There are no cost-sharing provisions under the terms of the current contract with GD/A.

The CHAIRMAN. And what the incentives are or were as the case may be?

Mr. CORTRIGHT. Yes.

One point I would like to throw in here if I may.

We collaborated with the Department of Defense some time ago in arriving at incentive-type contracts with our launch vehicle producers, and I will get that information also as part of the total picture since it reflected our own desires even though the contract was finally implemented by the Department of Defense.

In addition, we are utilizing throughout our program the most modern techniques of program control and project management, such as the PERT system.

Although it will never be possible in a research and development program to eliminate all unforeseen contingencies, we are confident that our attempts to establish the best possible management practices will materially reduce our problems in future years.

To this point, I have summarized the broad elements of the space sciences flight program. I would like now to turn to the individual areas and discuss in some detail the progress which has been achieved on the various projects and that which is projected for the immediate future.

Program review—Geophysics and Astronomy:

Consider first the area of geophysics and astronomy. The Explorer and Monitor satellites which were launched during 1962 are shown in the next chart (fig. 37, Explorers and Monitors, 1962 Launchings).

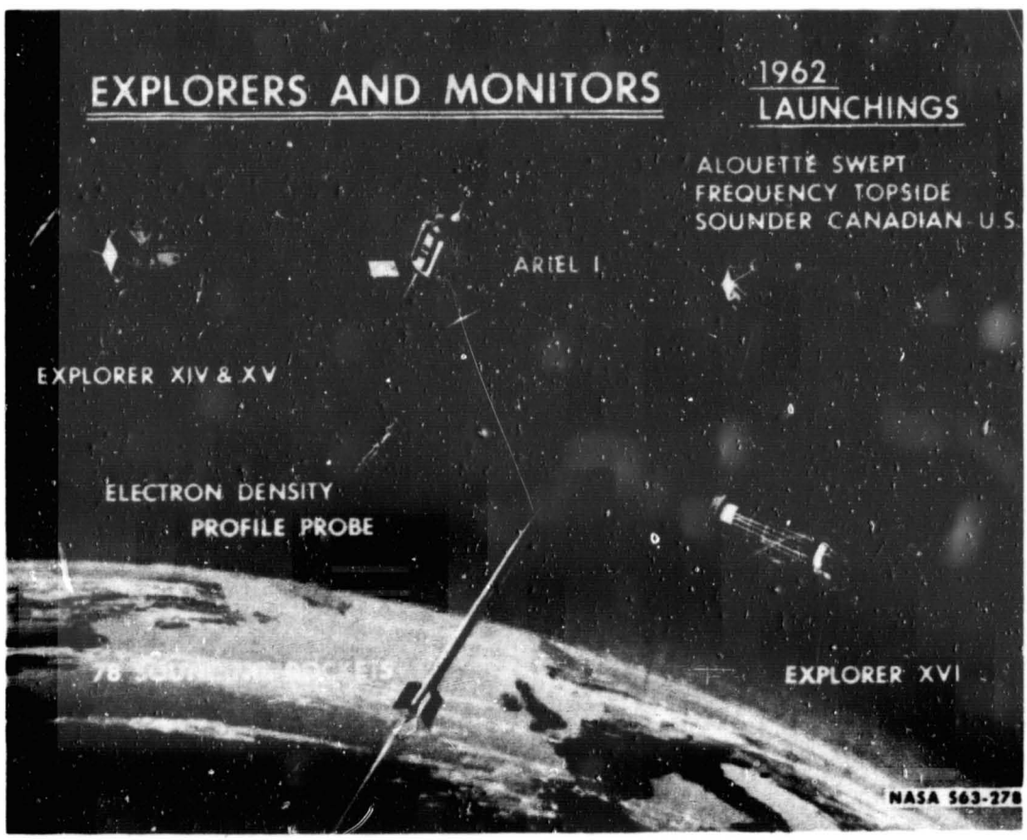

FIGURE 37

Explorer XIV and Explorer XV were designed to study both the natural and manmade radiation belts surrounding the Earth and to map out the magnetic field through which they flew.

Explorer XVI is measuring the micrometeoroid concentration around the Earth.

Ariel I was our first satellite in the cooperative international program. The experiments on Ariel I were developed entirely by scientists of the United Kingdom to primarily study the Earth's ionosphere by direct measurements.

Alouette was an ionospheric monitoring satellite using the topside sounding technique. Alouette was developed entirely by the Canadians as the second launching in the international program. This satellite was particularly interesting inasmuch as it was the first scientific satellite launched by NASA from the Pacific Missile Range into a polar orbit, and our first use of a Thor-Agena launch vehicle.

We were very gratified, I might say, by its performance.

In addition to these 5 successful satellites, a successful electron density profile probe was launched and some 78 sounding rockets.

In 1963, as illustrated in the next chart (fig. 38, Explorers and Monitors, Planned 1963 Launchings), we plan to launch seven additional satellities in this category of Explorers and Monitors and international satellites.

One of these is the interplanetary monitor, which is designed to provide monitoring of solar flares.

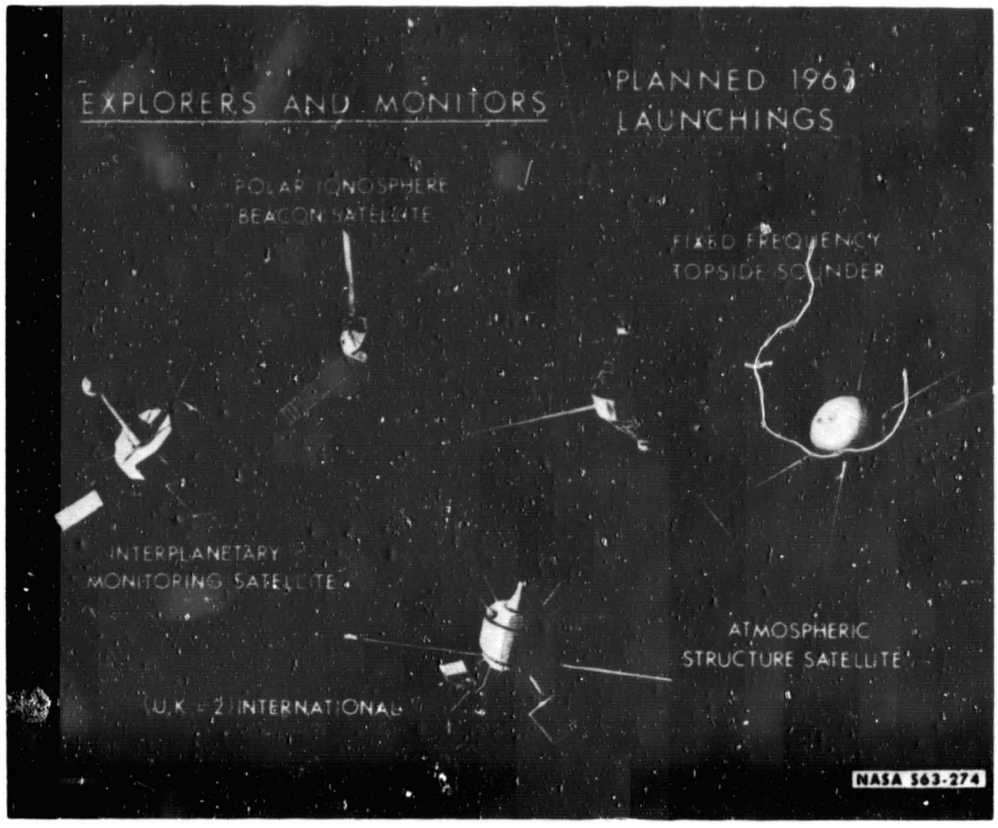

FIGURE 38

Projects of this type may some day lead to the timely prediction of such flares as a safeguard to extended manned space flight. Also shown are three satellites designed to study the ionosphere as well as particles and fields in the space immediately surrounding the Earth.

The signals from the polar ionosphere beacon satellite will be monitored by scientists throughout the world in a large cooperative study.

The second United Kingdom satellite also will be launched in 1963, and, in addition, an ionosphere Explorer developed by this country.

Also in 1963, we will launch our first Explorer satellite to study the chemical structure of the outer atmosphere of the Earth. This launch will occur shortly.

Some of the more important and interesting characteristics of our first Solar Observatory are illustrated in the next chart (fig. 39, The First Solar Observatory).

This 450-pound satellite is in many ways the most ambitious and successful satellite ever launched. The OSO was placed into a nearly perfect circular orbit by a Delta launch vehicle in March 1962.

This satellite operated for almost 1 year with the 2½ months' operation being virtually perfect.

It is still delivering useful data although it is beginning to run out of gas.

I don't mean that literally, it is just wearing out.

In addition to the scientific importance of these results, which were discussed earlier, this satellite has demonstrated that it is possible to attain a high degree of reliability in an unmanned orbiting space-

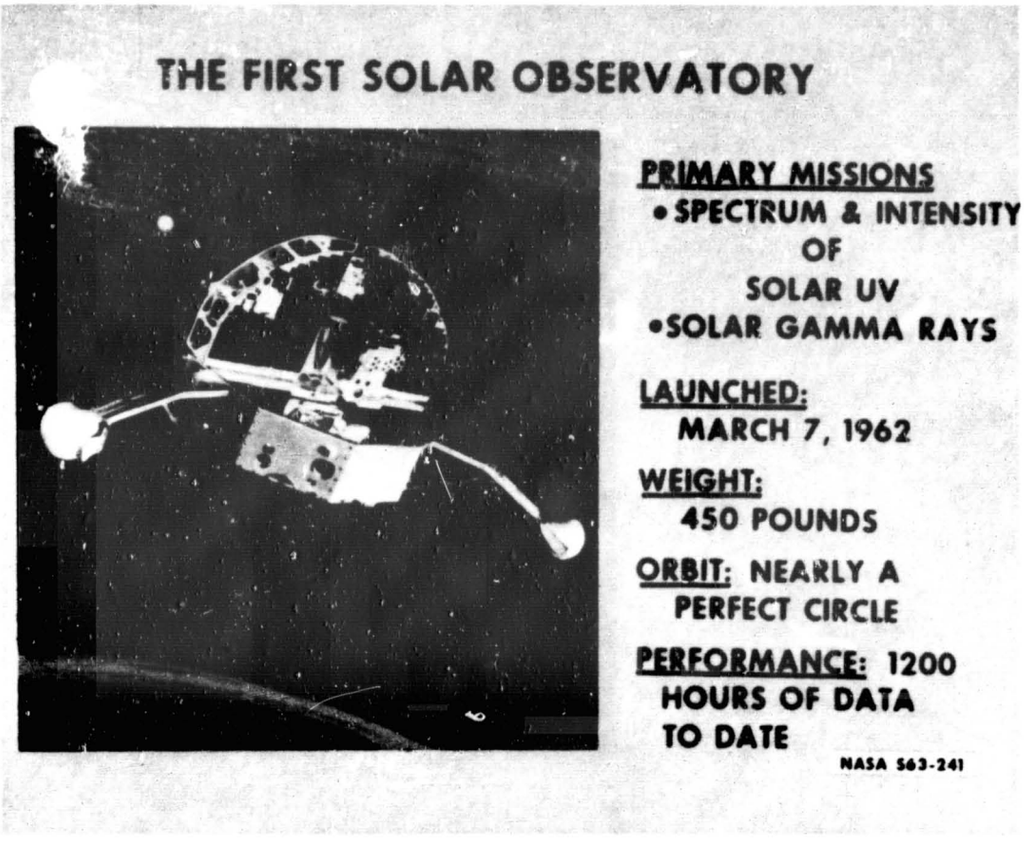

FIGURE 39

craft, particularly in the stability and control system, while maintaining simplicity of design concepts.

It has also demonstrated without doubt that machine elements such as bearings and sliprings can be operated successfully in actual space environment for periods of up to a year.

The CHAIRMAN. I wonder if we could conclude our hearings today on that note.

The last remaining member of the minority side has left and we cannot continue to sit without representation on both sides.

So if you and Dr. Newell are disposed to returning on Monday morning, you can continue at that time.

I would like to start at 9 o'clock Monday if it is acceptable to both you and the membership of the committee.

(Discussion off the record.)

The CHAIRMAN. We will adjourn until 9 o'clock on Monday morning unless you hear from Mr. Hammill.

Dr. NEWELL. Thank you, sir.

(Whereupon, at 11:55 a.m., the subcommittee adjourned, to reconvene at 9 a.m., Monday, Mar. 11, 1963.)

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1964 NASA AUTHORIZATION

MONDAY, MARCH 11, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SPACE SCIENCES
AND ADVANCED RESEARCH AND TECHNOLOGY,
Washington, D.C.

The subcommittee met at 9:23 a.m., pursuant to adjournment, in room 214–B, New House Office Building, Hon. Joseph E. Karth (chairman of the subcommittee) presiding.

Mr. KARTH. The meeting will be in order.

We had reached page 71 of your prepared statement, as I recall, Mr. Cortright.

While we are waiting for the arrival of other members you may continue with your prepared testimony. Later on, when some of the other members come in, we may have some questions we would like to ask.

Mr. CORTRIGHT. Thank you, Mr. Chairman.

FURTHER STATEMENT OF DR. HOMER E. NEWELL, DIRECTOR, OFFICE OF SPACE SCIENCES, NASA; ACCOMPANIED BY EDGAR M. CORTRIGHT, DEPUTY DIRECTOR

Mr. CORTRIGHT. The next observatory-type satellite which I would like to discuss is the Orbiting Geophysical Observatory shown in the next chart (fig. 40, Orbiting Geophysical Observatory). This advanced satellite is designed to obtain integrated simultaneous measurements of a large number of geophysical and solar phenomena to provide a better understanding of the Earth-Sun relationships. Twenty correlated scientific experiments are now being tested for the first OGO mission and 19 experiments were selected during 1962 for the second OGO mission. This spacecraft weighs slightly over 1,000 pounds including a scientific payload of 150 pounds. The OGO satellite is designed to fly with complete attitude control maintained by a combination of gas jets and inertia wheels. This control provides the required satellite orientation or positioning for Earth and space pointing experiments as well as Sun pointing of the experiments and the 32,000 power generating cells mounted on the solar panels toward the Sun. The satellite carries an advanced high bandwidth data system capable of stored and direct data transmission which will be monitored by a series of ground stations in the Northern and Southern Hemispheres.

OGO will be launched with a Thor-Agena into a circular polar orbit at relatively low altitudes. That is one of the two orbits I men-

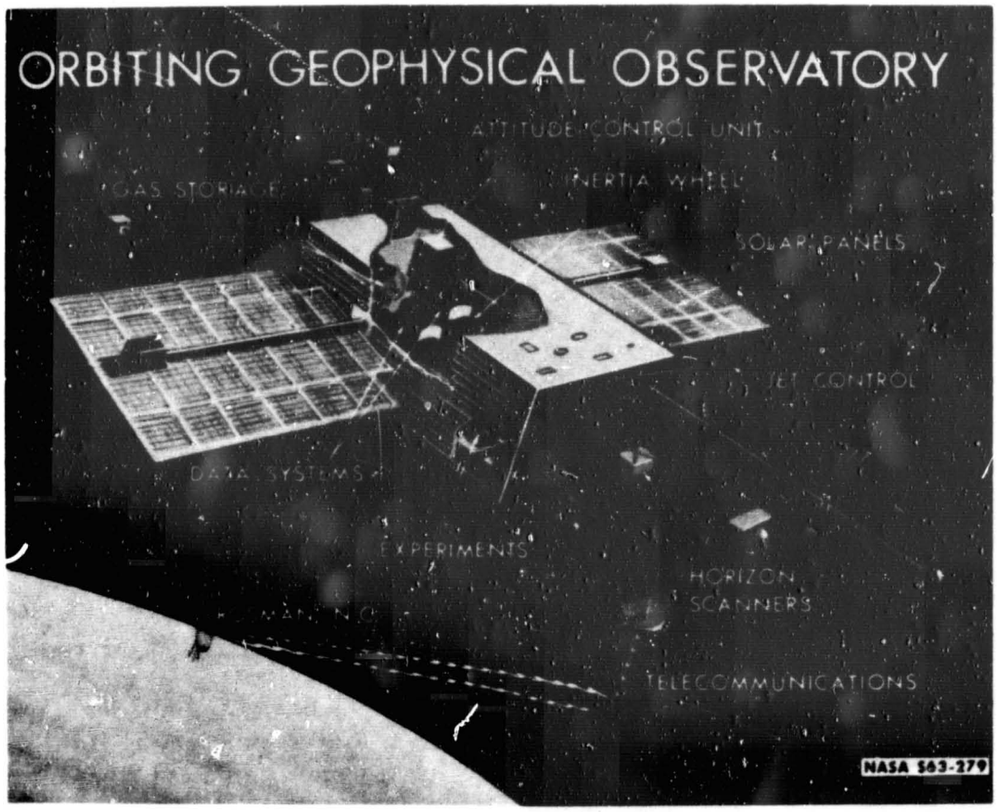

FIGURE 40

tioned the other day we use this spacecraft in—and by an Atlas-Agena into a highly elliptical orbit with apogee exceeding 50,000 miles.

During 1962 considerable progress has been made in the development, fabrication, and test of the OGO by the Space Technology Laboratories under the direction of the Goddard Space Flight Center. This chart (fig. 41, OGO—Spacecraft Progress) illustrates a small portion of the spacecraft hardware and test equipment that has been completed, or is near completion, by STL. At this time, the prototype or prooftest observatory is assembled and nearly ready for final checkout. The first flight observatory will follow in 2 to 3 months for launch in late 1963. In order to continue the geophysical exploration of near space through a complete solar cycle of 11 years, it is planned to maintai two OGO's with different orbits in space during this period.

If you will recall, I mentioned that we have three per year programed in an attempt to keep two per year in orbit.

Throughout history, astronomers have been constrained to view the heavens through the filtering Earth's atmosphere. As discussed earlier, the radiations which are prevented from reaching the Earth's surface by the atmosphere are important to the understanding of the universe and the stars and interstellar gases of which it is comprised. In recent years, techniques have been developed to carry large telescopes to high altitude by means of gas-filled balloons. This technique has resulted in spectacular astronomical studies, such as those of Dr. Martin Schwarzschild which were mentioned earlier.

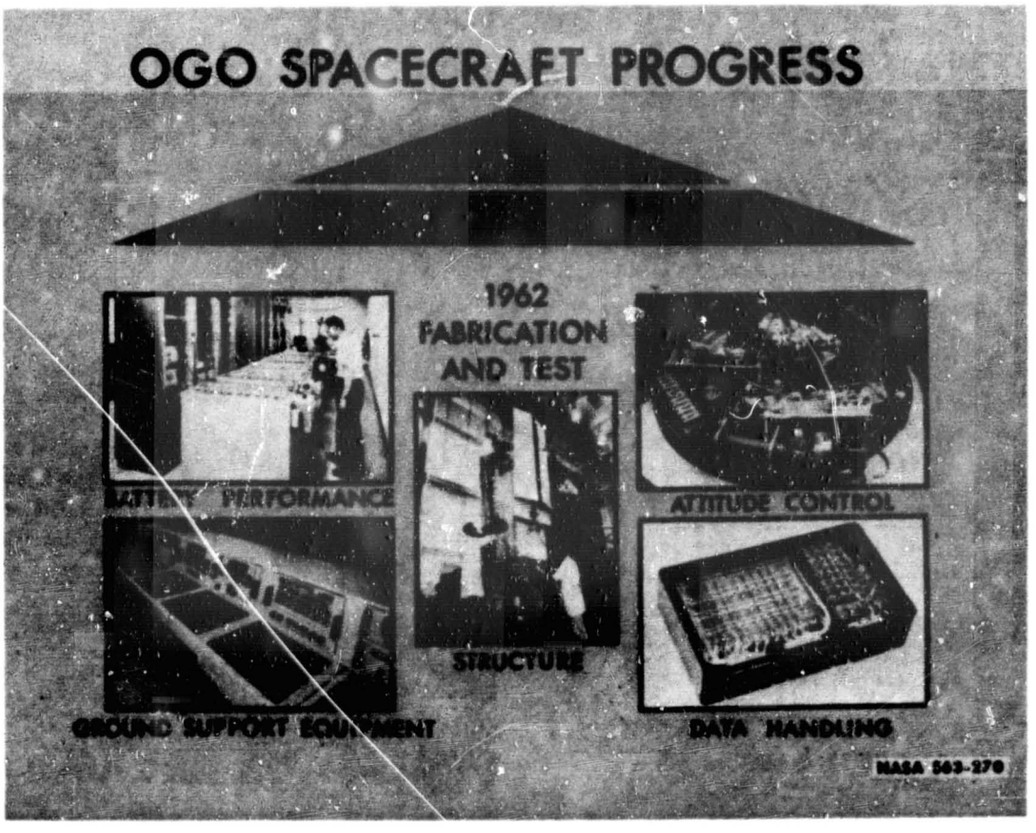

FIGURE 41

However, the gases which remain above balloon altitudes are still a serious hindrance to the astronomer. For example, ultraviolet radiation does not penetrate even these tenuous gases. To surmount these difficulties and take a giant stride forward in the science of astronomy, the NASA is developing an Orbiting Astronomical Observatory which is pictured in the following chart (fig. 42, Orbiting Astronomical Observatory). The Orbiting Astronomical Observatory is a 3,600-pound spacecraft to be launched into 500-mile circular orbit by the Atlas-Agena launch vehicle, early in 1965. A number of important experiments are being developed for this satellite. They include four 12-inch telescopes to map the sky in ultraviolet, which are being developed by the Smithsonian Institution; four 8-inch and one 16-inch telescopes being developed by the University of Wisconsin to study selected bright stars and nebulae; a 3-foot Goddard telescope for detailed studies of 5,000 stars and nebulae, approximately, and a 32-inch Princeton telescope for detailed studies of interstellar matter. In order to make full utilization of these advanced instruments, we are solving a series of very difficult technological problems. These include the problem of maintaining a precisely alined structure following the rigors of launch and in the heating and cooling conditions which prevail in Earth orbit. In addition, the attitude control system will have an eventual capability of pointing the OAO to an accuracy of one-thirty six thousandths of a degree, and registering where that point is, I might add.

The spacecraft computer and its data-handling system represent significant advancements in the state-of-the-art.

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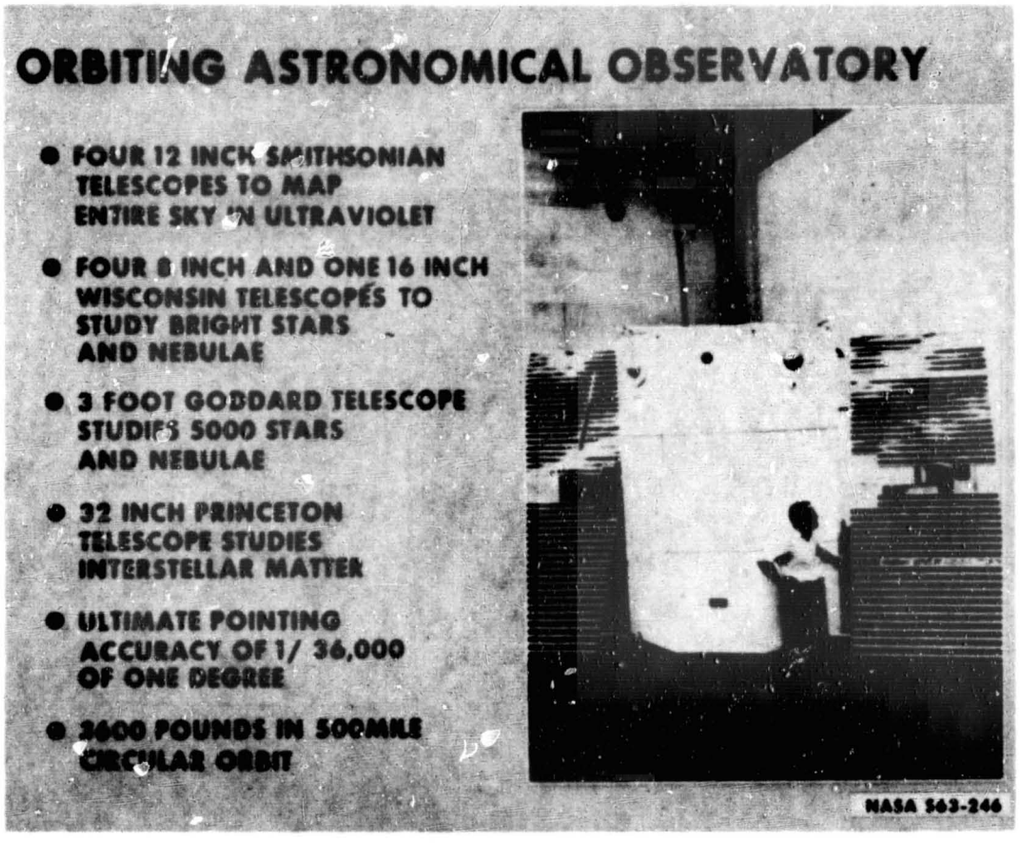

FIGURE 42

Orbiting Astronomical Observatories will be launched at 9-month intervals, and we are taking every precaution to insure a high probability of successful launch and a long lifetime in orbit. To do this, an elaborate qualification, test, and checkout program has been developed. This chart (fig. 43, OAO Current Testing and Fabrication) indicates some of the progress during the past year, both in the fabrication, assembly, and test of the spacecraft, and in the development of its ground control equipment.

Mr. KARTH. Mr. Randall.

Mr. RANDALL. Where is this work being done? Who has the contract?

Mr. CORTRIGHT. Grumman Aircraft Engineering Co. on the OAO.

Mr. RANDALL. On the OGO?

Mr. CORTRIGHT. Space Technology Laboratories.

Mr. RANDALL. Where is that?

Mr. CORTRIGHT. That is in Los Angeles, Calif.

Mr. RANDALL. That is a private contractor?

Mr. CORTRIGHT. That is correct.

Mr. RANDALL. Space Technological Laboratory?

Mr. CORTRIGHT. Space Technology Laboratories.

Mr. RANDALL. Thank you.

Mr. CORTRIGHT. The Grumman Corp. is located in Bethpage, Long Island.

Mr. RANDALL. That is all.

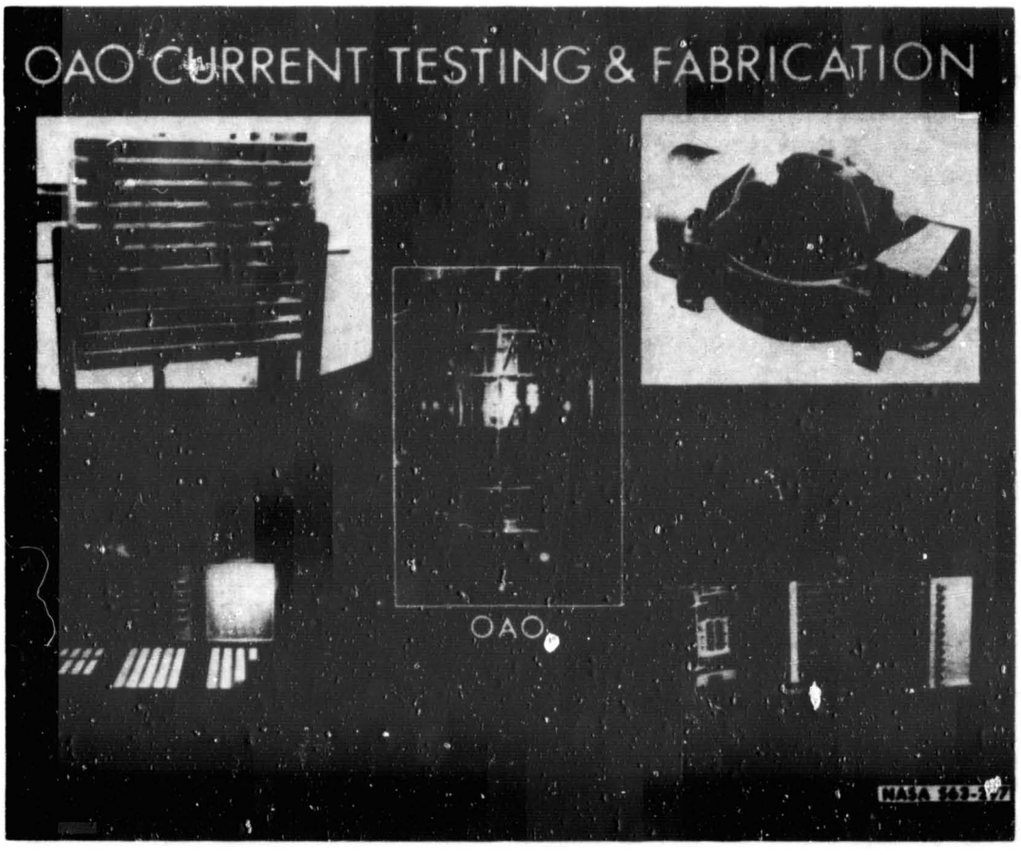

FIGURE 43

Mr. CORTRIGHT. Both of these projects are monitored by the Goddard Space Flight Center.

Program Review—Lunar and Planetary Programs

Since the national decision to proceed with the manned lunar landing project, NASA intensified its efforts in the area of unmanned lunar exploration. This step was taken in order to obtain significant data about the Moon and its environment prior to the manned mission and in support of the manned mission. In acknowledging this fact, however, it is important to recognize that the program to explore the Moon by means of automated spacecraft has great scientific value in its own right. There is little doubt that it will precede by some years the manned exploration, and for many years after initial manned exploration, the unmanned spacecraft will remain the only means of sampling the more remote and inaccessible areas of the lunar surface.

The CHAIRMAN. Mr. Cortright, it seems that almost every program has some value or some orientation toward the manned lunar landing program. Would you, for the benefit of the committee, tell us about what percentage of the Office of Space Sciences' program is oriented toward a successful manned lunar landing program?

Mr. CORTRIGHT. I can tell you the projects which will be of major benefit to the manned lunar landing program, and I will do that, in just a moment. But if we did not have a manned lunar landing pro-

gram, virtually all of the flight projects we have would be going forward on the basis of their own scientific value.

The projects that do support the manned lunar landing program include the Ranger and the Surveyor.

Mr. KARTH. Excuse me, Chairman Miller of the full committee just came in. Good morning, Mr. Chairman.

Chairman MILLER. Good morning.

Mr. KARTH. We are glad to have you here.

Chairman MILLER. Thank you.

Mr. CORTRIGHT. Good morning.

The Ranger and Surveyor in the lunar and planetary segment are in direct support, as well as having their own scientific value.

The Orbiting Geophysical Observatory, which I just mentioned, will be gathering important solar radiation data and additional data on the radiation hazard in the Van Allen belts. The interplanetary monitoring satellite, which we initiated last year, will gather radiation data outside of the magnetosphere, which we mentioned the other day is a disturbance to solar radiations. If you make the measurements within the magnetosphere it is more difficult to interpret the solar flare radiations.

The Pioneer, which I will be mentioning again in a moment, but I think Dr. Newell introduced it, will be monitoring these solar flares at distances well removed from the Earth. Thus, we can correlate the lateral or circumferential extent of solar flares, and learn a little bit more of just how they propagate out from the Sun, which will help us in our prediction process.

The Orbiting Solar Observatory is a direct benefit, inasmuch as it monitors the solar activity and provides measurements which we can't otherwise get in an effort to analyze the nature and origin of the solar flares. I think that is at least the bulk of the direct support. Maybe Dr. Newell would like to elaborate on that.

Dr. NEWELL. In addition, there are the Explorers and Monitors, all of which gather information on the radiation belt, and the outer portions of the Earth's atmosphere.

Mr. KARTH. Thank you, Doctor.

Chairman MILLER. Mr. Chairman.

Mr. KARTH. Mr. Chairman.

Chairman MILLER. Dr. Newell, Dr. Van Allen is credited with having discovered the radiation belts which bear his name. But isn't it true that to do this he had to extrapolate information from all available sources. Have we learned a great deal about these belts, or are we just scratching the surface? Are we just beginning to really learn what they are and their hazards, or do we know enough about them to be able to dispense with these projects that are designed primarily to explore them?

Dr. NEWELL. At this stage and time, although we have collected a great deal of information about the belts, we have not arrived at the point where we fully understand them. There are many questions yet that remain to be answered. For example, we are not yet able to determine precisely what are the lifetimes of particles injected into the Van Allen belts. This is important, not only in connection with the natural belts, but also in connection with artificial belts that may be created.

Also, we are not yet in a position to understand how the particles in the belt, in the natural belt, get their tremendous energies. It is clear, from measurements that have been made so far, that there is a relationship between solar activity and very marked variations by factors of as much as a thousand or more in the intensity of the belt, but it is not clear how these variations are brought about, what the mechanism is.

Also, it is clear that there is some relationship between the radiation belt and magnetic storms and auroral displays, which have their impact on radio communications. But again, the understanding of what this connection is is not yet at hand.

In addition, it has become clear during the past year that the radiation belts extend very far out in the antisolar direction to as much as 20 or more Earth radii from the center of the Earth, whereas in the solar direction they extend only half that distance.

Now, we have been unable to explore the belts in this antisolar direction fully, which is one of the reasons why the interplanetary monitoring satellite was introduced into the program.

In addition to this, there is the 11-year solar cycle over which the activity of the Sun varies markedly from high activity during the sunspot maximum to very low activity during sunspot minimum, and we have not yet been able to observe the relations between the Sun and these belts throughout an entire solar period.

I think this gives you a picture, Mr. Chairman, of the number of problems that still exist in connection with the radiation belts. They turn out to be an exceedingly complex region about the Earth which is important to continue to study.

Chairman MILLER. Well, do the belts revolve around the Earth, or are they stationary, and does the Earth revolve in them? From what you say, they apparently point away from the Sun?

Dr. NEWELL. Yes, the Earth revolves around the Sun. The portion of the radiation belts that extends in the opposite direction from the Sun is the elongated portion, so there is this change in the shape of radiation belts during the course of the year. In addition to which——

Chairman MILLER. Not daily?

Dr. NEWELL. It is not daily. The Earth slips inside the belts, as far as that shape is concerned. But in addition, there are circulations of the particles within the belt. We know that these oscillate from magnetic pole to magnetic pole along the magnetic field line. We also know that there are drifts of these particles around the Earth in a longitudinal direction, but these drifts are not completely understood, and there is at the present time considerable controversy as to whether there really exist sizable electric currents due to these drifts, that would be associated with magnetic effects that are observed at the ground.

Chairman MILLER. Then a knowledge of these belts is essential if we are going to understand our own form of radial communication; and then we get into the matter of communication by satellites. It is essential that they know the forces within these belts, is it not?

Dr. NEWELL. That is correct.

Chairman MILLER. Besides the necessity for knowing them in the manned effort?

Dr. NEWELL. That is correct.

Chairman MILLER. Thank you.

Mr. KARTH. Dr. Newell, what association have we been able to find existing between the Van Allen radiation belts and weather changes? Is there a direct relationship, or don't we really know?

Dr. NEWELL. We don't really know, but there are indications that there may be some important relationship. I believe last year we presented to the committee some evidence that indicates that when there are great changes in the radiation belt, these may be associated with changes in the weather pattern at the surface of the Earth.

For example, some time ago it was noted that when there was a large auroral display and radio communications blackouts, accompanied by magnetic storms and ionospheric disturbances, the weather pattern in the polar regions was greatly disturbed, and was accompanied by related disturbances over the southern portion of the United States which experienced unseasonably cold weather, including snowstorms.

Now, we don't really understand this connection yet. There is a considerable amount of research yet to be done to determine just what this connection is, and what its significance is.

Mr. KARTH. So in this one area alone, Doctor, I suppose we could say continued research is extremely important, as far as weather prediction is concerned, perhaps?

Dr. NEWELL. Yes, both weather prediction and climate prediction—long-term weather prediction.

Mr. KARTH. Is there any evidence of a direct or indirect association between changes in weather and artificial radiation belt centers?

Dr. NEWELL. We have no data that establishes any such connection up to now.

Mr. KARTH. Thank you.

Mr. STAEBLER. Dr. Newell, are we dependent wholly upon rockets, orbiting observatories, and so forth, for new information about these belts, or is it possible to collect some data from observation on the surface of the Earth?

Dr. NEWELL. We must rely completely on rockets and satellites to study these belts. The only related effects that we can study at the surface of the Earth are the magnetic storms and radio blackouts that were really not completely understood until we had gotten equipment into the radiation belt and had begun to study the effects of the Sun upon these belts.

Mr. STAEBLER. So any advance in understanding is dependent upon efforts of NASA?

Dr. NEWELL. That is correct.

Mr. RANDALL. Mr. Chairman.

Mr. KARTH. Mr. Randall.

Mr. RANDALL. I don't know whether I understood your meaning of the expression "antisolar direction." You said it was 20 Earth diameters?

Dr. NEWELL. By antisolar direction I mean the direction opposite to the direction of the Sun.

Mr. RANDALL. In other words, an axis between the Earth and the Sun, on the other side of the Sun?

Dr. NEWELL. The other side of the Earth.

Mr. RANDALL. The other side of the Earth, I see.

Dr. NEWELL. From the Sun.

Mr. RANDALL. I could hardly see how it would be the other way.

Now, you mentioned this slippage of the Earth within the Van Allen belts, which you say exist. I thought the charts you showed us earlier show those pretty much constant. Is there a relationship between—speaking of the Van Allen belts now—well, you have a slide up there now, the shape of magnetosphere (see fig. 10, p. 1474, Shape of Magnetosphere). Where is the Van Allen belt with relation to that?

Dr. NEWELL. The Van Allen belts are the charged particles that are trapped in between these magnetic field lines [indicating]. If there were no wind of charged particles from the Sun, these field lines would have a perfectly symmetrical shape—would be the same size in both directions, both toward the Sun and away from the Sun. Now, there is a solar wind. Mariner II has shown this, for example. And this solar wind compresses the field lines, flattening them out on the side toward the Sun, but blowing them out on the side away from the Sun.

Now, this dotted region here [indicating] is the region virtually unexplored, whereas we have done quite a bit of exploring of the opposite portion of the belt. The remote parts are those for which we need the interplanetary monitoring satellite.

Mr. RANDALL. I follow you. Contrary to at least some slides we have seen, there is nothing constant or spherical about the Van Allen radiation belts?

Dr. NEWELL. There appears to be very little constant about the belts.

Mr. RANDALL. Yet there were some earlier slides which seemed to show it circular and fairly uniform.

Dr. NEWELL. That is correct.

Mr. RANDALL. And it is a true statement or an accurate statement to say the Van Allen radiation belts are really a part of the overall magnetosphere?

Dr. NEWELL. They are a part of the magnetosphere, yes.

Mr. RANDALL. Thank you.

Dr. NEWELL. The magnetosphere is defined as the cavity in the solar wind that is carved out by the magnetic field lines of the Earth.

Mr. RANDALL. Thank you.

Chairman MILLER. How do you define this solar wind? We look upon wind as a current of air. This is not a current of air, because there is no air there.

Dr. NEWELL. No, but it is a current of material particles, in this case electrons and protons, blowing out from the Sun. It is, of course, much less dense than our atmosphere. There are maybe 15 to 20 particles per cubic inch, but they do constitute a wind of sorts.

Chairman MILLER. As I remember it, when this was first brought up, didn't they tell us they thought it was the light that compressed the belt on the side of the Sun?

Dr. NEWELL. There is solar radiation pressure, but the solar wind contains much more energy than the solar radiation pressure.

Mr. KARTH. Dr. Newell, I think the fourth illustration in the book that Mr. Cortright and you have been giving your prepared statement from, which shows the level of activity during a sunspot cycle

increasing since 1900. In your opinion, is this because we have been better able to measure it, or is this really part of the phenomena we don't understand?

Dr. NEWELL. This is part of the whole phenomenon we don't understand. It has been observed that not only do you have an 11-year cycle in which the numbers of sunspots vary from a maximum to a minimum and back to a maximum, but you also have a 22-year cycle in which the direction of the magnetic fields is reversed.

Sunspots appear in pairs, and in these pairs, during one sunspot maximum, the leading spot of a pair will have a north pole, and the following spot a south pole. At the next sunspot maximum this is reversed, and the leading spot will have a south pole and the following spot a north pole. So in addition to an 11-year cycle you have a 22-year cycle.

In addition to that, it is observed the sunspot maximum intensity increases, so that you run from very low sunspot maximums up to very high sunspot maximums. The recent maximum is just one such case that has been observed. Other cases have been observed where there is a growth like this, and then a fall-off.

Now, the prediction here is that there will be a falloff. We don't know that that will happen. It may well be that the next sunspot maximum will be even higher than this latest one, which turns out to be the highest maximum on record. In that case, the intensity of radiation in space may be very severe indeed during that period.

Mr. KARTH. And if it is, Doctor, let's say that it is higher than the 1960 part of the cycle that you see there; what effect is that going to have on our manned lunar shot, if any?

Dr. NEWELL. In that case, that makes it very important that we do everything we can to learn about predicting the occurrence of these solar flares and the solar proton beams from them so that we can pick out the times when it will be safe to be out in space.

Mr. KARTH. If the solar activity is substantially heavier, might it mean that we have got to provide additional shielding?

Dr. NEWELL. If we are unable to lick the problem of predicting the occurrence of these solar beams, then increased shielding would have to be the answer.

Mr. KARTH. How much higher, or how much more active would this period have to be, Doctor, before we would have to reschedule the lunar shot? Or don't you foresee that it could possibly reach that maximum?

Dr. NEWELL. At the present time we don't foresee that you would have to reschedule the shot. The choice is either between going ahead with increased shielding or going ahead with better prediction methods. But it does not appear that you will have to postpone these plans.

Mr. KARTH. Is there a possibility you might have to?

Dr. NEWELL. There is always that possibility, but the bets are that you would not have to.

Mr. KARTH. I see. When is your predicted peak, Doctor?

Dr. NEWELL. It is in the 1967 time period—1967 or 1968, somewhere around there.

Mr. KARTH. I thought you said that the predicted peak will be lower than the 1955 through 1960 peak.

Dr. NEWELL. That is correct. This peak [indicating] is the highest on record so far.

Mr. KARTH. The peak during this decade will be reached about 1967 or 1968, is that correct?

Dr. NEWELL. No; I misunderstood your question, then. The next maximum is for 1967 or 1968, and the guessing is that that will be lower than the peak for the 1955–56 time period.

Mr. KARTH. But it will be the maximum during the 1960 to 1970 decade?

Dr. NEWELL. That is correct.

Mr. KARTH. That will be the peak?

Dr. NEWELL. That is correct.

Mr. KARTH. Thank you very much, Doctor.

Mr. CORTRIGHT. The exploration of the Moon is proceeding in a series of logical steps as shown in the next chart (fig. 45, Lunar Ex-

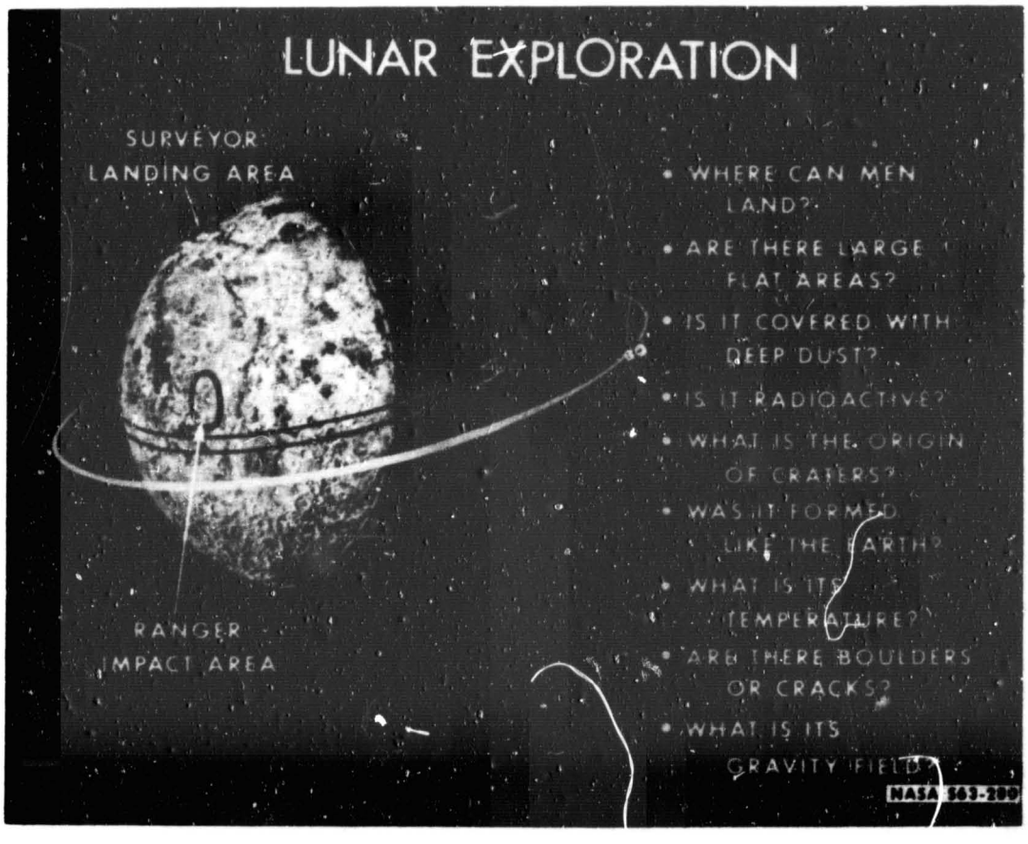

FIGURE 45

ploration). The first step is being carried out with Project Ranger. Ranger will result in impacts and rough landings in the area indicated by the small ellipse. In addition, the Ranger may be programed to stray from this area of vertical descent in order to extend its television sampling of the lunar surface. With the advent of the Surveyor soft landing spacecraft, the area of the Moon accessible to us will be increased to over one-half of the visible lunar surface. The lunar Orbiter then will not obtain such detailed information as the landing spacecraft, but it will permit complete photo-reconnaissance of the Moon within any selected latitude range.

By "complete" I don't mean total photographic coverage, but coverage in selected areas any place within that region.

Thus, these three missions combine to provide a well-integrated assault on the secrets of the Moon. Some of the questions which we hope to answer are also indicated in this chart. They include: "Where can men land?"; "Are there large flat areas?"; "Is it covered with deep dust?"; "Is it radioactive?"; "What is the origin of the craters?"; "Was it formed like the Earth?"; "What is its composition?"; "What is its temperature?"; "Are there boulders or cracks?"; and "What is its gravity field?"

Mr. STAEBLER. May I raise one other elementary question? Is it dark on the side of the Moon away from the Earth?

Mr. CORTRIGHT. It varies, depending on the phase of the Moon. You see, sometimes the far side of the Moon is light and the near side is dark, depending on the Earth-Moon relationship relative to the Sun.

Mr. STAEBLER. But the Moon would be as dark as the Earth is dark under similar circumstances?

Mr. CORTRIGHT. It is just that a Moon day is 28 days, and an Earth day is one day. When the near side is all lighted, the far side is dark, and when the near side is half lighted the far side is half lighted.

The Ranger program, which constitutes our first attempt to explore the lunar surface, has now resulted in five launchings which are summarized in this chart (fig. 46, Five Rangers Launched). Rangers I and II were launched in 1961 to test the spacecraft itself and were not directed at the Moon. Failure of the Agena stage of the Atlas-Agena resulted in these two Rangers being injected into low-Earth orbits.

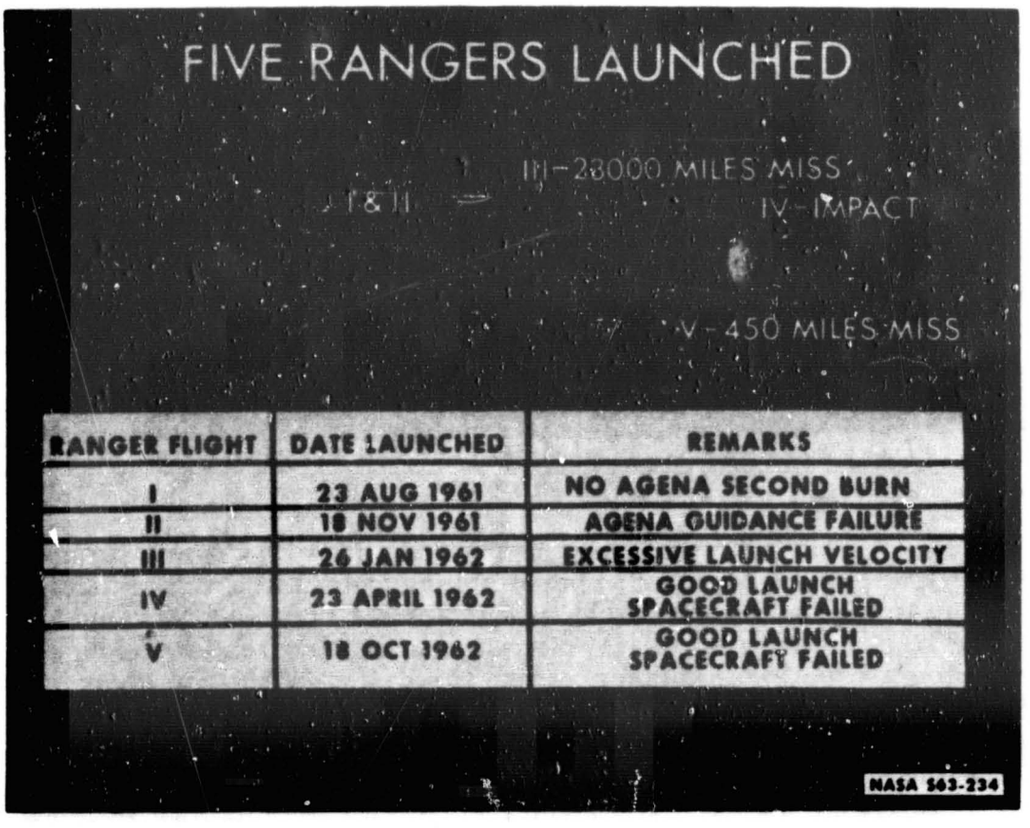

FIGURE 46

You may recall that this type of failure has occurred in the Soviet program in a number of instances.

Although the Ranger was not designed to function well in this low altitude orbit, it did function well enough to indicate that the basic systems were working properly, before the spacecraft came back into the Earth's atmosphere.

The third Ranger was launched in January 1962 in our first attempt to hard-land an instrumented capsule, and to do the photographic work on the way in. A malfunction of the Atlas guidance system, however, resulted in an excessive velocity at injection and the spacecraft passed well ahead of the Moon. During its flight to the Moon, the spacecraft functioned properly and performed all commands as directed, including the first midcourse maneuver ever attempted. An attempt at a terminal maneuver in order to take photographs of the Moon while passing ahead of it failed, however, due to a malfunction in the spacecraft control system. The Atlas–Agena launch vehicle performed properly during the launch of Rangers V and VI in April and October of 1962, respectively, resulting in our first lunar impact. However, in both of these launches, the spacecraft experienced early failures.

The Ranger spacecraft performance to date is very similar to that of the typical major flight systems developments which I illustrated earlier. Our task is to find ways and means of bettering these "normal" development cycles. An intensive review of the Ranger project was recently completed by the Office of Space Sciences and the Jet Propulsion Laboratory. This review identified a number of areas in the design, fabrication, quality control, and testing of the Ranger in which improvements could be made to increase the potential reliability of the spacecraft. Steps have been taken to implement these recommendations of our review teams. Some of these steps are as follows: the sixth Ranger spacecraft, that is, the fourth model designed for flight to the Moon, has been removed from the flight program for an intensified series of engineering qualification tests. This has delayed the flight program several months but may actually advance the date for a completely successful mission, more than the several months indicated here.

Our next flight is scheduled for December. We hope the improvements we are injecting in the program will actually advance the date when we achieve a completely successful mission.

Mr. KARTH. Would you yield at this point?

Mr. CORTRIGHT. Certainly, sir.

Mr. RANDALL. I observe the slide. It is a question in connection with the slide. We know I and II were complete failures, and III—that was the one there was some kind of a guidance failure. Now, IV, you show an impact, and yet I don't recall any testimony either here or in the press release as to what we accomplished from that. What were the findings? Are the findings those which we have been discussing earlier, these charts or maps, the geological charts? What happened after the success of it?

Mr. CORTRIGHT. From a scientific point of view, Rangers IV and V did nothing.

Mr. RANDALL. You mean after a successful head in the impact, there was no successful results?

Mr. CORTRIGHT. That is because the spacecraft itself failed within 20 minutes after launch on Ranger IV.

Mr. RANDALL. It was the capsule itself, and nothing else; it was just the spacecraft?

Mr. CORTRIGHT. It was the spacecraft, and not the launch vehicle. The launch vehicle performed very well in both Rangers IV and V. That dispersion is normal dispersion for the Atlas-Agena. We have to correct trajectories with our midcourse maneuver to be more accurate.

Mr. RANDALL. Yes, I understand there was a successful correction and that is a midcourse correction.

Mr. CORTRIGHT. That was on Ranger III. We didn't have enough correction capability to get to the Moon on Ranger III, so as we flew by ahead of the Moon we attempted to maneuver to turn around and look at the Moon, and there our computer failed.

Mr. RANDALL. The point I wanted to get was, what happened after the apparent success, by the chart, of Ranger IV?

Mr. CORTRIGHT. It was not a success.

In addition, a complete engineering design review was undertaken and recently completed. A number of critical subsystems within the Ranger are being modified. One thing we are doing, for example, is to greatly increase the redundancy in our various subsystems. Components which have been sterilized by heating are being replaced wherever possible inasmuch as heat sterilization is suspect as a possible detriment to high reliability of electronic components.

We are confident that the Ranger spacecraft series will succeed and will yield valuable data to science and in support of the manned program. This confidence is, in part, based on the fact that the team which developed the highly successful Mariner at JPL is also hard at work on improving the Ranger. Also, the successful Mariner was a direct evolution from the Ranger spacecraft and utilized many of its subsystems and parts, as I will discuss later.

I might point out, however, the Mariner was designed some time after experience had been gained with the Ranger, and incorporated several improvements which are now being fed back into the Ranger program.

The Ranger project has contributed importantly to spacecraft technology as illustrated in this chart (fig. 47, Technology Developed by Ranger). Ranger first demonstrated an ability to receive and execute a midcourse trajectory correction. This system was later used by the Mariner spacecraft in order to correct its flyby distance from 233,000 miles to 21,600 miles. In addition, the Ranger developed the attitude stabilization system utilizing Earth-Sun reference lines, which was also used on the Mariner. In addition, the Ranger was the first spacecraft to make use of and hence help develop the injection-from-parking-orbit technique with the Atlas-Agena B launch vehicle.

I mentioned earlier, I believe, that the Ranger utilized the second Atlas-Agena B flown in this country.

Mr. KARTH. Mr. Cortright, would you like to discuss with us at this time the contractual changes that have been made in the Ranger program, if any?

Mr. CORTRIGHT. I will be glad to do that.

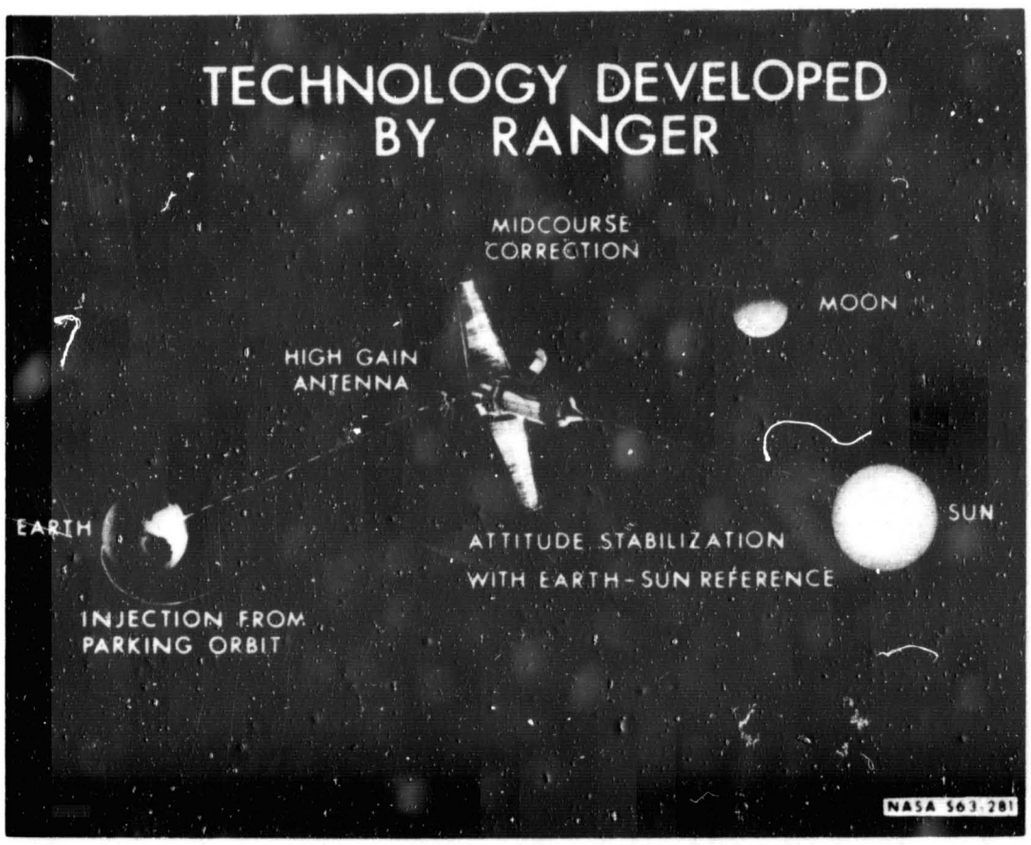

FIGURE 47

NASA announced on Friday that it was contracting with the Northrop Corp. to provide assistance to the Jet Propulsion Laboratory on the Ranger project. This assistance will take the form of the following initial aids:

Northrop will provide qualified manpower to review and assist in updating existing drawings, specifications, test procedures, and manufacturing plans to insure adequacy and completeness. They will provide qualified manpower to review and assist in implementing quality control and quality assurance requirements compatible with the overall program objectives.

They will provide manpower at JPL to support a test program for design evaluation and live testing of Ranger spacecraft. They will provide appropriate support to the Jet Propulsion Laboratory technical divisions to accomplish system and subsystem integration. Where the subsystems are procured from an off-laboratory supplier, support will be provided to the responsible technical division. They will provide qualified manpower to support the JPL technical divisions in system testing of flight spacecraft at JPL.

They will provide qualified manpower to support the Jet Propulsion Laboratory technical divisions in spacecraft tests, and launch operations at AMR—at Atlantic Missile Range. They will perform other designated supporting tasks to gain a complete familiarity with the Ranger spacecraft, and they will provide qualified manpower to support the space flight operations at JPL during prelaunch, launch, flight, and postflight activities.

Now, in addition, after what we call Block IV, which are the last of our 1964 launchings, if this corporation has done the good job we anticipate——

Mr. KARTH. Excuse me, what corporation is this?

Mr. CORTRIGHT. Northrop.

Mr. KARTH. Northrop; yes, sir.

Mr. CORTRIGHT. They will build the spacecraft for 1965 launchings. They will be what we call the spacecraft systems manager.

Mr. KARTH. This is a very substantial change in management of the Ranger program to a point where JPL will have nothing to do with it by 1965, if I understand you correctly, or at least very little?

Mr. CORTRIGHT. They will still be the project manager. There is a lot to Ranger besides building the spacecraft. The Ranger has to be pulled together with the launch vehicle, launched, tracked, data recovered——

Mr. KARTH. But there is no more to it now than there has been initiated, is there?

Mr. CORTRIGHT. That is correct. This is a major transfer over a period of time.

Mr. KARTH. There is a substantial transfer of responsibility and activity. What is the reason for this transfer of responsibility and activity, or is there any?

Mr. CORTRIGHT. There are two reasons I think I could comment on. One is to supplement the technical ability of the Jet Propulsion Laboratory to insure better performance of the Ranger project. The second is to gradually unload the Jet Propulsion Laboratory from the requirement to run a production-type operation, onto a corporation which is used to this type of operation. The Jet Propulsion Laboratory, then, would be free to work on the more advanced concepts that are yet to be developed, such as our Mariner C and advanced Mariner planetary spacecraft beyond that.

The combination of the JPL creativity and imagination and the industrial know-how in reproducing equipment to uniform quality standards will be a very potent factor in making this project go, we think.

Mr. KARTH. Is there a report on this overall study that took place? I suppose it was responsible for the action that you took on Friday?

Mr. CORTRIGHT. Yes, sir; there was. It was partly responsible for the action. It was a report authored by——

Mr. KARTH. Who instigated this study, Mr. Cortright?

Mr. CORTRIGHT. Dr. Newell.

Mr. KARTH. It was an in-house initiation?

Mr. CORTRIGHT. Yes, sir.

Mr. KARTH. Maybe Dr. Newell could answer this question: This was after you became dissatisfied, Dr. Newell, with the progress that was being made on Ranger, or lack of it?

Dr. NEWELL. This was after the Ranger V firing had failed to produce a success. We felt that we simply had to dig into this in order to maximize our efforts to produce a successful Ranger.

Mr. KARTH. What kind of an organization is the Jet Propulsion Laboratory?

Mr. CORTRIGHT. The present organization of the Jet Propulsion Laboratory—well, let me ask a question before I answer it. Do you

want me to describe the structural arrangement of the various groups within the Jet Propulsion Laboratory? Is that the question, Mr. Chairman?

Mr. KARTH. I think it would be worthwhile describing that for the record so that the members later on can take a good look in the event they have a question relative to the organizational structure; how is JPL set up? Is it a nonprofit organization, and if so, does it operate under the auspices of Cal Tech?

Mr. CORTRIGHT. Cal Tech.

Mr. KARTH. Would you explain this for the benefit of the committee?

Mr. MORRIS. Could you tell us the corporate structure of the JPL?

Mr. CORTRIGHT. The Jet Propulsion Laboratory does work under the corporate structure of the California Institute of Technology, and in contractual matters it is the California Institute of Technology that is contractually bound. We have a contract with the California Institute of Technology——

Mr. MORRIS. That is a nonprofit organization?

Mr. CORTRIGHT. Yes, the Jet Propulsion Laboratory is a nonprofit organization.

Mr. MORRIS. Supposedly, that is?

Mr. CORTRIGHT. Pardon me?

Mr. MORRIS. Supposedly it is a nonprofit organization?

Mr. CORTRIGHT. It is a nonprofit organization, sir.

Mr. MORRIS. Under the laws of the State of California?

Mr. CORTRIGHT. Yes, sir. The Laboratory operates on Government-owned land, with Government-owned facilities, but the employees are not civil servants.

Mr. KARTH. Their salaries are paid by Cal Tech, who in turn are reimbursed as a result of the contract between Cal Tech and NASA; this is pretty well the indirect method by which these people work; is that correct?

Mr. CORTRIGHT. I would like to consult on that question.

(Discussion off the record.)

Mr. CORTRIGHT. Yes, sir, that is correct; the contract is with the California Institute of Technology to operate the Laboratory, and they hire and pay the salaries of the employees.

Mr. KARTH. How do we arrive at a figure of reimbursement to Cal Tech by project? This must be a rather difficult job. Or is this a prenegotiated figure, Mr. Cortright? Has the contract been so drafted that every 6 months, for example, they inform NASA of their financial stability as a result of the numbers of people they have assigned to a project, and then we reimburse them for that, or is the specified amount predetermined? I am not sure I understand at all how we operate.

Mr. CORTRIGHT. I can explain that. At the outset of the year; that is, when we begin our normal development of our budgets and our financial operating plans for the coming year, we work with the Jet Propulsion Laboratory directly in much the same way as we work with our own research centers. We review in depth each project that the Jet Propulsion Laboratory is handling for us, whether they are building the equipment in-house, or procuring it. We make cost estimates of what this project is going to cost during the coming year, and arrive at a figure which we agree upon.

The funds are then transferred from NASA headquarters to the Western Operations Office, which is our arm in the Los Angeles area to handle matters like this. These funds are in turn transferred to Cal Tech on a quarterly basis, nominally 30 days before the end of each financial quarter. We transfer funds to the Institute to carry on with the funding of JPL tasks for the next quarter.

During the course of the year, normally on a quarterly basis, we review the financial status of the Laboratory and the projects to see how they are going, and at that time review whether we have the proper allotment of funds.

Now, this outlines the mechanics of how the funds are gotten out there and how they are controlled. Does that answer your question?

Mr. KARTH. I think so; yes.

Mr. STAEBLER. Mr. Chairman.

Mr. KARTH. Before we have any further questions, I would like to mention the fact that the majority leader, Mr. Albert, is here. Thanks for stopping in, Mr. Albert.

Mr. Staebler.

Mr. STAEBLER. I would like to pursue the description a little further.

Has the Jet Propulsion Laboratory followed the procedure in the past of producing the components or some substantial part of the components of the Ranger, or has it confined its activities to assembly of parts produced elsewhere?

Mr. CORTRIGHT. They produce some parts. The procedure has been roughly as follows: During the early conceptual design phase, the Jet Propulsion Laboratory designs parts and breadboards them, which means they put them on a flat board in their Laboratory and try to get them functioning to a point where they know they can go out on contract.

They do then go out on contract, and I believe they contract out at least 80 percent of the parts. I don't have with me, although Mr. Taylor may, the exact breakdown of how much of this money we send to Cal Tech goes to industry on an overall basis. About 91 percent of the total Office of Space Science funds are spent in industry on what would be considered non-in-house procurements. It is about 80 to 85 at JPL. They are a little bit lower than the average.

Mr. STAEBLER. As systems manager, then, Northrop will be taking over a substantial part of this last 20 percent of the operation?

Mr. CORTRIGHT. Starting with the 1965 spacecraft, they will, that is correct. However, that work, I might add, will begin this year, this calendar year. They will have to start the procurements for the 1965 spacecraft.

Mr. STAEBLER. Has there been generally in the past the policy of maintaining systems managements within the various parts of NASA? Does this represent a departure from the past course?

Mr. CORTRIGHT. We have examples of spacecraft systems management being largely with a contractor. The Surveyor is such a case. We have the practice of maintaining project management responsibility within the Government in all cases.

Mr. STAEBLER. NASA has had flexibility, then, at the systems management level and at levels of smaller subdivisions of a system of doing some work itself, subcontracting or contracting out parts of it; this is not a departure, then, from past policy?

Mr. CORTRIGHT. This is not a departure. There are other examples besides Surveyor. I just didn't go through the recounting of them.

Mr. KARTH. Mr. Cortright, I wonder if you would give us the benefit of your thinking as to the areas of weakness within JPL? Now, I believe I have read some veiled editorial criticism, if I may refer to it as such, of JPL in the past. I suppose the stock answer is: "Well, they are no better or no worse than other general contractors," but I doubt if this is the kind of an answer the committee would like to have. Rather, if you can, give for us the weaknesses, as you see them, that existed at JPL which caused NASA to take the action it just recently has taken.

Mr. CORTRIGHT. Mr. Chairman, I will be glad to answer your question, although it always pains me to discuss this question from the negative side only, inasmuch as the virtues and strengths of the Jet Propulsion Laboratory are very considerable.

Mr. KARTH. I think you can give us the strengths too, if you like, Mr. Cortright, but we would like to have both sides of the argument too, you see. It is extremely difficult for the committee to keep things in proper perspective, I think, without hearing both sides.

Mr. Randall.

Mr. RANDALL. This is not along this line. When was this announcement made? Our desk is flooded with announcements, but so far as I know, I haven't received any announcement. You say it was done Friday?

Mr. CORTRIGHT. Friday at 5 p.m., the press release was made, and we notified the chairman of this committee in the morning.

Mr. RANDALL. Thank you. I didn't want to interrupt you, but I wondered why we didn't hear about it.

Mr. KARTH. Dr. Newell and Mr. Cortright on Friday called this to my attention, the fact they were going to take this action, and asked whether or not they could talk about it in front of the committee on Monday—that is, today—hoping that this would be the day that we would talk about the Ranger project, and it happens we are on page 81, and we are talking about the Ranger project. I think it is appropriate we talk about it now.

Mr. CORTRIGHT. Very well, Mr. Chairman, I will answer your question to the best of my ability. I will begin with a summary statement of the virtues of the Jet Propulsion Laboratory. The Jet Propulsion Laboratory is comprised of a highly talented, creative group of engineers and technicians. This talent resulted in such imaginative concepts as the Mariner and the Ranger.

I might point out that had the Ranger functioned properly, it too would have provided an important scientific and technological "first" for this country. This group has developed from a research laboratory, and hence has had some teething problems with getting geared up to an industrial-type operation, wherein one has to produce a series of spacecraft to uniform standards with tight quality control, and with a great deal of internal discipline in order to achieve this.

Mr. KARTH. Hasn't this been evident over the years, Mr. Cortright, they really were not tooled up to do this kind of in-house industrial work, if you wish to refer to it as such?

Mr. CORTRIGHT. Not entirely, because they did develop the Sergeant Army rocket, which is a short-range weapons system——

Mr. KARTH. Although it wasn't evident to begin with, it is now evident they are not set up properly to do this type of work?

Mr. CORTRIGHT. It is now evident they would benefit materially from help of the type they will get from Northrop. Incidentally, in the case of the Sergeant, they did turn over the production of those vehicles to Sperry, I believe, after they had done a few themselves and developed the concepts on the system.

We are developing major steps with them within the Laboratory to tighten up their quality control, their standards, specifications, drawings, and so forth, which do contribute to—in fact, which are necessary to the production of this type of complex electromechanical equipment in a reliable fashion.

I think they have responded very well to the problem, and we are quite pleased.

Mr. KARTH. Now the Kelley report, as I understand it, was quite critical of JPL. Would you for the record give us those major points of criticism?

Mr. CORTRIGHT. Mr. Chairman, I think the letter I sent you would be suitable for insertion in the record, with your permission, to answer that question. Basically the major points of criticism were the same I have just been going through; namely, that the quality control was spotty. The uniformity of standards from technical division to technical division varied considerably. The monitoring of their subcontractors varied considerably from division to division. They simply were going through many of the same problems that all large engineering groups go through when they undertake a new project.

(The information referred to is as follows:)

DECEMBER 28, 1962.

The Honorable JOSEPH E. KARTH,
Chairman, Subcommittee No. 3, Committee on Science and Astronautics,
House of Representatives, Washington, D.C.

DEAR MR. KARTH: As a result of your call last week, I agreed to transmit to you additional information on the status of the Ranger project and the findings and recommendations of the technical team which reviewed the project for us. Subsequently, I called you and read to you over the phone the press release which NASA was making on the subject. The purpose of this letter is to provide additional background information.

The report submitted to the Office of Space Sciences by the review team is classified secret and is considered an internal working document. The classification is based on material contained within the report which was supplied by the Air Force under secret classification and which we are honoring as such. In general, this material relates to launch vehicle performance. The basis for considering the report an internal working document stems from the belief that, when individuals are called together to review and critique our own operations for the purpose of improving said operations, they should do so with the feeling that whatever they say or write will not later be subject to release to the press and a completely public airing. I believe this to be a sound policy.

On the other hand, I recognize that this policy should not be misused to cover up facts purely to avoid embarrassing NASA or its contractors. We have always conducted our operations openly and frankly and intend to continue to do so. Accordingly, in response to queries from Members of Congress, we are proposing to abstract in some detail the results of our review and to submit this along with a statement of measures being adopted to improve the reliability of the Ranger spacecraft. This material will precede our regular authorization request presentations which will also include discussions of Project Ranger.

As an interim measure, and to fulfill my oral commitment to you, I am enclosing a summary of the findings and recommendations of the review team. This material has not been released to the press, although I have discussed some of it with Mr. Hines of the Washington Evening Star in order to clarify

his understanding of the technical problems we face in Project Ranger. I would appreciate your using the enclosed material primarily as background information.

I was somewhat concerned by your indication that you received no notification of the formation of the technical team to review Project Ranger. Your name has been on the mailing list for all NASA press releases for the past year or so.

Should we be able to provide any additional help to you or your staff, we will be happy to do so.

Sincerely yours,

EDGAR M. CORTRIGHT,
Deputy Director, Office of Space Sciences.

RANGER PROGRAM

On October 29, 1962, Dr. Homer E. Newell, Director, Office of Space Sciences, establish a Board of Inquiry to review the Ranger Program including the spacecraft, launch vehicle, tracking network, space flight operations, and launch operation. With Dr. Albert J. Kelley of NASA Headquarters as Chairman, the Board was composed of the additional following members, all top men in their respective fields:

Mr. Frederick J. Bailey, Manned Spacecraft Center.
Mr. John Foster, Ames Research Center.
Dr. John Hornbeck, Bellcomm, Inc.
Mr. James Koppenhaver, NASA Headquarters, Office of Programs.
Mr. Herman Lagow, Goddard Space Flight Center.
Dr. Arthur H. Rudolph, Office of Systems (Huntsville), Office of Manned Space Flight.
Mr. Francis B. Smith, Langley Research Center.
Dr. John Walker, Secretary, NASA Headquarters, Office of Advanced Research and Technology.

Mr. Newton W. Cunningham, Chief, Ranger Program, NASA headquarters, and Mr. Walter Jakobowski, Ranger Program Engineer, NASA headquarters, were appointed ex officio to assist the Board.

In his original memorandum to the Chairman, Dr. Newell asked that the Board review the history of the Ranger spacecraft and its present status and recommend to the Office of Space Sciences steps it deems necessary to achieve early successful Ranger operation, including but not limited to recommended changes in management procedures, systems, components, testing, quality control, reliability assurance procedures, and operation procedures. In addition, the Board was asked to prepare its recommendations in time to determine whether or not the next Ranger firing should proceed as presently scheduled or should be delayed in order to introduce necessary changes.

During the intensive 1-month survey, the Board held detailed discussions, including onsite inspection of Ranger associated hardware and operations, where applicable, with the following organizations:

Jet Propulsion Laboratory.
Aeronutronics Division, Ford Motor Co.
Lockheed Missiles & Space Co.
Nortronics Division of Northrop Corp.
RCA, Astro-Electronics Division.
NASA Western Operations Office.
Marshall Space Flight Center.
NASA Headquarters:
  Office of Manned Space Flight.
  Office of Tracking and Data Acquisition.
  Office of Space Sciences.
USAF Space Systems Division.
NASA Launch Operations Center.
USAF 6555th Test Wing.

Upon completing the discussion and inspection portion of its investigation, the Board met in executive session at NASA Headquarters to arrive at findings and to prepare the final report. This report was completed on November 30, 1962, and submitted to the Director, Office of Space Sciences, on December 4, 1962.

In general, it was found that the Ranger spacecraft design concept is basically sound as evidenced by the recent flight of Mariner II whose design evolved

directly from Ranger and which made extensive use of Ranger components and technology. The Board did find, however, that improvements could be made which could increase flight reliability. The Board's recommendations may be summarized as follows:

TECHNICAL

(*a*) Initiate a combined testing and design review program for Rangers 6–9 which will provide the basis for the correction of any deficiencies which may exist in the present design. This effort should be conducted by review teams which include personnel not directly assigned to the Ranger project. In addition, it was recommended that an outside industrial contractor possessing the type of skill required for this type of effort be recruited to assist in these reviews.

(*b*) Abandon heat sterilization of all materials for the Ranger Program immediately and reexamine other presently used methods of sterilization to determine their effectiveness. Heat sterilized components already assigned to Rangers 6–9 should be replaced wherever possible with unsterilized components.

(*c*) Apply stricter quality control and quality assurance procedures and methods to all material fabricated inhouse or procured via subcontract and maintain quality surveillance and quality control of all material through launch.

(*d*) Halt fabrication of assemblies for Ranger 10 and subsequent spacecraft until the implications of the review and test program are clearly understood and necessary design improvements are incorporated.

MANAGEMENT

(*a*) Strengthen the Ranger project management at JPL by providing increased staffing and more clear-cut lines of responsibility and authority.

(*b*) Augment the Office of Space Sciences headquarters staff to enable closer monitoring of the Ranger project, and assign a NASA headquarters technical representative to JPL.

(*c*) Bring to bear on Ranger Atlas boosters the knowledge and experience of the Aerospace technical teams that have been monitoring the factory rollout inspection and AMR prelaunch preparations of the Mercury Atlas boosters. In addition, it was recommended that the complete responsibility for Atlas-Agena checkout and launch operations at AMR be either retained completely by NASA or delegated completely to the Air Force, rather than the current joint sharing of responsibility.

Plans have been formulated to implement the above recommendations. An extensive design review and test program is being initiated. The Ranger 6 spacecraft which was being readied for launch early next year will not be flown but will be subjected to an exhaustive test program. The sterilization or germ-free requirement under which electronic components must be heat baked has been abandoned. Procedures governing reliability and quality assurance are in the process of being improved. Efforts to increase the reliability of the launch vehicle have been active for the past 18 months and will continue. Positive steps are being taken to strengthen both the JPL project management staff and the NASA headquarters Ranger staff.

Modifications resulting from the improvement program will be incorporated in future Rangers. It is anticipated that this will delay the launch of the next Ranger to mid-1963, but that the lost time will be subsequently recovered.

I think that if we went back and examined each of the systems that I used to get my average reliability versus flight curve, which is on an earlier figure, you would find that every single one of those companies that had initial bugs with their equipment—and they all did—suffered from the same sort of teething problems that the Jet Propulsion Laboratory has. I think they had to solve the same management and technical problems that we are now solving at JPL.

Mr. KARTH. Over the years, JPL has been provided with equipment, I suppose, at NASA's request, along with their funding. Now that most of this work will be done by someone else, what happens to the equipment, the moneys that we have invested, to bring JPL's qualifications up to a point where they, up until Friday, at least, were ex-

pected to do this work? What happens to all that money that has been spent?

Mr. CORTRIGHT. That money is well spent, in our opinion, Mr. Chairman. The Jet Propulsion Laboratory will continue to be a major—the major arm of the NASA, in executing the unmanned lunar and planetary program. The equipment that they don't build in-house they will have built out-of-house, and will provide the technical direction for those contractors, such as they are now doing on Surveyor.

Mr. KARTH. What other programs does JPL head up for NASA?

Mr. CORTRIGHT. Mariner. Our current Mariner project is the Mariner-Mars, which you will see in just a moment. It will be launched in 1964. And beyond that, JPL promises to play an important role in our advanced planetary exploration, such as the Mariner B, and Voyager projects.

We are counting on JPL to continue to be a mainstay in that area. The equipment which we have put in there will be utilized 100 percent. The facilities in terms of housing, which are still inadequate and must be improved, will be well occupied.

The Surveyor project, which you are well acquainted with, is managed by and technically directed by the Jet Propulsion Laboratory.

What we should say about the arrangement with the Northrop Co. is that they will unload the Laboratory beyond 1964 of the requirement to produce carbon copy spacecraft of the Ranger type. Prior to that they will provide needed technical assistance.

Mr. KARTH. I can appreciate, Mr. Cortright, where any firm, regardless of the name, may have trouble with technical problems, because almost all of these programs are pushing the state of the art, but technical problems and management problems are two different things. I am somewhat of the opinion JPL's problem is probably as much management as technical. I wonder if you would care to address yourself to some of the management problems that you are aware of, that were brought to your attention by the Kelley report, as far as JPL is concerned, and what has been done about it.

Mr. CORTRIGHT. I think, Mr. Chairman, it is a popular misconception that technical and management problems have a clean cleavage. Frequently technical problems arise from management problems, and are very closely interrelated, and vice versa. You have to organize and manage in different ways to do different technical jobs.

Mr. KARTH. Just use your own judgment, then, in each instance where you think they were interrelated. You give us the benefit of your thoughts, and we will decide whether they were management or technical or whether they were engineering.

Mr. CORTRIGHT. The problem of maintaining uniformity of standards, both on in-house equipment and procurements from contractors, is both a technical and a management problem. The way in which the management approaches that problem has a vital bearing on how successful a company is in doing these advanced technical projects.

The Kelley report pointed out to us some problems in this area of which we were generally aware and were trying to do something about with JPL. The standards were spotty, as I mentioned earlier, and required a closer knit team effort in the upper echelons of the JPL management, say the division chiefs on up.

Mr. KARTH. How do you plan to eliminate that problem in the future? This will probably be of interest to the committee.

Mr. CORTRIGHT. A number of things have been done. The lunar and planetary programs had been separated at the Laboratory under two directors. They have now been pulled together under one. All of the supporting research and technology work at JPL has been pulled together under another man, and all of the tracking and data acquisition effort is pulled together under another man. These men, by the way, are Mr. Parks, for lunar and planetary programs; Dr. Goddard for supporting research and technology; and Dr. Rechtin, for tracking and data acquisition.

These three men meet much more frequently than they used to with the Director, Dr. Pickering, and the Deputy Director, Mr. Sparks, and with the Director of Business Administration, Mr. Larson, in a senior council effort to maintain close integration.

Mr. KARTH. Substantive management changes have been made in the organization structure; is that correct?

Mr. CORTRIGHT. They certainly have, and within the divisions themselves. The division chiefs are pulling together much tighter team efforts down through their own divisions in order to see that the components for which they are charged are handled in a manner that is entirely acceptable to everyone concerned.

Mr. KARTH. Is anyone on unemployment compensation, Mr. Cortright?

Mr. CORTRIGHT. I don't believe I understand that question.

Mr. KARTH. Has anyone been dismissed for anything?

Mr. CORTRIGHT. Not to my knowledge. There has been some shifting around of personnel.

Mr. KARTH. Have there been some replacements?

Mr. CORTRIGHT. The manager of the Ranger project is now Mr. Schurmeier, who formerly was Chief of the Systems Division, and had much to do with the technical design and development of the Ranger. He has moved up to manage that project. As I mentioned earlier, the lunar and planetary projects have now been pulled together under Mr. Parks, who was in charge, with Mr. James, of the Mariner project.

We have great confidence in these individuals. It is a very fine group of men. They can do this job, if anyone can. It is a tough job.

Mr. KARTH. Are there any questions? Mr. Morris.

Mr. MORRIS. Well, when did you ask for proposals when you selected Northrop?

Mr. CORTRIGHT. Northrop was a sole source procurement. Although the concept of bringing in an industrial contractor has been under serious consideration for 1 or 2 months, it has sort of been on the back burner while we handled more immediate problems, such as design changes that had to be made immediately for the launches beginning in December. In addition, some of the internal organizational and procedural changes within the laboratory, had to be solved first.

The decision to bring a contractor in was only made about a week and a half ago—and we then decided within the agency that speed was of the essence. The Northrop Corp. was very eminently qualified to do this job, largely by virtue of the fact that they are already an important contractor on two of the most critical systems within the Ranger spacecraft; namely, the attitude control system and the central computer and sequencer.

Mr. MORRIS. The answer to my question I asked you, Mr. Cortright, is that Northrop was the only contractor that you contacted, and others did not submit proposals?

Mr. CORTRIGHT. Yes, sir. We did not go out and request proposals.

Mr. MORRIS. Who made this so-called Kelley report? Is this the name of the individual who made the report?

Mr. CORTRIGHT. Yes, Dr. Al Kelley, and a group of about six highly skilled technical people.

Mr. MORRIS. When did they start on this project which led to this report?

Mr. CORTRIGHT. I will get that answer in just a second.

They were directed to form on about the 19th of October, a day or two after the Ranger V launch.

Mr. MORRIS. The 19th of October, in 1962?

Mr. CORTRIGHT. Yes.

Mr. MORRIS. When did you receive their report?

Mr. CORTRIGHT. About 30 days later.

Mr. MORRIS. That would be the 19th of November of 1962. Then you only made up your mind 2 weeks ago that you needed to bring in an industrial contractor?

Mr. CORTRIGHT. We only made up our minds that we would. We thought seriously that we would have to do this during that intervening time, but we took the course of first things first, and the first thing we had to do was to determine what to do with the next batch of Rangers, which were largely on hand as far as their subsystems were concerned. We went into intensive technical reviews.

Mr. MORRIS. Mr. Chairman, I think it would be pertinent to the subcommittee's deliberations if we had at least one copy of the so-called Kelley report so that either our staff or someone else could review it.

Mr. KARTH. Does the gentleman make the request?

Mr. MORRIS. I make the request.

Mr. RANDALL. I would like to join in the request.

Mr. MORRIS. We make the request of NASA that the Kelley report be furnished to the subcommittee.

Mr. RANDALL. I don't know how we can discuss this until we know a little more about the Kelley report. I want to pursue this quite a little bit further, Mr. Chairman. This timelag in here, you said something on the back burner, you couldn't get around to it. That was these Rangers you are talking about. There is quite a timelag here. We talk quite a lot about time, how we are trying to push ahead in crash programs, but here is something that hasn't been going too well, it seems to me.

Mr. MORRIS. Mr. Chairman, I would request this first by unanimous consent.

Mr. KARTH. Are there any objections to the request made by the gentleman?

Would you supply to the committee staff one copy?

Mr. CORTRIGHT. Yes, sir; you are aware this is a classified document.

Mr. KARTH. I wasn't aware it is. Can you tell us why it is classified?

Mr. CORTRIGHT. Yes, sir, I will discuss that.

Mr. KARTH. Does it have anything to do with the national security?

Mr. MORRIS. Mr. Chairman, why don't we have a special committee of the Government Operations Committee, headed by Congressman John Moss of California, who looks into matters of classification—why don't we just turn the thing over to him to look into it? He has a professional staff that does nothing but look into these kinds of matters. It would be nice for the record if they would tell us their reason, but then I think we should turn it over to the Government Operations Subcommittee.

Mr. KARTH. I understand that. I would like, first, however, to find out why NASA feels this document should be classified.

Mr. CORTRIGHT. There are discussions within it of the launch vehicle, referring to material which the Air Force has defined as classified, and hence we are bound to honor their classification.

Mr. KARTH. I wonder, then, if you would indicate, by letter to the committee staff, those areas that are classified for reasons of national security?

Mr. CORTRIGHT. I would be glad to do that.

Mr. KARTH. And then any other areas classified for any other reasons in the opinion of NASA that deserves classification?

Mr. CORTRIGHT. Yes, sir. Mr. Chairman, if I may, please, the abstract which we have submitted to the committee a month or so ago is an accurate summary of the Kelley report and we have indicated that it might be desirable for a man of your choosing to read the original and confirm the authenticity and completeness of the abstract of the technical and management findings of this committee. That is an unclassified version, and could be made available tomorrow, or this afternoon, to every member of this committee.

Mr. KARTH. I think it would be good if each member of the subcommittee were furnished with the public, unclassified compilation of the report, but then, in addition to that, I guess the request has been made and approved that the committee staff be furnished with one copy.

For the benefit of each individual subcommittee member, if he wants to avail himself of the information that is in it, the report should be available. With that in mind, I suppose we will later pursue the subject, if any committee member so chooses.

Mr. CORTRIGHT. Mr. Chairman, I would like to address myself to a statement by Mr. Randall which indicates that I have left an extremely erroneous impression in his mind. And that is, that the last 2 months have not been filled with 70-hour workweeks trying to improve our situation on the Ranger project, for they have.

This included very intensive examinations of how an industrial contractor would be brought in and what he might do. It is not a simple matter just to say "Well, we will bring in this company and he will do this job for us." We have been working very hard on this problem in NASA and at the Jet Propulsion Laboratory since the submission of the Kelley report. My choice of the words "back burner" was unfortunate, but it wasn't the first thing we had to do.

The first thing we had to do was pin down the technical difficulties within the Ranger spacecraft. Although all corrective measures were studied simultaneously, there was a priority.

Mr. RANDALL. Mr. Chairman, I didn't want to be unduly critical. If there was anything that sounded so, I thought we had come upon an area of inquiry here that was most important, and I resubmit there

was a report on November 19, 1962, and apparently this Kelley report was acted on only Friday.

Mr. CORTRIGHT. No, all the other recommendations have been acted on by now. We have been working on them as fast as we could resolve the action items.

Dr. NEWELL. Mr. Chairman, if I may make a comment here?

Mr. KARTH. Dr. Newell.

Dr. NEWELL. You will recall that the Rangers have now been set aside into the form of several different blocks of Rangers, and as Mr. Cortright has mentioned, it is our estimate that the contractor can be brought in in full measure on this project only in Block V. That would be the point where he could pick up and be the full systems contractor for the Ranger.

Now, we can't wait until Block 5 to have a success. We must make sure that the Rangers we are going to fire toward the end of this year, and the Rangers of Block 4, are successful also, and therefore our first problem has been to make sure the right things are done, the right tests are conducted, the right quality control introduced into the program, the right design changes made, if any, so that these Rangers between now and when the contractor picks up in full measure, also are successful. This is what is being done.

Mr. KARTH. Doctor, are you recommending design changes?

Dr. NEWELL. Do you want to answer that?

Mr. CORTRIGHT. Yes, there are design changes being made.

Mr. KARTH. Really, are we coming up with a brand new spacecraft?

Mr. CORTRIGHT. No, sir, these are improved components. These are the design changes. For example, the central computer and sequencer, in Block III, which is the next series, is being built by Nortronics, of Northrop, and it has improvements in it which we have evolved as a result of the experience we have had. The Block IV computer and sequencer is being redesigned to provide more stability in the circuits. To provide redundancy, the television equipment, where we have six cameras on the impacting TV systems, are being separated completely, three and three, so that one system can fail and the other will work; it wasn't quite that clean a separation in the earlier design. That is the sort of work we are completely enmeshed in now, trying to maximize the probability of success.

Another thing we are doing, the gyros in the old design had to run all the 66 hours to the Moon. We are now putting in the Mariner-type system where you turn the gyros off, except when you want to use them, which of course was mandatory for Mariner, since it had to fly for 109 days. It is less mandatory, but desirable for the lunar mission.

Mr. KARTH. The heart of this whole Ranger program, however, is electronics and guidance, is it not?

Mr. CORTRIGHT. Electro-mechanical systems.

Mr. KARTH. We are really redesigning the Ranger spacecraft, aren't we, Mr. Cortright?

Mr. CORTRIGHT. I don't think that I would say it that way. I think that we are making design improvements. The basic functions that these systems are to perform and the manner in which they perform them will be the same, or very similar. But there are circuit improvements which can be made, which will make a better piece of equipment.

Mr. KARTH. Who proposed these redesign changes in guidance and electronics? Was this proposed inhouse within JPL, or within NASA, outside of JPL, or by some other contractor who studied the Ranger?

Mr. CORTRIGHT. This is the result of a combined NASA–JPL effort to make a better piece of equipment, and it goes back beyond Ranger V, actually. After Ranger III, we thought we had a good piece of equipment, because on the first two Ranger flights the spacecraft appeared to function properly, as best it could in the low-altitude orbit. On flight 3 it operated the 66 hours to the Moon properly. After Ranger IV, where we had an early failure, we had Nortronics conduct a design review of the central computer and sequencer, which we felt was the cause of the Ranger IV failure.

Mr. KARTH. What kind of a contract do we have with Nortronics on this? Is it a cost plus incentive, cost plus fixed fee, or what is it?

Mr. CORTRIGHT. As of today, it is a letter contract to be definitized into a hard cost-plus-fixed-fee contract within 2 weeks for Phase I, and should a Phase II contract be negotiated with Northrop a cost-type contract with an incentive clause would be considered.

I cannot answer you at this time, but I would be glad to provide the answer to whether this will be cost plus incentive or cost plus fixed fee.

Mr. KARTH. But in any event, it has not been let for bid, there has been no competition for this?

Mr. CORTRIGHT. That is correct.

Mr. KARTH. No submissions have been made, no proposals?

Mr. CORTRIGHT. This is correct.

Mr. KARTH. Are there any other questions?

Mr. RANDALL. Yes.

You mentioned Dr. Kelley and six men, Dr. Al Kelley?

Mr. CORTRIGHT. Yes.

Mr. RANDALL. Who is he? Where does he fit in?

Mr. CORTRIGHT. He is the Director of Electronics and Control in the Office of Advance Research and Technology in NASA headquarters.

The staff that he used was gathered from our various field centers, and this total procedure followed the directive by Dr. Newell to utilize men who were not personally involved in the Ranger project. So there were no members on this group that had any personal involvement in the Ranger. And there were no members from the Office of Space Sciences on the group. This was deliberate.

Mr. RANDALL. The review, however, took place during the 1 month from October to November 1962?

Mr. CORTRIGHT. Yes, sir.

Mr. RANDALL. I don't know whether I got the full answer to the question, Mr. Chairman, about the Northrop proposal.

You say there was a proposal by Northrop. He asked a question, I think, about the incentive-type contract. Was there a type of contract to Northrop of that type?

Mr. CORTRIGHT. The contract is not definitized yet for this new work. I just don't know the type of contract that will be. I imagine it will be either cost plus incentive fee or cost plus fixed fee.

Mr. RANDALL. Do you have any estimate at this time as to the amount of that contract?

Mr. CORTRIGHT. Excuse me a moment.

(Discussion off the record.)

Mr. CORTRIGHT. I think the Phase I portion of it is $2 million. The Phase II, which would be a much heavier involvement in hardware, will be larger. For example, Rangers built by Northrop, if they cost about what they have cost at JPL, or a little bit more, will run in the neighborhood of $11 million apiece. This price is up a little bit from what we initially figured the carbon copy cost would be because of the improvements we are having to make.

Mr. RANDALL. How many do you intend to build?

Mr. CORTRIGHT. The Block V, in 1965, will contain five.

Mr. RANDALL. That raises the question, Mr. Chairman, I think it will be helpful to all members of the committee if we could get a description of what is contained in the different blocks. We have heard of Block IV and Block V over here. You make some reference to Nortronics, at Block III, while Northrop itself is at the head of Block IV. Now you refer to Block V. Can you break that down? When it gets buried in the record there we have to turn through pages and pages. Can't you give us a memorandum when you come back the next time?

Mr. CORTRIGHT. It is very easy to do. I can do it by memo.

Mr. KARTH. Fine.

(The information requested is as follows:)

A. DEFINITION OF RANGER BLOCK CONCEPT

Block I: The first two Rangers (Rangers 1 and 2) launched in 1961 had the objective of carrying out engineering tests of the spacecraft and obtaining interplanetary scientific data.

Block II: The next three Rangers (Rangers 3–5) were launched in 1962. The objective of these missions was to obtain medium-resolution television pictures of the lunar surface and to determine the presence of radioactive elements in the lunar crust by means of a gamma ray spectrometer. In addition, a survivable capsule containing a single-axis seismometer was to be hard landed on the surface.

Block III: Four Rangers (Rangers 6–9) will be launched in this block which is scheduled to begin in late 1963. The objective of these flights will be to obtain high-resolution television pictures of the lunar surface while the spacecraft is approaching the Moon.

Block IV: The next three Rangers (Rangers 10–12) will be launched in the second half of 1964. As presently planned, these flights will carry an improved version of the television cameras used in Block III plus some nonvisual experiments designed to yield information about the lunar environment.

Block V: The Rangers beyond No. 12 (the program is tentatively planned to extend through Ranger 24) will be launched in the 1965–66 time period. It is planned to use the hard-landing technology developed for the Block II Rangers to land different types of payloads on the lunar surface.

B. CONTRACT TYPES REGARDING NORTHROP

(*a*) Existing contracts with Nortronics (a division of Northrop) for the Ranger attitude control system and the central computer and sequencer are of the cost-plus-fixed-fee type.

(*b*) The new Phase I contract with Northrop for assistance to JPL on the Block III and IV Rangers will be cost plus fixed fee.

(*c*) Should a Phase II contract be negotiated with Northrop, a cost-type contract with an incentive clause would be considered. Under Phase II, Northrop would assume system responsibility for the Ranger spacecraft for the Block V missions.

C. RANGER BOARD OF INQUIRY CHRONOLOGY

October 19, 1962: Dr. Newell's memo directing establishment of a Board of Inquiry.
October 29, 1962: Started investigation.
November 23, 1962: Completed investigation.
December 4, 1962: Oral briefing to Office of Space Sciences.
December 5, 1962: Written report submitted.

D. JPL ORGANIZATION CHART

The type of organization chart which was requested is not available at the present time. We will make every effort to get such a chart to you within the next week.

Mr. RANDALL. We can go back now to jet propulsion. In the first place it is a part of the State of California. It is a university chartered by the State?

Mr. CORTRIGHT. No, sir, California Institute of Technology is privately endowed.

Mr. RANDALL. How have you classified this contract with JPL? Would you classify it as a contract with private enterprise, then? Is it like you would another corporation?

Mr. CORTRIGHT. A contract with a university. We have hundreds of them—although none like this.

Mr. RANDALL. All right, Mr. Chairman.

Mr. KARTH. Mr. Staebler.

Mr. STAEBLER. Mr. Chairman, supplementing the very appropriate inquiries that have been made here into the details of this change, I think we ought to note the larger aspect of it, which pleases me very much, that the evidence of flexibility is shown in the operation of our system. When I think of how our opposite numbers other side of the curtain deal with problems like this, I see in this kind of competition between different methods of production and research a very good demonstration of one of our assets in this country.

In fact, we can do things in different ways and have a choice of alternatives.

Mr. KARTH. Well, I would say this for the record, that certainly I want to compliment Dr. Newell and the Office of Space Sciences for looking into their own backyard, so to speak, when they feel a program is not proceeding as they would like to see it proceed. In effect, I guess you would say, investigate themselves. I appreciate this sometimes runs the limit of the decisionmaking process.

Dr. NEWELL. Thank you, Mr. Chairman.

Mr. KARTH. It normally is something that is well hidden and not very highly regarded by those who are in charge, so I do want to compliment you, Dr. Newell. I think it is very good that you took the initiative.

Dr. NEWELL. Thank you.

Mr. KARTH. But, on the other hand, I know that you agree the committee wants to be properly informed as to why this action was necessary, why in your opinion it had to be done, and what the results are.

All right, Mr. Cortright, would you like to proceed?

Mr. CORTRIGHT. Yes, sir.

We plan to continue an active program with the Rangers and to conduct a number of important lunar measurements. This is pos-

sible because of the versatility of the basic spacecraft as illustrated in the next chart (fig. 48, Ranger Capabilities). The upper part of the chart shows the high-resolution television package which will be flown in the next Ranger series. There are actually seven of these planned, I might add.

This package provides up to 3,250 pictures of the surface during the final descent of the spacecraft. The resolution of the final pictures before impact may approach 1 foot, although it will not be possible to identify objects quite that small, in all likelihood. From these pictures we hope to learn much about the topography of the landing area, the surface texture, and to utilize the data to evaluate potential landing sites. In addition, we are developing a small capsule which could be landed by the same technique planned for the first three Rangers; namely, a rough landing with instrument protection by means of a balsa wood shell on the capsule.

This particular system would provide a full panoramic photograph of the local lunar surface with resolution of one-tenth of an inch in the immediate vicinity of the capsule. In addition, of course, we have yet to land the seismometer capsule which has already been developed, and this payload remains a serious contender for future flights. Then, in essence, we are not yet certain of what payloads will fly on the 1965 Rangers, whether they will be the television, the high-resolution facsimile capsule, or perhaps even the seismometer.

Mr. KARTH. Mr. Cortright, let me interrupt to ask you a question at this point. The photofacsimile capsule, as I understand your chart, is the capsule that will give us 360° panoramic pictures, is that right?

Mr. CORTRIGHT. Yes, that is right.

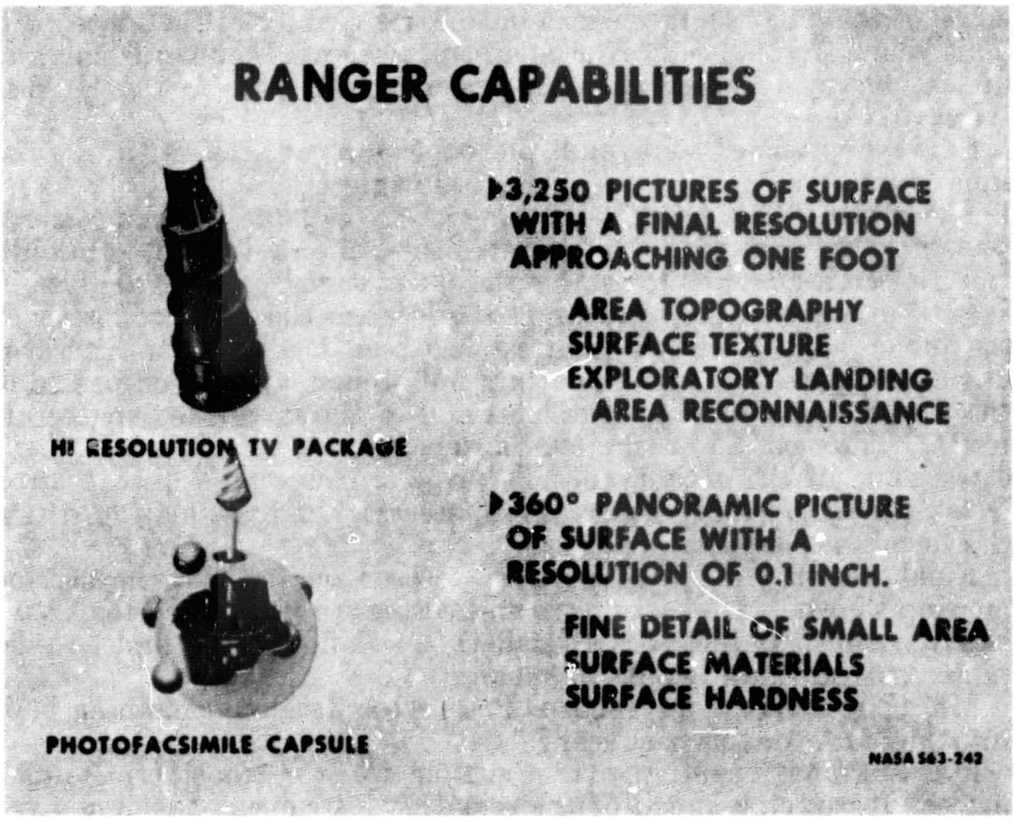

FIGURE 48

Mr. KARTH. Would you explain what a 360° panoramic picture is?

Mr. CORTRIGHT. I would be glad to. The approach is as follows: When the capsule lands, the balsa wood shell absorbs the impact, and we have demonstrated that we can do this, both with our seismometer and with this other type of equipment. We have a righting system inside the capsule which uses a fluid suspension and a low center of gravity of the instruments floated within the fluid in such a way that it rights itself, no matter which way the capsule lands.

Having righted itself, with this design, a hole is blown out of of the top, and through it erects an antenna—this is an inflatable antenna—a little plastic container with a fine, foil-type, spiral antenna. When inflated it holds its shape from then on.

Mr. KARTH. The panoramic picture then is taken after it has hit the surface of the Moon, is that correct?

Mr. CORTRIGHT. Right out of this shaft [indicating].

Mr. KARTH. I see.

Mr. CORTRIGHT. There is a little photocell.

Mr. KARTH. That is after it is effected?

Mr. CORTRIGHT. Yes. This photocell continually rotates and changes its look angle slightly, and it measures the light strength from each direction. This is radioed and put together on Earth to give a high-resolution picture. We have examples of pictures developed with this particular system which are very, very good.

Mr. KARTH. Thank you very much.

Mr. CORTRIGHT. Project Surveyor is designed to make a giant stride in lunar exploration technology beyond that of the Ranger. Surveyor will demonstrate soft-landing technology, will survey various landing areas on the lunar surface, and will measure physical-chemical properties of the lunar surface in the immediate vicinity of the spacecraft. This chart (fig. 49, Surveyor Spacecraft) shows the "hard" mockup of the Surveyor spacecraft as it is being fabricated at the Hughes Aircraft Co.

Surveyor is fitted with multiple television cameras to survey the lunar surface as it approaches and following landing.

I might interject here, these cameras are capable of taking stereo photography, and they also cover a 360° panoramic field. In addition, it carries devices to sample the lunar surface and to analyze it, as well as instruments to measure the local mechanical properties of the lunar surface. Good progress has been made on the Surveyor during the past year with important milestones having been passed in the design of all of the subsystems and of the integrated spacecraft itself. The next chart (fig. 50, Surveyor Spacecraft Progress) indicates some of the activity in this project, including full-scale drop tests of a dynamically equivalent spacecraft, and the mating of the Surveyor and the Centaur.

Final design changes have been worked out on the engineering mockup shown. The main retro and vernier propulsion systems have been developed and tested. In a short time, landing tests under rocket power will be conducted at Holloman Field, N. Mex.

Mr. KARTH. Have any of the Prospector developments been built into the Surveyor this past year?

Mr. CORTRIGHT. Actually, at the time we were considering doing project Prospector, much of the scientific instrumentation was envi-

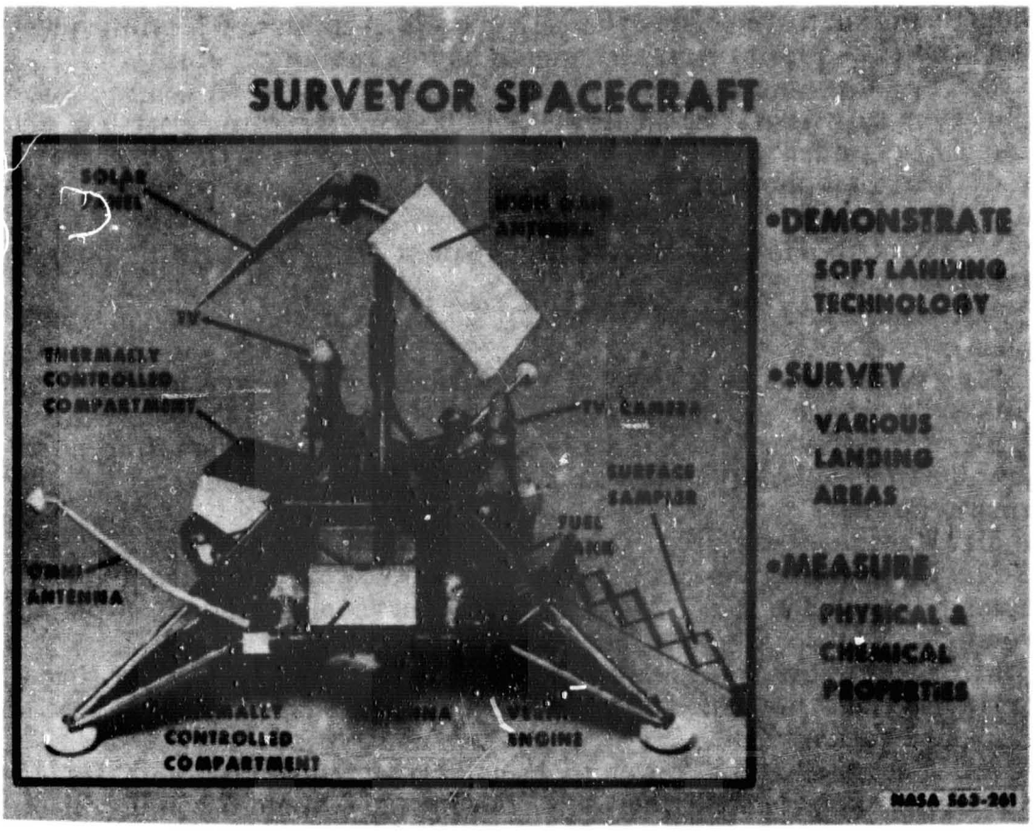

FIGURE 49

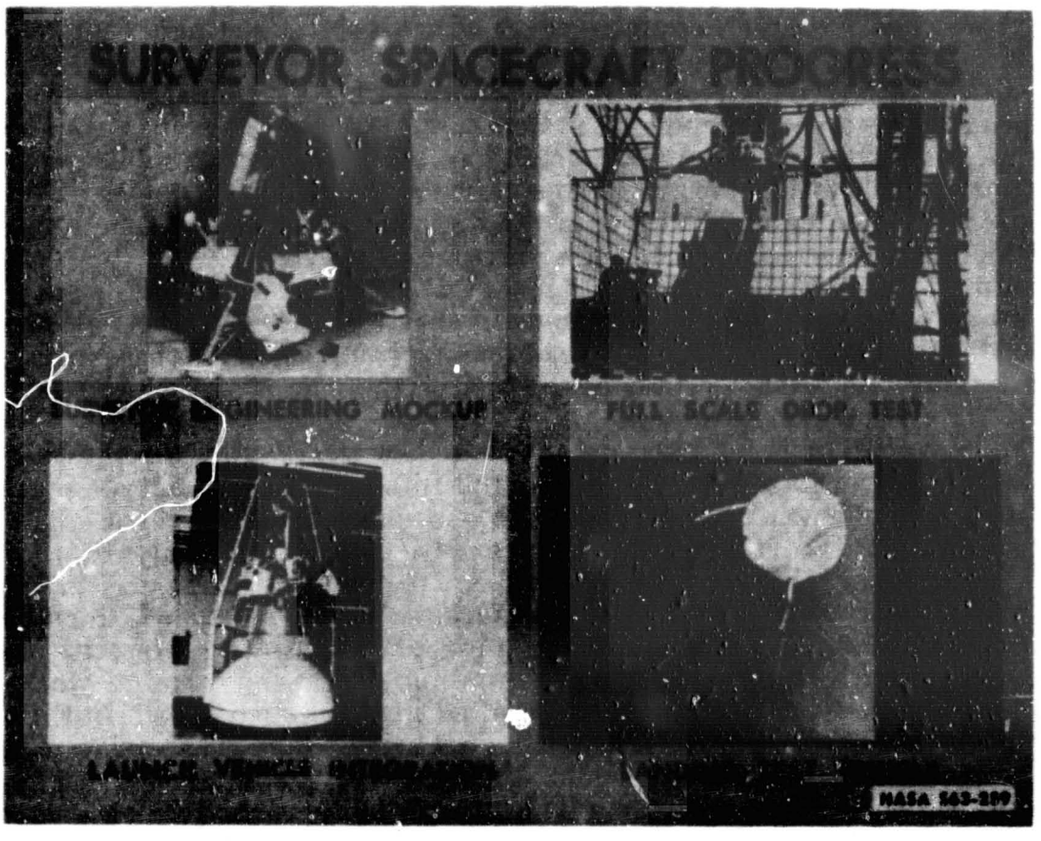

FIGURE 50

sioned similar to the Surveyor. In more direct answer to your question, the Prospector originally was to have a roving capability.

We are now seriously engaged in a design study to upgrade the Surveyor to where it can carry a small rover, weighing between 100 and 200 pounds, which can cover several miles from the spacecraft, and provide photographic coverage as well as surface-bearing strength.

Mr. KARTH. Have you made any request for funds in this budget for that program?

Mr. CORTRIGHT. No, we haven't. That is in the low-level study phase.

Mr. MORRIS. What kind of a powerplant would you consider for this roving vehicle?

Mr. CORTRIGHT. There have been many proposals, including solar power, fuel cells, and radioisotopes. We have not determined the answer to that.

Mr. MORRIS. I wondered if you were considering isotopes.

Mr. CORTRIGHT. Yes, sir; we have a radioisotope system for development under the AEC for use on the Surveyor in the 2,500-pound version. The 2,100-pound version is better with the solar cells.

Mr. KARTH. As you envision it today, however, the Surveyor spacecraft has the same experiments on it that it had last year. Is that a fair observation?

Mr. CORTRIGHT. But fewer of them. It now has about 100 to 115 pounds of experiments, whereas in the full 2,500-pound configuration this would have been in excess of 200 pounds of instruments.

Mr. KARTH. Thank you.

Mr. CORTRIGHT. A photograph is shown of a test of a recovery system used in the development of an aerodynamically stable configuration for the drop and landing tests.

I would like to interject. When you are flying a tethered Surveyor on its own vernier propulsion system, as we have it hanging from a rope, if things go wrong we won't lose it. It is flying on its own landing rockets, and we are getting close to the point where we will be attempting to land a Surveyor on Earth, on its own power, something which has never been done by an untethered rocket.

In addition, this spring a test model of the spacecraft will be subjected to simulated lunar operations in the desert at Goldstone, Calif. These tests will exercise the remote control operation of the experiments by telemetered commands, which is the manner in which they will be operated on the Moon.

The Surveyor is not entirely automated, where it goes through its exercises according to a program we put into it on Earth, but a scientist can sit in a control room on Earth and instruct the Surveyor what to do next. We think this feature will add considerably to the Surveyor reliability.

Developments of the Surveyor Orbiter were restricted during fiscal year 1963 to permit reprograming of funds into more critical areas in the Ranger and Surveyor landing programs. Design work has proceeded, however, and has resulted in the system shown in this chart (fig. 51, Surveyor Orbiter). This system makes extensive use of Surveyor Lander components. In fiscal year 1964 we will begin work on the flight hardware. The lunar Orbiter will provide complete photo reconnaissance coverage which will permit us to extrap-

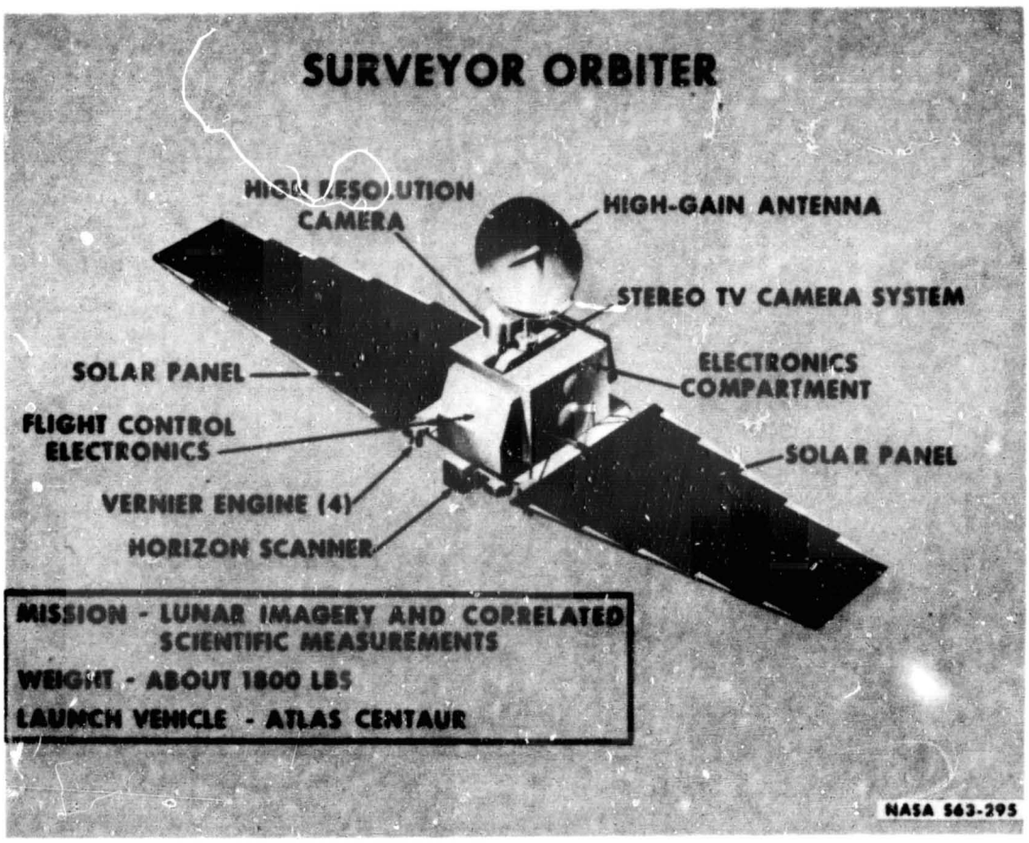

FIGURE 51

olate to other areas our knowledge about local spots in which we have landed with Ranger and Surveyor. We will then be able to make selections of potential manned lunar landing sites. In addition, the Orbiter will enable us to determine the gravity field of the Moon which will affect the Apollo orbits, in the manner in which the excursion module rendezvous with the basic Apollo capsule.

Mr. MORRIS. That will affect also the touchdown characteristics of the lunar landing, this information that you will derive?

Mr. CORTRIGHT. Yes, sir. The information about the lunar surface will be allowed for in the excursion module.

Mr. KARTH. What about the gravity field; wouldn't that have some effect on how you are going to build it?

Mr. CORTRIGHT. The gravity field may play a role in the detailed trajectory, which the Lem follows in leaving the lunar orbit in going down to the surface. The actual touchdown will probably not be affected by these measurements, because we know the lunar gravity close enough to accurately predict and simulate on Earth what the actual touchdown dynamics are apt to be.

Mr. KARTH. I see.

Mr. CORTRIGHT. The exploration of the planets is proceeding in an evolutionary manner as is the exploration of the Moon. This is illustrated in the next chart (fig. 52, Steps in Planetary Exploration). The Mariner II flyby constituted our first step toward planetary exploration. This type of mission will be repeated for Mars in 1964. The next milestone will be the landing of instrumented capsules on

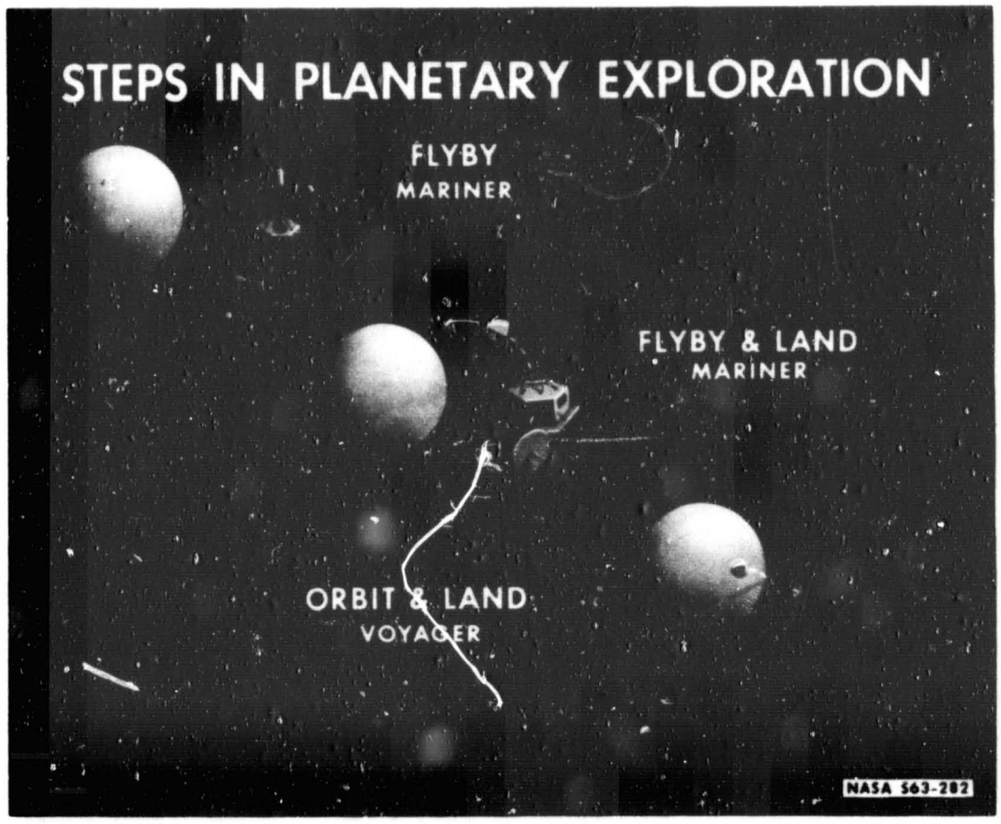

FIGURE 52

Venus and Mars to telemeter back to Earth the data about the planetary surfaces and possible life forms which may exist there. The development of this landing technology will thus be the next big technological step in the Mariner program. Beyond this, however, it is important that this country proceed with the development of planetary exploration spacecraft of much greater weight and much greater capability to explore. The Voyager mission, which was discussed last year, will continue to be intensively studied throughout fiscal year 1964.

In Dr. Newell's discussion, he covered rather completely the scientific results from the Mariner II mission. This chart (fig. 53, Mariner II) shows the Mariner spacecraft configuration and lists a few of the vital statistics.

I won't dwell on these, because this is a much-publicized mission and you are all familiar with it.

The Mariner flight history is summarized in the next chart (fig. 54, Mariner II Flight). The science has been reviewed earlier, however, I would like to highlight the technological achievements of this mission. The Mariner functioned properly for 109 days before reaching Venus and at the planet all subsystems and instruments functioned properly, except I am forced to interject here that the system to automatically turn on the instruments did not function properly, and we had to use a backup command to turn them on. As a note of interest, that backup command was added after a Ranger failure, because we would have liked the backup command in the Ranger mission.

FIGURE 53

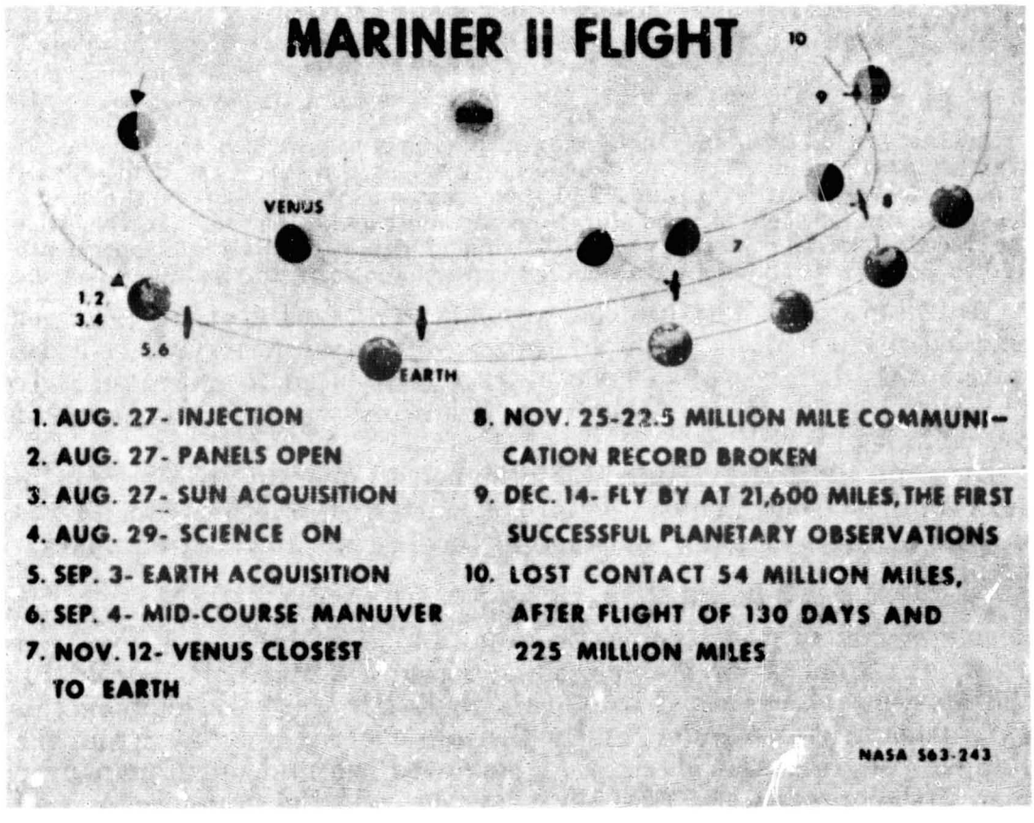

FIGURE 54

During the entire 180-million-mile flight to Venus, the Mariner maintained precise attitude control with the utilization of only a few pounds of attitude control gas. Telemetery was transmitted and received from a distance of 54 million miles with only a 3-watt transmitter before contact was lost.

Mr. MORRIS. Mr. Chairman.

Mr. KARTH. Mr. Morris.

Mr. MORRIS. There is one question I would like to ask.

You covered something we are working on in some other matters involving another committee. Now, would this telemetry received from 54 million miles be accurate?

Mr. CORTRIGHT. High quality, right to the end.

Mr. MORRIS. That is all, Mr. Chairman.

Mr. KARTH. Thank you.

Mr. CORTRIGHT. We used only a 3-watt transmitter, but because we had a directional antenna on the spacecraft pointed to the Earth, and very excellent antennas and amplifiers on Earth, we were able to pick up a signal strength of less than one billionth of a billionth of a watt in power. That is all we had.

Do you have a question, Mr. Morris?

Mr. MORRIS. Yes. Can you break that down for me? How would that compare with a background noise, say, from solar radiation?

Mr. CORTRIGHT. Well, we weren't looking at the Sun, so we didn't have to worry about that. But we had background space radiation, and I don't know what the signal-to-noise ratio was, frankly.

Mr. MORRIS. Could you find out?

Mr. CORTRIGHT. Certainly.

Mr. MORRIS. I wish you would, I would like to know. And if so, could I ask unanimous consent to put it in the record at this point?

Mr. KARTH. No objection, we will put it in the record at this point.

MARINER II COMMUNICATIONS DATA

On January 3, 1963, the DSIF station at Johannesburg acquired the spacecraft at 0354 G.m.t. With the telemetry signal at threshold, the demodulator was not locked until 0430 G.m.t. and then went out of lock at 0521 G.m.t. and remained out of lock for the duration of the tracking period. At this time the received carrier power was —157 dbm or approximately 10 pentillionth (10^{-15}) of a watt, and the data channel signal-to-noise ratio was about —2 db.

Mr. CORTRIGHT. The midcourse maneuver feature of the Mariner enabled us to make a flight of unprecedented accuracy wherein the initial miss-distance of 233,000 miles was reduced to approximately 21,600 miles, which compares very favorably with the aim point of 11,000 miles.

Incidentally, the Mariner was designed to operate properly out to 40,000 miles from Venus. This is a matter of whether you hit the middle of the 10-ring or the edge of the 10-ring, if you are a marksman.

The Mariner II was made possible only by the technology and developments of the Ranger program and the Mariner A program (fig. 55, Evolution of Mariner II). From the Mariner A program, the Mariner II borrowed a long-range Earth sensor development, a gyro pack, a transponder, and a thermal control system. From the Ranger program, the Mariner II borrowed the midcourse maneuver motor, the antenna, the Sun sensor system, and the structure, as well

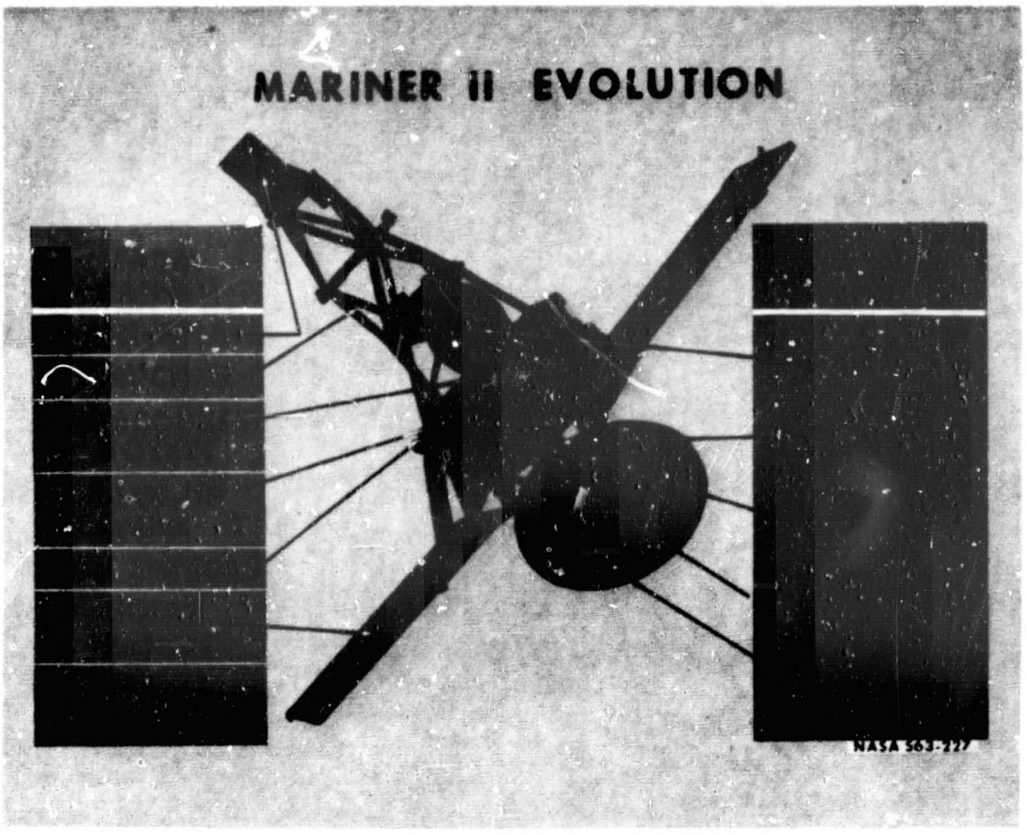

FIGURE 55

as solar panels, a backup command system, and the flight operation procedures, which are a major portion of a successful mission.

It was only by this melding of developments that it was possible to do a spacecraft of this complexity in 1 year's time, and achieve complete success on its first mission.

Now that we have successfully developed the technique of getting to our neighboring planets, we will exploit this technique in 1964 for additional flyby missions. The year 1964 will see our first missions to the planet Mars, on which missions we will attempt to obtain high quality television photography of the planet and to conduct initial experiments in infrared spectroscopy to evaluate the possibilities of life on the planet's surface. The spacecraft design for the Mars mission is shown in this chart (fig. 56, Mariner to Mars—1964).

Mr. STAEBLER. Mr. Chairman, may I ask a question?

Mr. KARTH. Mr. Staebler.

Mr. STAEBLER. Do I remember correctly that the Russians have the vehicle on the way to Mars now? Have they a probe on the way to Mars?

Mr. CORTRIGHT. Yes, they do.

Mr. STAEBLER. Do we know anything about it?

Mr. CORTRIGHT. The only thing we know about it is the newspaper reports that they release. They have reported it was functioning properly.

Mr. STAEBLER. Is this announced as a probe that will land?

Mr. CORTRIGHT. No, sir; it has been announced as a probe that will fly close by the planet by virtue of a midcourse maneuver. To the

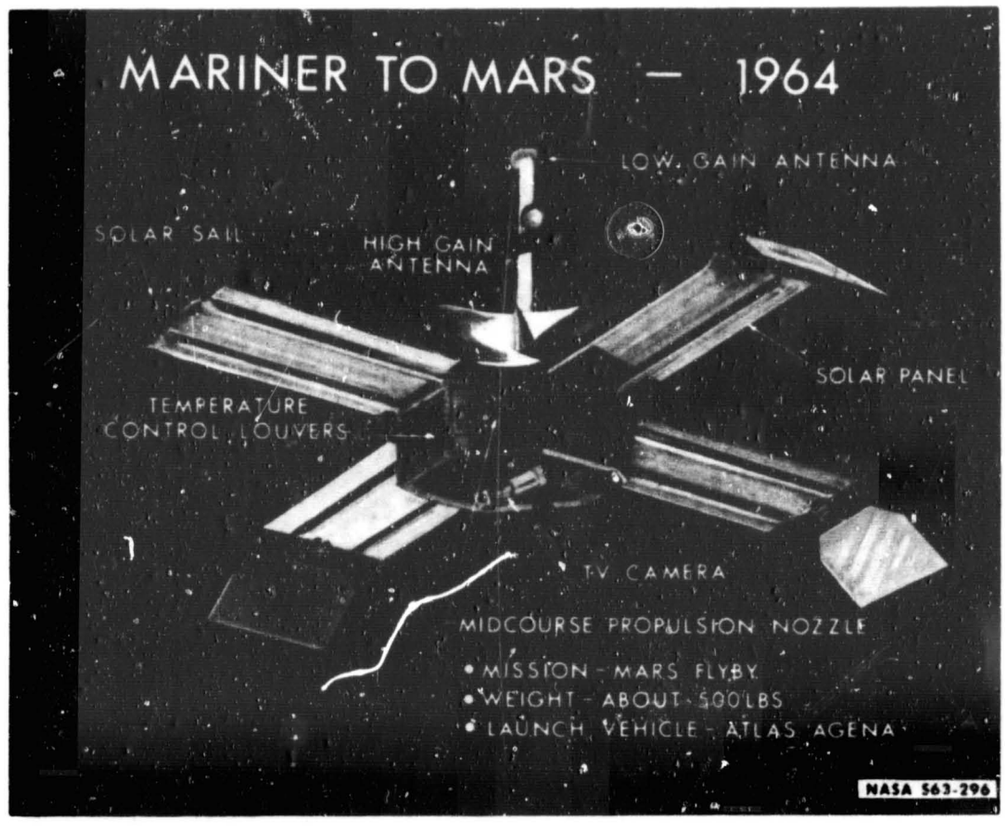

FIGURE 56

best of my knowledge, they have not announced a successful midcourse maneuver yet; however, and it is getting sort of late, according to the way we would have done a midcourse maneuver and did our own.

They have announced that they will obtain photographs of the planet, and radio them to Earth. But the exact manner in which they intend to do this is not described.

Mr. STAEBLER. Thank you.

Mr. RANDALL. Mr. Chairman.

Mr. KARTH. Mr. Randall.

Mr. RANDALL. Have we been making an effort to track or check on this ourselves?

Mr. CORTRIGHT. We tried, but they don't communicate with their spacecraft like we did ours.

Mr. RANDALL. Is it in code?

Mr. CORTRIGHT. Well, it would be in code, yes, but we know the transmitter frequency, I believe. I think they announced that. But it is very hard, first of all, to point at it, and you never know when they are going to interrogate it. That means we would have to run a 24-hour watch on where we think that spacecraft is, in the hope that we would be looking at it just at the same time they turned it on, and it just isn't worth the effort.

Mr. KARTH. That would employ one of our facilities full time; is that correct?

Mr. CORTRIGHT. It would be worse than that. It would interfere with the operation of all three of our deep space instrumentation facilities. It isn't worth the effort, because the Soviets will release their data when they get it. They don't communicate, except about once a week, whereas we kept 24-hour contact with our spacecraft.

Mr. RANDALL. According to Time magazine, much of the data relayed back gets back to all of us. Mariner II was in code, but it was no secret code, was it? It was open to the world?

Mr. CORTRIGHT. You would have to have a demodulator and know what the system was, what the telemetry system was, to make sense out of the data. You do that simply to make it convenient to send and receive your data. But it is possible to take raw data like that and have a stranger make something out of it sometimes.

Mr. RANDALL. One of the great difficulties of their checking on our Mariner, or ourselves upon their project to Mars, whatever it is, is not simply the tying up of a tracking unit, but there are still a lot of technological difficulties being able to lock onto it; isn't that right?

Mr. CORTRIGHT. We have to modify all of our receiving equipment; that is right. Actually, you bring in a jerry-rigged receiver setup and adjust to their frequency.

Mr. RANDALL. Thank you, Mr. Chairman.

Mr. KARTH. Does the Russian effort to communicate with their probe only once a week indicate they have a very limited power source for it?

Mr. CORTRIGHT. It could mean a number of things, but I think it means that their power system probably is suited to bursts of data and then recharging. There is another possible interpretation, and that is that they are cruising in a mode whereby their antenna is not normally pointing at the Earth, and they have to go through a maneuver to point the antenna.

I don't think they do that, but if they were doing that, they wouldn't want to do it every day. There is just that much chance of introducing a failure.

Mr. KARTH. But does this indicate a solar-cell-type powerplant, or what?

Mr. CORTRIGHT. It has solar cells on it. They have released a photograph of their spacecraft. You may have seen it.

Mr. KARTH. I don't remember that I did. Thank you very much.

Mr. CORTRIGHT. Although this system does not look much like Mariner II, it is a direct development and uses many of the subsystems as well as the general technology.

Beyond 1964, we plan to make our first flights with Mariner spacecraft designed to deposit instrumented capsules on the planetary surfaces. The next chart (fig. 57, Mariner Flyby and Land Capsule) illustrates one of our advanced designs which would be capable of executing this maneuver. This particular spacecraft—which, incidentally, was designed by the Jet Propulsion Laboratory—is designed to be launched with the Atlas-Centaur vehicle. Intensive exploration of Mars and Venus must await the entrance of the Saturn launch vehicle into the space sciences program. Project Voyager, which is now in the preliminary design phase and which will continue in that status in fiscal year 1964, is being designed to make use of the Saturn capability. The spacecraft on Voyager would be capable of executing

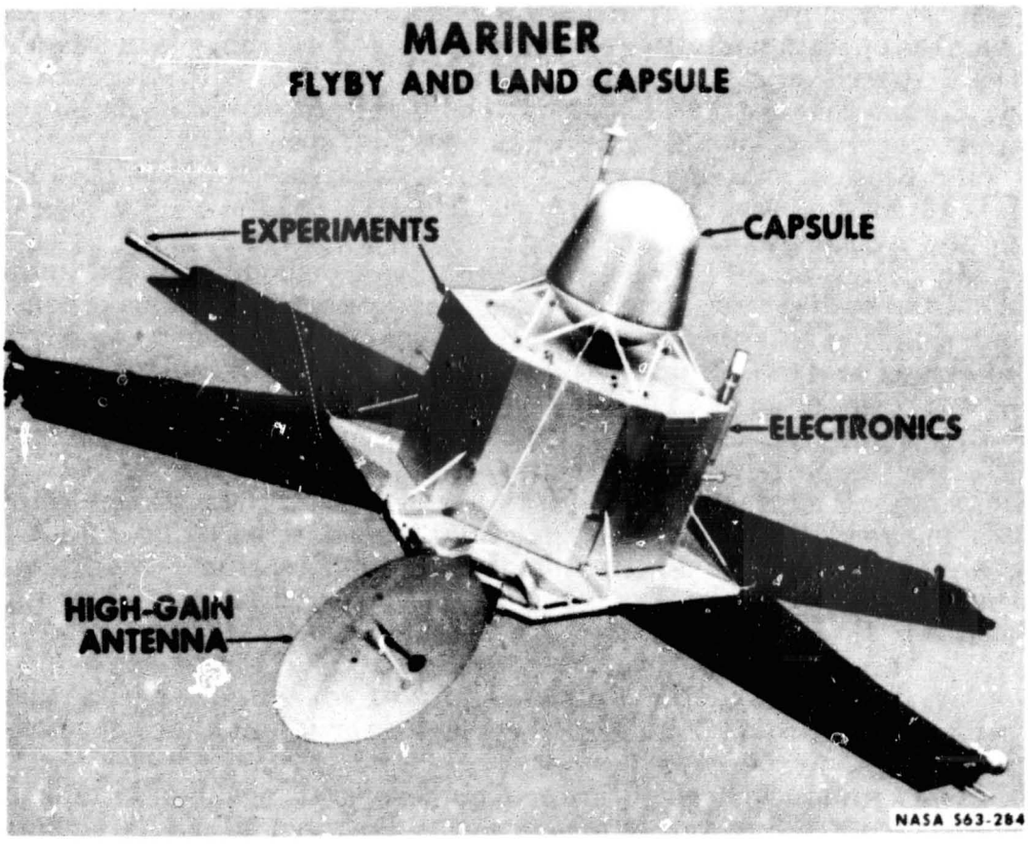

FIGURE 57

a planetary orbit as well as landing a capsule on a single mission or, in an alternate mode, could land a very heavy instrumented capsule on the planetary surface during a flyby mission.

Program Review—Biosciences

Turning now to the area of biosciences.

Mr. KARTH. Let me ask a question. How far down the road are we on the Voyager project?

Mr. CORTRIGHT. Not too far, actually, Mr. Chairman. We are still studying it intensively. There are a number of contractors studying it with their own funds, and have been for up to 2 years.

We are contracting for two industrial design studies during this fiscal year to help firm up in our minds what the best possible mission would be, since there are so many different modes that you can use. We are still thinking and studying.

Mr. KARTH. How much money has been budgeted for this project up to this 1964 budget request?

Mr. CORTRIGHT. $330,000 in 1962; $701,000 in 1963; and $900,000 in 1964, plus miscellaneous advanced research on concepts that would be applicable, but are not identified with any particular project. We will have to draw on the advanced research and technology.

Mr. KARTH. Yes. What kind of a timetable are we talking about for Voyager?

Mr. CORTRIGHT. The end of this decade, 1969, for example.

Mr. KARTH. That is about as "end" as you can get, isn't it?

Mr. CORTRIGHT. Just about.

Mr. KARTH. Wouldn't some of this program be controlled by the availability of Saturn boosters?

Mr. CORTRIGHT. It is.

Mr. KARTH. Completely?

Mr. CORTRIGHT. Well, that is a major pacing item, because we need a three-stage Saturn for this mission.

Mr. KARTH. We are not likely to get one for this purpose until after the manned flight program people can spare one without feeling that they have in any shape, manner, or form hurt their own program; is that right?

Mr. CORTRIGHT. There is no 3-stage Saturn in the Saturn program, other than the big Saturn V for the Apollo mission, that is right. And these are heavily programed.

Mr. KARTH. Well, what kind of a Saturn are we talking about for the Voyager program?

Mr. CORTRIGHT. We will either have to use the Saturn V, which is a giant rocket, or will have to do a third stage for Saturn I–B, sir.

Mr. KARTH. Could Centaur be the third stage?

Mr. CORTRIGHT. Centaur is a candidate for that stage.

Mr. KARTH. What other candidates are there?

Mr. CORTRIGHT. A new stage.

Mr. KARTH. I see.

Mr. CORTRIGHT. But this has no status. These are just the things we are looking at.

Mr. KARTH. Mr. Morris.

Mr. MORRIS. What is the configuration you are looking at now?

Mr. CORTRIGHT. One of the configurations that has been proposed—and these, I might say, are merely proposed at working meetings, within-house.

Mr. MORRIS. We understand that. The only thing we found out, when these things are down in the lower working level, the first thing you know it is on a high working level, we don't know how it got there or what it is about. This is a very interesting program.

Mr. CORTRIGHT. Yes, sir; I will be glad to describe it for you. The lunar logistics vehicle study conducted by the Office of Manned Space Flight yielded as part of its results a system which would be launched to the Moon with the C–5, and would land in an automated fashion, large, logistic payloads of up to 20,000 to 30,000 pounds of equipment. One of the retro-rocket stages of this system is a good "fit" to the Saturn I–B, and we are looking at that to see if it makes sense to combine forces here and see if this is something the country should do. It has another feature, in that it is a flexible stage, it can be stretched into various sizes to serve a number of missions.

Mr. MORRIS. The first stage of the Saturn 1–B, is that 3 F–1 engine thrusters?

Mr. CORTRIGHT. The first stage of the I–B has eight engines.

Mr. MORRIS. Eight F–1 engines?

Mr. CORTRIGHT. Not F–1's. They are H–1's.

Mr. MORRIS. Then in the second stage?

Mr. CORTRIGHT. There are two second stages for the Saturn I. The first one is the S–4 stage which has a cluster of six RL–110–A3 engines of the type we are using on Centaur. That will be replaced by

a larger S–4B stage using one J–2, which is a 200,000-pound thrust hydrogen-oxygen engine now being developed.

Mr. MORRIS. The third stage would be the Centaur?

Mr. CORTRIGHT. That is one candidate; yes, sir.

Mr. RANDALL. What are the other candidates?

Mr. CORTRIGHT. I mentioned the only other one we are looking at now is the one that is an outgrowth of the lunar logistics vehicle study. Whether NASA will propose to do this is undetermined. We have not proposed to them and it is not included in the budget.

Mr. KARTH. What are we talking about in terms of money for the Voyager program?

Mr. CORTRIGHT. What would it cost to do a Voyager program?

Mr. KARTH. Yes.

Mr. CORTRIGHT. We have not costed that out, Mr. Chairman. We have the top-of-the-head estimates.

Mr. KARTH. I suppose it is safe to say—at least for the benefit of this committee—that the Voyager program would be an extremely costly program?

Mr. CORTRIGHT. That is very accurate.

Mr. KARTH. And in short order I suppose the cost estimate would need to be made by NASA so that they can inform this committee as to whether or not they are going to level off or ask for increased funding in the years to come; isn't that correct?

Mr. CORTRIGHT. We will have to make it as part of the fiscal 1965 budget, which we are now starting to work on, if we are to begin in fiscal 1965. And I think that we may have to begin in fiscal 1965, if we are to meet the 1969 flight date. This will be a national decision.

Mr. CHENOWETH. Mr. Chairman.

Mr. KARTH. Mr. Chenoweth.

Mr. CHENOWETH. I would like to follow briefly, Mr. Cortright, what the chairman started to ask; that is, the cost. What is the function of the Voyager? Is that an integral, essential, indispensable part of the manned lunar landing program?

Mr. CORTRIGHT. No, sir; it is not related to the manned lunar flight at all. The Voyager is predicated on the fact that this country is serious in exploring planets in detail prior to eventual manned flight to the planets.

Mr. CHENOWETH. You have gone beyond the Moon, now you are going to other planets?

Mr. CORTRIGHT. Yes, sir; this is Mars and Venus.

Mr. CHENOWETH. Do we find ourselves so short of funds we can't take on everything; is this one of the items that can be set aside temporarily while we are going ahead with the manned lunar flight?

Mr. CORTRIGHT. Depending on the national posture; yes.

Mr. CHENOWETH. What do you mean, now?

Mr. CORTRIGHT. I mean the country can decide at what time in history it wants to go to the planets with heavyweight spacecraft and put heavyweight equipment on the surface of the planets.

Mr. CHENOWETH. Right now the concentration seems to be to get to the Moon. As I understand it, you are concentrating all of your efforts to that objective. Now, then, couldn't we postpone this contemplated visit to the other planets for a little while, while we accom-

plish the No. 1 objective, which seems to be the Moon program at the moment?

Mr. KARTH. Mr. Chenoweth probably wasn't here when we explored how much money has been spent on this program. Incidentally, the record will show I think approximately $1 million in total.

Mr. CHENOWETH. I heard him say it is going up every year. I heard the figures.

Mr. CORTRIGHT. It is up to $900,000 now.

Mr. CHENOWETH. Is that an item which we could eliminate without any great damage being done for next year? I am just curious to have your observations because there are some places we are going to have to curtail. I wondered if this was one of them.

Mr. CORTRIGHT. Mr. Chenoweth, I think study efforts of that level are the best investment that the Agency can make.

Mr. CHENOWETH. This is just a study effort up to now?

Mr. CORTRIGHT. That is all, and it is insurance that we will make a good decision when we make the Voyager decision. We have to do this, otherwise we will find ourselves in a position of having to rush a decision through, and we may not like it some years hence.

Mr. CHENOWETH. This is a million dollars, then, that we should spend?

Mr. CORTRIGHT. Very well spent; yes, sir.

Mr. CHENOWETH. You are not in a crash program on this as on some of the others?

Mr. CORTRIGHT. Absolutely not.

Mr. CHENOWETH. This is a rather leisurely project you are engaged in here; you are taking your time and exploring all avenues?

Mr. CORTRIGHT. That is a fair statement.

Mr. CHENOWETH. Thank you very much, Mr. Chairman.

Mr. STAEBLER. Mr. Chairman, you said we ought to be prepared to view this as a very costly program. How costly?

Mr. KARTH. Well, there has been no estimate made, apparently, but probably there has been a "guesstimate" made. I wonder if Mr. Cortright would care to explore that?

Mr. CORTRIGHT. To develop a spacecraft of this complexity, and build and fly four of them, for example—and I could be off 30 percent here—would probably cost in the neighborhood of $300 million.

Mr. KARTH. This does not include the launch vehicle?

Mr. CORTRIGHT. And to develop the launch vehicle on top of that would cost an additional sum of money, which could vary widely depending on the number of test flights we needed for the stage. If we could find a cheap way of flight testing the third stage, that would reduce the cost. But that still would be measured in terms of a couple hundred million dollars. So I think you can say that to develop a new third stage, if you did that, and the spacecraft, and make four flights to the planets, would be a $500 million program.

Mr. KARTH. Really, this program, and programs like it, constitute the U.S. future space program, isn't that correct?

Mr. CORTRIGHT. This is the future, Mr. Karth, this is the future.

Mr. KARTH. That is right. I personally feel we put too much emphasis on the manned lunar program, and not enough emphasis in some of the other areas of space exploration we have got to engage in. That is one reason why I think we should look very closely at a redundancy which I think we are providing for, the manned lunar

landing program. I would much rather put money in a project like this, for example, than to have three or four or five ongoing, unmanned lunar programs such as we have, Orbiter, Surveyor, and Ranger.

I think maybe it's my inquisitive mind, but I think something like this over the long haul is much more important to our space program than to put "all of our eggs in one basket."

Mr. CORTRIGHT. I think we certainly welcome that expression of opinion. We feel strongly ourselves the future lies in this type of exploration. On the other hand, having undertaken to explore the Moon with men, we also feel that we have to do it in a careful manner, and minimize the risk.

During the past several years, the NASA program in biosciences in space has concentrated on Earth-based research as was discussed in the first part of this presentation. In addition, we have entered into balloon-borne experiments such as those summarized in this chart (fig. 58, Balloon Borne Observatories). In one type of equipment,

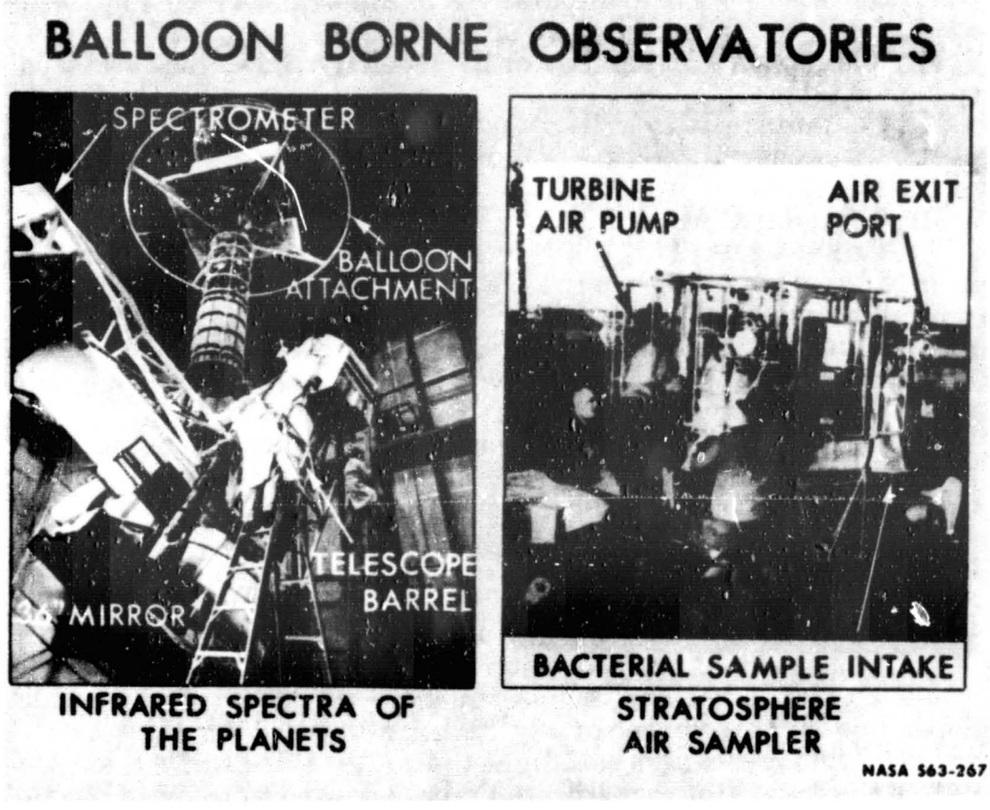

FIGURE 58

we utilize balloons to carry the Princeton stratoscope to high altitudes in order to measure infrared spectra of the planets. This type of measurement, while perhaps not as good as that which would be made from a close planetary flyby, may well give us an indication of the presence of lifelike organic molecules on the planet Mars. And as I mentioned earlier, there was a successful flight of this in the past few weeks—last few weeks.

In addition, we have been conducting experiments on sampling the upper atmosphere for the presence of life forms and, as was discussed

earlier, this has produced some very interesting scientific results, the full significance of which is not yet fully appreciated.

This year we are initiating a series of fundamental biological experiments in Earth orbit. This Biosatellite project, which was introduced earlier, is now completing an intensive system study phase. Following this phase, contracts will be let leading to a simple recoverable satellite capable of flights of at least 1 month. Biosatellite will make extensive use of systems already under development, such as that shown in this chart (fig. 59, Biosatellite Experiments) for illustrative purposes.

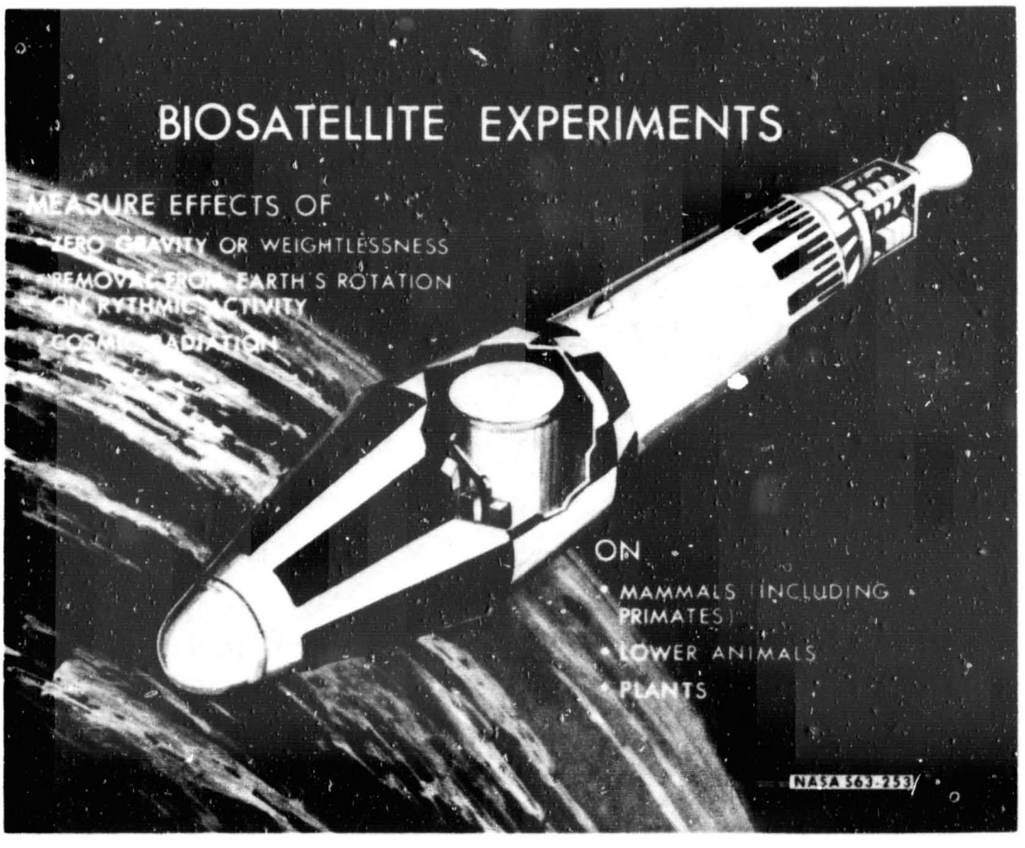

FIGURE 59

The satellite will be launched with the Thor-Delta. One proposed is shown in this chart for illustrative purposes. The satellite could be launched with either the Thor-Delta, or Thor-Agena, and our people are looking at all systems.

The funds requested in fiscal year 1964 will be required to continue this project.

Turning now to light and medium launch vehicles: Since the beginning of the national space program, one serious problem which has confronted us has been obtaining high reliability in our launch vehicles. This is particularly important when one considers that the spacecraft which we are not attempting to develop are as difficult as the development of a launch vehicle itself.

This is a fact that is not generally appreciated. One cannot really begin to iron out the "bugs" in the spacecraft until they can be launched with consistent success. The next chart (fig. 60, Improved

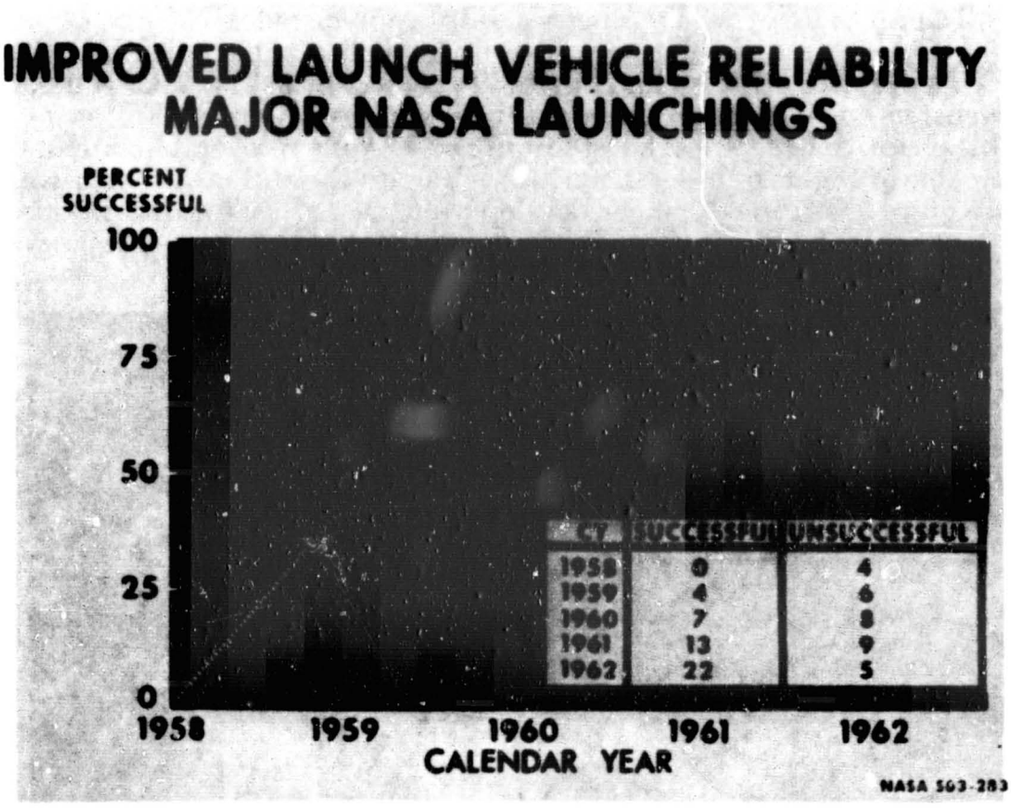

FIGURE 60

Launch Vehicle Reliability) summarizes the history of major NASA space launchings insofar as the vehicle performance is concerned. I think this is a highly significant chart. We are beginning to approach the reliability required to conduct a successful space program. For example, the percentage of launches which achieved complete vehicle success has increased from 40 percent in 1959 to 47 percent in 1960, to 59 percent in 1961, and to 82 percent in 1962.

This record stands despite the problem we have had with the Atlas-Agena. It now appears to us that the Scout, Delta, and Thor-Agena have reached the state where we can count on high reliability from them. Every effort is being made to obtain equally high reliability from the Atlas-Agena and Centaur.

This chart (fig. 61, Scout Progress) summarizes the status and progress of the Scout launch vehicle. The Scout, as you recall from last year's testimony, is this country's only solid propellant satellite launch vehicle. It is programed for heavy use by both NASA and the Department of Defense.

Mr. MORRIS. Just one thing. You indicated the Scout is a very highly reliable piece of equipment.

Mr. CORTRIGHT. I said back in the middle of page 92, the Scout has now reached the stage where we can count on high reliability. I will have a little more to say about that in discussing this chart.

Mr. MORRIS. Fine.

Mr. CORTRIGHT. During its developmental series of eight launches, the Scout achieved a success record of about 60 percent. More re-

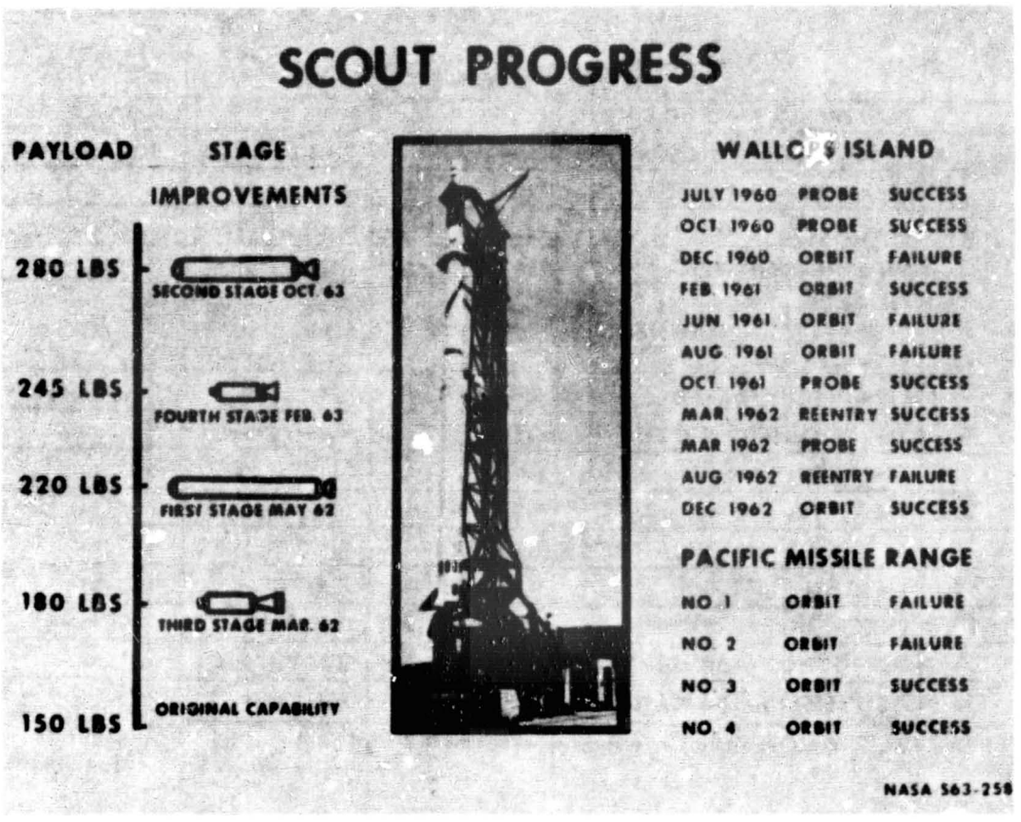

FIGURE 61

cently, the last four attempts to launch satellites with the Scout have been completely successful, and we now feel it is fully operational, and we have great hopes that we can achieve a very high reliability record with it.

As the development series has progressed, the Scout launch vehicle has been improved by uprating the various stages. This has been done primarily by loading and qualifying them with a higher performance solid propellant. As of this month, the Scout will be qualified for a 250-pound payload into a 300-mile circular orbit, compared with its initial capability of slightly over 150 pounds. A last step, then, will be to uprate the second stage to a total payload capability from 280 to 300 pounds. Its $1 million price tag makes the Scout the least expensive of all space launch vehicles.

The work horse of our space sciences program has been the Thor-Delta. Performance of this vehicle is summarized in this chart (fig. 62, Delta Progress). After an unsuccessful first launch, the Thor-Delta has performed successfully on 15 consecutive missions. These missions have included communications satellites, meteorological satellites, and a long series of explorers and monitors. The December 13 launch of the Relay satellite constituted the first flight of the uprated version of the Delta. The Delta improvement program which culminated in this uprating is shown in the next chart (fig. 63, Delta Improvement Program).

The last flight, which was the Syncom, was the second launch of this uprated Delta, and the Delta performed very well in both cases. We

DELTA PROGRESS

DELTA NO.	EXPERIMENT	POPULAR NAME	LAUNCH DATE	REMARKS
1	PASSIVE COMMUNICATIONS	ECHO	MAY 13, 1960	UNSUCCESSFUL
2	PASSIVE COMMUNICATIONS	ECHO	AUG.12, 1960	SUCCESSFUL
3	WEATHER -INFRARED	TIROS II	NOV.23,1960	〃
4	MAGNETIC FIELD	EXPLORER X	MAR.25,1961	〃
5	WEATHER-INFRARED	TIROS III	JULY 12, 1961	〃
6	ENERGETIC PARTICLES AN ELECTROMAGNETIC RADIATION	EXPLORER XII	AUG.15, 1961	〃
7	WEATHER-INFRARED	TIROS IV	FEB. 8, 1962	〃
8	SOLAR OBSERVATORY	OSO I	MAR.7, 1962	〃
9	IONOSPHERE	ARIEL I	APR.26, 1962	〃
10	WEATHER	TIROS V	JUN.19, 1962	〃
11	ACTIVE COMMUNICATIONS	TELSTAR I	JULY 10, 1962	〃
12	WEATHER	TIROS VI	SEPT.18, 1962	〃
13	ENERGETIC PARTICLES	EXPLORER XIV	OCT. 2, 1962	〃
14	ENERGETIC PARTICLES	EXPLORER XV	OCT.27, 1962	〃
15	ACTIVE COMMUNICATIONS	RELAY I	DEC.13, 1962	SUCCESSFUL (IMPROVED DELTA)
16	ACTIVE COMMUNICATIONS	SYNCOM I	FEB. 14 1963	NASA S63-235

FIGURE 62

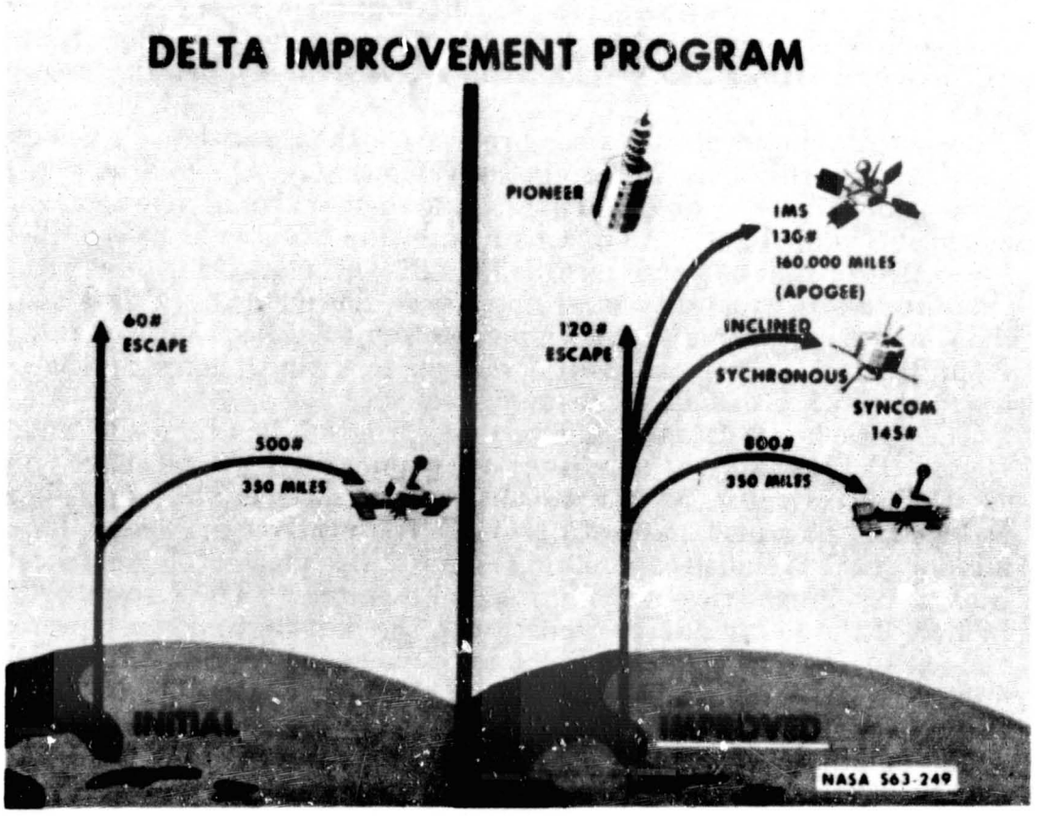

FIGURE 63

think we accomplished the improvement program without detriment to reliability.

I will have a slide on the extent of the improvement program now.

Prior to the 15th launch, the Delta had a capability of 500 pounds and a 350-mile circular orbit with an eastward launch. Its payload capability for escape-type missions was approximately 60 pounds. Because a number of missions needed somewhat improved performance, we undertook to increase the size of the Delta second stage and to effect various reductions in the weight of some of its components, including the guidance system, I might interject.

The net effect of this has been to increase the escape payload to 120 pounds, which has made the new Pioneer series of interplanetary probes possible. In addition, the Delta is now capable of the 130-pound interplanetary monitoring satellite designed to achieve an apogee of 160,000 nautical miles, and get outside the magnetosphere. The 145-pound Syncom communications satellite is also launched with this uprated Delta, as was the Relay. The basic payload in a 350-mile circular orbit is now 800 pounds compared with the initial 500 pounds, with a potential increase to over 1,000 pounds merely by stiffening the structure. The total energy is there to do a thousand pounds with the Delta.

During the development of the improved Delta, every effort was made not to jeopardize its inherent reliability and it would appear at this time that this effort has been successful. This performance increase of the Delta vehicle was obtained with no increase in the $2,500,000 unit price for the Delta.

The Atlas-Agena launch vehicle is utilized for our lunar and planetary probes and for the heavy observatory Earth satellites. Its performance to date is summarized in the next chart (fig. 64, Agena Launch Summary). The second Atlas-Agena B flown was utilized for a NASA launch of a Ranger test spacecraft in August 1961. Following this period, both the Air Force and NASA have utilized the Atlas-Agena extensively. Of seven Atlas-Agena launches from the Atlantic Missile Range, only two have achieved complete vehicle success, however. In addition, however, the Mariner II launch was a qualified success inasmuch as the desired trajectory was achieved even though the launch vehicle malfunctioned during the boost phase.

Mr. KARTH. Who was the prime contractor on Delta?

Mr. CORTRIGHT. Delta—Douglas.

Mr. KARTH. How about Thor-Agena, who is the contractor on that?

Mr. CORTRIGHT. The Lockheed Corp. is contractor for Agena, and the Douglas Corp. is the contractor for Thor. The systems integration is done by the Air Force Space Systems Division.

Mr. KARTH. Mr. Morris.

Mr. MORRIS. Would it be practical to use any of these Jupiters which we are in the process of dismantling, in the NASA program?

Mr. CORTRIGHT. We have looked into that recently and have come up with the following conclusion with regard to both the Thor and the Jupiter. The only launch vehicles we are now using which utilize either the Thor or the Jupiter are the Thor-Delta and the Thor-Agena.

In order to make a space booster out of the Thor we have had to modify it, both structurally, and in the guidance system. And there are some other modifications I am not personally acquainted with. In

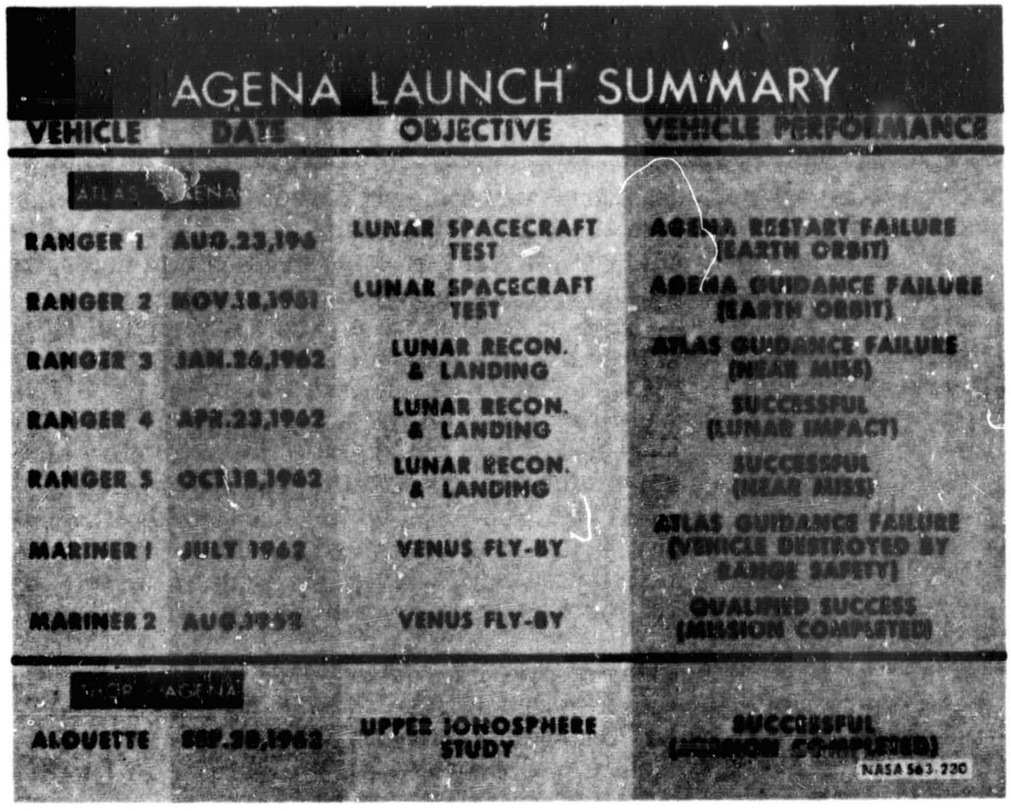

FIGURE 64

order to take the military Thors and renovate them, modify them, requalify them, the cost comes to within about $150,000 of the price of a new bird, if I remember those figures correctly.

If we were to suffer any degradation of our present very high reliability and lose one flight, it would make the effort not pay off, because you see, we have spacecraft on the upper ends of these which are equal in cost to the launch vehicles.

Mr. MORRIS. Yes, I understand that.

Mr. CORTRIGHT. Considering the total cost, we can't risk losing one, we don't think for that difference it is worth risking. We have, however, indicated that we would like several Thors delivered to NASA for experimental work.

Mr. MORRIS. What about the Jupiters?

Mr. CORTRIGHT. The Jupiter is even a more clear-cut case. Our only Jupiter-based launch vehicle was Juno II. The Juno II did not perform well in terms of reliability. Its accuracy is not good and its payload is low. It is not an attractive vehicle. Therefore, to take the Jupiter and build a new launch vehicle around it, with new upper stages, make the integration—and go through the series of test flights—does not appear to be either technically or economically desirable, although we did give this a very serious consideration.

Mr. MORRIS. But you have looked at it?

Mr. CORTRIGHT. Yes, we have.

Mr. KARTH. What do we do with the Jupiters and the other excess vehicles; put them out in the New Mexican desert?

Mr. CORTRIGHT. I think you will have to ask the Department of Defense that question, Mr. Chairman.

Mr. KARTH. You don't suppose we will have to pay rent for these to the New Mexican Government if we do park them out there, do you?

Mr. CORTRIGHT. I think you would know more about that than I would.

Mr. KARTH. I was thinking of past history and how much it costs to park our obsolete aircraft out there.

Mr. CORTRIGHT. There is a possibility some of the test flights that merely lob a payload out 200 or 300 miles can utilize these vehicles. I think this will continue to be looked into. Suborbital launches—you recall we have done them with the Echo, when we were trying to develop the inflation technique.

Mr. MORRIS. I also noticed on the Surveyor, or didn't you have some type of a drop test for the Surveyor in mind, too?

Mr. CORTRIGHT. Yes, sir; we will drop Surveyors from balloons.

Mr. MORRIS. I suppose neither of those vehicles could be made structurally adequate to accommodate such spacecraft in a suborbital flight?

Mr. CORTRIGHT. They wouldn't fit.

Mr. MORRIS. If you needed them to do such a thing?

Mr. CORTRIGHT. No, sir, they wouldn't. We don't want to lob the Surveyors up that high. They are not aerodynamically suited to that. We want to land them from 1,000 feet, that sort of thing.

Mr. MORRIS. That is all.

Mr. CORTRIGHT. Our single experience with the Thor-Agena was completely successful. As a result of the unsatisfactory performance of the Atlas-Agenas, NASA and the Air Force, which has served as the NASA agent in the procurement, modification, and launch of our Atlas-Agenas, have jointly undertaken an intensive quality improvement program. The Agena B upper stage is being standardized into the Agena D configuration which features simplicity and standardization. In addition, the Atlas D is being standardized into the standard Atlas space booster which also features design changes for improved reliability. In addition, we are undertaking an intensive program to control the quality of components issuing from all subcontractors and the quality of the total vehicle assembly and checkout procedures.

The largest vehicle under development by the Office of Space Sciences is the Atlas-Centaur. This vehicle utilizes a hydrogen-fueled upper stage which was begun in 1958. By virtue of this very high energy upper stage, the Atlas-Centaur will make possible high velocity missions which we cannot now undertake with the existing family of launch vehicles. These missions include the very important lunar Surveyor project, as well as the launching of advanced Mariner series of spacecraft to the planets. At our hearings last year, the Atlas-Centaur project was reviewed in great detail. Because of this, I will merely summarize here the most important events and progress of 1962.

Following the failure of the first Centaur in May 1962, an intensive design review was undertaken by the Marshall Space Flight Center. This review highlighted a number of problem areas which required increased attention for their effective solution. In order to get this

attention without interfering with the development of the vital Saturn series of launch vehicles, the Atlas-Centaur management was transferred to the Lewis Research Center in Cleveland, Ohio. This transfer was accomplished and the Lewis Center undertook to determine with the contractors and the consulting of Marshall, the approaches to be taken in the solution of the various engineering problems which have been encountered.

The design decisions which have been made in the past 6 months are highlighted in the next chart (fig. 65, Atlas-Centaur Design Decisions). In summary, our confidence is running strong. The ability

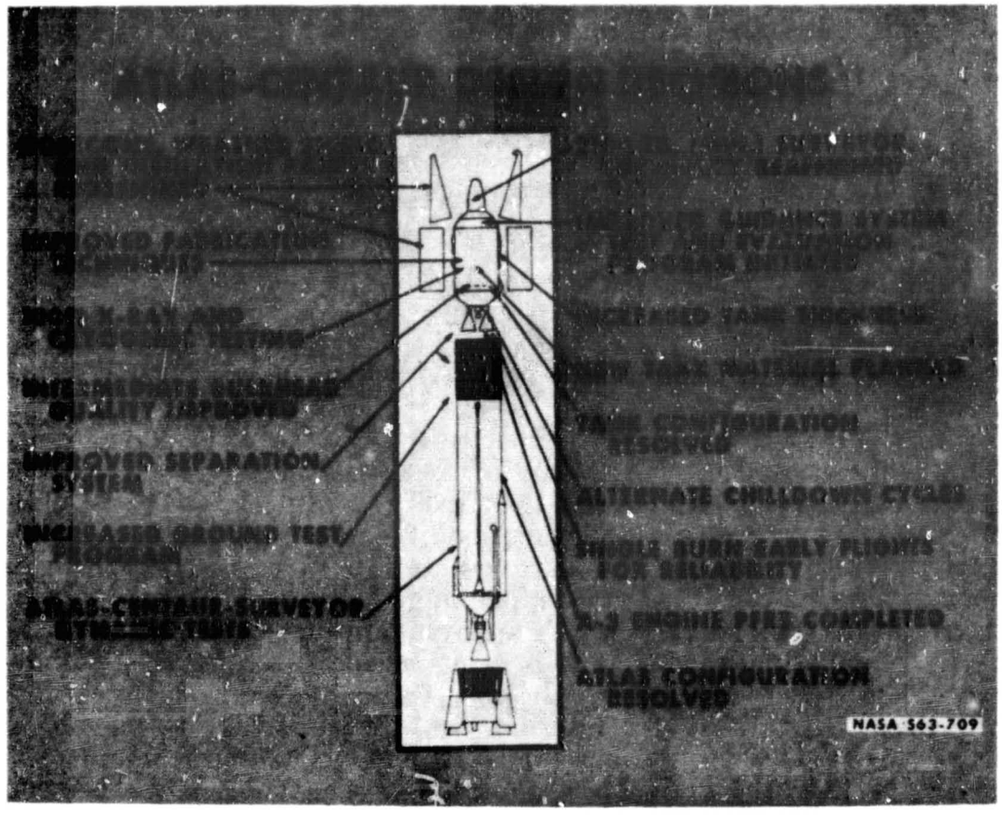

FIGURE 65

of the Centaur to handle the Surveyor and Mariner missions without major redesign was confirmed. In addition, we now plan to use single burn launches of the Surveyor wherever possible in order to simplify the mission and increase the reliability. What I mean by that, since it may be a confusing term, is simply that we ignite the Centaur engines once and go straight on a lunar trajectory rather than shut them down and coast, as we have to do with the Atlas-Agena and then go.

Some of the engineering spadework which has taken place is highlighted by the next two charts (fig. 66, Centaur Special Ground Tests).

The first Centaur, despite the failure in flight, did demonstrate our ability to service and launch the world's first hydrogen-fueled space vehicle. A thermal test chamber was constructed to complete development of the intermediate bulkhead which separates the liquid hydrogen

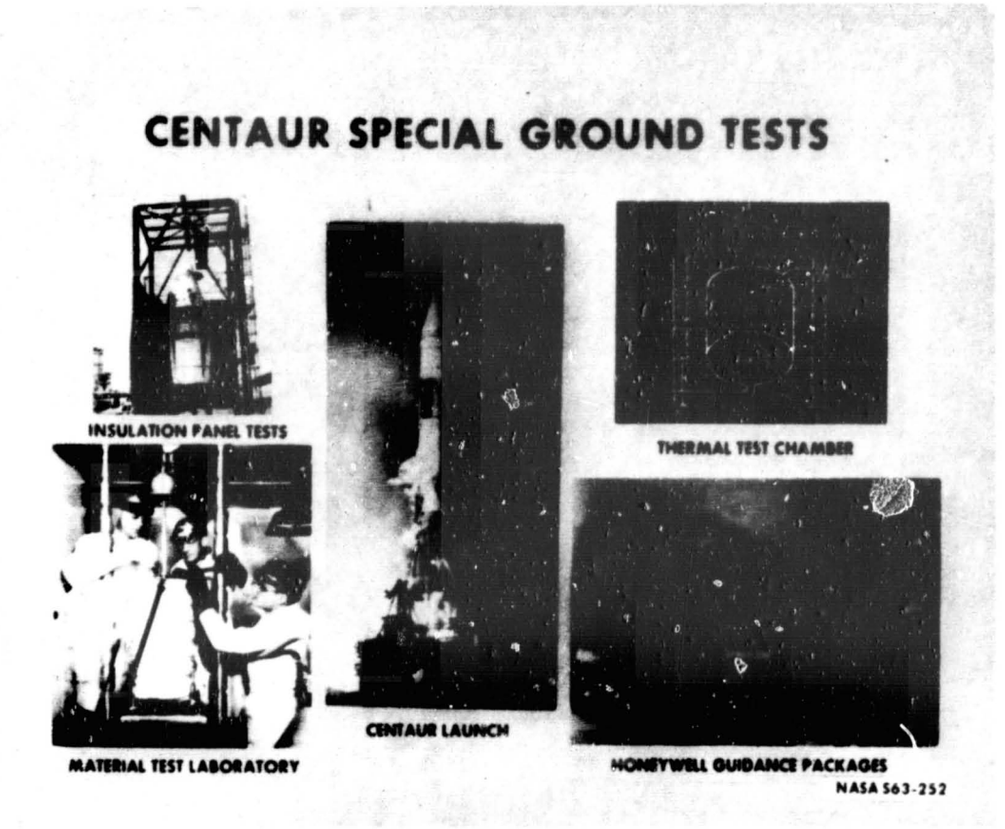

FIGURE 66

and liquid oxygen. At one time, as you may recall, this bulkhead was found to leak due to fabrication problems, which destroyed its insulating properties. In fact, it was speculated this type of bulkhead might not be feasible. Corrective measures were taken with the result that the bulkhead is now fully qualified and performs better than the design specification. Both the structural integrity and the separation of the large insulation panels which surround the liquid hydrogen tank have been reviewed and subjected to intensive test. In addition, the type of stainless steel utilized in the hydogen tanks has been subjected to a series of laboratory tests which indicated a desired change in material to one having greater strength at liquid hydrogen temperatures. The review of the guidance system has indicated that, although the system represents the most accurate lightweight guidance system in existence, it requires a greatly increased program of testing to insure sufficient reliability. This is now being done.

The next chart (fig. 67, Centaur Development Testing) illustrates some additional engineering measures which have been undertaken or are planned for the immediate future. The Centaur stage, which had been planned for the second launch early in 1963, has now been diverted for test and evaluation as a spacecraft in the large space power chamber at the Lewis Research Center. These tests will check out the guidance and attitude control system as well as all the electrical circuitry under vacuum conditions. Tests of this type have never been performed before on a launch vehicle stage of this size. In addition, the Lewis Research Center will conduct dynamic tests of the entire

FIGURE 67

Atlas-Centaur vehicle in its E–5 dynamic test stand at the Plumbrook facility. The separation mechanism is being redesigned and tested to insure clean separation of the stages after Atlas burnout prior to Centaur ignition.

The Centaur has to come out of a hole, and you have to make sure they don't hit during that time period. We found that we could profitably make some improvements in that.

The S–4 static test stand at Sycamore Canyon, Calif., will be used for intensive propulsion testing of Centaur test vehicles.

Mr. MORRIS. In the 1964 budget, is there anything in the budget for that?

Mr. CORTRIGHT. The 1964 budget? Yes, sir; there is.

Mr. MORRIS. Was there any money in the 1963 budget?

Mr. CORTRIGHT. Yes, we reprogramed to increase the entire Centaur budget for 1963, as Dr. Newell mentioned the other day.

Mr. KARTH. I might say at this point that, in my opinion, we should have Dr. Silverstein appear before the committee for 1 day, at least, to go into detail on the Centaur program, so if you feel you would like to ask questions at this point, why, fine, but I can assure you we will have at least 1 day set aside for Dr. Silverstein, to make an exhaustive investigation of the Centaur program.

Mr. RANDALL. In the first place, the dynamic test, that is in Ohio, that is simply a shape test, isn't it, that is about all it adds up to?

Mr. CORTRIGHT. Yes, sir, but this is rather unique, with a vehicle with all its stages.

Mr. RANDALL. The static test then in California, will be a firing, but it will be held down. You used the expression "the Centaur would be held in a hole." Is that the word you used?

Mr. CORTRIGHT. No, sir. I did use words like that. It is confusing. The Centaur fits into an adapter on top of the Atlas, and its engines and rear equipment section project down into this adapter. When you burn out the Atlas and separate the Centaur before ignition, you have to shove it free. Now, sometimes the expression is used "flying it out of the hole." We don't do that. We are now backing the Atlas away with retro rockets, pulling it out of the way.

We had been flying the Centaur out of the hole with very small rockets, and it took too long, so we weren't satisfied with the probabilities of getting clear.

Mr. RANDALL. All of that terminology is at the time of the separation?

Mr. CORTRIGHT. Yes, sir, it is jargon, I am afraid. To answer your question, Mr. Morris, the S–4 stand is going to be used and will require some relatively minor modifications with which I am not familiar. Dr. Silverstein can tell you about it. It is not in the budget as a construction item.

These steps, and others, are being aggressively pursued to insure availability of an operational Centaur launch vehicle by the end of 1964. Surveyor test missions will be flown in 1964 and the full Surveyor lunar landing mission is now planned for mid-1965. The next two Centaur development flights will be conducted this year, beginning in the third quarter.

I would like to summarize in the last chart (fig. 68, Launch Vehicle Capabilities), the performance of the family of launch vehicles con-

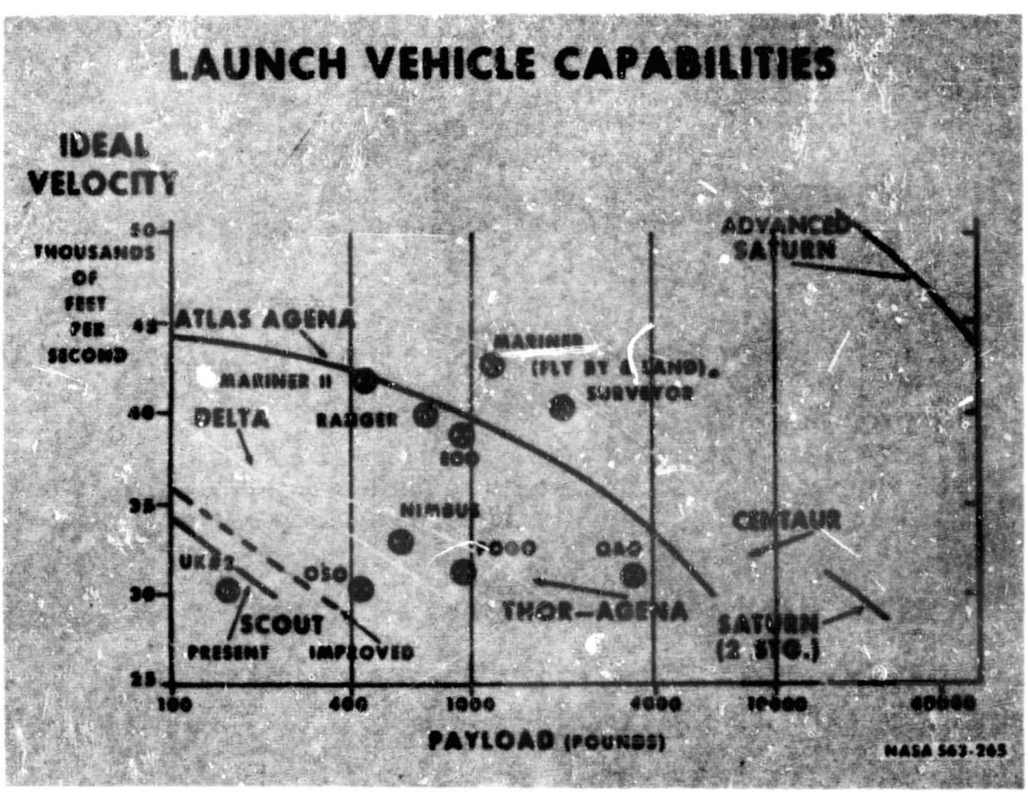

FIGURE 68

templated for use in the NASA national space science program. First of all, let me say, I wanted you to have this chart for your records. I am not going to discuss it in detail.

The prime observation to be made from this chart is that each of the launch vehicles which remains in the basic family serves a unique purpose. The small explorers and monitors are well suited to the Scout and Delta launch vehicles. The intermediate-to-heavy Earth satellites require the Thor-Agena or Atlas-Agena. The lightweight lunar and planetary missions require the Atlas-Agena. These were the missions we could get started early.

The intermediate weight lunar and planetary missions require the Centaur. Lastly, the very heavyweight planetary missions can be accomplished only with utilization of the Saturn launch vehicle.

Also it is worthy to note the effectiveness of hydrogen-oxygen as a propellant combination is clearly illustrated by comparing the Atlas-Centaur with the Atlas-Agena. The large increase in payload for the high velocity missions is due primarily to this high impulse propellant combination; since that is a logarithmic scale, I think the best way of saying that is we have 800 pounds to the Moon with Atlas-Agena, and 2,300 pounds with Atlas-Centaur.

In summary, I have attempted to make clear the extent of the technological challenge to the space sciences program. It requires all of man's skill and ingenuity to cope with the host of launch vehicle, spacecraft, and scientific instrumentation problems which must be solved in the conduct of this program. I am convinced that we are making excellent progress on all fronts.

Mr. KARTH. Thank you very much, Mr. Cortright.

I think, if there is no objection at this point from the committee members, we will adjourn until tomorrow morning. It may be 10 o'clock. I think we could get through all the preliminaries tomorrow morning without going into specifics on individual programs. Or, if we have time during the 2-hour period, we can begin that too. There has been some objection to the 9 o'clock starting time. So we will begin tomorrow at 10 o'clock, in room 304 of the Old House Office Building.

Mr. CHENOWETH. Which is that, Mr. Chairman?

Mr. KARTH. It is a committee hearing room belonging to the Armed Services Committee.

Mr. CHENOWETH. No. 304?

Mr. KARTH. Yes.

If there are no further questions at this time, we will adjourn until tomorrow morning at 10 a.m.

Thank you very much.

Mr. CORTRIGHT. Thank you.

(Whereupon, at 11:58 a.m., the subcommittee adjourned, to reconvene at 10 a.m., Tuesday, March 12, 1963, in room 304 of the Old House Office Building, Washington, D.C.)

1964 NASA AUTHORIZATION

TUESDAY, MARCH 12, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SPACE SCIENCES AND
ADVANCED RESEARCH AND TECHNOLOGY,
Washington, D.C.

The subcommittee met at 10 a.m., pursuant to adjournment, in room 304, Cannon Building, Hon. Joseph E. Karth (chairman of the subcommittee) presiding.

The CHAIRMAN. The meeting will be in order.

Dr. Newell, you may begin at this point and complete the prepared statement that you and Mr. Cortright have been making to the committee. Would you introduce the other witnesses who are with you today to the committee?

FURTHER STATEMENT OF DR. HOMER E. NEWELL, DIRECTOR, OFFICE OF SPACE SCIENCES, NASA, ACCOMPANIED BY EDGAR M. CORTRIGHT

Dr. NEWELL. Thank you, Mr. Chairman.

I would like to introduce to the committee Dr. John T. Holloway, who is chief of our university programs.

We have asked him to be with us this morning because we proceed now to discuss our sustaining university program.

The CHAIRMAN. We are very happy to have you, Dr. Holloway.

Dr. HOLLOWAY. Thank you, sir.

Dr. NEWELL. Mr. Chairman, with your permission, when we complete this testimony I would like to insert a few additional comments on the overall space science program, if I may.

The CHAIRMAN. Yes, sir; please do.

Dr. NEWELL. Since its inception, NASA has encouraged and sponsored significant amounts of research in universities, nonprofit institutions, and industrial laboratories, to provide a substantial base upon which to build a new and highly sophisticated technology directed toward a better understanding and the eventual conquest of space.

With the decision to expand and accelerate the national space effort, it immediately became apparent that neither the magnitude nor the usual mechanism of the sponsored research program was adequate to utilize fully the unique capabilities of universities to help preserve and advance the role of the United States as a world leader in aeronautical and space science and technology.

Accordingly, the sustaining university program was initiated in fiscal year 1962 to enlarge university participation in aeronautical and

space science and engineering endeavors and to complement NASA's sponsored research activities by—

Increasing the future supply of scientists and engineers required in space-related science and technology;

Helping universities provide facilities urgently needed for space research; and

Enabling universities to increase their role in support of NASA's program through encouragement of creative multidisciplinary investigations, development of new capabilities, and consolidation of space-oriented activities.

The greatest source of scientific research talent in the country resides in the university community. Many of the ideas upon which our accomplishments in space are based have originated there.

NASA is determined to work within the existing university structure rather than foster activities tending to weaken the university, or pull the university researcher away from teaching.

In such a partnership NASA expects to encourage research, advance the training of talent to conduct that research, and assist in the provision of research facilities which will allow American scientists to do the first-class job of which they are capable.

A rapidly growing space program will place increasingly severe demands on the already limited supply of highly trained people. The national demand is growing for two general types of technical personnel—those required to solve immediate space problems and those required to conduct long-range research, teach new students, and evaluate vast amounts of new scientific data.

During the summer of 1962, a group of senior scientists and engineers from universities, Government, and industry, assembled by the National Academy of Sciences for an 8-week space science study, gave wholehearted endorsement to the NASA research training program.

Further, the President's Scientific Advisory Committee has just completed a study indicating that qualified students are available who will not enter graduate research training unless new opportunities become available and that an immediate increase of 8,000 "new starts" should be made in the number of federally assisted graduate students in engineering, mathematics, and the physical sciences.

NASA initiated its graduate training program in 1962 with grants to 10 universities for the support of 10 graduate students at each university for a period of 3 years. The total cost of this program was approximately $2 million.

In fiscal year 1963, NASA is increasing this program by approximately 800 trainees at about 90 universities. Thus by the fall of 1963, 900 graduate students will be in this type of training.

The first trainees will not complete their work until the spring of 1965. The next chart (fig. 69, Training) shows the emphasis being given the training program in fiscal year 1963 and fiscal year 1964 in order to establish an equilibrium level of 1,000 students graduating per year by the spring of 1967. This training process is impervious to "crash" treatment.

Practically every student who could obtain a doctorate by 1970 has already entered college. No amount of money injected at some late date will produce scientists or engineers in 6 months to ease some suddenly recognized manpower crisis.

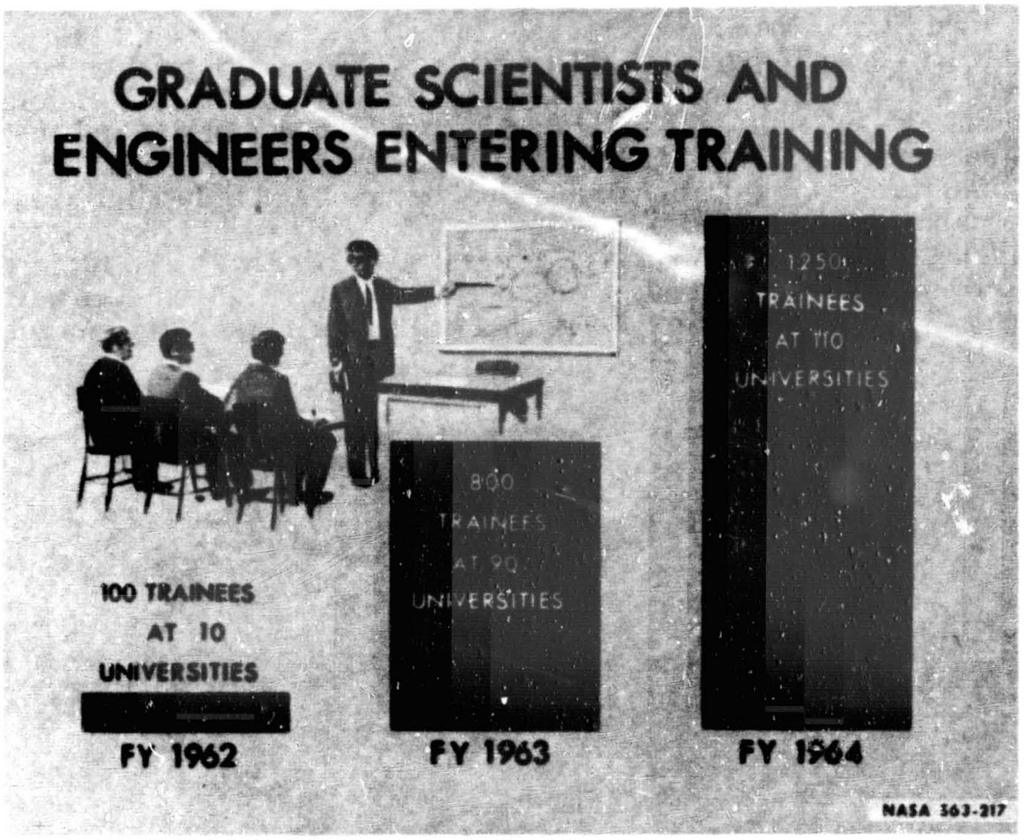

FIGURE 69

The main element of the training program provides 3-year predoctoral training opportunities to selected graduate students at qualified universities offering Ph. D. degrees in space-related areas.

As recipients of these traineeships, young scientists and engineers will conduct research in space-related fields while acquiring a high level of individual competence.

Those universities which participate in the program are selected by NASA on the basis of proposals which they submit.

Individual trainees are selected by senior members of the faculty who know their capabilities, who may supervise their research training, and who in many cases are directly engaged in research activity supported by NASA.

Such close ties with NASA provide additional motivation for the trainee to continue work in this area and participate directly in the space program.

The predoctoral training grants are aimed directly at alleviation of the most critical manpower deficiency.

In addition, the training program includes a small number of related training activities such as post-doctoral conversion of scientists who wish to enter space-related fields, enhancement of unique individual capabilities, and summer seminars for carefully selected students with outstanding potential.

In selected institutions, where additional laboratory facilities are urgently needed for the conduct of space research, and the university has declared its intent to seek ways in which the benefits of the research

can be applied to the social, business, and economic structure of the United States, NASA may provide funds for research facilities.

NASA's enabling legislation and subsequent appropriation acts reflect a clear appreciation of the need for such activities. Before acting, NASA must be assured that its assistance is required and that other sources of funds such as university endowments, grants from philanthropic organizations, individual bequests, and State appropriations have been explored.

These other sources simply have not kept pace with the rapidly increasing demands for adequate laboratory research space. The next chart (fig. 70, University Research Facilities) shows the magnitude of the NASA effort.

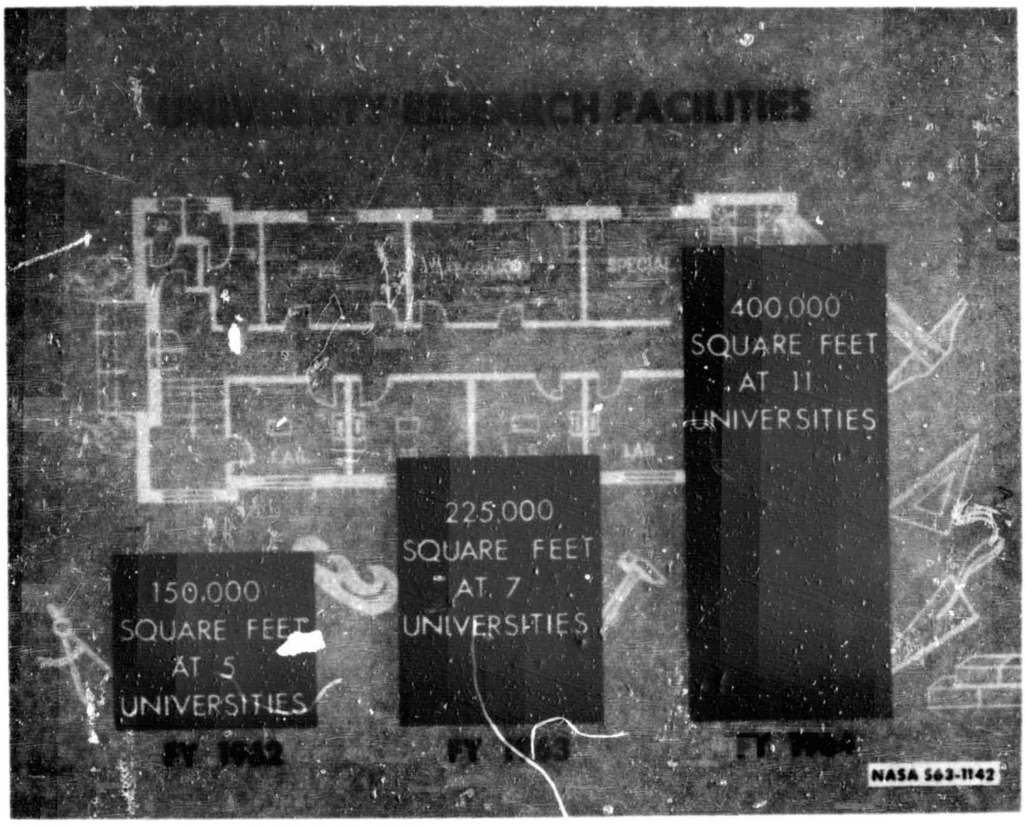

FIGURE 70

In 1961, research laboratories in colleges and universities were occupied by the equivalent of about 80,000 full-time scientific and engineering personnel, faculty and staff, professionals, research fellows, and graduate students, and supporting technicians, machinists etc. This figure is expected to reach 150,000 by 1970.

Major criteria for selecting the recipients of these facilities are the relative importance to the national space program of the particular fields of research involved, the university's commitment to work in the space sciences, and its demonstrable competence, achievements, and potential for further contribution to the space program.

More flexibility than that allowed by usual project-type research is required to accommodate broad NASA requirements for cooperative

efforts of biologists, geologists, physicists, chemists, electronic specialists, metallurgists, engineers, and many others.

Part of the sustaining university program concerns itself with those universities possessing multidisciplinary research capabilities who wish to respond to those requirements. Encouragement is given the consolidation of related research projects, initiation of new investigations to fill existing gaps, and participation of promising new groups with high potential.

The next chart (fig. 71, University Research) shows the magnitude of our university research endeavors.

Establishment of able research groups at presently nonparticipating institutions provides new incentives for scientists to remain there

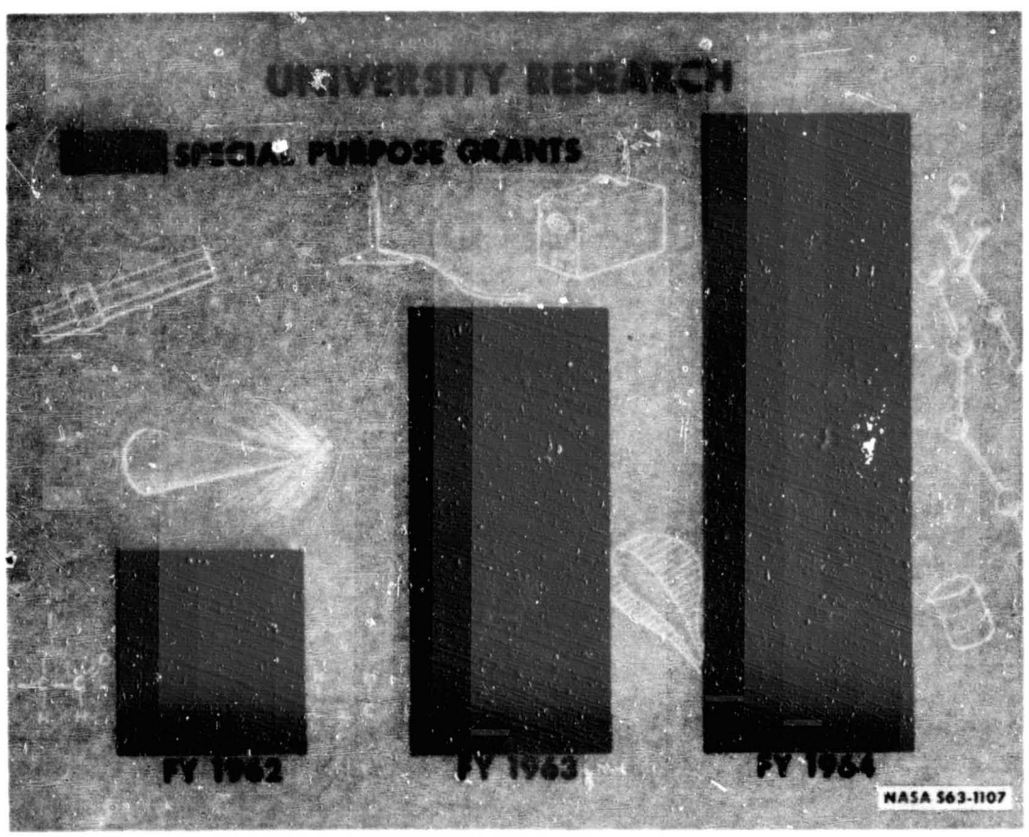

FIGURE 71

and reduces the excessive drift of skilled manpower from growing institutions to those few universities with already heavily supported programs.

Further, it can increase appreciably the number of universities interested in investigating the problems facing NASA's scientific programs and broaden the base of the Nation's university space research capability both intellectually and geographically.

Thus, through the sustaining university program, NASA devotes specific attention to approaches which utilize all the flexibility and inventiveness that entire universities can display and which mobilize their total capabilities for space research in pursuit of mutually beneficial objectives.

Mr. Chairman, at this point I would like to interpolate a few remarks on the overall space science program.

In looking back upon the testimony of the past week, one cannot help but be struck by the fact that a lot of the questioning by the committee has been directed toward the support that space sciences can give to the manned lunar landing effort.

It is possible that the discussion developed by these questions might give the impression that the space science program should be justified solely in terms of its support to the manned flight program.

I would hope that the committee members do not feel this way. It is not a conclusion that we would want to put forward.

The space science program that we have described to you is, we contend, entirely justifiable on its own merits as a sound basic research program designed to advance our basic knowledge in a broad, important, and challenging area of science. It is directed toward solving an impressive array of some of the most important problems discerned by today's leading scientists.

Some of our best scientists are engaged in the program. Indeed, the program is built on their ideas and on their participation in carrying it out.

The scope, imaginativeness, and quality of the program is designed to establish and maintain our Nation's preeminence in space research. The pace that we recommend is needed to keep us in the lead.

The scientific investigation and exploration of space is a worthy thing for this Nation to be devoting an appreciable share of its resources and talent to.

It also is a worthwhile investment, because basic research programs such as this one are the fountainhead of knowledge, ideas, skills, and capabilities that we put to use in making this world a better place for humanity.

Pick at random anything that our engineers are trying to design and build. You will find that they call upon facts, principles, and experience derived from past basic research.

But you will also quite often find a tendency to forget that this stockpile of human knowledge actually stemmed from research that at one time was nothing more than the inquisitive probings of the scientist who, more likely than not, had no particular practical application in mind.

So it is with space science. While tackling some of the most fundamental problems in the investigation of our universe, as its principal aim, space science also provides us with the information that is essential to the space engineer, both for what he is trying to do now, and for what he will want to do in the more distant future.

The principle I wish to state is that a broad and well-balanced space science program is exactly the thing that the engineer does need to support properly his requirements for data. The reason he has as much data available as he now has is that there was a broad scientific effort in the past in the areas in which he now needs the information.

The reason he is able to pinpoint areas where he needs additional data is very often due to the fact that the scientist himself is telling him that he needs those data and showing him why.

The reason he needs a well-balanced approach to future scientific investigations is that no one has any way of knowing what future

needs for data will be, and the best insurance is to move ahead scientifically on a broad front.

And the engineer is and should be sufficiently wary of the unexpected, especially out in the hostile and unfamiliar environment of space, to want the protection afforded by an imaginative scientific program. This is the only way to avoid going from one scientific fire drill to another, which, in addition to precluding the doing of good science, would not render maximum service to the engineer.

Another important point that we would like to emphasize is that quite often the engineer and scientist both need to know the same things.

The scientist who is trying to understand the complex system we call our atmosphere, needs to know about its temperature, pressure, density, composition, and winds. But so does the engineer who is designing high speed airplanes, or missiles, or space rockets, or artificial satellites.

The scientist who is trying to unravel the mysteries of the Earth's magnetosphere and the radiation belts, must know about the particles that are trapped in the belts, about their sources of energy, their fluctuations with solar and magnetic activity, their lifetimes in the magnetosphere, and their distribution in space.

But so must the engineer who wishes to design communications satellites to operate in these regions, or to design and build space stations, or to design spacecraft to traverse the magnetosphere.

The scientist who is trying to understand the causes and nature of solar activity and its relation to interplanetary space and to terrestrial phenomena, must know about solar flares, particles and fields in space, their effect on the magnetosphere, and in general the behavior of matter under the extremely high vacuum conditions of space. But so must the engineer who has to shield spacecraft against these conditions of outer space, or alternatively has to devise ways of predicting safe periods of operating in space.

The scientist who is interested in exploring the origin of the solar system, with its tremendously important bearing on whether or not we are alone in the universe, finds in the Moon a means of exploring these questions. For this purpose, he wishes to know about the structure and properties of the Moon.

He will be assisted in this quest by investigating the physical properties of the lunar surface, especially its radioactivity, the heat flow from the interior of the Moon, its seismic properties, its gravitational field. But all these measurements are also important to the engineer who is going to try to land a man on the Moon.

The scientist who studies the history of the Moon, must measure the present lunar environment, the radiations to which the Moon is exposed, the micrometeors that bombard it together with their effect on the lunar surface, and the behavior of the materials of the lunar surface under the extreme conditions of temperature, vacuum, and electrostatic charging.

But this is exactly the information about the lunar environment that those who are going to design spacesuits, shelters, lunar logistics operations, etc., must know in order to do their jobs.

The scientists who explore the planets in order to delve further into the origin of the solar system, to search for extraterrestrial life, and to

make comparative studies of these bodies with the Earth, are pressing forward with some of the most exciting and philosophically important investigations of the space science program. But they are also laying the groundwork for future manned expeditions to the planets.

Thus, space science has a wealth of important and fundamental problems to solve, to advance our understanding of the universe in which we live.

The fundamental and far-reaching nature of these problems fully justifies a broad and vigorous national space science program.

In addition, the returns from a good space science program support the other things we wish to do in space, in our applications and manned space flight programs.

Incidentally, one of the important reasons for putting man in space, or on the Moon, or on the planets, is so that he can do science there.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you very much, Dr. Newell.

I am quite happy that you added this statement to the record.

I cannot speak for the committee, but speaking for myself I was somewhat of the opinion that a major portion of the Office of Space Sciences' program was being justified on the basis that it had some manned lunar landing orientation, and that programs not so oriented were probably considered not to be important.

I don't know who makes these decisions, but speaking for myself, I would like to see the Office of Space Sciences be what I think it should be, and that is, a real scientific program of scientific investigation. If we are going to make a given program in effect an adjunct to the manned lunar landing program, then it seems to me we may as well transfer that program to the Office of Manned Space Flight.

I am very happy that you added this statement this morning, and I hope that as time goes on the Office of Space Sciences will be allowed to proceed with a program that is a truly scientific investigative program and which is not oriented to the manned lunar landing program

I wonder, Doctor, inasmuch as you did prepare the follow-on statement, whether you could inform the committee as to what programs the Office of Space Sciences may have in mind for the future, which would, in your opinion, really give us preeminence in space as the President has stated we should have?

Dr. NEWELL. I will be glad to do that.

As I mentioned earlier in our testimony, one of the fundamental processes in the Office of Space Sciences is to develop an appreciation for the major scientific problems of importance that face the space scientist, and out of this list of important problems to pick those that we tackle in the space science program.

This means that at any stage in our program we are looking far ahead to see what we ought to do next.

In the case of the astronomical observations, we have described to you the orbiting astronomical observatory and its capabilities for investigating the galaxies, the stars, and closer at hand the planets.

We have been studying the usefulness of the orbiting astronomical observatory for future researches, and particularly asked the participants in the space science summer study to tell us their thoughts on this idea.

Their feeling is that there will come a day about the end of this decade when a facility of higher capability will be required to continue our investigations in this very fundamental field.

Their statement was accompanied by the opinion that the present orbiting observatory would be a satisfactory device for the remainder of this decade.

But in the course of time, it will be necessary to have a larger mirror, more precise instrumentation, what one might call a second generation or third generation set of experiments on the properties of our galaxy and, in particular, on studies of other galaxies than our own.

In this area, then, we are in the fortunate position that we approach this far enough in advance to think through what the real needs are—to have some of the best scientists in our country explore these problems.

We will be assembling such a group of scientists in the course of the next year or so to study whether the next facility required in this important program is an advanced orbiting observatory of the unmanned type, or perhaps an observatory attached to a manned orbiting observatory, or perhaps an observatory created on the Moon, which might be manned or unmanned.

We are thinking quite seriously and quite deeply into this area.

Closer at home, we have, as you know, a very intensive program of studying the Sun and the interplanetary medium, and the relationships between the Sun and the interplanetary medium.

We can see, as advances beyond the present program, the need for sending probes close to the Sun. It turns out that many of the physicists who are struggling with the problem of magnetic fields and particles in space feel that the solution to some of these problems will not be obtained until we get space probes that go in very close to the solar surface. Some have suggested that there is very likely a tangled area of solar generated magnetic fields surrounding the Sun somewhere, perhaps between the solar surface and the planet Mercury.

Investigations of these, then, require that we design spacecraft and send them very close to the solar surface.

We are considering this very seriously.

It is also thought that there is some boundary to the solar magnetic field, that is, the boundary between the interplanetary field and the galactic magnetic field, somewhere out beyond the Earth's orbit.

In order to investigate this, in other words, to reach out of the domain completely dominated by the Sun in the interplanetary medium, one will need to send a spacecraft out away from the Sun, in the direction opposite to the Sun, to great enough distances to cross this boundary.

Some estimates place the boundary at five astronomical units, that is, five times the distance from the Earth to the Sun.

I believe, also, that I mentioned that some physicists feel that this boundary between the interplanetary magnetic field and the galactic field may move in and out in the course of a solar sunspot cycle, and possibly might move inside the orbit of the Earth.

We will want to look for this and to investigate this with our current space probes, like the Interplanetary Monitoring Satellite and the Pioneer for the International Year of the Quiet Sun.

Another topic of great interest is to continue to explore the origin of the solar system by investigating other bodies in the solar system than the Earth, Moon, and the near planets.

This means that we will want to investigate the planet Mercury and the planets Jupiter and Saturn in the course of our program.

Jupiter and Saturn will be of particular interest because it seems clear from Earth-based observations that their composition is quite different from the composition of the Earth, Mars, and Venus. Whereas Earth, Mars, and Venus are primarily solid bodies, with a surrounding atmosphere, Jupiter and Saturn are primarily composed of gaseous constituents, perhaps with frozen cores.

They are, of course, considerably larger than the Earth, and show us, through their radiowave emission and other emissions that there are many fascinating and puzzling activities going on in these bodies.

The CHAIRMAN. Doctor, what group within NASA has the responsibility of working on oncoming manned space programs?

Is it quite the responsibility of the Office of Space Sciences to work out future programs in this area, as well as purely scientific investigations?

Dr. NEWELL. The Office of Space Sciences has responsibility for the space sciences programs.

The Office of Manned Space Flight will have responsibility for manned missions.

The CHAIRMAN. You are referring to all manned misisons?

The Office of Manned Space Flight has been set up not only to take care of the lunar landing and return program, but all manned space flights, is that correct?

Dr. NEWELL. For the present, that is correct. But this means that the Office of Space Sciences and the Office of Manned Space Flight are going to have to work together very closely in order that as the capability of man to do science in space grows, the space science contribution to this program will be the proper one.

The CHAIRMAN. What do you see in the future for our space program, the major portion of it being manned, or instrumented, or is it a safe bet to say it will be about half of each?

Dr. NEWELL. I would say that at this time it is a safe bet to say that both the unmanned and manned programs will for some time to come contribute to comparable efforts to the total.

The CHAIRMAN. But manned programs, after the lunar landing, will probably be Earth orbit or lunar programs rather than going out tc the other planets, isn't that correct?

Won't planet investigative programs be instrumented or unmanned?

Dr. NEWELL. Well, you posed a problem on which a national decision has to made.

One has to decide after the completion of the lunar manned landing effort, whether one then goes on with an intensive manned exploration of the Moon, whether one goes on to building a manned laboratory or observing station on the Moon, or to the development of a large manned orbiting laboratory in the vicinity of the Earth, or whether one sets out to make deep space expeditions into the far reaches of the solar system, which would include expeditions to the planets.

We are approaching the time when some decisions of this sort will have to be made.

The CHAIRMAN. There would be a good deal more study, Doctor, over a long period of time, which will have to be made on the effects of prolonged weightlessness, isn't that a fair statement to make?

Dr. NEWELL. I think it is, yes.

The CHAIRMAN. When you are talking about being gone for several months, it is considerably different than talking about being gone for a week or a week and a half.

Dr. NEWELL. Yes.

The CHAIRMAN. You have had some experiments, isn't it true, which indicate some major biological breakdowns of a sort, I suppose you could say, as a result of prolonged weightlessness?

Haven't we had some animal tests over long periods of time, some form of living matter, that has been adversely affected through prolonged weightlessness?

Dr. NEWELL. The biologists tell us that there are indications that this could be a problem.

At the same time they admit at the present stage they cannot be sure it will be a problem, but they point to such things as the fact that a man who is a bedridden patient for a long period of time shows a progressive decalcification of the bones of the body, and they point to the fact that prolonged weightlessness without adequate and properly designed exercise to maintain muscle tone, may be a real problem.

This means to me that we should have a research program to look into problems such as this.

The manned space flight program, as I understand it, is being so designed and carried out that attention will be paid to these problems, and the moment there are signs that difficulties are cropping up, these problems will be looked into and taken care of.

The CHAIRMAN. The reason for my asking the questions, Doctor, is to get from you, if I can, an opinion as to whether or not a good deal of intensive investigation must be made in this area before we plan any future manned space flight programs to one of the farther-off planets.

Dr. NEWELL. I think so.

And as I was about to point out, both the Office of Advanced Research and Technology and the Office of Space Sciences have an extensive program of fundamental researches in just such areas as the one you mentioned.

The CHAIRMAN. So as far as manned space flight is concerned for the next decade or two, perhaps it will be pretty well confined, will it not, to Earth orbits, and Earth-lunar programs?

Dr. NEWELL. Well, again, I say this is a matter of national decision.

One will have to look into all factors, such as those you just brought up, in making such a decision.

But to say that the program will be confined to Earth orbit, is prejudging that decision.

The CHAIRMAN. Well, Earth-orbit, or lunar programs.

Dr. NEWELL. Well, again, the comment still applies.

The CHAIRMAN. What does a round trip to the Moon take, about a week or more?

Dr. NEWELL. A round trip to the Moon is a matter of a week or so, yes.

The CHAIRMAN. How long would a round trip to the nearest planet take, Doctor?

Dr. NEWELL. There you get into a time period of a year or so.

The CHAIRMAN. So you jump from a week to a year.

Then what is the next jump, 2 years?

Dr. NEWELL. No; if you go to the more distant planets, then you get to many years. For example, to Jupiter or Saturn, then you get to very many years.

The CHAIRMAN. How about Mars?

Dr. NEWELL. In the case of Mars, you would go to a couple of years.

The CHAIRMAN. So we are talking about a whole year's jump from the Moon flight to a Venus flight, and then another year's jump from a Venus flight to a Mars flight, isn't that right?

Dr. NEWELL. That is correct. And it poses very serious problems. It poses problems, not only in the matter of weightlessness that you brought up, but also in the matter of providing food, air supply, temperature control, and all the needs for the man over that long period of time, plus the problem of providing radiation protection over that long period of time.

The CHAIRMAN. It seems to me that after the manned lunar landing program has been completed, our job then becomes one of an unmanned nature, doesn't it?

Dr. NEWELL. Yes.

The CHAIRMAN. A space sciences program, rather than a manned program, Doctor?

Dr. NEWELL. Well, I would like to phrase it that our continuing job is one of unmanned space science.

We have a continuing need for this sort of investigation to support the variety of things that we might want to do out in space, whether they be manned or unmanned.

The CHAIRMAN. Is there anything else you would like to add, Doctor, on this subject, before we continue?

Dr. NEWELL. Well, I was going on to say that one of the very important areas in space science that we are now approaching is that of fundamental biological researches in space.

We are, as we described to the committee, going ahead with studies of a relatively simple recoverable Earth satellite to initiate these studies, but it is already becoming clear to the Office of Space Sciences, and the Office of Advanced Research and Technology, that there will be a future need for a manned laboratory to carry out researches of this type.

Therefore, we are looking into this problem. This is one of the decision questions facing us, as you have just brought out, in our immediately past discussion.

The CHAIRMAN. Will it become a program for the Office of Manned Space Flight or for the Office of Space Sciences?

Dr. NEWELL. That, too, will have to be a decision as to which has the major requirement in establishing responsibility for it.

The CHAIRMAN. There is no reason why we should have such clear cleavage between the two groups, that one should have nothing to do in the manned area, and the other has nothing to do in the unmanned area. This is pretty much what you are saying, isn't it?

Dr. NEWELL. Quite the contrary. I think it is becoming quite clear that all of these offices must work closely together, because their interests and needs come together at so very many points.

The CHAIRMAN. The reason I asked is that I wanted a little clarification as to what the jurisdiction will be among these various offices in NASA.

Dr. NEWELL. I think the pattern may well be that for a long time to come the Office of Manned Space Flight will have to be in charge of manned missions, because of the difficulty of executing those missions.

This is a pattern that we have followed in the past in which during the developmental phase of, say, a large space vehicle, the rocket people are in charge of the missions until they have developed the launch vehicle to an acceptable degree of reliability.

Once that vehicle becomes sufficiently reliable, then the mission control passes over to the user, whether it be the Office of Space Sciences, or the Office of Applications, or some other office.

Again, here, one may look down the road to a time when the ability of man to place in orbit a manned orbiting laboratory and to operate that laboratory has been so well established that mission control would be in the hands of, say, the Office of Advanced Research and Technology. But that is, I feel, probably quite a way down the road.

For the time being, the accomplishment of a manned flight mission will require that the manned space flight people be in charge of the mission, and that the other offices be participants in it.

The CHAIRMAN. Thank you.

I would like to ask Dr. Holloway a question or two, if you have concluded, Dr. Newell.

Dr. NEWELL. Mr. Chairman, may I ask Mr. Cortright whether he has anything to add to the list of things we are talking about?

The CHAIRMAN. Yes, Mr. Cortright.

Mr. CORTRIGHT. I think Dr. Newell has covered it quite well, as a matter of fact.

The only additional statement I would like to make is that the unmanned spacecraft enjoy a peculiar advantage that I think we should all recognize; the advantage is that no life is involved that need be sustained or protected. Thus the weights can be smaller, and they can be sent to far more different places throughout the solar system than man can be sent. This can be done many years in advance of man. Therefore, this gives a great flexibility to the automated spacecraft exploration program.

I think that the variety of scientific explorations that we are considering, and which Dr. Newell has outlined, attest to this, and therein lies the strength of the unmanned scientific program.

The CHAIRMAN. What are the competing costs program per program, Mr. Cortright—10 to 1, 5 to 1, 20 to 1—what would you say would be a good estimate?

I realize that some of the manned programs as opposed to unmanned programs are designed to achieve similar objectives. However, I realize you will get bits of different information from each; that is the instrument probably cannot duplicate precisely what the human can, and vice versa. But those differences being what they are, and

what they will continue to be, what is the difference in cost between the two programs?

Mr. CORTRIGHT. Well, the costs of the various programs are a matter of record.

I don't think they are competing in that sense. The automated program is designed to provide the forerunners of eventual manned exploration. When the man eventually gets there he can do things that instruments cannot really be designed to do. He can apply the judgment that a human being has to the problem.

So I don't think it is fair to consider them competitive in a strict sense.

Dr. NEWELL. I would like to amplify that.

The CHAIRMAN. Let's consider them competitive only in terms of cost; this is my point.

I recognize there are specific jobs that must be done, and in certain instances only man can probably do them, or at least do them better than instruments.

In other cases, man is not able to do certain things, for many reasons of limitations.

Could you give me an estimate of what the cost factor would be?

Dr. NEWELL. Are you looking for the ratio of the manned—

The CHAIRMAN. Let's say an instrumented landing on the Moon as opposed to a manned landing on the Moon; what is the difference in the cost between these two programs? Obviously, in the latter you are going to get the judgment of the human in addition to what you get from the instrumentation.

Mr. CORTRIGHT. I believe we quoted a cost for 17 Surveyor flights—I will ask Mr. Taylor to check this—of something like $496 million, and I guess you could compare that with the costs of the Apollo program, which is estimated at something less than $20 billion, for the first manned landing.

The CHAIRMAN. Thank you.

Dr. NEWELL. If I might, I would like to expand upon one point Mr. Cortright brought out—by pointing out, as I am sure you recognize, that there is no such thing as unmanned science. In past history we have seen man carrying out his science on the surface of the Earth with his instruments right along with him, but the man, his thinking, his consciousness and awareness, is the crucial part of that science.

When we talk about unmanned exploration of the solar system, we are really talking about unmanned satellites, instruments sent out into space, but the man remains an integral part of that program.

So again, when man gets to the Moon, he will, of course, be an important part of the exploration of the Moon, but he will also have to take instruments with him to extend his senses, to be able to observe things that he himself cannot observe, because his senses are not up to it.

It is simply a question of where the man is in the system, is he at home on Earth with his instruments out in space, or did he go out in space with his instruments?

The CHAIRMAN. The farther we go, the more we are going to have to be dependent upon instruments; isn't that right?

Dr. NEWELL. The farther we go the more we will have to be dependent on instruments, but also, the farther we go the more limited will

be the capability of those instruments to respond to surprises and the need for a quick change of orders.

In the vicinity of the Earth, we can quickly command instruments in an orbiting satellite to turn on and look at the Sun, if something has happened that is of great interest.

When we go to the Moon, then we have a delay time; it is appreciable, but probably can be overcome by anticipating and so on.

But when we go out to the planets, there is a serious question in the minds of people that have been thinking about this as to whether the delay times won't be such that we can't follow up on happenings rapidly enough to find out completely what did happen.

The CHAIRMAN. Of course, if you built the package as big as the Apollo, that is, a package made up exclusively of instruments, you would have a pretty sophisticated package; wouldn't you?

Dr. NEWELL. It could be pretty sophisticated.

But the judgment is, when you get too far away, the efficient way is to put the man there. In the unmanned approach.

You have to do as much and more in order to build a sufficiently sophisticated package to handle these unanticipated occurrences.

The CHAIRMAN. I see.

Dr. NEWELL. The man is the better way to do it.

The CHAIRMAN. Doctor Holloway, on the university program, I was somewhat surprised, but on the occasion when the Panel on Science and Technology of this committee met with the committee in January, Dr. Albert Noyes presented a paper to the committee.

The sense of that paper was that the university program that is being conducted by NASA really is not a well-thought-out program, is not doing the job that it is intended to do, and is not effective, because in effect, we are scraping the bottom of the barrel for talent even without that program; that is, scraping the bottom of the barrel in candidates for fellows, and doctors, and so on and so forth.

I might say I disagreed with him, but I would like to have you address yourself to his viewpoint.

Perhaps you have already read it in the record.

I wonder if you would address yourself to that? Inasmuch as we have a more ambitious program that we had when we started, with the 10-square program, I would like your views. Hopefully, at least on my part, we are going to continue to add to it.

Maybe you could take 10 or 15 minutes, or as much time as you need, to cross swords with Dr. Noyes, and point out to the committee where he may have been in error.

STATEMENT OF DR. JOHN T. HOLLOWAY, CHIEF OF UNIVERSITY PROGRAMS, OFFICE OF GRANTS AND RESEARCH CONTRACTS, OFFICE OF SPACE SCIENCES, NASA

Dr. HOLLOWAY. It might be presumptuous of me, Mr. Chairman, to point out how Dr. Noyes may have been in error as an individual, but I was surprised by the statement. This may be one of the surprises in space that Dr. Newell speaks of that you need a man to respond to and not instruments.

The CHAIRMAN. We have him right here.

Dr. HOLLOWAY. Obviously, we do not agree with the statement of Dr. Noyes. The evidence which we offer to substantiate our position is the expanded program.

Our analysis of the available manpower and the analysis reported by the President's Science Advisory Committee, contradict his statement.

The University of Rochester administration als does not agree with the statement, but Dr. Noyes was presumably speaking as an individual, which right I cheerfully concede him.

The CHAIRMAN. Let me ask you this, does the University of Rochester particpate in this program?

Dr. HOLLOWAY. Yes, sir.

The CHAIRMAN. Were they 1 of the original 10?

Dr. HOLLOWAY. No, sir. There was, on our desk, at the time Dr. Noyes was speaking, a proposal, however, for participation in the predoctoral training program.

The CHAIRMAN. Oh, before his statement they did not participate?

Dr. HOLLOWAY. They were not in the first 10, no, sir.

The CHAIRMAN. I see.

Dr. HOLLOWAY. But they had proposed participation in this year's program, and had been advised that their proposal was well received, and that we would proceed with the negotiation of a grant to provide them with the traineeships.

The CHAIRMAN. They had made that proposal to NASA about the time that Dr. Noyes was——

Dr. HOLLOWAY. Before.

Dr. NEWELL. Well before.

Dr. HOLLOWAY. Well before.

The CHAIRMAN. Before he presented his statement?

Dr. HOLLOWAY. Yes.

The CHAIRMAN. He is the president of the university?

Dr. HOLLOWAY. I beg your pardon?

The CHAIRMAN. What is Dr. Noyes' position? I have forgotten.

Dr. HOLLOWAY. He is a professor of chemistry, I believe——

Mr. HAMMILL. The head of the department.

Dr. NEWELL. Head of the chemistry department, I believe.

Dr. HOLLOWAY. Head of the chemistry department.

The CHAIRMAN. So the proposal to NASA was made by the university heads; is that right?

Dr. HOLLOWAY. Yes, sir. We have asked the university officially if this is the position of the university, and they have denied it. They have said that they wished us to continue with the negotiation of the training grant.

The CHAIRMAN. You are familiar with the Noyes' statement then; are you not?

Dr. HOLLOWAY. Yes, sir.

The CHAIRMAN. Would you care, then—I will try not to interrupt you again—would you care, then, to give us the benefit of your disagreement—why we are not scraping the bottom of the barrel?

Dr. HOLLOWAY. I think Dr. Noyes' comment is based on a belief which he himself holds, that an increase in training opportunities for graduate students would not increase the number of graduate students

who enter training and who continue that training to the degree that they wish to pursue. This is an opinion which I do no hold. I did not see in the report of Dr. Noyes' statement any evidence to this effect.

I believe that the most recent and relevant data concerning the available manpower which might be touched by a training program are those contained in the President's Science Advisory Committee report.

I would be glad to discuss or debate the issue with him, if I had evidence for his opinion. We can cite the numbers which have been gathered on available students in the post-baccalaureate region, those who, on the basis of past statistics, have the inclination and the ability to proceed to an advanced degree. We have from a number of universities rather strong statements of their belief that new training opportunities will indeed encourage an increase. They have stated that they disagree with the position taken by Dr. Noyes and in general substantiate our position, that without training programs of this kind for space scientists and engineers, and those of other Federal agencies who have other "customer" requirements, the graduate training capability of the universities would be seriously depleted.

We feel that the numbers which we speak of in our training program do not approach saturation of the available manpower reservoir.

I think that if you watch our program, and any other new program which arises, you will see a clear indication when this saturation begins to appear. Last year there were some number of training opportunities in the graduate schools, in engineering, physical sciences, life sciences, and the social sciences, which relate to the activities of various Federal agencies. All of those opportunities, or substantially all of them, were accepted.

There are not, in the major universities, training opportunities and fellowships under the National Science Foundation, Office of Education, NIH, and so forth, going to waste.

When you see them begin to go wanting, then you have seen the danger signal, and obviously a saturation effect of some sort is occurring. That has not occurred. We don't believe that it will occur as a result of our program or even a much larger program than we anticipate.

Mr. MOSHER. Mr. Chairman, could I ask a question?

The CHAIRMAN. Mr. Mosher, yes.

Mr. MOSHER. The danger must certainly exist here, though, doesn't it?

When there is a sudden increase in the opportunities for such a need for doctoral programs, creating, in effect, a demand for more doctoral candidates, the danger must exist that the caliber of the candidates will decrease.

You will attract a lot of people who are not of a caliber that you would like to have.

How do you control this?

I should think you would have to depend almost entirely on the integrity of the universities and their standards, and at the same time, here, don't you create temptations for the universities, too, who are hungry for money—don't you strain their integrity, perhaps, in the caliber of candidates they are willing to accept?

How soon are you going to come to the point where you have got money available to give the universities and the universities are going

to say, well, we cannot use this money, because we have not got candidates whom we consider qualified. We have a lot of candidates, but we don't think they are capable.

Isn't there a danger this whole process can take place?

Dr. HOLLOWAY. This is a question which I am particularly pleased to have an opportunity to answer. The danger is real; it does exist. We anticipated it at the outset, and I would like to describe the steps we have taken to prevent it.

If a training grant is made to a university with much of the discretion for its administration resting in the hands of the university administration, as ours are, then there is presumably nothing you can do to prevent a corrupt university administration from deforming its standards and stretching its acceptability criteria to accommodate a few students who might otherwise not pass muster. But this is not easy to do in a major university today.

Universities operate by and large in "fishbowls." The treatment received by a student on one of these traineeships must be comparable with that received by a student who is not on one, and our trainees will be in very large minority in an institution. We will, in this year's program, have no more than 15 at any university.

At one major State university, we have been told by a vice president that there were 2,000 qualified applicants at the time the selection was begun for 12 NASA trainees.

We have left——

Mr. MOSHER. Can I interrupt you a second?

Dr. HOLLOWAY. Yes, sir.

Mr. MOSHER. How many of the universities are participating in your program this year?

Dr. HOLLOWAY. Eighty-eight.

Mr. MOSHER. Eighty-eight?

Dr. HOLLOWAY. Yes, sir.

Mr. MORRIS. Mr. Chairman?

May I ask that he furnish the list of the universities to be inserted in the record at this point.

The CHAIRMAN. If there is no objection it is so ordered.

I think it would be wise indeed if we had inserted in the record at this point, Dr. Holloway, such pertinent information as it relates to this program in NASA.

Mr. MORRIS. Also, Mr. Chairman, how much money is allocated to each university?

Dr. HOLLOWAY. We will provide a list of the universities, Mr. Chairman and Mr. Morris.

The exact number of dollars is not determined to the cent at this moment. These grants are in the process of negotiation, and so I should prefer at this instant to deliver to you a list of the universities which have been advised that they will receive grants.

The amounts may change at the time they are executed, and to announce the dollar value now ties the hands of the negotiators in the negotiation process.

(The information requested is as follows:)

University	Trainees
Alabama, University of	10
Arizona State University	6
Arizona, University of	10
Arkansas, University of	8
Auburn University	10
Brooklyn, Polytechnic Institute of	12
California Institute of Technology	15
California, University of, at Los Angeles	10
Carnegie Institute of Technology	10
Case Institute of Technology	10
Catholic University	10
Chicago, University of	15
Cincinnati, University of	8
Clemson College	4
Colorado, University of	10
Colorado State University	6
Columbia University	12
Connecticut, University of	6
Cornell University	10
Delaware, University of	6
Denver, University of	6
Duke University	10
Florida State University	8
Florida, University of	10
George Washington University	6
Georgia Institute of Technology	12
Houston, University of	10
Illinois Institute of Technology	10
Illinois, University of	12
Indiana University	10
Iowa, State University of	10
Iowa State University	10
Johns Hopkins University	8
Kansas State University	8
Kansas, University of	8
Kent State University	2
Lehigh University	8
Louisiana State University	8
Maryland, University of	10
Massachusetts Institute of Technology	15
Michigan State University	8
Michigan, University of	15
Minnesota, University of	15
Missouri, University of	8
Missouri School of Mines and Metallurgy	4
Nevada, University of	3
New Mexico, University of	6
New York University	12
North Carolina, University of	10
North Carolina State College	10
Northeastern University	3
Northwestern University	10
Notre Dame, University of	8
Ohio State University	8
Oklahoma State University	10
Oklahoma, University of	10
Oregon State University	8
Pennsylvania State University	10
Pennsylvania, University of	10
Pittsburgh, University of	10
Princeton University	12
Purdue University	12
Rensselaer Polytechnic Institute	10
Rhode Island, University of	4
Rice University	10
Rochester, University of	10
Saint Louis University	8
Southern California, University of	8
Stanford University	12
Stevens Institute of Technology	6
Syracuse University Research Institute	8
Tennessee, University of	8
Texas, Agricultural and Mechanical College of	10
Texas Technological College	6
Texas, University of	10
Tulane University	8
Utah State University	4
Utah, University of	8
Vanderbilt University	8
Vermont, University of	3
Virginia Polytechnic Institute	10
Virginia, University of	10
Washington University (St. Louis)	8
Washington, University of	10
West Virginia University	8
Western Reserve University	8
Wisconsin, University of	10
Yale University	10
Total	786

The CHAIRMAN. Well, the programs that are in effect, you can furnish the dollar amounts for those.

Dr. HOLLOWAY. Yes, sir. I can give you a total amount of the 1963 program, also.

The CHAIRMAN. The committee can then assume, I suppose, that the cost will be nearly the same——

Dr. HOLLOWAY. Yes, sir; it will be nearly the same.

This is a very small error.

The CHAIRMAN. Mr. Morris, is there something else you want?

Mr. MORRIS. How much money would be involved?

Dr. HOLLOWAY. For the 88?

Mr. MORRIS. In terms of dollars what are we speaking of, in terms of what they might get and what they have been granted already.

You said it ties the hands of the negotiators. It might tie the hands of the people who are going to get this money appropriated in the first place, too. We may decide since we do not know where the money is going, there isn't any use in authorizing it, authorizing the appropriation.

Dr. HOLLOWAY. Oh, I will be delighted to provide you with the numbers, then.

This is simply an attempt to prevent a grant for $196,000 being nailed to 196, and not being possibly negotiated down to 194.

We are talking about very small——

Mr. MORRIS. I see. You are not talking about any significant amount of money. When I say "significant," I mean significant to the total cost.

Dr. HOLLOWAY. We are talking about less than 5 percent, a small adjustment, which is important only in the individual negotiation, and may be insignificant in the overall.

Dr. NEWELL. On the other hand, it is not insignificant in the overall, because if you make a saving of a few thousand dollars in each of 88 universities, you can pick up a few additional universities with what you save.

The CHAIRMAN. Mr. Mosher?

Mr. MOSHER. Dr. Holloway, the nature of the training grants. Once you have entered into a contract with the universities, do you approve the individual training grants or does the university have complete control?

Dr. HOLLOWAY. The grant is to the university. The selection of the individual students is the responsibility of the university. We require that the university report to us its method of selection, the qualification which these students possess——

Mr. MOSHER. Do you have a veto power over any one student?

Dr. HOLLOWAY. Before he is selected; no. He may be selected and may enter training without prior submission of his name to us. However, after his first quarter's performance, or his first semester's performance, the university reports to us on his performance, and if it is substandard, we then may point out to the university that this is not in conformity with the terms of the grant, which require outstanding students to participate.

The CHAIRMAN. Will the gentleman yield at this point?

Are you familiar with the Yellin case?

Dr. HOLLOWAY. The E-l-l-e-n case?

The CHAIRMAN. The Y-e-l-l-i-n case.

Dr. HOLLOWAY. No, sir; not by name.

The CHAIRMAN. Well, this is a case that involved a fellowship grant from the National Science Foundation. A fellow by the name of Yellin was granted a fellowship and was taking his training, but he had previously been found by some Members of Congress to be a Communist.

Dr. HOLLOWAY. I do remember.

The CHAIRMAN. Or a sympathizer, if I recall correctly, and one who had been known to the National Science Foundation as having had these communistic sympathies——

Mr. HAMMILL. They did not know it.

The CHAIRMAN. Once it was brought to their attention, they were rather hamstrung, or hand bound to do anything about it.

I was wondering if what you say is true, this also might happen to one of the NASA trainees; is that possible?

I mean, if you have no initial veto power, could that happen?

Certainly it seems to me they should submit the names.

Dr. HOLLOWAY. My knowledge of that case is so superficial that I am not sure whether the Science Foundation had the veto power in that case.

The CHAIRMAN. I see.

Dr. HOLLOWAY. And if they did, whether they exercised it or not. I just don't know.

The CHAIRMAN. Well, if I recall correctly, they did have the veto power, but they did not choose to exercise it.

I may be incorrect in my recollection.

Mr. MOSHER. When I mentioned the veto. I was thinking more of vetoing, as applied to the individual student's qualifications, and the subject matter of the research he proposes to pursue.

Do you have any supervision over that at all, or do you leave it up to the university?

Dr. HOLLOWAY. We have left the choice of student, and therefore the choice of field of endeavor, up to the university.

I did not complete the answer to your question before, I apologize. One interesting aspect of this, which discourages or prevents the effect that you describe, in which a university may try to maintain a substandard or borderline student in a qualified status in order to protect its own interest in that part of the training grant, I think, is our provision that the traineeship provided for any given student within the grant rests with the university, and does not attach to a particular student. If that student falls below standard, he may be excused from the program and another student inserted in his place, so that it avails the university nothing to maintain a substandard student in one of these slots.

It is always to the advantage of the university to produce high quality students. No university can gain by intentionally degrading the quality of the students involved in any such program.

Mr. MOSHER. How often do you review what they have done?

Dr. HOLLOWAY. We will review what they have done at the end of each term. I have, as a matter of fact, with regard to the areas of selection, a breakdown of the disciplines in which students were selected in the first 100, which went in last year.

The CHAIRMAN. I think, Doctor, I would like to have you submit that for the record also.

Dr. HOLLOWAY. I would be glad to.

(The information requested is as follows:)

Distribution of 1st 100 NASA trainees by disciplines

Physics	31	Space law	1
Chemistry	14	Chemical engineering	5
Mathematics	6	Mechanical engineering	9
Astronomy	4	Electrical engineering	5
Meteorology	1	Engineering mechanics	1
Geology	2	Aeronautical engineering	6
Computer science	1	Nuclear engineering	3
Physiology	2	Materials engineering	2
Psychology	3	Instrumentation engineering	1
Biochemistry	3		

SUMMARY

Physical sciences	55	Space law	1
Engineering	32		
Biological sciences	8	Total	100
Geosciences	4		

The CHAIRMAN. Certainly there are a limited number of disciplines that NASA is interested in.

Dr. HOLLOWAY. There are, and I thought the committee might be interested in the consequences of letting this decision rest with the university administration.

The CHAIRMAN. I wonder if you would just say that again.

Dr. HOLLOWAY. Well, we did not tell the university it must put, of its 10 students, 3 in the physical sciences, 3 in engineering, and 4 some place else.

The CHAIRMAN. No, but you do tell them they can't send them to art school, don't you?

Dr. HOLLOWAY. Yes, sir. We have suggested that sending their trainees to art school might be damaging to future relationships in the program.

But having left this——

The CHAIRMAN. Don't you give them a list of disciplines in which they can grant their fellowships, sir?

Dr. HOLLOWAY. We tell them in fields of space and related science and engineering.

The CHAIRMAN. I see.

Dr. HOLLOWAY. And do not try to define scientific disciplines. These have a way of changing with time.

The CHAIRMAN. I understand.

Dr. HOLLOWAY. Such a list is of little benefit.

The CHAIRMAN. But you give them this rather broad area in which to operate?

Dr. HOLLOWAY. Right.

The CHAIRMAN. They cannot operate without operating within the confines of that area, isn't that correct?

Dr. HOLLOWAY. Right. On their own last year, they distributed these 100 students as follows:

Physical sciences, 55, engineering 32, biological sciences, 8, geosciences 4, and others, specifically space law, 1—which we feel is a remarkable conformity with the interests of NASA. They have done this in good conscience, and without constraint in their first "try."

Mr. MOSHER. Mr. Chairman?

The CHAIRMAN. Mr. Mosher.

Mr. MOSHER. NASA has at least given "lipservice" to an interest in the social sciences, to the social implications of the whole NASA program.

For that reason, and because of your emphasis on a multidisciplinary approach, would you accept some doctoral programs in the social sciences?

Dr. HOLLOWAY. Yes, sir; we will have a few this year; in the new and larger list there will be some trainees in those fields.

Mr. MOSHER. But you would assume that these would have some bearing on the training of people who could be useful in the long run to NASA's interests in the social education field?

Dr. HOLLOWAY. That is correct.

Mr. STAEBLER. Mr. Chairman, before we leave this general field, could I pursue a question along the same line?

At the time Dr. Noyes gave us his opinion, there was other discussion along the same line to the effect that at the present time all the highly competent candidates for doctoral degrees were getting all the facilities that they could utilize. That disturbed me at the time, and I would like to see it pursued a little further.

The implication of it was that only the top 1 or 2 percent of the people were useful, were worth training, and that only these would make the great contributions in the field of science that would advance the interests of the country.

What evidence have you on the subject either way?

Dr. HOLLOWAY. The two best pieces of evidence which I might mention now are, first the proposals which we have received from the universities. There is no reason to believe a university will propose accommodation of this many students if, in fact, these students are not available and of high quality, when they know we will examine the records finally.

Secondly, explicit statements have been received from the universities in the form of correspondence to the effect this is not true. When we have asked if this is true at their institutions, they replied categorically "No."

These are the statements of responsible people with long experience in the university community. There is no obvious motivation for any falsification of any such answer. They stand to gain nothing by falsifying it.

Mr. STAEBLER. You are saying, then, that there are people worthy of doctoral training who are not under present circumstances securing the training?

Dr. HOLLOWAY. Yes, sir.

Mr. STAEBLER. Could you give us any illustrations in any universities?

Dr. HOLLOWAY. Yes, sir; the vice president of a major State university——

The CHAIRMAN. I wonder if we could put it this way, Mr. Staebler: Are there any universities that have indicated they are in agreement with Dr. Noyes' statement?

Dr. HOLLOWAY. No, sir, none.

The CHAIRMAN. Every university that participates in this program has given you indication that they have a number of students whom they would like to qualify in this program; is that correct?

Dr. HOLLOWAY. That is correct. Almost every participant in this year's program proposed quite a few more trainees than we were able to provide them. We cut essentially every request.

The one that I mentioned a while ago may be worth repeating, in which the university preparing to select 12 trainees under our program had 2,000 applicants on hand.

The CHAIRMAN. What university was that, Doctor?

Dr. HOLLOWAY. That was the University of Michigan.

The CHAIRMAN. That is a pretty poor State, no wonder there are several thousand there waiting to get educated.

Mr. STAEBLER. I am glad to see we have such confidence.

Dr. HOLLOWAY. It is a good school. Obviously the demand is high for training there.

The CHAIRMAN. Yes, it is.

Mr. MOSHER. That ratio would be high, wouldn't it?

Dr. HOLLOWAY. I think that is unusually high. I think that is an outstanding high ratio, but the students obviously regard it as an outstandingly good place to get the kind of training they want in graduate school.

Mr. STAEBLER. Could I pursue a parallel question a little that bothered me at the same time that Dr. Noyes and several other members of the panel talked on this subject?

They were suggesting that anyone who did not have the doctor's training was not in the—well, let me start over again, I want to quote this as accurately as my memory permits—it was to the effect that the facilities at the universities in the process of selection were such that any highly competent person would surely find it possible to get a doctor's degree, and that in the absence of the doctor's degree, one would assume that one had a different order of competence, in the individual.

In your opinion, is that conclusion warranted?

Dr. HOLLOWAY. Categorically, no, sir, as far as the latter statement is concerned.

If the latter statement were true, then I should be forced to conclude, as Dr. Noyes has concluded, that we had scraped the bottom of the barrel, but knowing so many people in science, in engineering, and in fields quite apart from these, with competence equal to that of those holding doctor's degrees that I have associated with, it simply is not true that all those capable of doing so and desirous of doing so have done so.

I am aware, as my colleagues are, of individuals who have desired to continue their education, and for reasons frequently involving modest financial assistance, simply could not and did not continue. They dropped out at a master's level, and continued to make a definite contribution to the field that they chose, but they were deprived, if you wish, of the opportunity to engage in creative, original research, which goes along with the work toward a Ph. D. degree, which we think equips them for the thing that we will need most in the rest of this decade, and in the coming decades; namely, imagination and creativity.

Some manage without it in the fields of pure science. Many more manage without it in engineering and in nonscientific pursuits, but we are attempting, in this part of NASA's program, to solve problems

which not only are unsolved but which we do not know the existence of.

The problems that these men will solve are problems which will not arise for another 5 or 10 years. If they have a vestige of creativity we think we should develop it. We will need all we can get.

Mr. STAEBLER. So that you would say a doctor's degree is a device for enhancing the person's capacities, but not an exclusive test of their credit?

Dr. HOLLOWAY. Yes, sir; I could not have put it that well.

Mr. STAEBLER. I have another set of inquiries I would like to pursue, but I should defer for the moment.

The CHAIRMAN. Mr. Morris?

Mr. MORRIS. No.

The CHAIRMAN. Go ahead, Mr. Staebler.

Mr. STAEBLER. I would like to pursue the question of relation of dollars and motives in scientific inquiry.

I think it is one of the tough problems with which we on the committee have to cope.

Under what circumstances can we justify the expenditure of public funds for research?

And I thought possibly looking at some of the broad questions might help to give us—give me at least, some illumination.

First, let me see if this statement is warranted.

We have talked about research as being desirable on a number of grounds, on the grounds first of real military defense.

Second, on the grounds of national scientific prestige, which also has some international connotations.

Third, on the grounds of utility.

This will be a very important source of development for industry in our way of life.

Then we come to a fourth motivation, and that is pure research, the area where there is no specified consequence.

But, as I hear the discussion of this, and think about it, I wonder whether there is any such thing as pure research, and whether when we give this as a justification, we are not understating our motivations?

That there is nothing you may be doing, as you described it, that does not have an ultimate relation to one of the other three purposes.

The only difference, as I see it, is that you cannot tell which of the purposes will be served. You can't even tell whether they will be served. But you are not doing it for any other reason except ultimately to have some bearing on one of the other three.

Is that a fair statement?

Dr. NEWELL. That is a fair statement, and brings us to a very important point.

In the matter of fundamental researches, if you entered a laboratory in which such research was going on, and the experimenter, or theorist, reviewed for you what he was doing, but no one told you what his motivations were, in many, many cases you would never be able to tell whether it was applied research or pure research, because they turn out to be the same.

It is the motivation that makes the difference.

You have an applied research laboratory, and you call it an applied research laboratory, because you are aiming your researches at some specific application that you wish to make.

Nevertheless, the fundamental researches that are made are the same sorts of researches as if you had say a pure research laboratory, where the idea was simply to extend knowledge, to follow up on the important problems that exist in the minds of the scientists.

However, there is an important point here to recognize, and that is, that it is essential for this country to have a substantial pure research program in which the motivation of the research is to advance the frontiers of knowledge in distinction to the applied research program in which the end result is prescribed.

The reason for this is as follows: If you think of our body of knowledge as let's say a circle or roughly a circular area here, where inside of that area are contained the known facts, and principles, and so on—where the boundary is the frontier of knowledge, and if you think that off up here some distance away from this area there is another little target area that you want to get to in an applied research program, the scientist who is participating in that applied research program, even though he may be doing fundamental researches, will always have that target in mind, and as he proceeds along the path from the known, through the unknown, to the goal, he will very often throw away researches and opportunities to explore, because they don't seem to him to advance him along that prescribed path to the prescribed goal.

The pure researcher, however, is simply trying to advance in the scientifically most promising directions from this area of the known to the unknown, and as he goes along, he feels free to zig and zag as important problems appear to him.

He is not constrained. He does not have the blinders.

This unconstrained basic research is very important to have as a substantial part of your total national program, because this creates the climate, sets the stage for those very happy accidents we call discoveries, or some times even breakthroughs.

This is why we are urging that a substantial part of our space science program be this pure research, as opposed to applied research.

Mr. STAEBLER. Could I as a businessman apply a business term to this, that in order to get applied research in adequate quantities, one needs an inventory, or a pipeline of pure research——

The CHAIRMAN. You can if your money holds out.

Mr. STAEBLER. This is precisely why I am raising the question here.

Isn't it as important to be keeping the future stockpile of pure research built up, so that there is a constant flow available to come in to the sphere of applied research as it is to do the applied research?

If you are cutting, is it any more sensible to cut the immediate than it is the remote?

You were shaking your head, yes, but I am not giving you an adequate chance to answer.

What kind of relation do you think ought to be maintained here between the inventory of the pure research and the immediate?

What kind of judgment can be applied here?

Must we always take this on the advice of scientists, and on whose advice, and what kind of optimism and what kind of desire to pile up an inventory must we take into account?

Dr. NEWELL. That is probably the most difficult question that you could pose in this area.

I think a good rule of thumb is to say that our Nation should have a significant program in each important area of science.

We cannot afford to let any area go completely ignored.

If you have some significant research going on in each area, you will be protected against the surprises and loss of progress in the fundamental research areas.

This means, in our day and age, we must have good researchers going on in nuclear physics, in classical physics, in the fundamental biosciences, as well as clinical medicine, and—we claim—in space sciences also.

Mr. STAEBLER. By keeping a program in each one of these, which might some times be "thin," and other times get further in advance of the practical, but by keeping some sort of program going there, we would be in a position to make continuing progress in each field?

Dr. NEWELL. Yes, and that has to be a significant program. It cannot be superficial or trivial, or you really are not doing enough in that area.

You should be tackling, trying to solve, at least one of the major important problems as discerned by the scientists in each of these important areas—with a determination to solve them.

The CHAIRMAN. Dr. Newell, we have to depend pretty much on the scientists to come up with this determination, do we not?

Just as we depend on the automobile manufacturer to determine how many retail outlets he needs to make the product available to the public?

Dr. NEWELL. We do.

The CHAIRMAN. As long as we have to depend on someone to make the judgment, doesn't it almost go without saying that we have got to depend upon the man who knows the most about the problem?

Dr. NEWELL. We do. In fact in the Office of Space Science we have to depend upon the scientists in the universities and those who are working right at the frontiers of their specialties.

Mr. STAEBLER. Mr. Chairman, how do members of this committee satisfy themselves that the scientists haven't gotten overenthusiastic, and decided that a lot more work in a given direction is needed, when in the minds of the members of this committee we are finding difficulty—I am stating this only hypothetically here—finding difficulty in justifying the program, and something ought to give.

What grounds are there for judgment?

Dr. NEWELL. Well, we in NASA do our best to act as your representatives in this respect, as we also act as the representatives of the scientists in presenting the program here to you.

The scientists will tell you, in almost every area, that we are not doing enough in that area.

You will find, for example, that the nonspace scientists, will tell you that we are not doing enough in their areas.

In the space area, you will find that the astronomers will tell you we are not doing enough in astronomy.

The atmospheric scientists will tell you we are not doing enough in atmospheric researches.

The lunar scientists will tell you we are not doing enough in the lunar sciences.

What we are attempting to do in NASA in putting this program together is to build up a program that is properly paced to maintain our leadership, does tackle one or a few important problems in each significant area, and is a sound investment from the point of view of balance relative to the development and applied research parts of our program.

Mr. STAEBLER. Then, he presumably represents only a part of the proposals that have been presented to you? And which may have some merit?

Dr. NEWELL. Yes.

Mr. STAEBLER. You have held them down in presenting them to us?

Dr. NEWELL. As a matter of fact, it represents a small part. The total program that we could in good conscience say is a worthwhile, sound, scientific program, would be a factor many times the present budget that is being presented to the committee.

The CHAIRMAN. Speaking as a scientist now, Doctor?

Dr. NEWELL. I am speaking as a scientist, that is right.

Dr. HOLLOWAY. May I speak briefly to Mr. Staebler's question, and offer for his consideration one guide by which a nonscientist may, by questioning, reach at least a partial understanding of whether the fundamental research or the applied and developmental and engineering component has gone out of balance?

Let us say the engineer represents the application of the information to a job that is to be done, and let us say that the fundamental researcher represents the other category.

When you have reached the point where the engineer has several choices of fundamental information by which he may solve a given problem, and it is his worry as to which one he uses, then, in my opinion, you have an indication that that particular field of basic research is rather well-equipped.

On the other hand, if it is the researcher who is being constantly pressed by the engineer to provide new information—the engineer says we do not have the necessary fundamental information—then you have at least a gross indication that that particular part of fundamental science has been undernourished.

It resolves itself sometimes into a question of who is doing the worrying, the engineer because he must make a choice among known solutions to his problem, or the scientist who is pressured by the engineer that needs an answer.

Mr. STAEBLER. That is a very helpful statement.

The CHAIRMAN. Of course, you see, Dr. Holloway, this committee, I think, is in a rather unique position.

As I have said before, I think none of us really are qualified to interrogate scientists, because we ourselves are not scientists. I would say in the field of science we are probably less informed than other members of other committees are informed on the subjects before their committees.

Another real problem that I see which makes it difficult for this committee to function properly is that we never get two sides of the argument. It is fairly easy for me to make up my mind as to who is right or wrong, for example, on the question of medicare, or tax reduction, or tax revision, or any one of the other highly controversial matters of the day, because I have someone else doing my research for

me. I mean there are those who are opposed and who will mention all of the reasons why this act should not be allowed, and then there are those on the other side who give all the reasons why it should be allowed—and have done a tremendous amount of research in order to substantiate their arguments.

The committee member becomes the beneficiary, you see, of all of this prepared knowledge.

There are very few, if any, witnesses who ever appear before this committee in opposition to any one of Dr. Newell's programs, for example.

We don't have people appearing before this committee in opposition to the manned lunar landing program, or the Orbiting Geophysical Observatory, or the Surveyor program, or whatever it is.

You name it, and I am probably correct in saying to you that no one has ever appeared before the committee in opposition to that program, giving us the reasons why we should not allow the budgetary request.

So you see this committee is at a real disadvantage, a serious disadvantage, as compared to other committees of the Congress, and therefore, if on occasions we appear to be critical in our pursuit of getting information, or in the manner in which we ask questons, it is only because I feel more often than not we feel frustrated for lack of having the information with which to properly compete with those who are sitting on the other side of the table.

And it may be because of this we ask for more information than the witnesses would like to supply, or which in their own personal opinions they feel is not necessary for us to judge the final verdict.

So I hope that those who are here today, and those who will appear before the committee in the future, just bear this in mind, and try to make our job a little easier, if possible, even though it means that by making that job easier we may have some legitimate reason to curb, or bridle, or even eliminate, on occasion, a program that is not absolutely essential, or a project within the program that is not absolutely essential.

Mr. DOWNING. Supplementing that, Mr. Chairman, I would like to say all of these witnesses have to have patience. We are propounding questions to them, that I am sure, to them, were not too significant.

I think all of us here appreciate that.

Dr. NEWELL. Thank you, Mr. Downing. We do understand this problem, and we do want to give you the information that you need to have.

The thing that worries you, as I said before, also weighs on our conscience very heavily when we are building up this program.

When we come to you, we believe in it, and we believe that we have thought through these matters in a responsible and conscientious way.

Mr. DOWNING. You all do pay taxes, don't you?

Dr. NEWELL. We do.

The CHAIRMAN. I am not sure I get the significance of that.

Mr. DOWNING. They are like every other taxpayer, they want dollar for dollar.

The CHAIRMAN. I will say this, Dr. Newell, and not at all in a critical sense, because I think the Office of Space Sciences has been extremely cooperative, and on occasion has volunteered information that probably on a temporary basis at least they would have been

better off had they not volunteered it, although I would not care to debate that with anyone.

I am sure I am correct.

But I would like to just call this to NASA's attention.

I think it is well worth their while to be completely candid and scrupulously honest in their presentations, because it is only going to take one time, I think, for some major program, or substantive portion of a major program, not to work properly, or not do the thing that it was designed to do, or not do what the witness said it was going to do, and you might have to stretch your imagination there to follow me in the line of thought or the line of reasoning I am attempting to make here, but once I think the committee should lose confidence in the judgment or in the veracity of the statements or testimony that is being given, I think, then, just because of the nature of the beast that we do face—I think probably it would be extremely disastrous. So from that standpoint I would just like to say that we appreciate anything you can do to help us, even though on a temporary basis it may appear to you that it is not helpful to your cause. I think we are all attempting to reach the same objective, really.

Our objectives are the same, namely, to do the most good for the most people in this great country. In many of these cases, I have a feeling, it amounts to doing the most good for all of the people.

This space program, like the national defense program, I think is a matter of the most good for all of the people.

It applies to this area more than any other program before the Congress, in my opinion.

Mr. STAEBLER. Mr. Chairman, as a foothote to what you just said, wouldn't you want to add one more point perhaps?

In our questioning, I notice that we frequently get quite exercised about programs that were changed, or programs that were tried out and found unsatisfactory, and we quite properly looked into these and asked for reasons, and so forth.

But wouldn't you want to add that we would not want to discourage NASA's inclination to take chances, and to try, and to experiment, and we would not want to contribute to any rigidity of attitude or of thought; the scientific process needs that flexibility and willingness to assume risks, and without it we could introduce a kind of bureaucratic rigidity which would be quite harmful?

The CHAIRMAN. If I gave any such indication in anything I said, of course, I certainly retract it, because this was not my intention.

What I was trying to say, I guess, without being so candid or so blunt about it, is that if we should find that the Agency appears before this committee requesting funds for programs that are not necessary, but merely for the purpose of having funds available to do other things at a later date, then I think this becomes a very serious matter, and one that would cause this committee to look with considerable doubt upon every single program that should be presented by NASA to the committee.

This was what I was thinking about, rather than giving any indication that NASA should not use the kind of courage we know they have got to use; otherwise this program just cannot be successful, because they are always working in the field of the unknown. I guess you could say, Dr. Newell.

Dr. NEWELL. Yes.

The CHAIRMAN. We have never gone to the Moon before, and we have never had an orbiting geophysical observatory before, or surveyor programs, or all of the things we have been talking about ever since these hearings began.

So we know that you have got to have courage, and we hope and we trust the greater the courage the greater the benefit, and the greater our success.

So I hope I am not being misunderstood.

Mr. STAEBLER. I think that is a very eloquent statement of the situation.

The CHAIRMAN. Dr. Newell, I wonder if it would be possible for us to meet again tomorrow morning and begin to take the individual budget items one at a time. As we go through, committee members may have questions that they would like to ask.

I guess we have now made arrangements for Dr. Silverstein to be here on Tuesday next to discuss the Centaur program?

Dr. NEWELL. Wednesday, I believe.

The CHAIRMAN. Wednesday next.

He will cover the Centaur program.

Other than that, I cannot think of anything that we have got to do, or any further information we need from the Office of Space Sciences. If we should run into a problem area, Dr. Newell, as we discuss this program among ourselves in executive session later on, it may be that we would again want either you or one of your staff, to appear before the subcommittee to give further explanation or clarifications of a particular request.

Dr. NEWELL. We will be glad to be at your call.

The CHAIRMAN. If I can encourage the subcommittee members to be here at 10 sharp, we could get through the budget items tomorrow morning.

Dr. NEWELL. Very good.

The CHAIRMAN. If there is nothing else today, we will adjourn until 10 o'clock tomorrow morning.

(Whereupon, at 11:50 a.m., the committee was recessed, to reconvene at 10 a.m., Wednesday, March 13, 1963.)

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1964 NASA AUTHORIZATION

WEDNESDAY, MARCH 13, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SPACE SCIENCES
AND ADVANCED RESEARCH AND TECHNOLOGY,
Washington, D.C.

The subcommittee met at 10 a.m., pursuant to adjournment, in room 304, Cannon Building, Hon. Joseph E. Karth (chairman of the subcommittee) presiding.

The CHAIRMAN. The meeting will come to order.

Dr. Newell, today we had set aside for the backup book review, if I may call it that, and I see the committee has been presented with a new volume desigated as volume No. 5 on budget estimates, and as closely as I can tell, this is a detailed breakdown of all of the items in the two volumes of backup books that are assigned to the subcommittee. Now is that correct?

FURTHER STATEMENT OF DR. HOMER E. NEWELL, DIRECTOR, OFFICE OF SPACE SCIENCES, NASA, ACCOMPANIED BY EDGAR M. CORTRIGHT, DEPUTY DIRECTOR

Dr. NEWELL. That is correct, yes.

The CHAIRMAN. Do you care to proceed, Doctor, and if you have any other witnesses who are here today, you may introduce them as you proceed.

Dr. NEWELL. Thank you, Mr. Chairman.

I would like to introduce to the committee Mr. Eldon Taylor, on my left, who is Resources Management Officer, and has been with us for some time and has recently taken the position of Director of our Office of Program Review and Resources Management.

We are prepared, Mr. Chairman, to review with you the presentation in the yellow books, and to answer any questions that you might have.

The CHAIRMAN. Doctor, volume V that we were given this morning is exactly the same as the backup books, with the exception that it does not have the supporting language as it relates to each program, but merely gives us the figures and the budget estimates, is this right?

Dr. NEWELL. But it gives you more.

The CHAIRMAN. More detailed breakdown?

Dr. NEWELL. It is a more detailed breakdown.

The CHAIRMAN. I see. Fine; why don't we use the volume V backup book for today's hearing?

Mr. Taylor, are you going to present this?

Mr. TAYLOR. I am only going to act as supporting witness as needed, sir.

The CHAIRMAN. Dr. Newell, if you would like to begin then, with the first insertion, under Office of Space Sciences, I think we may as well take it in that order.

Dr. NEWELL. All right.

The first insertion under the Office of Space Sciences is Geophysics and astronomy, and as we have stated in our overall program review, the geophysics and astronomy area covers the use of explorers, monitors, orbiting solar observatories, orbiting astronomical observatories, orbiting geophysical observatories for carrying out researches at the edge of the Earth's atmosphere and beyond.

It also uses sounding rockets and what we call "geoprobes," which are really large-size sounding rockets, for exploring the atmosphere and conducting measurements below those altitudes at which you can use satellites.

The first detail is on geophysics supporting research and technology, which, in general, provides for the laboratory work, computer type work, development of instrumentation, and so forth, that goes on in advance of specific projects, of the type I have just described.

As shown in the new book that was just given to you, the total geophysics supporting research and technology requested for 1964 is $9.5 million, which is approximately the same as last year—slightly less—while the total for solar physics is $2 million, which is somewhat more than requested last year.

In the astronomy area, the total is $3 million, which is about twice what was asked for last year.

There is an item for interrelated studies, interdisciplinary space science, amounting to $700,000, which is about the same as last year.

The total, then, comes out to $15.2 million as compared to a total of $13.7 million for 1963.

The CHAIRMAN. What, Doctor, could we expect in this area for next year?

Have we reached a plateau now on these explorers and monitors, and the OSO, OAO and OGO programs?

Dr. NEWELL. I think in the area of sounding rockets we are witnessing a leveling off. In the area of explorers and monitors, we are pretty close to the plateau.

In the use of the advanced type satellites, however, I expect we will not be leveling off for a few years yet.

The CHAIRMAN. Are you speaking of the orbiting astronomical observatory, for example?

Dr. NEWELL. Yes, and the geophysical observatory.

The CHAIRMAN. Are there any questions?

Mr. STAEBLER. Yes, Mr. Chairman.

The CHAIRMAN. Mr. Staebler?

Mr. STAEBLER. I would like to ask Dr. Newell the connection between some of the things that you do here and some of the things done elsewhere.

For example, in the study of micrometeorites I believe there is a probe now going on, or has just been authorized.

How does that operation fit in with what you are doing, and what part of NASA is conducting the probe?

Dr. NEWELL. The micrometeorite program has in NASA two aspects: One, the basic research aspect in which we try to learn about the distribution of material particles in the solar system, and to understand where they came from, and the astronomical implications.

The other aspect is that of a practical need to know about these particles, because of their high speeds and potentially damaging effects on sensitive surfaces such as solar cells, and to thin structures such as radiator systems for power supplies in space, or large antennas.

The first aspect, the fundamental research aspect, is carried out by the Office of Space Sciences. In this respect we conduct measurements and observations on our deep space probes and research satellites.

The second aspect is carried out by the Office of Advanced Research and Technology. For this purpose they conduct experiments that are slanted toward the ultimate application. For example, they expose surfaces to the pitting effects of these particles and thin-walled containers to observe their penetration effects.

The two programs are closely integrated, and we work very closely together, because the information that we find provides them with basic design information for designing their engineering-type and applied-research-type experiments.

At the same time, their engineering experiments add data to the fundamental research mill.

Mr. STAEBLER. There must be many fields in which the research is divided between several parts of NASA.

What means do you use to coordinate information and to make sure that there is not duplication of effort?

Dr. NEWELL. The general procedure is to name an office as responsible in an assigned area.

For example, in the fundamental space sciences, the Office of Space Sciences is the general watchdog for NASA.

In advanced research and technology, the Office of Advanced Research and Technology is the watchdog for NASA.

The supporting research and technology that we have described to you here, for example, has been carefully reviewed with the Office of Advanced Research and Technology, and they have assured themselves that the total NASA program is not duplicative, that what is done in OSS complements the general advanced research and technology work that they are responsible for and are carrying out.

Likewise, they do the same for all the other offices; for example, the Offices of Tracking and Data Acquisition, Manned Space Flight, and Applications.

Mr. STAEBLER. Is there a similar clearance with the Armed Forces in their research efforts, and how does that operate?

Dr. NEWELL. There is a process for comparing notes on the programs of the Department of Defense and NASA.

There has been established what is called the Aeronautics and Astronautics Coordinating Board.

The original Chairmen of this Board were Dr. York and Dr. Dryden. The present co-Chairmen are Dr. Brown and Dr. Seamans.

The Board is comprised of members who have high-level positions in the Department of Defense and in NASA.

The members are chosen so that when decisions have been arrived at—or agreements have been arrived at—they are then in a position to go back to their respective agencies and put these into effect.

The operating rules of the Board are that there may be no substitutes. A member of the Board must attend. This is to avoid the all-too-frequent tendency of committees having the members send substitutes and then sending substitutes for them, until the effectiveness of the committee or board is lost.

The Aeronautics and Astronautics Coordinating Board has six panels in appropriate areas of interest. These panels cover unmanned spacecraft, manned flight, aeronautics, ground support systems, launch vehicles, and advanced research and technology. Again, the membership on the panels is at the appropriate level in what we call the working levels so that when problems are brought up the agreements can then be put right quickly. So that you avoid the process of sending a recommendation up the line on one side, and then down the line, where it goes around for a while, over to the other agency, comes back up and goes over and back down, and the changes are not concurred in, so it goes through the process again. This is avoided so that once an agreement is arrived at, it can go into effect immediately.

Now, examples of agreements that have been arrived at include, for example, the national launch vehicle program. The launch vehicle panel arrived at an agreement on the vehicles that were needed by both the Department of Defense and NASA, and have also agreed that neither agency shall start a large vehicle development program without the concurrence of the other agency. This agreement has been adopted by the Administrator of NASA and the Secretary of Defense.

Another example came up in the area of meteorological satellites, which was under the purview of the unmanned spacecraft panel, and the programs of the two agencies were reviewed and a combined program agreed on.

Another example: It was discovered that in the Department of Defense there was an ionospheric research program that appeared to duplicate the NASA program. The two were then reviewed. It was found that the two programs were duplicative, with the outcome that the Department of Defense agreed to drop their program.

So you see it is not the case of "you scratch my back and I will scratch yours."

This process is effective in weeding out duplication.

Mr. STAEBLER. Is it sufficiently inclusive and sufficiently specific so that you can be assured that there is no duplication?

Dr. NEWELL. We feel that it is effective, in that there is no gross duplication. No one can ever say there is no duplication. But it is kept within reasonable proportions, we feel.

The CHAIRMAN. Isn't it true, Dr. Newell, that sometimes you have duplication on purpose?

Dr. NEWELL. That is true, but then the duplication is a desirable duplication for attaining either a comparison of different techniques for getting the same data, or for getting a total amount of data that one agency alone would find difficult to get.

The CHAIRMAN. What are these areas where duplication is desirable?

Dr. NEWELL. Well, in the exploration of the atmosphere, for example, the combined sounding rocket programs of NASA and the Department of Defense make for a better total program than if one agency alone were doing it. But, even there we are careful not to have useless duplication. The programs are compared on the working level, and are reviewed periodically in panels like the Unmanned Spacecraft Panel, or at the Interdepartmental Committee on Atmospheric Sciences.

The CHAIRMAN. How often do these panels meet, Dr. Newell? Is this a regular thing, or kind of a spotchecking thing, or are meetings called at the direction of the Chairman, or what?

Dr. NEWELL. They meet periodically. The typical interval is every 2 months.

The CHAIRMAN. If they have differences of opinion, who settles the differences?

Dr. NEWELL. The differences of opinion have to be either resolved between the cochairmen, or if they cannot resolve it, then it has to go up to the Administrator of NASA and Mr. McNamara.

As far as I know, this has never had to be resorted to yet.

The CHAIRMAN. Dr. Weaver?

Dr. WEAVER. Dr. Newell, I noticed the main increase in the budget for this coming year is in the field of astronomy.

Do you feel that the benefits justify an increase from $1.2 to $2.8 million? If we held the line on that, our budget would be about the same as it was in fiscal year 1963.

Do you feel we need this additional boost in astronomy?

Dr. NEWELL. Well, astronomy is one of the challenging fields in basic research, and as we approach the time when the orbiting astronomical observatory will go into operation, you do need a strengthening of the supporting research and technology program.

I feel this is an important element of this program.

Dr. WEAVER. Could we do the job in space sciences while holding the line at $1.3 or $1.4 million?

Dr. NEWELL. Not in our view. It would be a lesser job and would not be an adequate job.

Dr. WEAVER. Is this basically equipment for the orbiting astronomical laboratory?

Dr. NEWELL. It is advanced work on instrumentation, development of techniques, development of the experiments for the observatory.

Dr. WEAVER. A cut of $1.6, or $1.5 million would handicap the program in your opinion?

Dr. NEWELL. Yes, it would, and actually, as you will observe, as we go through these numbers, the cost of the experiments is in many cases a small fraction of the total cost of the building of the observatory and launching it.

In this case, the work going into developing experiments is a small fraction of the cost of the orbiting astronomical observatory.

Dr. WEAVER. There is no private research or private foundation work in this field that can be relied upon to do some of this basic research for you, such as a university?

Dr. NEWELL. Well, the universities participate here, but their research has to be paid for, and they do not find themselves in a position to do this work unless we pay for it.

Dr. WEAVER. Thank you.

Dr. NEWELL. I should point out that in work of this type in addition to preparation for the immediate satellites, those that are forthcoming immediately, there is always work going on looking toward the future. For example, I mentioned that in the ultraviolet region, we have the most important area to study for learning about the evolutionary processes in stars.

This is a region we cannot see from the surface of the Earth.

The first three orbiting astronomical observatories are devoted to this ultraviolet area, and some of the work on that area is covered by this $2.8 million.

Dr. WEAVER. Would that be the three observatories, or two, or one, included in that for fiscal year 1964?

How many observatories are involved in that?

Dr. NEWELL. There are three definitely in the program right now.

Now in addition, I also pointed out that the information on the early birth processes of stars is to be found in the infrared region, and some of this funding here is being used to develop infrared instrumentation and experiments.

Dr. WEAVER. This is all new?

Dr. NEWELL. Yes, this is all new.

Dr. WEAVER. Thank you.

The CHAIRMAN. Are there any further questions? Mr. Staebler?

Mr. STAEBLER. No questions.

The CHAIRMAN. For the record, how much money, Dr. Newell, was reprogramed in this area during fiscal year 1963?

Dr. NEWELL. For the geophysics and astronomy area total there was a $7.4 million reduction, of which $2.8 million was a reduction in supporting research and technology.

The CHAIRMAN. I am not sure I understand.

Dr. NEWELL. Well, we are looking——

The CHAIRMAN. That is the total for research and technology—that is the total, you say, was reduced $7.4 million, but $2.8 million was in research and technology.

Dr. NEWELL. The total in geophysics and astronomy—this whole section here—which will include flight projects, and so on, was $7.4 million reduction.

However, of that, $2.8 million was a reduction in supporting research and technology.

The CHAIRMAN. Mr. Hammill.

Mr. HAMMILL. Dr. Newell, may I return for a moment to this question of NASA-DOD coordination, to which you addressed yourself a few moments ago?

How many military personnel are assigned to the Office of Space Sciences now?

Dr. NEWELL. Two.

Mr. HAMMILL. To your knowledge, are there any NASA personnel from any of the NASA offices assigned either to OSD, D.D.R. & E., or to the Air Force?

Dr. NEWELL. To my knowledge there are none.

There is, as you well know, an interagency set of mutual assignments between the AEC and NASA, but I do not know of any with DOD.

Mr. HAMMILL. I wonder if it might not be a good thing to have some sort of mutual arrangement?

Now we understand that there are over 200 military officers assigned to NASA at the present time; I am not sure of that figure, however.

Wouldn't it be a good thing to have some—perhaps not that many—but some NASA personnel actually working with the Department of Defense on DOD programs; a sort of mutual arrangement; if it is a good thing from the standpoint of coordination to have military officers in NASA, might it not be good to have it the other way?

Dr. NEWELL. That is a very interesting suggestion.

I must reemphasize that in my answer to the question, I said to my knowledge there is no such assignment.

In the Office of Space Sciences we do not see the same sort of need as might be seen in the developmental areas.

We do work very closely with the Department of Defense, for example, the Naval Research Laboratory and the Air Force Cambridge Center participate in our program, and it is in such cooperations in carrying out the Office of Space Sciences' program that we have effected the ties.

Mr. HAMMILL. Well, we were told that originally the main reason for assigning military personnel to NASA was because NASA was in a formative stage, and while building its own competence, NASA simply had to rely upon the expertise that existed elsewhere, particularly in the military.

Now the rationale has changed, and we are told that it aids in coordination. NASA is beyond the point where it really has to rely upon technical help from the military.

I wonder if you would be good enough to explore this, and perhaps submit for the record your observations on this question.

Dr. NEWELL. I would be glad to do that.

Mr. HAMMILL. Thank you.

(The information is as follows:)

In response to the committee's request, I have considered the value of possibly having Office of Space Sciences personnel temporarily assigned to duty with military offices and installations. As a general observation, it appears to OSS that the close working relationship we have established with our counterparts in the Department of Defense in space science areas precludes the need for having NASA Space Science people assigned to positions in the Department of Defense. For one thing, the work of the Space Sciences people is best done in the NASA setting, and is not of the same nature as the Department of Defense weapons systems development activities. Secondly, the NASA results are readily available to the Department of Defense, both through informal communications channels and through formal publications and reporting processes.

There is, however, one possible exception. It could be of value to the Office of Space Sciences to have one or two men in the launch vehicle area on detail to appropriate rocket activities. Since our work on advanced launch vehicles, for example, the Centaur, can be of considerable value to the Department of Defense, it may be that the DOD would find such an arrangement useful, also. The Department of Defense would, however, have to make that determination.

Dr. STAEBLER. Mr. Chairman, I have a question.

The CHAIRMAN. Mr. Staebler?

Mr. STAEBLER. Dr. Newell, I don't recollect what was said about space chemistry, and I don't understand if it might be included in your research in celestial mechanics.

Can you indicate those two fields?

Dr. NEWELL. I would be glad to do so.

Space chemistry is under the area of geophysics, so it applies to the geophysical aspects of the field of chemistry.

For example, in the Earth's upper atmosphere some of the most intricate and important processes are chemical in nature.

The Sun's radiation in the ultraviolet and X-ray region, for example, impacting on the Earth's atmosphere, causes the molecules of oxygen and nitrogen to become disassociated, and in so doing deposits energy in these atoms and molecules.

The process gives rise to the ionosphere. It gives rise to radiations from the upper atmosphere, which we call the airglow.

The auroras are a process in which chemical activity takes place. So the study of the auroras involves space chemistry.

When we get to the other planets, Venus and Mars, with equipment we can insert into the atmosphere of these planets, instead of just flying by them, we will then be in a position to study the chemistry of atmospheres other than the Earth, and then make comparative studies between those atmospheres and our Earth's atmosphere.

When we get to landings on the Moon, and landings on the other planets, then we will be able to study the chemistry of the surfaces of these bodies.

Now, actually, much of the support for this will come under the lunar and planetary line item rather than the geophysics line item.

However, the two are closely associated, and for this reason I thought I should mention it here.

In the area of celestial mechanics, one principal interest in the space sciences area is in the effect of the gravitational fields of bodies like the Earth, the Moon, and the planets, on the orbits of satellites or the trajectories of space probes.

A second principal interest is in the interpretation of these effects to tell us what they can about the internal structure of these bodies.

For example, from the study of satellites that have been put in orbit about the Earth, we have been able to determine that the mantle of the Earth, which is the section of the Earth below what we call the crust, is of strength equivalent to an ordinary brick wall. It is not molten. The molten portion is farther in the interior. And we have been able to determine that this more or less solid mantle has a slight plasticity so that the response to changing stresses on it is in the order of about 50 million years.

For example, the Earth's rotation rate is slowing down. As it slows down, the centrifugal force operating on the Earth's mantle is reduced.

You would expect, if the Earth were perfectly plastic, that as the stresses on the Earth reduced, the bulge would reduce right with it, but it does not. It lags. This bulge stays there and the decrease in the bulge lags by about 50 million years.

We have been able, from the study of these Earth satellites, to determine that the bulge in the Earth is not the only distortion in its shape, or in its gravitational field. There are higher components. These higher components have important effects on satellites and space probes.

So this in general is what is covered by celestial mechanics.

Mr. STAEBLER. Thank you.

The CHAIRMAN. Dr. Newell, for my own benefit, although I think I understand it, I wonder if you would just briefly explain the analysis of OSS.

On the top line there, Dr. Newell, geophysics and astronomy, you will notice the first column is fiscal year 1963 request.

Dr. NEWELL. Yes.

The CHAIRMAN. Then we go along the horizontal, and you will notice the third and fourth column items, NASA allocation of appropriation adjustment in 1963 budget.

Dr. NEWELL. Yes.

The CHAIRMAN. Will you explain that minus 18 million, sir?

Dr. NEWELL. This is an overall NASA adjustment to accommodate a new estimate of personnel operating costs, and the adjustment to the new organization.

You recall that when the Office of Space Sciences was created, it took with it part of what was the Office of Space Flight Programs, and took into it part of what was in the Life Sciences Office, and assumed responsibility for grants and research contracts.

This is an overall NASA adjustment to take into account all of those.

The CHAIRMAN. So the $151,900,000 is the amount that NASA themselves adjusted to for the geophysics and astronomy programs, is that correct?

Dr. NEWELL. In research and development, yes.

The CHAIRMAN. And then in addition to that, NASA reprogramed another $7½ million?

Dr. NEWELL. In addition to that, then, the Office of Space Sciences recommended a reprograming of $7.4 million.

The CHAIRMAN. Who recommended the $18.5 million, Doctor, the Office of Space Sciences, or was this an automatic adjustment from the top administrative office in NASA?

Dr. NEWELL. This was an adjustment by the top administrative office based on our own recommendations and recommendations from other offices to meet the total needs of the agency.

The CHAIRMAN. But your recommendation was $18.5 million less than we gave you.

Dr. NEWELL. What I say is that this adjustment is based on combination of our recommendations and those of Manned Space Flight, Advanced Research and Technology, Applications, and Tracking and Data Acquisition.

This is top management's best adjustment to meeting all the needs that were expressed.

The CHAIRMAN. Was this done immediately after the appropriation bill was passed, or when was it done?

Mr. TAYLOR. Let me see if I can suggest a partial explanation of this problem. There is a combination of things here which tends to make a net number like this confusing.

In the Office of Space Sciences our primary responsibility is in the research and development area.

Now, as we discussed with the committee last year, our many Centers have personnel and overhead costs that are associated with the projects.

Now, as of last year, our initial conversion was made from a salaries and expense presentation to a research and development presentation, where these costs were associated with the projects.

This initial conversion was rather arbitrary, and the amounts estimated in December, last year, to be associated with these projects, were

not as good as our experience has taught us they should be, so there is some reassociation, some readjustment of the personnel and operations figures here.

This adjustment process is in an area in which we have no budgeting control, it is an accumulation of costs, you see, by the Centers, and their proportionate assessment to projects.

The CHAIRMAN. Is it because of their instability in personnel—that is, instability in numbers?

Mr. TAYLOR. No, sir.

The CHAIRMAN. They give an estimate at the beginning of the year how many personnel they are going to have working and then that estimate does not hold true for any number of reasons?

Mr. TAYLOR. No, sir; it is not that.

The estimate given for personnel as a total for a Center for any given year is very good.

The determination of those costs to specific projects, like OAO, Ranger, OGO, was initially attempted within NASA last year in the December time period. We had not previously made this association.

So it is not the question of whether we have altered this association during the year.

The question really is that at the time we made this association last year we were not nearly as good at determining these costs as we are at this point in time.

There is a net reduction of some amount in the personnel and maintenance area reported against the geophysics and astronomy programs.

The CHAIRMAN. What you are saying is that your second estimate was $18.5 million more accurate than your first one; aren't you?

Mr. TAYLOR. In this particular area, the total of maintenance and operation within NASA has not changed drastically, but we have grown smarter since we tried to make this association last year, and in trying to present to you an honest representation of what projects really cost.

There is a reduction in this area.

The CHAIRMAN. How much smarter this year are you than you were last year—$15 million worth, or $10 million worth?

Mr. TAYLOR. I don't want to leave the impression——

The CHAIRMAN. This is hardly a fair question, I suppose.

Mr. TAYLOR. It requires a subjective conclusion, sir.

The CHAIRMAN. I am not sure it is fair, but I would like to have something on that.

What changes have you made; what makes you more sure today that you are more accurate this year than you were last year?

What have you done to improve the situation?

Mr. TAYLOR. One thing that makes us more confident is that we have worked with our Centers in the intervening time period to get them on a basis to accumulate costs in this manner, whereas in the past there was not a good accounting basis for doing so.

Under the old NACA organizational structure, and the Centers associated with this type of accounting system, we really did not have the best mechanisms for making this association.

I think we are improving and we may have to improve some more.

However, I will go back to a point.

This net reduction does not affect the total NASA requirements for running Centers and for paying the people.

It is just a better estimate of what that total requirement is in this particular area.

The CHAIRMAN. Dr. Newell, I assumed that substantial amount of this was done for you by competent administrative officers in NASA.

So let me ask you this question: Have the programs of the Office of Space Sciences suffered as a result of any priorities that might have been given some other program?

Dr. NEWELL. The overall program of the Office of Space Sciences actually came out somewhat ahead in this adjustment by about $45 million overall.

The total readjustments within NASA enabled OSS to initiate a biosciences program, and to get well into the sustaining university program which we described yesterday, and also to——

The CHAIRMAN. So these two areas are the areas where most of the funds that were reprogramed, or rescheduled to OSS——

Dr. NEWELL. These along with Centaur.

The CHAIRMAN. These along with Centaur, yes.

Dr. NEWELL. Yes.

The CHAIRMAN. All right. Thank you.

Doctor, I was asking Mr. Hammill earlier this morning whether or not he was aware of the biosciences program being split up within NASA, and whether or not therefore it would differentiate groups within NASA if it had partial responsibility for the overall program.

Is all of the biosciences program, including animal experimentation, et cetera, et cetera, is all of this now under the Office of Space Sciences or is some of it under some other office?

Dr. NEWELL. No; there is a division within NASA.

The Office of Manned Space Flight handles the medical aspects that are directly associated with carrying out the Mercury, Gemini, and Apollo missions. This is basically direct application-type program for their mission.

The Office of Space Sciences is responsible for what is called fundamental space biosciences—fundamental research into the effects of the space environment on life processes, effects such as weightlessness, radiation, the change in rhythms. If you remove objects from the 24-hour day periodicity, what happens to them? And for the so-called exobiology, the search for and study of life on other bodies of the solar system.

The Office of Advanced Research and Technology is responsible for what might be called the applied research and initial development work in biosciences, that is, for studies of human factors, man-machine relationships, the problem of supporting men and living organisms for long periods of time in orbit, or on trajectories to the planets. The work that has to go into the development of life-support systems is involved.

The CHAIRMAN. This is fine, Doctor, but why can't we put them under one or the other of the two offices?

Don't you have some duplication some place along the line?

I mean you have got to have a certain number of supervisors I suppose, let me call them that for lack of a better word; some type of administration.

If we put them all under one office, couldn't we eliminate personnel?

Dr. NEWELL. I think not.

The CHAIRMAN. Not that I want to increase the number of unemployed in this country, but it seems to me this is a rather bad management structure.

Dr. NEWELL. I think not.

The previous organization of NASA had all of these under one office, and that experiment did not work too well because of the fact that the requirements for the fundamental research are quite different from those for the application to Apollo, for example.

The CHAIRMAN. I understand the requirements will be different, there is no question about it.

Dr. NEWELL. The requirements are different in such a way that it was a natural to place the fundamental work under OSS, because of the things we were doing——

The CHAIRMAN. Each experiment you are conducting, Dr. Newell, has a different requirement. I mean, for example, you are studying the effects of prolonged weightlessness.

This is one requirement that you have, and you are doing extensive experimental work on it.

What is the effect on the human being when he is changed from the regular 24-hour day, you know, to three or four of these within that period of time, or more?

That is another requirement, so you have another experimental program there.

These are two different requirements, but they are all under the Office of Space Sciences, and you have many other different requirements and many other different experiments.

So you have one under the manned space flight program. I can't understand why just because it has a little different requirement, it could not all be under the same head.

Dr. NEWELL. It is not a little different requirement. Perhaps the word "requirement" is the wrong word to use.

What I am trying to get at is that the suggestion that you put it all under one office will tend to build up a duplication in the personnel staffing and the building of facilities for carrying this out.

The CHAIRMAN. That would tend to build up a duplication?

Dr. NEWELL. Yes.

The CHAIRMAN. I thought it would tend to eliminate a duplication.

Dr. NEWELL. This is a paradox we are faced with.

The basic research type of activity is the activity the Office of Space Sciences is dealing with.

We have the staffing of this type of individual in the Office of Space Sciences.

Now if you should undertake to move this fundamental research over to the Office of Advanced Research and Technology, then they would have to build up a different type of activity in their Office which would duplicate what we are carrying on, or vice versa.

The CHAIRMAN. Let's say we just transfer what they are doing to your Office, transfer the requirement, the people, the work, the experiment.

Dr. NEWELL. There again, the human factors research, the applied research and development work, is something that is natural to their activity.

The CHAIRMAN. You can assure this committee the way you are doing it actually tends to reduce the personnel?

Dr. NEWELL. This is our belief, and we feel this is the most effective way to do it.

It was arrived at after trying the approach that you suggest. That approach was not successful in getting an adequate applied research or fundamental research program underway.

The CHAIRMAN. Do both Offices, for example, have need for animal experimentation?

Dr. NEWELL. They both have need for animal experiments, but they both work very closely together in developing this program.

For example, I described to you studies that we are making now of a satellite system to be used for supporting our fundamental biosciences program.

The CHAIRMAN. Let me ask you this, Do you have one kennel for all of the animals—I don't know whether "kennel" is the correct word—do you have one laboratory area for the animals, or do you have two of these, one for the Office of Space Sciences and one for the other?

Dr. NEWELL. We will not duplicate them, we will use them together.

The CHAIRMAN. Are they both at Ames?

Are both of your people doing experimental work in this area, the OSS, and the manned group, are they both at Ames?

Dr. NEWELL. Ames Research Center supports both Offices, yes.

And as I was about to say, this satellite that we are studying is or will be developed if we go into the development of it according to specifications from both Offices, so there will be only one facility developed for the use of NASA.

The specifications for the study were drawn up by both Offices. As a matter of fact, the directors of the life sciences programs in the three Offices meet periodically at least once a month, and sometimes more frequently, comparing notes on what they are doing, to make sure there is not duplication, to make sure that if a facility is being developed by one Office it will be useful to all three, and will be used in the programs of all three.

The CHAIRMAN. It might be easier for you, Dr. Newell. I would hesitate to agree on whether it would be easier for the Congress to keep track of an area such as this that is broken up and segmented through provision and control of two different Offices.

I think it is rather difficult for anyone really to keep track of the program from A to Z, when they only have responsibility from A to D, you see.

Then someone else has responsibility from E to X, and a third for Y and Z.

It makes it difficult for us. It may be what you say is true—I assume that it is. You tried it both ways, and feel confident this is the better.

Would you care to proceed, Doctor?

Mr. STAEBLER. Mr. Chairman, may I ask a somewhat extraneous question?

The CHAIRMAN. Mr. Staebler.

Mr. STAEBLER. This question is in connection with the biosciences activities.

You mentioned the animal experiments.

There is a growing interest in the humane treatment of animals, particularly——

Dr. NEWELL. We have the very best laboratory.

Mr. STAEBLER. Is there some attention to the standards of humane treatment of the animals experimented on?

Dr. NEWELL. Oh, yes, this is given very careful attention.

The CHAIRMAN. Are the quarters air-conditioned, Doctor, as some people are suggesting they be?

Dr. NEWELL. I assume they are properly conditioned for the health of the animals. It is a necessity.

The CHAIRMAN. I was not being facetious, really.

Dr. NEWELL. I don't know.

The CHAIRMAN. This has caused quite a storm. I know what Mr. Staebler is speaking of, because I have a stack of letters in my office from people who live in my State, and are very much excited about whether or not these animals are being treated properly, whether or not they have proper accommodations, and they speak at great length about the need for air-conditioned kennels, for example, when talking about housing of the animals that need kennels. There is no question about it.

Dr. NEWELL. As time goes on, each animal becomes an extremely valuable animal, becomes an investment not only of money, but of the time of the experimenter.

It is in the nature of the setup that the experimenter will take good care of his animal.

The CHAIRMAN. That is a very different answer.

I had not thought of that, Doctor; we will be using that answer. Thank you.

Would you care to proceed, Dr. Newell?

Dr. NEWELL. We come now then to the flight projects in the geophysics and astronomy area.

The CHAIRMAN. What page are you on?

Dr. NEWELL. We are on page 26 of volume 5.

First, in the geophysics area, the explorers and monitors. The explorers and monitors, to refresh your memory, are the smaller-sized satellites, those launchable by the Scout and Delta-type launch vehicles, primarily.

In the case of the explorers and monitors, we are asking for a total spacecraft and supporting budget of $800,000 for energetic particles explorers this year. The Delta launch vehicles, to launch them, were paid for last year, so that the total is the spacecraft and general support.

This pays primarily for the wind-up of the energetic particles explorers described here, the data reduction, and the obtaining of the information for which the program was instituted in the first place.

The CHAIRMAN. What will happen to that for the following fiscal year?

That I suppose is the end of the program, Doctor?

Dr. NEWELL. Of that particular item, yes.

The CHAIRMAN. Thank you.

Dr. NEWELL. The next is the interplanetary monitoring satellite, which the Goddard Space Flight Center has named interplanetary monitoring platform.

This is designed to go into a highly eccentric orbit in order to investigate the geomagnetic field, the magnetosphere, out through the boundary, even in the antisolar direction, the direction in which the boundary is blown out to more than 20 Earth radii from the surface of the Earth.

Here the total that we are asking for is $2.3 million for spacecraft, $1.2 million for experiments.

Ground operations, and test and support amounts to about three-quarters of a million dollars, for a total of $4.1 million.

The Delta launch vehicles, $7.3 million for a total of $11.4 million for the interplanetary monitoring satellite.

Here we are asking for $2.3 million for spacecraft, $1.2 million for experiments, and about three-quarters of a million dollars for ground operations, and test and support, for a total of $4.1 million; plus $7.3 million for the Delta launch vehicles for a grand total of $11.4 million for the interplanetary monitoring satellite.

The CHAIRMAN. How much money was reprogramed in these two areas during this fiscal year, Doctor?

Dr. NEWELL. In order to pick up primarily what we called Explorer XV, which was to study the effects of the nuclear tests last summer, we had to add to this program $10.3 million.

That is the energetic particles area.

The CHAIRMAN. That was the total program.

Dr. NEWELL. Almost, yes. This was an added satellite that we had not planned on.

We had planned on Explorer XIV, which went right before it, which was similarly instrumented but not quite properly instrumented to study the artificial particles.

Explorer XIV did go, as you know.

In order to add an additional satellite to study the artificial belt, we had to add $10.3 million.

The CHAIRMAN. How about the interplanetary monitoring?

Dr. NEWELL. For the interplanetary monitoring, we had to add $5 million. This was a new start.

The CHAIRMAN. That was all new?

Dr. NEWELL. Yes, that was a new start.

The CHAIRMAN. How far down the road is that?

Dr. NEWELL. The experiments are well underway.

Equipment from most of the experimenters is at hand.

The satellite structure is in good shape.

We are planning a launching of it the third quarter of this year.

The CHAIRMAN. How many total interplanetary monitor probes are you thinking about at the present time?

Dr. NEWELL. We are thinking of one every half year through the solar minimum, and into the next solar maximum.

The CHAIRMAN. Is it a fair estimate for me to make, if I added up these figures, and said that each one of these interplanetary monitors costs in the neighborhood of $16 or $17 million?

Dr. NEWELL. For a total of seven shots it would be about $30 million.

The CHAIRMAN. What we have done really is we have funded for half of the program.

Mr. CORTRIGHT. This was for two.

The CHAIRMAN. For almost half of the program.

Dr. NEWELL. Well, this was for two, or two-plus of the shots, a total of seven will be $30 million.

The CHAIRMAN. We have already funded $17 million.

Dr. NEWELL. Yes, with this year's funds. I was looking at the $11.4.

The CHAIRMAN. How many shots are you talking about this total will take care of?

Dr. NEWELL. The total of 30 would take care of 7 shots.

The CHAIRMAN. The 17 that we see in the backup book here, how many do you have planned through 1964?

Dr. NEWELL. Through 1964, three or four.

There are three firings on the schedule, and we would, of course, have been preparing for the follow-on firings in 1965.

The CHAIRMAN. Continue, please.

Dr. NEWELL. The next flight program involves the atmosphere explorers and monitors.

These are spacecraft to study our Earth's atmosphere.

For spacecraft experiments, ground operations, test and support, we ask a total of $3.2 million, and completion of funding on Delta launch vehicles of $500,000, for a total of $3.7 million.

The CHAIRMAN. This is less than you requested last fiscal year?

Dr. NEWELL. That is correct.

The CHAIRMAN. How much did we reprogram on this item last year?

Dr. NEWELL. We added $3.8 million to the program in 1963.

The CHAIRMAN. OK.

Dr. NEWELL. The addition of those funds was required because of technical difficulties in developing this spacecraft.

Although the atmospheric research sounds like a very simple and direct sort of thing, we are attempting, in this satellite, to make measurements to much lower pressures than have ever been attempted before.

The next are the ionosphere explorers.

Here, for the spacecraft and experiments, ground operations, test and support, we ask a total of $700,000 in fiscal 1964 as compared to $1 million in fiscal 1963.

And we ask for the funding of the Scout launch vehicle at $1 million, which is complete funding for the vehicle.

The CHAIRMAN. So your program really is less, but the addition of the vehicle to launch it is causing it to be slightly higher than last year?

Dr. NEWELL. That is correct.

The CHAIRMAN. How much was reprogramed last year, Doctor?

Dr. NEWELL. $800,000.

The CHAIRMAN. Plus or minus?

Dr. NEWELL. Plus—added.

The CHAIRMAN. This is kind of a small program to begin with. Any particular reason why $800,000 should have been reprogramed?

Dr. NEWELL. This ionosphere explorer is the fixed frequency topside sounder, which, as we mentioned to the committee, we have delayed because of the success of the Alouette topside sounder.

This permitted us to delay this and also to improve the instrumentation in it, to take advantage of what the Canadians have learned with Alouette.

The CHAIRMAN. All right; proceed.

Dr. NEWELL. Under ionosphere monitors, which you will see we are introducing in fiscal 1964, we are asking for the spacecraft experiments, ground operations, test and support, a total of $3 million.

The total for ionosphere monitors, then, will be $3 million.

This is the satellite which we mentioned earlier in our testimony as the satellite we are discussing with Canada. The Canadians have indicated that they would like to undertake the preparation of this satellite and, if they do, would pay for the preparation of the satellite.

If they do that, we will have to support the launching of it, so that these funds, although they are listed here as support of development of the spacecraft, may have to be transferred to paying for the launch vehicle instead of the spacecraft.

That will be a case where we gain because Canada pays for the development of the spacecraft.

Mr. STAEBLER. Mr. Chairman, may I proceed on that point a little further?

The CHAIRMAN. Yes, Mr. Staebler.

Mr. STAEBLER. Do I understand that the spacecraft is included in the item of $3 million?

Dr. NEWELL. As of the present listing, the spacecraft—the item $3 million is labeled "Spacecraft and Support."

If our negotiations with Canada go as we hope they will, then Canada will pay for the spacecraft, and we will have to pay only for the support and the launch vehicle.

Mr. STAEBLER. There will be a reduction then in the total cost?

Dr. NEWELL. Yes.

Mr. CORTRIGHT. It will be a reduction in the total cost of the project to the United States.

Dr. NEWELL. Yes.

Mr. STAEBLER. Wouldn't there be a reduction in the $3 million?

Mr. TAYLOR. I think not; in that this program was predicated on a launch in 1965.

Mr. CORTRIGHT. 1965.

Mr. TAYLOR. At that time, that involved the United States making the spacecraft and launching it on a Delta launch vehicle.

Our discussions with the Canadians now indicate we may have to go to the Thor-Agena launch vehicle, which is a heavier and more costly vehicle, and also the launchings we are discussing will be at an earlier date, so we are almost sure, no matter how the negotiations turn out, to require this amount of funds to support this cooperative agreement.

But in the terms of the total overall, over time, the savings to the United States would be substantial.

Mr. STAEBLER. Then it is evident from the uncertainties in the ultimate disposition of the program, why you have to have some leeway in your estimate?

Dr. NEWELL. Yes.

The CHAIRMAN. Mr. Hammill?

Mr. HAMMILL. Dr. Newell, how do you distinguish ionosphere explorers from ionosphere monitors?

Dr. NEWELL. An explorer is primarily a discovery-type research vehicle in which you are attempting to make measurements of and

observe phenomena that you do not yet completely understand, to look for things that perhaps you do not even know are there yet.

Whereas the monitor is a satellite devoted to continuous collection of data that are needed for setting basic data lines, and against which to reflect the discovery-type research.

For example, a monitor might be used to keep a check on the behavior of the geomagnetic field, so that you can get a picture of its normal steady state, and against that be able to study changes in the field during magnetic storms. Or a monitor might be a satellite designed to keep a steady check on cosmic radiation against which then you could study the cosmic ray storms, and so on. Or a monitor might be to keep a check on solar activity, to know at all times what the Sun is doing.

Mr. HAMMILL. The monitors will be most effective if there is long lifetime built in them?

Dr. NEWELL. Long lifetime is a primary requirement of the monitor-type satellite.

Mr. HAMMILL. Have we reached the place where we have achieved what is considered a satisfactory length of life?

Dr. NEWELL. We feel we can do fairly well with the smaller type satellites, but we are not by any means satisfied. We are going to continue to work on the problem of long lifetime.

The CHAIRMAN. Proceed, Doctor.

Dr. NEWELL. The total, then, for explorers and monitors in the geophysics program comes out to be, for spacecraft, $11.8 million, for launch vehicles, $8.8 million, for a sum total of $20.6 million.

In the orbiting geophysical observatories area, for spacecraft, for system development, and for integration with the basic spacecraft system, a total of $14.9 million is required.

The CHAIRMAN. How many spacecraft is that for, Dr. Newell?

Dr. NEWELL. The 1964 number covers payments on the second group of three satellites of a program in which we have a total of nine planned.

The CHAIRMAN. What reprograming action did you take in this area last year?

Dr. NEWELL. In the orbiting geophysical observatory program, we stretched the schedule beyond the launching of the first, so as to reduce the fiscal year 1963 requirement by $16.6 million.

Mr. STAEBLER. Mr. Chairman?

The CHAIRMAN. Mr. Staebler. May I ask that we go back to the preceding item.

Would you clear me up as to which items are included in the total of $20,600,000?

I am trying to relate that to the preceding figures, and I don't seem to understand which are which.

Mr. STAEBLER. That is the explorers and the monitors under the geophysics flight projects.

Dr. NEWELL. Under interplanetary monitor, there is a 7.3 million figure for launch vehicles, and under atmosphere explorers and monitors a half a million dollar figure, and under ionosphere explorers, a Scout launch vehicle for $1 million——

Mr. STAEBLER. These were not included previously?

Dr. NEWELL. These were not included previously.

Mr. STAEBLER. In this $20 million, there is not a total of anything that goes before?

Dr. NEWELL. No; this is just fiscal 1964, and the subtotal for explorers and monitors.

Mr. STAEBLER. I was trying to relate this to some of the previous items in 1964. That is incorrect. This is a new item?

Mr. CORTRIGHT. No.

Dr. NEWELL. It is a subtotal for all the items under explorers and monitors under geophysics.

So it should be the correct total for those vehicles I just listed—8.8 million is the total for launch vehicles—plus the spacecraft work.

Mr. TAYLOR. Sir, it is not additive. It is just an accumulation of the parts we have been discussing.

Mr. STAEBLER. Yes, and I am trying to relate it to which parts we have been discussing.

Dr. NEWELL. Let me run through the list again.

The $8.8 million of that subtotal of $20.6 million is the total of the following numbers——

The CHAIRMAN. Doctor, to make it clearer, I think, Mr. Staebler, if you start on page 26, the second item there, flight project, do you notice that in the middle of the page?

Mr. STAEBLER. Yes.

The CHAIRMAN. Geophysics. You add those figures and all of those on page 27, and you come up with $20.6 million, shown on page 28.

Mr. STAEBLER. All right.

So that the $20.6 million, then, is the sum of everything beginning with flight projects on page 26, and all of page 27——

The CHAIRMAN. As I understand it——

Mr. STAEBLER. OK.

Dr. NEWELL. So far, but now you should recognize it is the subtotal for explorers and monitors.

We will come up with a new subtotal shortly for orbiting geophysical observatories.

The CHAIRMAN. Which is the next item on your page 28?

Doctor, let me make this observation.

I have noticed that using the other backup book now for a moment, that for supporting research and technology under the geophysics, solar physics, and astronomy programs, the personnel costs, for example, are 15 percent of the total and the operation of installation costs are 15, or more than that.

It amounts to almost 35 percent of the total cost of these programs.

Dr. NEWELL. For supporting research and technology.

The CHAIRMAN. Yes in personnel costs and operation of installation costs.

Isn't that rather high?

Dr. NEWELL. This is because of the in-house character of a large part of the supporting research and technology.

The CHAIRMAN. OK.

Dr. NEWELL. The orbiting geophysical observatory is, as the committee knows, one of the larger type observatories, and is, therefore, designed to carry a large number of experiments.

For example, the first one will carry about 20 different experiments.

The experiments for this spacecraft require $14.9506 million in 1964.

The CHAIRMAN. Dr. Weaver?

Dr. WEAVER. I would like to ask Dr. Newell this: Are these experiments keyed to the manned space flight, or for general knowledge?

Dr. NEWELL. These are keyed primarily to extending our general knowledge of the environment around us—the radiation belts, the interplanetary medium.

However, in being so keyed, they obtain data that are fundamental to the applications program, and the other programs, including the manned flight program.

Dr. WEAVER. We should try to limit ourselves, again coming back to this item, to the fiscal year 1963. Limiting ourselves just to, say, national security and just to our preliminary for manned lunar space flight, would we be able to cut back or not—be able to accomplish the same goals?

If we cut out we will say the general knowledge that we are getting from some of these experiments, and just stick with experiments related to our manned space flight or national security, would we get it back to 7 or 8 million?

Dr. NEWELL. This depends on how you define what is important to our national security.

The point I would like to emphasize is that no one really knows when what you described as general knowledge will become a vital element in maintaining our national security.

This program that we are describing to you is, we feel, the properly paced program to keep us advancing in the areas of geophysics and astronomy at the rate necessary to maintain our strength in science and in the things that we can do with science.

In addition, since we are well down the track on this program, we are not in a position to cut back without costing more to the overall program.

Our slowdown, we feel, was about the maximum stretchout that one should reasonably try to make.

Dr. WEAVER. Well, the answers we get through our experiments are available to all nations, isn't that correct?

Dr. NEWELL. That is correct.

Dr. WEAVER. In other words, anything we gain from this will be available to the Russians?

Dr. NEWELL. That is correct.

Dr. WEAVER. The Russians do not have to be carrying on these kinds of experiments and spend this kind of money?

Dr. NEWELL. But they are.

Dr. WEAVER. We are not gaining from their experiments at all, are we?

Dr. NEWELL. I would say not to the same degree they are from ours.

However, this is the type of race, if you wish to call it a race, in which you are safe only if you keep running.

You are not safe if you let someone else do the running for you. You are not in a position to understand thoroughly what he is doing if you are not also doing a substantial part of it.

Dr. WEAVER. If you are giving him the information you are also making it possible for him to go ahead with all of the extra cost we have involved in the program?

Dr. NEWELL. He is in a better position to play the game that way, than we are, that is true.

But we are not in a position to gain by not doing it.

The CHAIRMAN. Dr. Weaver, will you yield for just a moment?

Dr. WEAVER. Yes, sir.

The CHAIRMAN. Do you arrive at this conclusion because the United States is doing more in the field of space sciences than the Russians? Let me ask: How does our program compare with the Soviet program in this area?

Dr. NEWELL. In these areas of fundamental research, I feel that our program is considerably better than the Russian program.

The CHAIRMAN. Are we doing twice as much?

Is there any way you can compare this and be fairly accurate?

I know it is difficult, but it would help us.

Dr. NEWELL. We could give launch numbers, perhaps, but that is not a real comparison.

I would say the strength of our——

The CHAIRMAN. Haven't they stepped up this part of their program here the last 6 or 8 months?

Haven't I properly assessed this, when I read in the newspaper they have gone into the explorers, or at least the Explorer-type spacecraft, such as we are discussing now?

Dr. NEWELL. They have had a large number of what they call scientific firings during the past year.

The CHAIRMAN. How many, Doctor?

Mr. CORTRIGHT. Using Soviet-announced information, plus two Venus shots which were not announced by the Russians, they launched 15 satellites and deep space probes which they classified as scientific last year. We launched 11. This does not include any failures they might have had and did not announce, or any launchings that we may not know about.

Dr. WEAVER. They stand to benefit by all of our experiments, and we do not by theirs, is that correct?

Mr. CORTRIGHT. We publish more than they do, and probably our data are more rapidly and more readily available.

Dr. WEAVER. Is this one of the fields where we are trying to get joint international action, shall we say, in scientific exchange of ideas?

Dr. NEWELL. Yes, it is.

Dr. WEAVER. We have not succeeded?

We have succeeded partially. But this is the field we are trying to press on forward in, sharing the costs of this type of program?

Dr. NEWELL. This is an area in which we have succeeded in getting the Russians to agree in principle to develop a cooperative program, which includes sharing of information and the conduct of related operations.

That is to say, we would launch a satellite in a program, they would launch a satellite, and the two satellites together, then, make a combined program that is more effective than the one nation doing only its part.

One fundamental requirement of this program is that the data be shared completely.

Another fundamental requirement is that the United States not enter into a direct exchange of data with Russia until they are in a position to send back to us directly an equivalent amount of equivalent information.

The Russians have agreed in principle to this approach to the problem.

The CHAIRMAN. How recently was that agreement reached?

Dr. NEWELL. That agreement was the basic agreement arrived at in Geneva last spring.

The CHAIRMAN. Why are they getting more information than we are, then?

When their launches have been 15 as compared to our 11 in the past year?

Dr. NEWELL. Are you asking why is their program larger than our program?

I don't really know the answer to that.

The CHAIRMAN. I am asking why they are getting more information from us than we are getting from them, when their launches, their scientific satellite experiments, have been greater in number than ours?

Dr. NEWELL. Their publications in the open literature have not been as extensive as ours, or as rapid.

The CHAIRMAN. Do you feel that this agreement is being violated in any sense of the word?

Dr. NEWELL. The agreement is to work toward a cooperative program in which those will be the basic elements of the program.

The CHAIRMAN. Thank you.

Mr. HAMMILL. Along Dr. Weaver's line of questioning, can you explain why the Soviets bother to go into these areas at all when we publish the results of all of our experiments in the open literature? It appears they could divert those funds to other areas in their space program.

Dr. NEWELL. It is my belief that they recognize that in order to make most effective use of information that comes out of programs like this, they also have to be in the running, they have to be doing some of this.

Their scientists are not in a strong position if they are told all you can do is look, see what the United States is doing, and make use of that data.

Mr. HAMMILL. That is what our scientists do with our own data, isn't it?

In other words, the Data and Tracking Acquisition people come up with the information and they hand it over to others who analyze it?

Dr. NEWELL. Oh, no, no.

The people who analyze and interpret these data are the people who designed the experiments and followed very closely the development of the instruments and worked with the centers that were preparing the satellite, right through to the end, where they finally reduced the data and interpreted it.

In fact, it sometimes becomes almost impossible to interpret the data if you are not right in with it.

An example is that of the Mariner temperature data, wherein a little problem crept up about the interaction between the radiometer measurements and the infrared measurements, which could be understood only by the people who were living with that experiment.

The CHAIRMAN. Let me see if this is a fair statement to make.

You may have a very complicated problem when you put it on the blackboard. You provide along with it a very complicated formula to solve the problem, and then just give the answer, but don't go through the working of the problem, to tell the individual how you arrived at the answers.

Is this fairly comparable, Doctor?

Dr. NEWELL. That is a very good analogy.

The student who just sits in the class, say as an auditor, and just watches, but does not do the work——

The CHAIRMAN. He does not get anything out of it.

He does not know how he got the answer, does he?

Dr. NEWELL. That is right.

Dr. WEAVER. Mr. Chairman, on the other hand, we spend millions of dollars on the reseach experiments, and if they benefit with the subsequent knowledge, it seems to me we are giving them a chance to demonstrate communistic superiority in contrast with our superiority.

The CHAIRMAN. In the analogy that I drew, if you put the problem on the blackboard, and put the answer alongside of it, the student knows what the answer is to the problem, but does not know how to arrive at it. He does not know how to work the problem to get the answer.

My question was: How valuable is this information? That is, the answer we get from the experiment, to the Soviets, compared to the value that we get by knowing how we arrived at the answer? This was my question.

Dr. NEWELL. Your analogy was a good one.

The CHAIRMAN. The fact of the matter is, the answer is not nearly as important, then, is it, Doctor, as the way you arrived at the answer; working the problem?

Dr. NEWELL. It is not nearly as important as the understanding of how you got at the answer and the perspective in which that answer sits.

The CHAIRMAN. So though they get some information, this is really not valuable unless they go through the process. It may help them in working out an experiment of their own that is similar, but before they really benefit, they must almost go through the whole process.

Is that what you are saying?

Dr. NEWELL. They must go through a large portion of that process.

The CHAIRMAN. I would say this probably accounts for the reason why they are now embarking upon an extensive scientific program when, if the answers were of any great value, they could take the answers from our program, and not have any scientific program.

Dr. NEWELL. I suspect that may well be true.

Also, there is another point one should recognize, and that is that the total product of a program like the space sciences program is not just the papers that come directly from the funded program.

It is also the papers that come from other people, in other areas, who watch this, and then insert these products into their researches and come out with new ideas in other corners of the total research activity.

We want that product not only from our own people but also from other countries around the world who work along with us.

I think a good example of how this works is given by the carbon dating technique that has become so familiar nowadays, in which

radioactivity of materials contained in, say wood or stone, and so forth, can be used to determine how old that object is, whether it is a human artifact, or perhaps natural deposit.

The techniques of using radioactivity were known to the physicists.

The need to know the age of old deposits, paleontologic deposits, and so forth, was known to the bioscientists.

It was not until a couple of them got together in an open, unclassified meeting, that their combined knowledge was brought together to develop this new and very powerful technique.

Now if we had attempted to classify both of these into, say, only those that have a need to know will know about these techniques, we would have kept the nuclear techniques and bioscience techniques apart, and you would not have had this combined result.

Another example was given some time ago by, I am afraid I have forgotten who provided it, but it is in the nuclear field.

In the early 1930's, a paper was published by Fermi on the subject of nuclear energy.

This paper was published in the open literature. The following year several papers were published on the subject.

The following year more. Until in the late thirties there were large numbers of papers being written on this subject by people in various countries.

Out of this whole process came the ability to develop the nuclear bomb, and reactors, and so on.

If you had classified Fermi's paper, you would not have gotten the input from all of these other people, including those in the other countries. And furthermore, you would have been in trouble, because Fermi's first paper was wrong, but it stimulated a process that led to the right results.

And then there is a third point that I think one should keep in mind, and that is, that there are not really any secrets of nature.

If you attempt to classify secrets of nature, you penalize yourself more than the other country, because nature is just as ready to reveal its secrets to others as to you.

There are, however, secrets of technology. These are inventions of man, equipments, processes, and so forth.

So that if you wish to increase your position relative to the enemy's position, you should concentrate on classifying those inventions that you have made, and make him work at guessing what they were and also producing the invention. But in order to benefit by the process of exploring nature, and learning the facts of nature, the best way to do it is to keep that open and unclassified.

Dr. WEAVER. Mr. Chairman?

The CHAIRMAN. Yes.

Dr. WEAVER. My concern has been the application of this knowledge by the Russians is not the same application we are applying.

Their application is to demonstrate the communistic superiority.

We are doing it for other purposes. We can spend money on developing products, or as the English did, penicillin, but if you don't apply it we are going to have trouble.

It seems to me they can take this knowledge and are taking it to apply to their superiority and to their attempts at superiority in communistic philosophy.

This is my basic concern.

Mr. CORTRIGHT. Dr. Weaver, I would like to make a comment in response to that.

It seems clear to me that the Soviets have made a national determination to be a major "spacefaring" nation.

They recognize the stakes are high, world technological leadership in their judgment.

I think it is inconceivable they would make this determination and then rely on fundamental data obtained from a competitor to make it all possible. They recognize that fundamental data and knowledge of space is absolutely necessary for success.

It is a prerequisite to carry on with the space exploration they have in mind.

I think the same applies to us.

The CHAIRMAN. Could I make another analogy, and see if this will help the situation?

For example, was it during the Korean war the Sidewinder was developed—yes, it was; wasn't it?

Mr. HAMMILL. Yes.

The CHAIRMAN. Here is another situation. They were the unhappy target. When the first Sidewinder was fired they knew we had it, Dr. Weaver. As I say, it homed in on the target, and the principle was there for everybody to see it, an infrared sensor seeking type vehicle, and went up the tail pipe of the airplane.

But for them to develop one, or make one, that did the same thing, I suppose it was substantially different from knowing that there was one that actually had this effect, or did this kind of a job.

Is this fairly close to what you are saying?

Dr. NEWELL. This is a very good example.

The CHAIRMAN. That if the Soviets really do not conduct these experiments, so that they know how and why they arrived at the answer, indeed they get very little value from the answers that we supply as a result of our experiment?

Is this correct or not?

Dr. NEWELL. That is correct. They do not develop the experts who then, working along with their engineers, can produce things of the sort as a Sidewinder.

Mr. CORTRIGHT. You would end up intellectually tagging along all the time, rather than leading.

There is no substitute for leading.

Dr. NEWELL. Take the distinction between what one calls a scholar, and a man who is really in there with his sleeves rolled up doing something.

The scholar can be very learned, spending all his time reading books, and knowing what other people have done, but may make no contribution.

We don't want to tend that way. We want to be in there contributing, and, in order to make the maximum contribution, we have got to make our results available to the total scientific community.

We have got to be carrying out these researches. And the payoff more than offsets the disadvantages that Dr. Weaver brings out.

The CHAIRMAN. Let me ask either one of you this question.

As long as we are talking about the Nation's security, how can this program be applied to answer some of the questions we face from the

standpoint of national security? How much of the Office of Space Sciences program is valuable to the Nation's security? Mr. Cortright, or Dr. Newell?

Dr. NEWELL. I would say that the Office of Space Sciences program is an essential part of our overall national program to maintain national security.

It is true that our program is a peaceful one. It is true that our results are published in the open literature.

It is true that we do not develop weapons. But, we do gather basic data and develop the understanding of our space environment that is encountered by space weapons systems, and these data and principles have to be used in the development of those space weapons systems.

For example, we gather the information needed to protect against radiation damage. We obtain data on geodetic effects and atmospheric effects that influence a weapon's accuracy.

We provide data on the radiation hazard to man in space. And, as you know, the Department of Defense is very much concerned about being able to use the man in space capability for national security.

We gather information about solar effects on weather and climate, both of which are important to military operations and military preparations.

And we develop technology that is important in these areas when we carry out our researches; the instruments, the spacecraft, the processes that we develop are then important to the inventors who develop military space systems.

Then, finally, and this is most important, we develop the experts who then can work with the Department of Defense, who have the knowledge, experience, and feeling for what these mean, to make these data usable to the Department of Defense, and our people are constantly consulting with the Department of Defense people on what we have learned and how it can be applied.

The CHAIRMAN. Dr. Weaver?

Dr. WEAVER. The chief area where I am a little bit concerned again, too, is the fact that if the Russians have as their goal military superiority in space, and we have as our goal a manned lunar landing, are we not perhaps dissipating some of our resources and our finances into that particular phase to the detriment of our national security?

Dr. NEWELL. I think we have as our goal the national preeminence in science and technology.

That is the overall goal. And we have as a supporting endeavor the manned lunar landing effort, because that manned lunar landing effort will contribute to the overall goal in several ways.

First. If we achieve it and do a good job of it, it will be a good advertisement for our science and technology.

Second. It makes our engineers and scientists work on an exceedingly difficult problem and, in the process, makes them develop techniques and skills and abilities and accumulate facts and knowledge and ideas that are then available to our whole national economy and to our whole research and engineering complex, to do all the other things that can be done with that.

It is like an exercise that is given to a man who is working toward a degree. He is working toward a degree as his main objective at

the moment, but the byproduct that he really wants is the ability to go out in the world and do things, get a job.

This is the sort of byproduct we are after.

This lunar landing project then serves as a focus for obtaining that byproduct in a very effective way.

The CHAIRMAN. Thank you very much.

Dr. Weaver, do you have something else?

Dr. WEAVER. That is all at this time.

The CHAIRMAN. I wonder if we could adjourn for the day on that note, Doctor?

We don't have authority to sit while the House is in session. Hopefully we will get through the backup book tomorrow.

Dr. NEWELL. All right, sir.

The CHAIRMAN. We will adjourn until 10 o'clock tomorrow morning.

Thank you very much.

(Whereupon, at 12:07 p.m., the subcommittee was adjourned, to reconvene at 10 a.m., Thursday, March 14, 1963.)

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1964 NASA AUTHORIZATION

THURSDAY, MARCH 14, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SPACE SCIENCES
AND ADVANCED RESEARCH AND TECHNOLOGY,
Washington, D.C.

The subcommittee met at 10 a.m., pursuant to adjournment, in room 304, Cannon Building, Hon. Joseph E. Karth (chairman of the subcommittee) presiding.

The CHAIRMAN. The meeting will be in order.

Dr. Newell, I think that yesterday when we adjourned, we had just completed the discussion of the orbiting geophysical observatory; is that correct?

Dr. NEWELL. We had completed the experiments portion of the orbiting geophysical observatory.

The CHAIRMAN. Would you care to proceed, Dr. Newell?

FURTHER STATEMENT OF DR. HOMER E. NEWELL, DIRECTOR, OFFICE OF SPACE SCIENCES, NASA, ACCOMPANIED BY EDGAR M. CORTRIGHT, DEPUTY DIRECTOR, AND ELDON D. TAYLOR, RESOURCES MANAGEMENT OFFICER

Dr. NEWELL. Thank you, Mr. Chairman.

We have been looking at the numbers that the committee gave us yesterday on comparison of present operating plans for the fiscal year 1963 with the request, and are in a position, if the chairman wishes, to provide a more complete answer to the questions you gave us yesterday.

If you would wish us to do so, I would like to ask Mr. Taylor to give that to you.

The CHAIRMAN. Yes, please proceed.

Mr. TAYLOR. Mr. Chairman, after reviewing the material that we were provided yesterday, I would like to say just a few things to clarify our testimony of yesterday.

As we mentioned to you, there are three things which can affect the numbers presented to you last year in 1963, and the number that you see in the 1963 column this year.

One of these things that can affect it is the application of salaries and other overhead expenses.

I discussed part of this at some length yesterday.

So that it won't be a misrepresentation, this segment is a very small part of the total. It is only about $3½ million.

In other words, last year our total salaries and support amounted to $57 million in space sciences.

This year the same application of salaries and support amount to about $53.5 million.

So that portion of our discussion was addressed to this $3.5 million adjustment, or this $3.5 million better estimating.

Another thing that can affect the budget, or affect the comparison of them, are re-structurings, and we have had some re-structurings from last year to this year.

The third thing that can affect it are the reprogramings, which we have been discussing item by item as we go through the book.

The CHAIRMAN. What was the second one?

Mr. TAYLOR. Restructuring.

The CHAIRMAN. Do you care to clarify that?

Mr. TAYLOR. Yes, sir. As an example, the effort that we presented to you last year in our supporting research and technology. When we completed our reorganization, it was obvious that some of this effort should be monitored by the Office of Advanced Research and Technology.

So about $14.3 million that was included in our program as basic work was transferred to the cognizance of the Office of Advanced Research and Technology.

A third thing that can affect this are the reprogramings we have been going over.

If you would allow me just to summarize in total, the total sheet that you have, I think it will become very clear what these differences were.

When we make some minor adjustments in the first column to make this the true research development and operation amounts in our budget last year, this adds up to about $550.6 million.

If we compare that R.D. & O., including salaries and support, with the column you have called Original Budget, which would be the conversion to R. & D., as opposed to R.D. & O., there is a difference of $71.1 million, and this is the area in which you were interested. What are these differences?

Now, that difference of $71.1 million——

The CHAIRMAN. That $71 million differs quite substantially from what we have, is that correct?

Mr. TAYLOR. Yes, sir. We made some adjustments in the 1963 request.

The CHAIRMAN. In other words, your figure is double what I have here.

Mr. TAYLOR. Approximately, yes, sir.

The CHAIRMAN. Your budget request was about $25 million more than I have on my sheet.

Mr. TAYLOR. Yes, sir. There are certain discrepancies in this sheet. For instance, the sounding rocket line, on your first page, was omitted completely from the sheet, and this is $19.1 million.

The CHAIRMAN. I see.

Mr. TAYLOR. So there are discrepancies like this, sir.

The CHAIRMAN. The sounding rockets and geoprobes, I guess, are what you are referring to here on page 1?

Mr. TAYLOR. Yes, sir.

The CHAIRMAN. All we have on our sheet is the $4.3 million for the Geo program?

Mr. TAYLOR. Yes, sir.

The CHAIRMAN. The sounding rockets was 19-what?

Mr. TAYLOR. $19,157,000.

When you adjust for these types of discrepancies the total comes to $550.6 million.

The difference is $71.1 million. Fifty-seven million of that difference is just personnel and support. We were comparing apples and oranges before, the apples being R.D. & O., which includes personnel and support and the other column being just the R. & D. So $57 million of that difference is just our personnel and support effort that we submitted to you last year.

The other difference is the $14.3 million that I just discussed with you, transfers of effort to the Office of Advanced Research and Technology.

The CHAIRMAN. Any other explanation you would like to give?

Mr. TAYLOR. No, sir; I think that will clarify our testimony for the record.

The CHAIRMAN. Thank you very much, Mr. Taylor.

Dr. Newell?

Dr. NEWELL. For the Orbiting Geophysical Observatories, in addition to the fund which we have discussed for spacecraft and experiments, there are requirements for ground operations, totaling $8 million, and for test and support, totaling $1.6 million, brings the total for spacecraft support, testing, and so forth, to $39.6 million, at the bottom of page 28. This compares with $27.5 million for 1963.

The CHAIRMAN. Mr. Morris?

Mr. MORRIS. How much of your 1963 money is unobligated? Do you have that?

Dr. NEWELL. Slightly less than half remains unobligated, sir.

Mr. MORRIS. Thank you.

The CHAIRMAN. Slightly less than half of what, Doctor—of the $27.5 million?

Dr. NEWELL. Of the total, in fact, it is quite a bit less than half. Let me give you the numbers. The obligations are $19.59 million, so we have to subtract that from the 27.5, so it is quite a bit less than half which remains unobligated.

Mr. MORRIS. Unobligated is about $8 million of the 1963 money.

The CHAIRMAN. $19 million is obligated?

Dr. NEWELL. Yes.

The CHAIRMAN. So there is about nine unobligated?

Dr. NEWELL. Yes; quite a bit less than half remains unobligated.

Mr. MORRIS. Under your program, as it looks now, this will be obligated by the time the 1964 budget money is available?

Dr. NEWELL. Yes, it is quite clear. The numbers we have are through January, so we have the month of February and part of March behind us also.

The CHAIRMAN. Well, most of these funds, if not all of them, in all of the project areas, are contracted for, aren't they?

That is, these contracts have been let to cover the dollar amounts of money that you received for fiscal 1963. Or are we going to have a nice healthy-looking balance sheet at the end of the fiscal year?

Dr. NEWELL. You mean by "healthy looking balance sheets," money left over?

The CHAIRMAN. Surplus, yes.

Dr. NEWELL. No; we will not have any surplus. A large fraction of these moneys go into contract.

For example, the amount to the systems contractor, the space technology laboratories, is $13.6 million.

The CHAIRMAN. The point is, all of your funds are in effect obligated, aren't they, or will be as of the 30th day of June?

Dr. NEWELL. They will be, yes. The commitments as you know run well ahead of the obligations, and the commitments are almost up to the $27 million.

Mr. MORRIS. Doctor, do you issue a letter of commitment?

The different agencies, and even within agencies, it seems to me they use different terminology and the different procedure.

When you say "committed," does that mean that you have issued a letter of commitment to someone for this money?

Dr. NEWELL. That means that within the agency——

Mr. MORRIS. Or is it a verbal commitment or just a plan?

Dr. NEWELL. No; this means within the agency, the moneys are assigned to this project and the process of bringing this to obligation is underway.

Mr. MORRIS. This is just an intra-agency commitment?

Dr. NEWELL. An internal agency commitment, yes.

Mr. MORRIS. When I think of an obligation, and when I was asking the question I was thinking of it as something whereby you had obligated your agency to spend that money.

In other words, you had signed a contract for that much money?

Dr. NEWELL. We use that the same way.

Mr. MORRIS. You think of it the same way?

Dr. NEWELL. When we make a commitment we have set those moneys aside, they cannot be used by anyone else for anything because we are in the process of working out a contract, negotiating with the contractor, obligations necessarily lag these commitments.

Mr. MORRIS. Suppose you have money committed and they just reprogram it.

Dr. NEWELL. They cannot. That is the agency's protection against that happening. When these are committed, they are nailed down so when the negotiation is complete the moneys are there. When the negotiation is complete, these become an obligation.

The CHAIRMAN. What is the difference in amount between the committed funds and the obligated, Doctor?

Dr. NEWELL. At the present time, the commitments are $23.2 million and the obligations are $19.5 million.

The CHAIRMAN. Mr. Morris?

Mr. MORRIS. This brings up a question.

What has the agency indicated they are going to do with the difference between the $23 and the $27 million which the committee authorized for this project?

Is this part of the reprograming "kitty," that may be used to reprogram?

Dr. NEWELL. No. These are to continue our work on the geophysical observatory, and these funds will be committed in the process of this year, and will be obligated, also, in the process of this year.

Mr. MORRIS. But they could, Doctor, since they have only committed to your office $23 million of the $27 million which the committee authorized for this project—this $4 million could be subject to reprograming?

Dr. NEWELL. It could be, technically, yes, but we have the funds assigned to the program.

It would not be good business to pull the funds away, unless our expenses or anticipated requirements did not need it, but that is not true.

Mr. MORRIS. Wouldn't it make it easier for you to run a project if the committee authorized $27 million and then that was a commitment to that project?

Wouldn't it be a little bit easier for you to plan your work for the next 12 months if you knew that money was going to be there, and was committed when authorized?

Dr. NEWELL. These moneys are in the hands of the Office of Space Sciences. Commitments are made upon our recommendation that we are now in a position to go forward with negotiation of the contract.

These funds are then committed, and we go ahead with negotiating the contract.

These $4 million you are referring to are in our hands to use on this project. It is our intention to do so.

Mr. CORTRIGHT. They are actually in the hands of the project manager at Goddard Space Flight Center but he has not started processing papers through the pipeline to commit that money to the contractor, or other procurements.

So it is not sitting in a pool someplace waiting to be reprogramed. It is set aside and assigned to this project.

Mr. MORRIS. All right. That is all I have.

The CHAIRMAN. Following that just one step further: What if some superior should say to you, Dr. Newell, that he thinks they need that $4½ million somewhere else? What do you do about it? Does someone else have that veto power, if I may call it that?

Dr. NEWELL. The top management, of course, has complete control of the NASA funds. If they should say to us they need that $4 million, then we will have to show to them what we need it for.

The CHAIRMAN. Are you saying to us that no matter what we authorize for an individual program, the Congress has not any control over that? That really the Administrator in this case can shift and reprogram and spend those funds as he sees fit?

Dr. NEWELL. I am saying that the legislation which the Congress passed gave the Administrator that reprograming authority within the R.D. & O. appropriation.

The CHAIRMAN. Well, yes, some authority.

Dr. NEWELL. With certain limitations.

The CHAIRMAN. But within a project area, there is no limitation, is there?

I mean only 3 percent of the OSS funds, for example, can be reprogramed in the manned space flight, or vice versa; isn't that it?

Dr. NEWELL. There is no limitation on the transfer of funds between projects in the R.D. & O. appropriation.

The CHAIRMAN. Mr. Hammill informs me that the percentage figure I was thinking of is not 3, it is 5; 5 percent of one appropriation

may be transferred to another appropriation. I thought we had changed that to three, but apparently not.

Dr. NEWELL. The reallocation authority within R.D. & O. is not so limited.

The CHAIRMAN. Yes. Some funds may be transferred from construction of facilities to research and development, or vice versa.

Dr. NEWELL. It is vice versa, subject to the reprograming authority in the authorization act.

The CHAIRMAN. Let's talk about research and development. What limitation is there?

Dr. NEWELL. From project to project there is no limitation.

The CHAIRMAN. What about within construction of facilities; is there no limitation there either?

Dr. NEWELL. There is a whole series of limitations on the reprograming of construction funds which we will be glad to discuss in detail at your convenience.

The CHAIRMAN. Mr. Hammill?

Mr. HAMMILL. Mr. Cortright mentioned earlier that this $4 million was not sitting in a pool someplace to be reprogramed in connection with this particular item we are talking about.

Now, is the implication of your remark that there is a pool someplace waiting to be used?

Mr. CORTRIGHT. Absolutely not.

What I meant was the following: The way we develop our financial planning for the year is as follows: we write what are called project approval documents with the Associate Administrator. When he and Dr. Newell sign this document, it constitutes an internal contract between the Office of Space Sciences and general management to carry out a specific project.

For example, in this case, the OGO, the project approval document tells us that the Associate Administrator has set aside so many dollars for OGO. This money is made available for the Office of Space Sciences, and we, in turn, transfer it to the Goddard Space Flight Center.

The money is inviolate unless the general management makes a determination that there is an overriding emergency which would require us all to reexamine our project approval documents and our plans for expenditures that year.

The CHAIRMAN. Yes; but that overriding emergency may be only in his mind. He does not have to prove to anyone, including the subagency within the agency. When he intends to transfer money from project X to project Y, he does not have to prove to anyone that there is an overriding emergency; does he?

Dr. NEWELL. Except in the case of facilities, he must notify the Congress.

The CHAIRMAN. But really, in fact, Mr. Cortright, I guess we could say it would be just as accurate as you are, that this money goes into one great big pool, subject to transfer at the discretion of the Administrator.

Mr. CORTRIGHT. In the sense that the Administrator has the legal authority granted by Congress to reallocate funds within the overall R.D. & O. appropriation.

The CHAIRMAN. Subject to the limitations spelled out in the legislative authority; is that correct?

Mr. CORTRIGHT. Yes; that is correct. I don't think it is accurate terminology to refer to it as a "pool," because we do, in fact, attempt to adhere to the program which we present to you and which you authorize.

The CHAIRMAN. I am just using your word.

Mr. CORTRIGHT. I will try to think of a different one.

The CHAIRMAN. I agree with Mr. Morris. It seems to me that Dr. Newell, for example, who is head of the Office of Space Sciences, could be in a very embarrassing position, if not a very critical one, if for some reason the Administrator decided Dr. Newell did not need the $14,950,000 for the OGO experiment, as much as the Administrator decided he needed it for something else.

Mr. CORTRIGHT. He has that authority.

The CHAIRMAN. And so all of the reasons why we need OGO, as you have very ably explained to this committee, could go for naught; isn't that correct, Doctor?

Dr. NEWELL. Technically, yes. Of course the Administrator and Associate Administrator have the responsibility of managing the total program so as to come forth with the most effective total program for the country.

The CHAIRMAN. Yes; there is no doubt in my mind but what this is not going to be done promiscuously.

The point I am sure you are attempting to make is that the Administrator does have this authority.

Dr. NEWELL. That is correct.

The CHAIRMAN. And there are no limitations one way or the other, except for those spelled out in the organic act limiting him to transfer of funds for reprograming.

Dr. NEWELL. That is correct with respect to the reprograming of the funds within the R.D. & O. appropriation.

The CHAIRMAN. As Director of OSS, have you had any problems with this?

Dr. NEWELL. Well, as a matter of fact, as the numbers show this year, the Office of Space Sciences came out ahead with $45 million to shore up the Centaur project and make two new starts.

Mr. MORRIS. In the reprograming and reshuffling of money around in NASA, how did the Office of Space Sciences come out in total?

Did you get less money than the committee extended to you last time?

Dr. NEWELL. We got $45 million more than we had presented to the committee.

Mr. MORRIS. Maybe this is where the manned space flight program was affected—we can say a part of their money went to your office.

I was down there and they were complaining that they were reduced about $200-and-some-odd million.

Dr. NEWELL. I heard tell they said that.

Mr. MORRIS. This is what brought this whole thing to mind, because it looks to me, Mr. Chairman, there is quite a bit of room for shifting around, maybe too much.

For instance, the Department of Defense can only reprogram $2 million at each command.

Mr. RANDALL. There seems to be some difference here.

You talk about 3 percent and 5 percent, and then within certain limitations R.D. & O. funds can be used for the construction of facilities. Could we go around the track on that again?

Dr. NEWELL. The story is that in terms of overall reallocation within the R.D. & O. appropriation there is no limitation. There are specific limitations in the authorization act with respect to the use of R.D. & O. funds for facility construction.

Mr. RANDALL. No limitation within R.D. & O.?

Dr. NEWELL. That is right.

Now, in the transfer of funds from R.D. & O. to the "construction of facilities" appropriation, there is a limitation of 3 percent on the amount that can be used for new facility projects.

Mr. RANDALL. Either route?

Dr. NEWELL. No, the 3-percent is from R. & D. to "Construction."

Mr. RANDALL. Is there any other limitation?

Dr. NEWELL. Mr. Taylor?

Mr. TAYLOR. You may transfer within the construction appropriation.

Mr. RANDALL. Without any limitation?

Mr. TAYLOR. No, sir; the authorization for a particular location may be increased by not to exceed 5 percent.

The CHAIRMAN. Would you say that once more?

Mr. TAYLOR. Yes, sir.

There are several types of appropriation transfer and reprograming authorities, and I realize that they may get confusing at times.

Perhaps we could run down these for the record.

Dr. NEWELL. The reprograming within R.D. & O. is without limitation.

The CHAIRMAN. I think that is right. That is why I was confused, Doctor.

We will have the staff check it and make sure the committee members are informed as to the precise authority that the Administrator has in transfer or reprograming of funds.

I think we will let it go at that.

Mr. RANDALL. Thank you.

Mr. CHENOWETH. What is this 5 percent you are talking about?

Mr. TAYLOR. There is authority that allows the Administrator to transfer 3 percent of the R.D. & O. funds to the construction appropriation, for unanticipated facility items.

Mr. CHENOWETH. Who fixed this 3 percent?

Mr. TAYLOR. The Congress.

Mr. CHENOWETH. Statutory limitation?

Mr. TAYLOR. Yes, sir.

Mr. CHENOWETH. You can take not more than 3 percent out of R. & D. funds for construction on any appropriation.

Mr. TAYLOR. Yes, sir; for new projects. An additional 2 percent of the R.D. & O. appropriation can be transferred to the CoF appropriation to fund authorized but unfunded construction projects.

Mr. CHENOWETH. That is a total of 5 percent?

Mr. TAYLOR. Yes. There is also within the construction appropriation, the authority to provide a minimal flexibility of 5 percent for

the transfer of funds between NASA installations to meet unusual cost variations.

Mr. CHENOWETH. The R.D. & O. appropriation has nothing to do with that?

Mr. TAYLOR. No, sir.

Mr. CHENOWETH. The 3 percent is what you are concerned with. They can't take more than 3 percent away from you.

Mr. TAYLOR. Out of R.D. & O. into construction for new projects; yes, sir. The total transfer authority from R.D. & O. to the "Construction" appropriation is 5 percent of which only 3 percent can be used for unauthorized or new projects.

Mr. CORTRIGHT. Regarding the point Mr. Taylor was making on the R.D. & O. appropriation, the Administrator can move R.D. & O. funds as he sees fit, without limitation, as long as it stays within R.D. & O.

Mr. CHENOWETH. He determines where the R.D. & O. funds go?

Mr. CORTRIGHT. That is correct.

Mr. CHENOWETH. That is the decision for the Administrator to make?

Dr. NEWELL. That is true.

Mr. CHENOWETH. He does not do it arbitrarily and capriciously, of course. Has your office run into difficulty because of such transfers?

Dr. NEWELL. No; as I said, we came out very well.

Mr. CHENOWETH. Do you have anything left over at the end of the year?

Dr. NEWELL. We never have funds left over at the end of the year we don't need.

Mr. CORTRIGHT. What was our obligation rate last year, Mr. Taylor?

Mr. TAYLOR. I don't remember the exact number, but it was within—our unobligated amounts were approximately 1 percent or less of the total. They were very close to the legal limitation of obligations last year.

The CHAIRMAN. Dr. Newell, I wonder if you would supply for the record so I won't have to continue asking you at the end of each project item—if you would supply for the record the amount of moneys reprogramed in each one of the areas that I have been asking you for the figure throughout the entire program?

Dr. NEWELL. We would be glad to do that.

The CHAIRMAN. Would you do that?

Dr. NEWELL. Yes.

(The information requested is as follows:)

OFFICE OF SPACE SCIENCES

Fiscal year 1963 reprograming—Summary of research and development

[In thousands]

Program/project	Fiscal year 1963 budget	Fiscal year 1963 column of fiscal year 1964 budget	Plus or minus difference
Total, R. & D., Office of Space Sciences	$479,493	$525,279	+$45,786
Geophysics and astronomy	151,900	144,500	−7,400
S.R. & T.	16,500	13,700	−2,800
Energetic particles	200	10,500	+10,300
Interplanetary monitor		5,000	+5,000
Atmospheric structure	200	4,000	+3,800
Topside sounder (S-48)	200	1,000	+800
Ionosphere monitor	2,000		−2,000
OGO	55,100	38,500	−16,600
OSO	13,600	11,350	−2,250
OAO	42,700	36,100	−6,600
International	5,400	12,850	+7,450
Sounding rockets and geoprobes	16,000	11,500	−4,500
Lunar and planetary	246,300	221,179	−25,121
S.R. & T.	10,760	20,244	+9,484
Ranger	42,022	78,970	+36,948
Surveyor	95,678	61,696	−33,982
Prospector	10,000		−10,000
Mariner (Venus flyby)	9,240	9,096	−144
Mariner (Mars flyby)		29,400	+29,400
Mariner (Lander)	72,100	18,273	−53,827
Voyager	6,500		−6,500
Pioneer		3,500	+3,500
Bioscience	7,093	21,000	+13,907
S.R. & T.	3,000	10,050	+7,050
Flight program	4,093	10,950	+6,857
Launch vehicle development	64,200	108,000	+43,800
S.R. & T.		2,000	+2,000
Scout	4,200	4,200	
Centaur	60,000	92,900	+32,900
Operational support		8,900	+8,900
Sustaining university program	10,000	30,600	+20,600

Mr. MORRIS. Mr. Chairman, could I ask a question at that point?

The CHAIRMAN. Yes.

Mr. MORRIS. How are you going to have this?

What form will it be in, in what form are you asking for it?

Are you going to have the amount of money reprogramed within the whole agency, or is it going to be broken down?

Dr. NEWELL. On each project item.

The CHAIRMAN. Yes. I am sure the Doctor understands it to be that.

Dr. NEWELL. Just to clarify this, we have provided a piece of paper which shows the fiscal year 1963 budget number, then the fiscal 1963 column in the fiscal 1964 budget books, and between these two, then, you get the amount of reprograming that occurred.

The CHAIRMAN. I see.

Dr. NEWELL. In addition, as of January, the end of January, 1963, our commitments and obligations are shown.

Mr. MORRIS. Do you have an extra copy of that so the rest of us might have one?

Dr. NEWELL. These were supplied.

Mr. MORRIS. Why weren't they given to the rest of the committee?

Mr. RANDALL. I would like to know that question also, and Mr. Chairman, I would like to say for the record we are asked here to do some computing, some subtraction and so forth.

I wrote a letter to your office yesterday, because I was not able to be here because of another committee, in which I asked for a list of these reprograming items, the amount, when it occurred, and the purpose.

I hope we can get that.

Dr. NEWELL. This list——

Mr. RANDALL. Doesn't this require some computation to arrive at the figure as to exactly what was reprogramed?

The CHAIRMAN. Very little.

Mr. RANDALL. By your testimony I thought you said you had to subtract this from that, in each case.

The CHAIRMAN. I might say to the committee members, the reason they may not have the tabulation that Dr. Newell is now quoting from is because the day they supplied them to the committee, you probably were not in attendance, and the staff did not give them to you the next meeting you came to. This is the reason.

But there is certainly no effort on the part of the committee chairman to withhold from the committee members any material.

Mr. RANDALL. I was not making that suggestion.

Mr. Chairman, I don't know how many of these things are involved, but it appears to me it should not be too big a job.

The CHAIRMAN. It is all right here, I guess.

Dr. Newell is correct when he says this is prepared. The only thing we must do here to get the answer that I requested is to subtract one number from the other, and then you have the amount of money that was reprogramed in dollars and cents.

Mr. CORTRIGHT. The rationale that went into these reprogramings has been supplied in the posture hearings and in a subsequent reading also.

Dr. NEWELL. There was a piece of paper which I submitted to you, Mr. Chairman, which gave the rationale for these items.

The CHAIRMAN. Yes.

Dr. NEWELL. We started through it and then left it for later. It is now part of the record. It is this piece of paper labeled "Summary."

The CHAIRMAN. Yes, I recall it.

(The information requested is as follows:)

OFFICE OF SPACE SCIENCES

FISCAL YEAR 1963 REPROGRAMING—SUMMARY OF RESEARCH AND DEVELOPMENT

To first summarize the reprograming, the total R. & D. budget for OSS was submitted as $479,493,000 for fiscal year 1963. Our budget submission this year shows that we are actually operating in fiscal year 1963 on a budget of $525,279,000, an increase of $45,786,000. What caused this increase? We initiated a flight program in biosciences and began developing the experiments to support it at a new increase of $13,907,000. We increased our effort on the Centaur in order to hold an operational date of 1964. Including an increase in operational ground support this increased our budget by $43,800,000. Lastly, we increased our sustaining university program by $20,600,000 from its original $10 million figure. These major increases totaled $78,307,000.

To partially offset these increases, the geophysics and astronomy program was decreased by $7,400,000 and the lunar and planetary program by $25,121,000.

These reductions left a new requirement of $45,786,000 which was added to the space science program.

Within the individual elements of our programs, other reprograming actions were required and they fall within these gross changes.

Geophysics and astronomy.—A significant event which influenced our programing this year was the high altitude nuclear tests. Immediately following the detection of significantly increased trapped radiation surrounding the earth, we initiated a project to investigate it. By using existing parts and technology and rescheduling the Delta launch vehicle, we were able to launch about 2 months after go-ahead. The flight was highly successful in determining the nature, extent, and probable lifetime of the artificial belt. Its cost was about $10 million for two flights, the second of which has now been deferred.

During the past year, it was determined that we needed more data on solar radiation to prepare for manned flight to the moon. Solar monitoring should be nearly continuous until we understand the sun and its disturbances much better than we do now. We thus instituted a series of three small Delta launched spacecraft called interplanetray monitors (which will orbit the earth in highly eccentric orbits. This project, which will have its first flight this year, required $5 million in fiscal year 1963.

In addition, we have completed negotiations with the Italian Government and are underway with a cooperative program which will culminate in an equatorial launch by a Scout of an Italian satellite. The launch will take place from a platform in the Indian Ocean off the east coast of Africa in 1964. Our part of this program is $6 million in fiscal year 1963.

These constitute most of the increases within geophysics and astronomy in fiscal year 1963. Decreases in other projects have more than counterbalanced this. The S.R. & T. effort has been reduced, thereby permitting a reprograming of $2.8 million; $2 million was saved on the Ionosphere Monitor by the decision of the Canadians to develop this satellite as they did the highly successful Alouette. We will again provide the launch services. It was possible to reduce the OGO project costs by rescheduling the follow-on launches for a later start and a launch rate of three per year rather than four. This resulted in a reduction of fiscal year 1963 fund requirements of $16.6 million. The success of OSO-I permitted us to defer the second launch while making some improvements, thus reducing fiscal year 1963 requirements by $2.2 million. OAO has slipped due to technical difficulties. We also rescheduled the follow-on launch and reduced the rate from every 6 months to every 9 months, thus hoping to operate at $6.6 million less in 1963. The last saving in G. & A. is the $4.5 million in sounding rockets and geoprobes. This was made possible by eliminating Scout-sized rockets, and by the fact that meteorological sounding rockets were funded by the Office of Applications.

Lunar and planetary.—A number of important changes accompanied the net reduction of $25,121,000 in the L. & P. program. The increase in S.R. & T. was necessary to permit additional study effort on advanced programs such as Voyager in lieu of hardware funding. Operating funds for JPL research constitute a major function of this money. Project Ranger was increased $36,948,000 to provide initial funding for five additional flights, bringing the total of approved flights to 14, with 5 already complete. This increase reflects the urgency of getting some early information about the lunar surface in support of Apollo. Project Surveyor was decreased by $33,982,000, although it continues as a high priority project. About two-thirds of this resulted from deferral to fiscal year 1964 of the lunar orbiter. The balance resulted from the Centaur slippage which postponed the date on which operational projects, such as Surveyor, will be charged for developed launch vehicles. Project Prospector was eliminated with a saving of $10 million.

In the area of planetary projects, the total funds were decreased about $27.5 million. This occurred as follows: Delays in the Centaur forced us to rely on the Atlas-Agena in 1964 for fly-bys rather than landers. The Centaur-launched lander was thus deferred to 1965. Mariner II was so successful that the 1964 Venus fly-by was canceled. The Mars fly-by in 1964 is proceeding under high priority. The Voyager project has been deferred at least another year and will continue with additional studies in fiscal year 1964.

We did have one new start in the L. & P. area. Project Pioneer, costing $3.5 million in fiscal year 1963, will provide radiation and field measurements from distances up to 50 million miles throughout the International Year of the Quiet Sun. These measurements will support our national participation in the world-

wide program as well as support our own efforts to understand the sun and its disturbances.

Biosciences.—For several years, we have been carefully studying the need to conduct fundamental experiments in the biological sciences in the radiation and weightless environment of space. The Soviets decided early and have conducted short duration flights. We have now determined that the need is for flights of very long duration, i.e., 2 weeks up to a year or more. These tests will initially be exploratory and will serve to determine the most promising areas for future studies. The longest duration flights will answer questions posed by manned planetary flights which will exceed 1 year. This program will cost an additional $13,907,000 in fiscal year 1963, equally divided between the flight programs and the supporting experiments.

Sustaining university program.—This program is designed to enable our universities to develop their full potential in support of the national space program. Where outstanding research teams exist and can help if funded, or where such teams can be built up with funds, such supporting research funds are provided. Where these groups are in dire need for facilities, they are provided. And where outstanding faculty groups are available to train more young men in graduate work, fellowships are provided to encourage such advanced study. The increase of $20.6 million in fiscal year 1963 over that amount programed in our first submission provides for a total of $15 million for training grants, $5.6 million for multidisciplinary research in support of our total program, and $10 million for needed facilities.

Launch vehicle development.—The need to increase our launch vehicle development funds was known and discussed with you last year. Nearly all of this $43.8 increase was required to rectify technical problems in the Centaur development. These steps, which I will discuss with you at a later hearing, are well underway, and we now feel that we are coming out of the woods on this project—although much remains to be done. Among the major requirements for these additional funds were: increased ground testing of the total system and its major subsystems; structural improvements; insulation panel improvements; and stage separation improvements. In general, we are ruggedizing this vehicle and simplifying its mission profile to reach operational status late next year.

The CHAIRMAN. While this is being done, Doctor, I think we can just continue through the budget items, then.

Dr. NEWELL. If we add the total for launch vehicles at the top of page 29, of $22.2 million to the total for spacecraft and support, we get the total figure for orbiting geophysical observatories of $61.8 million in 1964 as compared to $38.5 million for 1963.

Mr. RANDALL. What page is that, Doctor?

Dr. NEWELL. At the top of page 29.

The CHAIRMAN. About half of that is for additional launch vehicles, as I view it.

Dr. NEWELL. $22.2 million is the total for ——

The CHAIRMAN. I mean half of the addition, Doctor—about half of the increased amount, 64 over 63, is for additional launch vehicles.

Is that correct?

Dr. NEWELL. That is correct.

The CHAIRMAN. There is no way of reducing this, unless you don't want to fly the experiments after they have been prepared.

Dr. NEWELL. That is correct.

The CHAIRMAN. Do you care to go to geodesy?

Dr. NEWELL. In geodesy, which refers to Project ANNA, the geodetic satellite project started by the Department of Defense has been transferred now to NASA for management.

We have requested a funding of $3.4 million for spacecraft and support, and funding of Delta launch vehicles to the amount of $2.8 million, totaling $6.2 million.

And if we then add up the totals for geophysics, add up the subtotals, we get $88.6 million for the geophysics program.

The CHAIRMAN. Are there any questions?

Mr. MORRIS. Yes.

The CHAIRMAN. Mr. Morris?

Mr. MORRIS. On the geodesy program, you say it was transferred from DOD to NASA?

Dr. NEWELL. That is correct.

Mr. MORRIS. Was it funded in DOD in 1963?

Dr. NEWELL. That is correct.

Mr. MORRIS. What was the level of funding?

Dr. NEWELL. I don't know.

The CHAIRMAN. I am not sure what it was, either.

I might just say for the benefit of Mr. Morris, it was this subcommittee last year that looked into Project ANNA, on the basis of a suggestion that was made by Dr. Whipple——

Mr. HAMMILL. Correct.

The CHAIRMAN (continuing). When the Scientific Advisory Committee appeared before the full committee earlier in the year.

And he suggested that the ANNA project, which means Army, Navy, NASA, Air Force, Geodetic Satellite, be declassified, I believe.

At that time it was classified as secret. And as a result of his suggestion, the chairman of the full committee felt it might be appropriate for the subcommittee to look at it at least.

We did that, and the Department of Defense, I think shortly before we had our hearings, declassified the project.

Mr. HAMMILL. Yes.

The CHAIRMAN. And every one agreed that probably it should be in NASA, rather than the Department of Defense, just because of the nature of the experiment.

How much money was funded at that time, Mr. Morris, for it, by the Department of Defense, I just don't recall.

The fact of the matter is I am not sure we tried to find out.

Mr. HAMMILL. No, we did not.

The CHAIRMAN. I think it was substantially more than what is being funded for here.

Mr. MORRIS. It might not be pertinent to the record, but it would be interesting to know what level they were funding it at, and then what level NASA is funding it at.

The CHAIRMAN. I will ask for that.

Mr. MORRIS. I think we might find out.

(The information requested is as follows:)

OFFICE OF THE DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING

WASHINGTON, D.C.

APRIL 10, 1963.

Memorandum for the Executive Assistant, Research and Engineering.
Subject: ANNA funding.

I have been requested by Colonel Coe in Legislative Affairs to submit, through you, information on DOD funding for Project ANNA to date. The following is a summary through fiscal year 1963:

	Million
Air Force	$3.2
Army	2.1
Navy	[1] 8.2
Total	13.5

[1] Does not include $800,000 fiscal year 1963 emergency funding for which Bureau of Budget approval is pending.

I consider these totals to be unclassified.

F. W. AULT,
Captain U.S. Navy,
Office of Special Assistant for Space.

The CHAIRMAN. Doctor, solar physics.

Dr. NEWELL. We go on to solar physics.

The orbiting solar observatories, which are the observatories we have launched and are about to launch, we need for spacecraft experiments, operations, test and support, a total of $10.1 million, and for Delta launch vehicles, $4.8 million, giving a total of $14.9 million.

The CHAIRMAN. Now, what is the reason for the increase in the spacecraft amount, Doctor?

Does this mean you are providing additional spacecraft, or the experiment is farther down the road, so you are reaching peak funding, or what is this, you are getting closer to it?

Dr. NEWELL. Providing additional spacecraft and additional experiments for follow-on observatories.

The program is a continuing one in which we will use solar observatories for a number of years yet to come, and these additional funds provide for the continuing construction of spacecraft and experiments.

The CHAIRMAN. My question was really, are you funding for the same spacecraft in the 1964 budget request, or is it for additional spacecraft?

Dr. NEWELL. This is for additional ones.

The CHAIRMAN. How many orbiting solar observatories do we have in the total program at this time, Doctor?

Dr. NEWELL. Eight.

The CHAIRMAN. Eight?

The funding that has been made for this program, plus the budget requested this year, will fund how many of the eight?

Do you have an estimated cost per bird, on this?

Mr. CORTRIGHT. The total cost per launch of an OSO, including launch vehicle, is about $8 million.

The CHAIRMAN. And this was first funded for at the 1962 budget, is that correct, or were there some funds prior to that?

Mr. CORTRIGHT. There may have been.

The CHAIRMAN. If so, I suppose they are fairly minor.

Dr. NEWELL. It is one of our early projects, but I also think you are right, that the 1961 funding was minor.

Mr. CORTRIGHT. There was $5.523 million funded before fiscal 1962, total.

The CHAIRMAN. How much?

Mr. CORTRIGHT. $5,523,000.

The CHAIRMAN. Thank you.

So with this request, we will have funded for about two of the eight, is that the kind of arithmetic you would agree with?

Mr. CORTRIGHT. Yes. This will essentially complete the funding of the first three and provide for initiation of the follow-on series.

The CHAIRMAN. Any other questions?

Doctor, would you care to go to the advanced orbiting solar observatory?

Dr. NEWELL. As we described in the general part of our testimony, it has become plain that the pointing accuracy of the current version of the orbiting solar observatory must be improved by a considerable amount in order to conduct the advanced researches that our astronomers now have in mind.

Therefore we are proceeding at the present time with the design and plans for an improved orbiting solar observatory which is labeled here "Advanced Orbiting Solar Observatory."

The requirements for fiscal 1964 for spacecraft and support are $2½ million, which, at this time, is the total. The requirements for launch vehicles would be picked up in later budgets.

The CHAIRMAN. How many advanced orbiting solar observatories does the Office of Space Sciences have in mind in the program?

Dr. NEWELL. At the present time we have four in mind.

The CHAIRMAN. What will be the cost of each approximately, sir?

Dr. NEWELL. This is not yet determined, because at the present stage we are in the early study phase.

The CHAIRMAN. When do you expect to have the first one, Doctor?

Dr. NEWELL. In 1966.

The CHAIRMAN. When do you expect to complete the eight orbiting solar observatory experiments?

Dr. NEWELL. In the 1966 time frame.

The first advanced observatory may appear in 1966.

The CHAIRMAN. There will be an overlap?

Dr. NEWELL. Of about that year.

The CHAIRMAN. How many of the orbiting solar observatories do you expect to launch in 1966?

Dr. NEWELL. Of orbiting solar observatories?

The CHAIRMAN. Yes.

Dr. NEWELL. We have in mind a couple of attempts of both the present version and the advanced version, with the hope we will have one of each in orbit.

The CHAIRMAN. Do you call the advanced orbiting observatory a second generation experiment?

Dr. NEWELL. It is a second generation facility. Our space science summer study showed that in order to continue with the researches of the Sun, the accuracy of the present observatory would not be sufficient after a couple of years from now.

Therefore we had need to put the improved accuracy into the observatories.

Mr. RANDALL. Mr. Chairman?

The CHAIRMAN. Mr. Randall.

Mr. RANDALL. I don't know that you said what the improvements were, but I just fail to follow you, why we have to have this overlap here? What is the improvement? What is entailed here?

Dr. NEWELL. Well, as we showed you on one of the charts that we presented, the present orbiting solar observatory has a pointing accuracy of a few minutes of arc.

Now what this means is that the detail of the solar surface, which we need to study in order to understand what processes are going on in the solar atmosphere and in the vicinity of sunspots and solar flares, is completely missed by the resolution of the present observatory.

We must improve this pointing accuracy to some seconds of arc, in order to study these details. Without this improved pointing accuracy, we simply cannot continue with the solar researches.

Mr. RANDALL. Well do you know how to improve this resolution now? Do you have that accomplishment?

Dr. NEWELL. We are in a position, within the time period that we have indicated, to achieve this. The state-of-the-art is such that we know we can do it.

Mr. RANDALL. It seems to me, Mr. Chairman, that this might be a case where reprograming would have some very definite validity here, to hold up on a few of these.

You said there were eight of the regulars—if we can call them that—orbiting satellites?

Dr. NEWELL. That is correct.

Mr. RANDALL. I don't know if we have any control over it, if that money is already committed or pooled or whatever it is. But it occurs to me here is a place where it would be a very worthwhile reprograming.

Dr. NEWELL. But then you would stop your solar researches.

Mr. RANDALL. Not all of it—excuse me, I am sorry?

Dr. NEWELL. The orbiting solar observatory is our basic solar research facility, and this is an important thing for us to continue to work on during the International Year of the Quiet Sun.

Again, you have an operating facility here.

The CHAIRMAN. I think, Doctor, it is pretty much like the lunar program; isn't it?

We have got several configurations of Saturn vehicles. One or two of which is incapable of sending a man to the Moon, but we are building these vehicles so that we increase our ability to build the one that ultimately we hope will take the man to the Moon, and we know at least that it will have the thrust capability to take us to the Moon.

So I think, Mr. Randall, this is pretty much the same kind of thing.

I would ask the committee to take a look at this thing from the standpoint that this is one of the few pure scientific experiments that the Office of Space Sciences has in their whole program, and I think it should be involved more heavily, if anything, in this kind of a program.

I personally think that this is a normal sequence of events. I suppose we could hold up with any such experimentation until 1975, when we would probably even have the advanced orbiting solar observatory considerably increased in capability, and go from there.

But it seems to me we have just got to work out these experiments on a one-, two-, three-step basis. We can't skip any intermediate steps. Isn't this true?

You can't go right to phase 4 in the program, without working our way through phases 1, 2, and 3.

Dr. NEWELL. That is correct.

The CHAIRMAN. We learn in 1, 2, and 3, which is applied to 4, otherwise the knowledge cannot be applied to 4.

Dr. NEWELL. That is correct.

Mr. RANDALL. That is why I was trying to bring out the point whether we had the ability to build one of the advanced orbiting solar observatories?

Dr. NEWELL. We have the ability to go forward with the development work to have one some years after starting.

You should not interpret such ability as ability to substitute one of these right now for the current model of the orbiting solar observatory. There is a delay period.

The delay period involves going through the advanced techniques, to the point where you can launch a new observatory and use it.

As I have indicated this will not be available to us to use until the 1966 time period.

The CHAIRMAN. The first orbiting solar observatories will give us a great deal of information we need about the Sun; won't they, Doctor?

Dr. NEWELL. That is correct, in fact the first orbiting solar observatory which was launched last year has given us a great deal of information about the Sun.

The CHAIRMAN. And the advanced model will give us additional information; isn't that right?

Dr. NEWELL. Will give us additional information of a different kind, with more detail.

The CHAIRMAN. Just as the Saturn gives us additional thrust over earlier boosters?

Dr. NEWELL. This is correct. As you progress with the researches that you can do today, and to the limits of resolution and detail you can achieve today, you are always aware of the fact that better things could be done if you had better equipment, better resolution, and so forth, and you always are in a position of having to decide whether it is important to go on to this next step, or whether you have reached the point of diminishing returns.

In the case of solar researches, the astronomers tell us we have by no means reached the point of diminishing returns.

They tell us we should continue with the present orbiting solar observatory for the next several years, because there are many good researches to be done with that vehicle to the limits of its capabilities, but that after the next several years there will be a need for an increased resolution, and increased capability.

It is for this reason that we have recommended going ahead with the development of the improved capability. This recommendation also includes continuing to use the facility we now have available, that we now know how to fly—in fact, have flown.

What we are recommending is a continuing research program. This is a fundamental research program. To do this continuing research program, we say, use the technique we now have available.

But, we also recognize that a few years later we are going to have to have better instruments, a better way of doing this research.

Mr. RANDALL. Yet you know now you have to do it. I mean if you found it out along the line, your testimony is you now know there has to be an advanced version.

Dr. NEWELL. That is correct, and it is a good position to be in, that you know enough in advance that you can get to work on this facility so that a few years down the road when the astronomers say you have got to have this increased resolution to carry on in a sensible fashion, you will have developed the capability.

Mr. RANDALL. The implication is, the other is not ready, and we have to go ahead because of the Year of the Quiet Sun, is that what we come back to?

Dr. NEWELL. The justification is we have to go ahead for the Year of the Quiet Sun, and that we are doing good researches with the present observatory. The astronomers tell us the present observatory is a useful tool, and the researches that come out of it will be worth the effort and the funding.

The CHAIRMAN. Mr. Staebler?

Mr. STAEBLER. Mr. Chairman, may I ask whether there is an analogy here with a business that is very familar to us in Michigan, the automobile business.

While we are producing the 1963 model, we are engineering the 1964, and designing the 1965. We know the better things that are going to be put in the 1965 model, but we don't put them in 1963, because they have not been engineered yet.

So we are in all these different stages of development at the same time. If we waited to get a perfect car, it would never be produced.

Dr. NEWELL. That is correct; that is a good analogy.

The CHAIRMAN. I am not sure they are making better cars.

[Laughter.]

Mr. RANDALL. I am not either.

The CHAIRMAN. Michigan would disagree very vigorously.

Mr. Chenoweth?

Mr. CHENOWETH. I want to commend my colleague for his very diligent inquiry into these figures and this program. It raises some fundamental questions in my mind as to what our role is in this, Doctor, what the role of Congress is in this whole picture.

We are not scientists, we are not engineers, we cannot discuss and debate with you whether this program should go ahead or whether you are using good judgment on this and that. It is obvious we are completely handicapped to engage in that type of colloquy with you.

Is there any sphere in here, any place where Congress has any role or function to perform, except merely to approve what budgets you have prepared? Is there any place where we have any discretion, where we should exercise any of our own ideas?

The gentleman from Missouri has some ideas of his own concerning this, and perhaps some of the rest of us do too.

Are we going to destroy the whole program, if we seek to inject some of these ideas in this program, which might be contrary to what you think?

What is our role, what is our function here? Why do we take this time to go over all these figures? Is it just so that we may approve them, or should we have some challenge here?

Maybe we can change some of them. Maybe some of it is not exactly necessary right now, maybe it can be postponed without doing violence to our whole space research program.

Those are fundamental "ifs" in my mind. I am sure they will be asked on the floor of the House when we get there. What will we tell them? The other Members won't have the advantage of all of this information you are giving us. I want to say I have been very, very much impressed with you, Doctor. I think you and Mr. Cortright made a very splendid presentation.

I have confidence in what you are doing. I don't know that all of it is necessary, I really don't know. Maybe some of it could be postponed, in view of some of our budgetary problems. So, I repeat the question: What is the function of this committee as we sit here today, as you see it, Doctor?

Dr. NEWELL. Well, you pose a very challenging question.

Mr. CHENOWETH. I wanted it to be that. I would like your observations, Doctor. You see the situation we are in as elected representatives of the people. We have some responsibilities too, you know, regarding the budget. They expect us to protect their interests.

Maybe some say we are not going fast enough, some say we are going too fast.

Some may say we ought to keep our present pace.

Dr. NEWELL. I think an answer I can give to this question can perhaps be based on what we feel we are doing in presenting this program to you.

We are presenting to you a program that we, who participate in it, are convinced is of value to the country. And so in presenting it to you we are trying to show you why we think it is of value, what we think the output of the program will be, what the returns will be for your investment, and we try to give you—in addition to convincing you—the ammunition you need to fight for it for us, because you do have to carry the battle for us.

As I said before, when we build up this program, we recognize very clearly that the country cannot afford to do everything that the scientists would like to do, that there has to be a balance between this program and agrarian programs, medical programs, defense efforts, and so on. That balance has to be achieved by doing the right amount in each one of the programs.

So as we build up this program we try to develop criteria for the total amount of effort that we recommend to you in each area. And our criteria have shaped up in the following way:

We feel that this country should support a scientific research effort, a total scientific research effort, in which, in each significant area we are tackling at least one important problem with a resolution to solve it. This is a minimum adequate program to maintain our growth in science and technology, to maintain our preeminence in this field in the eyes of the world.

In addition, we feel that in the field of science there are sufficiently few good scientists in the country doing scientific research that this country can afford to support all of them. We ought to keep all of these good scientists busy.

I am not talking just about the space science program here, I am talking about science in general, across the board. The Congress

should ask itself: "Are good scientists working on this?" "Are we keeping them busy at a reasonable pace?"

Mr. CHENOWETH. One of your main problems, Doctor—it is not a question altogether of dollars. Dollars, unless translated into some production, some advantageous research, or some other reason, don't mean anything.

Suppose we give you another billion? Suppose we increase your figures a billion, it would not mean much to you, would it? What would you do with it?

You can't find the scientists today, if you had that money here. There is a shortage of scientists. We are not training enough scientists. Where are we going to spend all of this money?

Dr. NEWELL. That gives one of the criteria you can apply to determine when you have reached a point of diminishing returns. The country should not support a program beyond keeping the good scientists busy. It is a waste of money to push the program to the extent you are drawing in just anyone including those who do not have real talent and competence.

Mr. CHENOWETH. NASA is practically doubling its requests over last year. Do you have enough scientists you can profitably employ?

Dr. NEWELL. Our program is based on our estimate. We will be using only good scientists: yes.

Mr. CHENOWETH. They are available?

Dr. NEWELL. Yes.

Mr. CHENOWETH. Now, then, it is a question of what these programs and which ones to pursue. You have given it a great deal of study. I assume you want to go ahead with the entire program.

Dr. NEWELL. Yes.

Mr. CHENOWETH. Some of your group feel some parts are more important than others?

Dr. NEWELL. That is the nature of science; yes.

Mr. CHENOWETH. Do you recognize we have any responsibility, Doctor, here, in this picture?

Should we challenge any of these programs, should we be belligerent, or should we raise any questions about them, or is our present duty to go along without some of these, or postpone them, without completely upsetting your whole space effort? Is that possible here or not?

Dr. NEWELL. I think you should do as you are doing, challenge us to explain to you why we think these are important, and try to give you a feeling for why the scientific community is interested in doing these things, and what the returns will be, and on the basis of this, then, to make your decisions as to how much of it you feel you should fight for on the floor of the House.

Mr. CHENOWETH. You are very able, very capable, Doctor, in presenting this program. You have done a very splendid job.

Mr. MOSHER. Will the gentleman yield?

Mr. CHENOWETH. Yes.

Mr. MOSHER. Would you say this whole exercise—where you spend innumerable hours of your valuable time before our committee accompanied by a lot of excellent staff people—would you say this whole exercise is of value to you, to NASA, in that, preparing for it, the actual doing of it, the necessity you have of justifying your program

to Congress, helps clarify your own thinking on it, helps minimize the possibilities of waste and duplication, and so forth?

Can this exercise be justified in part on that basis?

Dr. NEWELL. I think very much so.

Mr. MOSHER. Is it a discipline you find valuable?

Dr. NEWELL. We do. I think, furthermore, reporting to the committee on the results from this program, as they come out, is of value.

This is one of the reasons why in my part of the testimony I tried to present to you some of the things that have come from the program in the past. As we go along in the future there will be more and more of this.

Mr. MOSHER. Is the fact that even though we are laymen—and perhaps are only lucky if we ask a pertinent question—is that mere fact, the possibility that now and then we might ask a pertinent question, one which keeps you on your toes, and is valuable to the country in that respect?

Dr. NEWELL. Gentlemen, it has been our feeling you ask most searching and pertinent questions. We are gratified to hear such questions asked. We like to have the opportunity to answer them.

I might also point out that it is our feeling that we have arrived at a point in our civilization when there are not, as E. P. Snow says, really two cultures, the humanities and the sciences. It is our feeling that the sciences have become a part of the humanities.

There is almost no avenue of life today that is not touched by science and the doing of science, and the accomplishments of science.

We feel, therefore, it is important for our citizens to know about science and have a feeling for it and an appreciation of it.

I think perhaps the Congress is in even a better position than the scientists are to try to get some of that feeling to the rest of the country. Because what is done by the Congress, the support that is given to programs like this, is clearly in the eyes of the constituencies, and I am sure is discussed with them, when you go back and talk with them.

This I think is one of the most important things you can do in connection with this sort of program.

Mr. CHENOWETH. I appreciate that, Doctor.

Just one observation, and then I won't take further time. I notice now that in practically all of these programs there is a substantial increase in the amounts you are asking for over last year. You are familiar I am sure with the problems we are facing here in the budget—taxes, fiscal responsibilities.

In the event that Congress comes to a point they feel they just cannot go along with everything, there has to be some reduction somewhere, would it be possible for some reduction to be made here?

Would you revise your thinking? No one ever gets everything he wants in this, there is going to have to be some compromise, or give and take in it, and I am sure you recognize that and would be willing to cooperate in that.

Dr. NEWELL. We would have to—if a reduction were made in the appropriation—we would have to go over this total program and try to achieve the best possible selection of the important scientific problems to tackle.

Mr. CHENOWETH. You would select those programs you consider the most important and most essential right now?

Dr. NEWELL. Yes, and the most likely to be productive of good answers.

Mr. CHENOWETH. Thank you very much, Doctor; I did not mean to take this much time. I appreciate your answers.

The CHAIRMAN. I think the questioning was very good, and I want to compliment you. It was a very appropriate line of inquiry.

Mr. CHENOWETH. Thank you.

The CHAIRMAN. As a matter of fact, that is why we are here.

Mr. Mosher?

Mr. MOSHER. Dr. Newell, you do consider the program you presented to us, as a minimum program, carefully considered, one that you can justify as a minimum program?

Dr. NEWELL. It is that.

As I have mentioned, it is a program that we have arrived at after weeding out a lot of other things that we could do, and after slowing down the pace that a lot of our scientists would like us to follow. I might point out that a large part of it is actually a continuation of the previous program. There are not too many new starts in here.

Mr. MOSHER. Mr. Chairman, I don't suppose it would be a fair question for us to ask Dr. Newell if he were on this side of the table, determined that we had to cut something, what would he cut?

The CHAIRMAN. I think it is a fair question. I am not sure you are going to get an answer. [Laughter.]

Mr. RANDALL. Not in three words.

Dr. NEWELL. Well, my position here is to defend this budget.

Mr. MOSHER. I did not feel it was a fair question.

The CHAIRMAN. The reason I did not think you would get much of an answer, is that I asked that question last year. Dr. Newell gave me the same answer he gave you today.

Mr. STAEBLER. Mr. Chairman, Dr. Newell gave us an answer several days ago when some of the members were not present, that meant a great deal in my thinking about this, and I would like to have him repeat it.

It was in response to a question dealing with pure research, something to the effect that a vast amount of pure research is needed.

How can you tell when we are doing enough, or how can laymen tell when we are doing enough, and what guidelines can we find as to when we are going overboard, when the pure research becomes an end in itself? We get too excited about it.

You gave an answer at that time that seemed to me to provide a rule-of-thumb guide for us laymen. Do you remember it?

Dr. NEWELL. There are two points, two parts to that answer. The first one is, a test to apply broadly. The test fails if you try to apply it too narrowly. But broadly, if you are trying to develop a rule of thumb for how vigorously should the country push a total basic research program, you find that the people who are trying to make applications, in the case of space sciences to, say, weather satellites, communication satellites, or navigation, or in the case of medical sciences, to specific clinical problems, or in the case of the geophysical sciences to, say, mining, petroleum exploration, and so forth—if you find that these people are constantly asking for more basic data, indicating they do not have enough to get on with the problems, the engineering problems they are facing, then, in general, you are not supporting an adequate basic research program.

On the other hand, if you find that they are enjoying a situation in which there are a great number of choices of how to solve their problem, then you can feel that you are supporting an adequate basic research program, and you can then try to feel your way toward whether you can perhaps afford less of the basic research and go more to the applied research.

The second part to this answer is to recognize that in any total program you should have a pure research component.

You should not try to apply the test of what specific applied goal will this give me to everything that you do in this type of activity.

The reason is as follows: As an applied research man moves from the area of known facts and principles to his target, his specific target, he moves directly toward that.

He has on blinders, so to speak, so as he moves along the line from the known toward his goal, if he finds that certain interesting and important researches are leading him off that track, he dispenses with them, and goes back to the track.

Whereas the pure researcher simply attempts to move from the known into the unknown, to advance the frontiers of knowledge, and as he goes he feels free to zig-zag, to follow those lines of attack that seem to be the most promising, the most fruitful scientifically, and he therefore moves ahead in an atmosphere that sets the stage for discovery and for breakthrough in a way that the applied researcher does not.

So these two criteria, I think, are ones that can be applied in trying to determine whether or not you have enough fundamental research going in the country.

Mr. CHENOWETH. Will my colleague yield?

Mr. STAEBLER. Certainly.

Mr. CHENOWETH. I would like to ask you this, Doctor.

Except for this race we are in now with our Russian opponents, to get the man to the Moon first, and the military significance involved, would you say that there is much of this that we would not be as vitally interested in as we are today if it were not for that?

We have lived many years without having this information which we are getting here, and probably could go on for some time to come without the knowledge.

Would you say that all of this is absolutely essential and pertinent to our survival? We would like to have it, of course, it is nice to have it; if we could afford to buy it and pay for it.

Sometime we may some interest in it, though not immediately—isn't there a twilight zone in here?

We are going into a lot of things we never thought of going into in the last 15 years, even the last 2 or 3 years.

The scientists think pretty fast too, they move in fast, they have a lot of ideas.

It is a question of how many we can finance, how far we can go, that occurs to me now.

Dr. NEWELL. I think it is unquestionably true that the pace of the program is set to a great extent by competition with the Russians, the need to maintain preeminence in the eyes of the rest of the world in the light of that competition with the Russians, the need to feed into those who are developing military systems for our defense basic information rapidly enough for them to keep ahead.

If we were not in such a situation, science could move ahead more gently. In fact the nature of science is that it moves at a more leisurely pace than sometimes we do today.

The fact of the matter is we are in a different situation, and therefore we do recommend a more rapid pace than we would otherwise recommend.

Mr. CHENOWETH. This is sort of a crash program we are in now, in this effort to beat the Russians to the Moon; isn't that what we are in? We cannot get the same value for money spent in this program, as we would in a leisurely program.

I think that is very fundamental, and recognized in not only your program or any other program. In haste there is going to be waste, there is no question about that. Not that you are deliberately wasting money, but there is bound to be some waste in a crash program.

Dr. NEWELL. It costs you more, but I question whether you call it waste. I think you call it increased cost to do the thing on a deadline basis.

In the case of the space science program—and this is true in the case of the other programs in NASA—I would not call them crash programs in the sense that you have set such rigid deadlines that you have to set up many different lines of attack, cover all your bets, in the development of engines, vehicles, landing modules, and so forth, which would be the nature of a crash program.

It is a tight program, but we have set it up so that you have essentially one line of attack with perhaps a few backups here and there. In this sense, it is different from a crash program. In the case of space science, I would say it is not at all a crash program. It is a fast program.

Mr. CHENOWETH. I think it has very many characteristics of a crash program, where you have a deadline, or are trying for a deadline. You are increasing all of your figures here. I assume you did a pretty good job this last year, I think you have done a competent and efficient job, and now you are moving it up very substantially.

Call it crash or whatever you want to call it, it is obvious you are moving ahead fast, much faster than you would ordinarily, I am sure. The incentive is obvious, someone is causing you to do that.

Dr. NEWELL. We are moving up, the total cost is moving up, but we are also moving into an area where the tools that we have to use to do some of the jobs are more costly.

Mr. CHENOWETH. I recognize that. That is what causes this drive to meet this target date which we fixed on this program to put a man on the Moon in this decade, isn't that it? Isn't that a good part of it? Maybe I am wrong.

The CHAIRMAN. Isn't it true, Doctor, that you are buying some of the tools in fiscal year 1964, and you will be buying more of the tools in fiscal 1965, that we completed feasibility studies for and did some other preliminary work for in fiscal 1963. Isn't this true?

The reason I say this is because Mr. Chenoweth was not a member of this subcommittee last year, and I can assure the gentleman that we took a very close look at this. The fact of the matter is——

Mr. CHENOWETH. I am sure you did.

The CHAIRMAN (continuing). The subcommittee reduced by a substantially greater percentage the budget request from the Office of

Space Sciences than all of the other subcommittees combined. I am not sure of that, but I think this will probably stand the test.

Mr. CHENOWETH. I have full confidence in you as chairman of the subcommittee.

The CHAIRMAN. I would like to join the witness on the other side of the table, and answer questions propounded by the committee.

Let me say this at this point, so at least my position is clear for the record: I think since 1940, or thereabouts, we probably have advanced scientifically and technologically to a greater degree than we have advanced in those two very important areas in the last 50, 75, or even 100 years.

I think it is well that we did. I would hesitate to make a guess as to whether or not we would be sitting here as citizens of the greatest Nation in the world if we had not advanced at the rate that we have advanced in these two areas in the last 20 years. I would just hesitate to guess whether or not we would be here under other circumstances.

I think it might be true that we have got to advance at an even more rapid rate. I think this pretty generally follows, because we have advanced at a more rapid rate in the last 20 than the previous 75 years.

So with this kind of a speedup, I guess you almost become part of the treadmill. You can't stop, because if you do something very serious is going to happen.

The question is, How much more rapidly should you move the treadmill, if at all?

I think this is probably the question. While I may disagree with Dr. Newell and Mr. Cortright on some parts of this program, I will say, Doctor, for the record, that at least at the moment I am in disagreement with you, either on part of your Ranger program or on part of your Surveyor orbiter program. I think this committee is going to have the opportunity to very seriously consider these two areas.

I would disagree on the other hand with those who say: "Well, as far as the pure scientific research areas are concerned, let's cut these out because maybe it is not important that we proceed along these lines just because next year might not be the crucial year when the decision is made." Are we going to stay alive or are we going to be dead because we did not advance rapidly enough in the pure scientific area?

I feel that these three orbiting observatory requests on the part of NASA are really the only pure research programs. I suppose there could certainly be a difference of opinion as to the word "pure" here. Isn't it true that this is really the only pure or semipure scientific area or program that is being conducted by the Office of Space Sciences, where we are going to get some of the answers that we really need to get into the applied research areas later on?

Dr. NEWELL. These are pure research, but so are planetary researches, and so are the lunar researches that I keep scrapping for.

I think in the case of the lunar discussion, it is unfortunate that we always turn back to saying, "Well, will this support the manned lunar landing effort?" because, as we have indicated, the Moon has a particular role to play in the investigation of the origin of our solar system, which is one of the major scientific problems of today.

The combination that we described to you of the Ranger, Surveyor lander, and Surveyor orbiter, we feel is the most effective way of getting a total investigation of the Moon in hand.

As we have explained, it is through the combination of the Ranger impacters and Surveyor landers, and the correlating features of the Surveyor orbiter that we will learn about the structure of the Moon. In the case of the orbiter, however, one keeps forgetting——

The CHAIRMAN. Doctor, let me ask this: We know more about the surface of the Moon today from just what viewing we have had from Earth than we know about Mars or Venus, or will probably know about those two planets during the next decade, despite our far-out experiments; isn't this true?

Dr. NEWELL. That is absolutely true. But in knowing more about the Moon, we have developed more questions that the scientists cannot agree on than we have developed in the case of Mars.

The CHAIRMAN. My only point is, Doctor, you get a long way away from pure research when you follow down a program that is designed to give you almost as much knowledge about the Moon as you have about Earth.

This is stretching this thing to be true, but my point is that when we are talking about these supporting lunar programs, if I may designate them as such, we are not really talking about pure science any longer, even if you want to stretch your imagination in those areas?

Dr. NEWELL. Yes, I am. I insist I am.

The CHAIRMAN. I beg to disagree.

Dr. NEWELL. We have in the minds of leading scientists like Dr. Gold, Dr. Pettingill, Bruce Murray, Harold Urey, some of them Nobel Prize winners, questions about the Moon that they regard as of basic importance in this basic research area. Questions that we want to follow up, that they can't answer from the Earth on the basis of observations made with telescopes and radars. They want to answer these.

Now, in our discussion of the lunar orbiter, people keep forgetting this orbiter will do more than just take pictures. It will provide us with a way of studying the radioactivity of the Moon, the geodetic properties of the Moon, and with a means of observing the local particle environment of the Moon, including micrometeorities, and micrometeor splashes—a much more effective way of getting at these than we can obtain from a lander.

A lander does a different job. So in order to do the complete, basic research, scientific job, we feel we need the combination.

The scientists are urging us to get on with the orbiter, and we agree with them that we should.

Mr. CHENOWETH. Mr. Chairman, will you yield?

The CHAIRMAN. Yes.

Mr. CHENOWETH. Why is it so important to get all this information on the Moon? What is involved? After we get all of it, what are we going to do with it?

Dr. NEWELL. Let us steer away from bringing in the question of support to the manned lunar landing.

Mr. CHENOWETH. Yes; leave that out.

Dr. NEWELL. It is important, because the scientists who have been studying the Moon say they have some challenging problems to study. This is one of their great tests.

If we ask them how searching are these, we find that they say, if we can find out about the origin of the solar system; if we can determine, for example, that the solar system really was formed by the collision of two stars, then we can say that it is almost certain that we are alone in the universe, at least in our galaxy, because the collision of two stars is a very rare event. It can happen, on the basis of probabilities, only a few times in many billions of years.

On the other hand, they say if our investigation of the Moon shows that the Moon was formed from cold materials, and therefore, very likely the Earth and the other planets were formed from cold materials, this then says that the process of formation of systems like the solar system is a very likely process, and that there are very likely similar solar systems around millions or perhaps billions of other stars in our galaxy, and that many of these millions or perhaps billions of them will have planets that are located just at the right distance with respect to their sun that conditions for formation of life are just right, and it is very likely that life has formed. Therefore, the probability is very high that we are not alone in the universe.

This philosophically is a very intriguing and challenging scientific problem. I don't know what you are going to do with it practically, but it is the sort of problem our scientists tackle, it is the sort of problem they should be tackling, so that we do get the practical products later on.

The CHAIRMAN. Doctor, that is a beautiful explanation. But answer this question, if you will. Why do we have to go to the Moon to find out whether or not the universe was formed after the collision of two stars, or whether it was formed from cold materials? Why can't we make those scientific experiments on Earth, and make that same determination?

Why can't we do it here?

Dr. NEWELL. The Earth, it turns out, is too big a body to do that.

When materials conglomerate into a body the size of the Earth, the ratio of the surface area of the planet to the volume is sufficiently small that the rate of escape of heat generated in the interior across the surface and out into space is slowed down to the point where the interior melts, as in the case of the Earth.

Radioactivity and the heat generated by the pressures developed in the interior of the Earth built up heat sufficiently rapidly, and heat was lost across the surface of the planet sufficiently slowly that the heat rose above the melting point of the materials in the interior of the Earth.

As a result, the iron melted and drifted to the center of the Earth. This means that the original structure was lost, and we cannot tell whether it was formed from cold materials or from the molten material pulled out from the Sun.

The CHAIRMAN. Doctor, are there any scientists that disagree with your theory, what you just said?

Dr. NEWELL. There are disagreements with the theory, but some of our leading scientists feel that it is true. One, for example, is Gordon McDonald, who is one of the leading geophysicists in the country

today. He and others feel that this is a correct explanation of what is going on. Indeed, I think perhaps most scientists agree with Dr. McDonald.

But now in the case of the Moon, if the Moon was formed from cold materials, it is sufficiently small that the ratio of its surface area to its volume is large enough so that heat leaks out through the surface sufficiently rapidly that the Moon may never become molten, and therefore is in the same gingerbread, or fruitcake form that it was when it was first formed.

If we find it is in that form, then we can conclude that bodies of a planetary system like the solar system are formed from the accumulation of cold materials, and we can conclude that we are very likely not alone in the galaxy.

The CHAIRMAN. Mr. Chenoweth.

Mr. CHENOWETH. I will be through with this, Mr. Chairman.

Suppose we do come to one conclusion or the other? What practical importance is it?

Dr. NEWELL. I am not going to attempt to justify this on the basis of practical importance. It is one of the challenging scientific problems.

From the practical point of view it is important for us to keep tackling these scientific problems, keep our scientists working on the things that they regard as challenging, so that we are in a position for those who are practical people to have the data, information, principles, and so forth, to make their inventions and their applications.

Mr. CHENOWETH. I must confess, Doctor, I can't follow you in all of the reasoning, and scientific terms you are using here. I can't see any practical value whatever to it, except to satisfy the inquiry of some scientists who have been studying this problem.

Dr. NEWELL. Well, now, if you had asked me back at the end of the last century what practical value it was for Roentgen to be playing around with these little evacuated tubes and electrical discharges, I would never have said he was going to discover X-rays. My answer could not have been that. But X-rays have turned out to be of practical importance in medicine, in research, and in industry in the examination of castings, for example, to find flaws.

One could hardly have thought of anything of greater value than X-rays, from a practical point of view, but if we had decided that these esoteric researches of Roentgen were not worthwhile, and we had decided we should tell him to go off and do something practical, that would have been lost.

Mr. CHENOWETH. I think there is a limit, frankly, Doctor.

I think probably some are taking advantage of this present lunar flight to do some things that otherwise would be rather frowned upon, or perhaps openly discouraged.

I say that without any criticism of you, of course. I think I can see the picture of what is going on.

Mr. STAEBLER. Will the gentleman yield?

Mr. CHENOWETH. Yes, certainly.

Mr. STAEBLER. I have been asking that same question, Mr. Chairman, every time we get together.

I sorted out four orders of priority I would like to try on Dr. Newell.

It seems to me that what we are talking about falls rather clearly under these four divisions.

First, research connected with the Moon landing. That is almost applied research, though it is pretty pure in the abstraction of it.

Second, the research dealing with the Moon without application to the Moon landing. This adds to our stock of knowledge without having an immediate discernible practicality, but this, almost all of it, rides along with the first.

This is kind of a bonus that we get in connection with our first research. Perhaps we would not do it this fast if we were not doing the first category, but having the instruments you just add on a few more and you get the second one almost free, at least at a cut price.

The third collection seems to be in connection with planetary questions, and here there is a different order of urgency, but still some urgency, because we can see a little element of defense and perhaps planetary travel, maybe in somebody's lifetime, the younger people here, in connection with the planets.

And then fourth, the galactic research. That seems to me to be almost pure research in terms of no discernible use we are going to make of it.

But we have always done that pure research. The reason that it looks so different to us now is that, whereas the observatories have always searched the heavens, and hundreds of people have done this, they have done it in small ways.

Now all of a sudden it is costing us $10 million or $20 million a look to get those observatories out into outer space.

The question on that point of pure research seems to be now that it cannot be done from a terrestrial point, should the Government undertake this and do that degree of pure research that heretofore lots of other individuals have done?

And even that, however, seems to be intermixed with the other because a part of it we get piggyback on these other forms of research.

Mr. CHENOWETH. They are doing a pretty good job of mixing all of these up together. It is hard to separate them.

Mr. STAEBLER. I would like to ask about this research, however.

Are there more than these four you are talking about?

Dr. NEWELL. I think you covered it pretty well, in the space sciences area.

You should include in the basic researches, with perhaps more immediate practical applications, the Earth researches on our atmosphere and the radiation belt, because these will have direct applications to better understanding of weather, communication satellites, satellites for navigation, the use of satellites say for military applications, and so on.

So that one category of Earth investigation should be added to the total.

Mr. HAMMILL. Dr. Newell, I have one question.

If we did not have a manned lunar landing program, and we could consider the Surveyor orbiter as a strictly scientific endeavor, you probably would not have any problem convincing the members of the committee that it is really essential, but based upon your earlier testimony I believe there is some question in Mr. Karth's mind and other members as to whether or not the scientific data which the Office of Space Sciences would like to develop and should develop cannot be

got, for all intents and purposes, and virtually in the same time frame by the manned endeavor, you see?

I believe that is the reason that there have been reservations expressed about the Surveyor orbiter program.

Dr. NEWELL. As I have stated, we have very carefully reviewed that question as one of the questions that should be looked into before making a decision, and have decided on balance we need the orbiter, because we are not going to fly men all over the Moon. They will come along later. They do face tremendous problems of engineering which we think will inevitably show up as schedule problems, and that in applying these judgment factors, then, it comes out better to include the orbiter in the total program.

The CHAIRMAN. One of the things that bothers me is getting into the hands of those who need it the information that we get as a result of our experiments.

I don't think that we have enough, if I may, of a central focal point, where we accumulate and disseminate all of this information. I can see why it is important to have it. I agree with the scientist that for too many years we neglected science. This is our problem. I think we neglected it so long that now we are probably moving at a pace that is probably a little too rapid for some.

If we had done our chores in this area during the last 100-year period we probably would not have to do it today.

But I am concerned that we are not really getting this information into the hands of all of the people who can use it as rapidly as it should be put into their hands.

Now, I wonder if you could just think about this until the next time we have you before the committee—and probably help us by telling us how you think we might be able to do this.

I think it is appropriate, because this committee does have a responsibility, in my opinion, other than merely approving or disapproving what you are here to support in the form of a budget request.

If we can add something in addition to evaluating whether or not you are correct or incorrect in making your presentations, and I think we are dutybound to do this, and if we can, through your suggestions, and others, who understand science a lot better than we do and know how important it is to get it in the hands of those who can put it to good use all over the Nation, not only in Government, but in every agency of Government and in private industry, in so many different industries, then I think that we will all have made a very worthwhile contribution.

I just don't think we are doing it today.

Dr. NEWELL. I would be glad to address myself to that.

The CHAIRMAN. I hate to ask you to take it upon yourself to accept another chore, because I know you have plenty.

But if you and your staff—Mr. Cortright could probably wrestle with this problem a half hour sometime—to see if you could not help this committee write some legislation that would set up a central retrieval office, and a dissemination office for this kind of information.

I know we have the Department of Defense retrieving and disseminating information to the services, and to anyone else in Government I guess who wants the information, but it seems to me these people have to request it.

If they don't know anything about what DOD has got, how do they request it?

This is the thing that bothers me.

It is like looking for a needle in a haystack when you don't know that the needle is there.

You have to know why you are there in the first place.

Then NASA, I guess, has some kind of a retrieval and dissemination program.

Dr. NEWELL. Yes.

The CHAIRMAN. But I am not sure I understand the extent to which we retrieve and disseminate information to industry and to all other agencies of Government who might find some use of it—maybe 90 percent of them don't. So, it is 10 percent that are important, not the 90 percent that have no use for it.

Mr. MOSHER. Mr. Chairman?

The CHAIRMAN. Mr. Mosher.

Mr. MOSHER. I have heard librarians indicate this is perhaps the most critical problem they face today. Not only in space sciences, but the whole problem of how the Library of Congress, or the New York Public Library, how can they conceivably make available the vast amount of information, cross indexed, readily available to all scientists.

You struck a very difficult problem.

The CHAIRMAN. How many people do we have in NASA doing this, Dr. Newell?

Dr. NEWELL. I would have to check on that.

We are doing a lot of thinking about it.

I have a number of people in the Office of Space Sciences alone working on this problem. But I ought to wait until I have a chance to work this up for you.

The CHAIRMAN. It seems to me, with the almost fantastic amount of information we are deriving from our whole effort in space—it seems to me if NASA came to this committee and said, Look, we need $50 million to make use of this information, not just to our own people within NASA, but to every one within the United States who may have use for it in private industry as well as other agencies of the Government, you would sell me, because I just think we waste it—not in the true sense of the word, but we don't use it nearly as rapidly or to the extent that we could. I would be pleased to have your ideas for the record.

STATEMENT OF HOMER E. NEWELL, DIRECTOR, OFFICE OF SPACE SCIENCES, NATIONAL AERONAUTICS AND SPACE ADMINISTATION

I would like to review the procedures and programs by which the scientific data which we acquire in the OSS program are disseminated into and used by the scientific and technical community. I will discuss the mechanisms by which the data from an energetic particle detector on a typical satellite, say Explorer XIV, is translated into the proper format to be of use to an engineer designing the shielding for Apollo. I will trace a datum point from the time it is measured on a satellite, through its scientific analysis, to its engineering application. In the process, I will use various reports, publications, bibliographies, data storage, and data retrieval techniques which NASA has established to insure that space science results will be available to those who need them, promptly and accurately.

Let us return to the experiments which are sending information earthward from the satellite. This encoded information is received and recorded on tape by a telemetry receiving station operated by the NASA Office of Tracking and

Data Acquisition. The tape is then shipped to the cognizant NASA field center; in the case of Explorer XIV, this is the Goddard Space Flight Center. Here duplicate tapes are made and the originals placed in archives for permanent storage. The duplicate tapes are processed by a computer. This processing includes the decoding and calibration of the telemetry data and uses the most modern electronic computers. The information from the particular experiment of interest, together with considerable other pertinent information such as the time, the location, and the orientation of the satellite, are transferred to another tape which is shipped to the scientist who is responsible for this particular experiment. This scientist is the man who thought up this experiment and who designed and calibrated the instrument. He is the man to whom NASA has assigned the responsibility for the analysis, interpretation, and publication of the data from this experiment. He is probably associated with a university, but he may be an employee of NASA or of some other Government laboratory.

At this point I would like to insert in the record the NASA management instruction which defines the rights and responsibilities of an experimenter with respect to the data from his experiment.

(See app. 1 at end of statement.)

The experimenter then begins the analysis of the data from his experiment. For the Explorer XIV energetic particle detector, the telemetered data are converted into numbers which tell him the number of particles within each particular velocity range which struck his detector. If he is studying the trapped radiation he will find that these numbers vary with the location and orientation of the satellite. At the same location and orientation they will probably vary with time. The experimenter must collect data over many orbits and for many days before he begins to understand in any detail what is happening.

Three or four months after a satellite has been launched a working group of all the experimenters is usually convened by NASA to discuss their data. The purpose of this is to correlate results from different instruments such as a magnetometer and an energetic particle detector. This correlation may on occasion show that some results are spurious because of interference from another instrument on the spacecraft. More frequently it will lead to the understanding of some phenomena which were confusing or even incomprehensible when looked at by the two experimenters separately. The important thing is that this is a part of the process by which the experimenter validates his results and assures himself that they are accurate.

You will note that so far there has been no public disclosure of the results. The reason that we must be so deliberate about this is that introduction into the literature of inaccurate results must be avoided, because once such results are introduced it is very difficult to eradicate them.

Shortly after such a working group session, the experimenter will present those results whose validity he considers established, either at a scientific meeting of a national organization such as the American Physical Society, or as a brief article in a technical journal such as the Journal of Geophysical Research. At this point, if the results are newsworthy, NASA will issue an official press release. We do not make a news release until the experimenter has either had this material accepted for publication in an established scientific journal or has presented it at a major scientific meeting. This procedure capitalizes on the critical technical reviews conducted by journals before acceptance, or on critical technical examination by one's peers in an open meeting and is a part of our effort to assure that as much scientific data as possible is published as soon as it can be considered to be valid. We know that when a scientist is prepared to present his data before his scientific peers he will have taken all possible steps to assure himself that he has not made any errors. I should emphasize that during the time prior to this public announcement we do not discourage him from talking to his colleagues about the data, nor do we prohibit him from talking to the press as an individual scientist. However, we do not make an official NASA public announcement until his results have been accepted for scientific publication.

The publication of the results in a scientific journal marks the introduction of the results into the scientific and technical information (OSTI) program of NASA.

At this point I would like to insert into the record a document which describes this program and which was originally prepared for the Committee on Government Operations.

(See app. 2 at end of statement.)

In the NASA OSTI program, an abstract of the article or talk will appear first in the International Aerospace Abstracts (IAA). This is a document which is prepared under a contract with the OSTI of NASA. From here on the information from our satellite will go several ways. It will be incorporated into a comprehensive article on the trapped radiation and be published in a review journal such as Space Science Reviews. An Apollo engineer will pick it up and write a contractor report concerning its effect on the shielding of Apollo. An abstract of this report will appear in the Scientific and Technical Aerospace Reports (STAR), the companion document to the International Aerospace Abstracts which covers information which is not published in the scientific and technical journals covered by International Aerospace Abstracts. A summary of the important results will be published in the semiannual report to Congress. A summary will be contained in an annual report to the Committee on Space Research.

The scientific data will also be compared to that from other experiments. Finally, the data will be sufficiently reliable and well understood so that we can prepare a handbook on the radiation belt such as this Handbook on the Standard Atmosphere which NASA has just published jointly with the Air Force and the Weather Bureau. We have published such a preliminary "Handbook on the Radiation Belt." However, it is already outdated by new data and will have to be revised. With their incorporation into a handbook, these particular data are available for general use by anyone with an interest in the subject.

I would like to return for a moment to the original data tapes which were put into an archive—what happens to them and how long do we keep them. At present we are keeping these indefinitely. They are stored at the NASA field center together with the necessary calibrations to decode them. At the conclusion of the time during which NASA gives the experimenter primary access to the data, we place these data in the public domain, available to anyone who can make worthwhile use of them, by transmitting to the world data centers a bibliography of the tapes and their location. A potential user can then ascertain what data are available and obtain copies of the original tapes.

Now I would like to review the functions of OSTI and some of the programs which are underway to insure that scientific results are disseminated promptly and accurately to the scientific community.

The NASA scientific and technical information program is based upon the following five operating principles, which are explained in detail in the introduction of appendix 2: Service designed for the ultimate consumer; timeliness—an essential; reliance on existing systems; centralization only when necessary; and a variety of products and tools for a variety of "publics."

In order to satisfy efficiently and economically the widest variety of needs with the widest practicable variety of products, tools, and services, OSTI has established the Scientific and Technical Aerospace Reports (STAR) shown in the next slide (slide 2). The complete texts of all the reports abstracted in STAR are reproduced on microform cards such as these. The information in STAR is stored on magnetic tape for computer storage and retrieval. The STAR indexes are actually computer printouts. We distribute the journal or the microform or the tape, whichever is more suitable, to NASA centers, NASA contractors, and to a large number of libraries and regional report centers. In addition, NASA reports are automatically provided to U.S. universities and colleges. As I have mentioned before, we use in STAR the identical indexing techniques, indexing terms, and formats which are used to cover the scientific journals in International Aerospace Abstracts.

In addition to the handbooks which I have shown you we have the following in preparation: "Vacuum Technology," "Bearing Technology," "Earth Orbital Manual," "Lunar Flight Manual," "Planetary Trajectory Manual," "Artificial Earth Satellites," "Spacecraft."

We do have a fundamental problem in the preparation of these handbooks. They must be prepared by people who know the field, who know which data are current and reliable and which are outdated or unreliable. In short, they should be written by the scientists themselves, since they are the ones who have this knowledge. These people are in short supply; they are not particularly interested in this type of chore; they would much prefer to spend their time tackling new problems and we prefer to have them do just that. If all the scientists sat down and started to prepare handbooks, we would rapidly fall behind in the race to understand nature. On the other hand, if the scientific results are not promptly translated into terms of use to the engineers, our technology will fall behind and ultimately this will slow our scientific investigations.

We recognize and understand the problem. We think we are maintaining the proper balance between undertaking new research and converting research results into appropriate engineering handbooks.

While we believe we have developed and have in operation a good system for technical information documentation, retrieval, and dissemination, we are constantly striving to expand and improve its speed of dissemination and responsiveness to the needs of the users. We are grateful for the keen interest of the subcommittee in this important aspect of our space program.

APPENDIX 1

PART IV

MANAGEMENT MANUAL

OFFICE OF SPACE SCIENCES
TECHNICAL MANAGEMENT INSTRUCTIONS

CHAPTER	37
NUMBER	37-3-1
EFFECTIVE DATE	April 27, 1962

SUBJECT: POLICY FOR RELEASE OF DATA ACQUIRED ON NASA SOUNDING ROCKETS, SATELLITES AND SPACE PROBES

1. PURPOSE

This Instruction defines the procedures to be followed in relations with the individual scientists or groups participating in the NASA Space Sciences Program with regard to release and publication of experimental data obtained in NASA sounding rockets, satellites, space probes or other spacecraft operations.

2. BACKGROUND

a. An important goal of the National Aeronautics and Space Administration is the encouragement of the widest possible participation in the Space Sciences Program. Within the scientific community the individual scientist is of prime importance to the Space Sciences Program. He is responsible for the conception of experiment, for carrying out the experiment, and for interpreting its results. To support the Space Sciences Program, NASA makes available vehicles and funds for research in space and assists in the dissemination of the resulting experimental information.

b. In assigning the use of its facilities for space research NASA endeavors to choose the best experiments and experimenters available. In order that new knowledge in the space sciences may be disseminated as widely and as rapidly as possible and to satisfy the requirements of the National Aeronautics and Space Act of 1958 (42 U.S.C. 2451 et. seq.), it is essential that the experimenters publish their findings as soon as they can.

3. DEFINITIONS

For the purpose of this Instruction, the following definitions will apply:

a. Original data records--Those records made by the various telemetering and/or tracking stations as part of the basic field operations. These recordings will generally require editing for the removal of useless segments, playback to introduce calibration factors, correlation with related recordings and the application of specialized processing techniques to recover weak signals from noisy recordings.

T. S. NO. 418

b. Reduced data records--Those records prepared from the original data records by editing, introduction of calibration factors and inter-record correlations. They will contain a minimum of extraneous information and/or noise and generally will present the value of the physical quantity measured as a function of time and position. It is from these records or the tabulations or graphs prepared directly therefrom that the responsible scientist will form his analysis and conclusions.

c. Analyzed data--Those data which have been reviewed and correlated by either the original experimenter or another scientist so as to form the experimental basis for a technical paper submitted for publication to either NASA or a scientific journal.

4. SCOPE

a. Scientists as a group feel a responsibility for making the results of their efforts known to the worldwide scientific community. Scientists have been the most vigorous proponents of free dissemination of the knowledge gained from their investigations and, in general, can be expected to release experimental scientific information rapidly.

b. In the usual case, an agreement that will assign the responsibility for the analysis and publication of the data to the scientist will exist between NASA and the scientist. In the period before the publication of the results of the experiment, it may happen that another scientist may wish to have access to the experimental data in its preliminary form. This is generally arranged informally by a request made directly to the experimenter.

c. Occasions may arise when it will be necessary for NASA to release the results of experimental investigations made under its sponsorship without waiting for publication by the cognizant scientist. It is expected that this will happen only when the responsible scientist is unable to meet his commitments within a reasonable time.

d. In many instances the data acquired from space vehicles, like the observations made in astronomy, will have a cumulative value. Whenever this is the case, it is desirable that such data be made available for the general use of the scientific community.

e. The original data received from a satellite or space probe is meaningless until the various channels are separated or demultiplexed, the

calibration of the instrumentation is introduced, and the data put in chronological order. Provisions for these operations must be included in the arrangements made for supporting the applicable experiments.

5. POLICY

a. The original data recordings received from a satellite or probe shall be stored at the cognizant NASA field installation.

b. Secondary records containing reduced data shall be prepared under the cognizance of the responsible NASA field installation. On occasion this operation may take place at the contractor's or experimenter's establishments. In the secondary records all extraneous material and all confusion of data will be removed to the fullest extent possible. The records will be prepared by the NASA field installation or contractor with the cooperation of the experimenter so as to satisfy the needs of the experimenter and NASA for reduced data.

c. The experimenter shall be given whatever original or reduced data from his experiment that his agreement with NASA calls for as soon as possible after they are received. The cognizant NASA field installation will retain copies of the reduced data furnished the experimenter. The experimenter will have sole use of the reduced data for study for a period previously decided upon between him and Office of Space Sciences, NASA Headquarters.

d. No general fixed time shall be set for the period of exclusive use of reduced data by experimenters. Each case shall be considered individually and no general rule shall be established.

e. If, during the period in which the experimenter has not reported the results of his experiment, information on the progress of the experiment or portions of the reduced data are requested by another scientist for designing space science experiments or for the preparation of a technical paper, informal arrangements for the release of the needed data will be made by the experimenter concerned. Both the cognizant NASA field installation and the Office of Space Sciences, NASA Headquarters, will be informed of these arrangements.

f. At the end of the agreed-upon period during which the experimenter will have the opportunity to analyze and report on the reduced data, the re-

duced data may be released for general use if such a course seems best for developing the space sciences. An extension of the period of sole use requested by the experimenter will require the approval of the Office of Space Sciences, NASA Headquarters.

g. All releases of the reduced data by NASA field installations to other than the original experimenter must be approved by the Office of Space Sciences, NASA Headquarters.

Homer E. Newell

Director, Office of Space Sciences

APPENDIX 2

THE SCIENTIFIC AND TECHNICAL INFORMATION PROGRAM OF THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, OCTOBER 1962

PREFACE

All scientific and technical programs of the National Aeronautics and Space Administration, whatever their specific objectives and accomplishments, have one common requirement and one principal product: knowledge. This knowledge is clearly vital to continued progress in the aeronautical and space sciences. It is equally, if less obviously, vital to all elements of society that in any way contribute to, or rely upon, technological advancement. In a very real sense, the scientific information deriving from NASA's endeavors is a critical national resource.

Information requirements internal to the NASA community can only be satisfied through an integrated, comprehensive system that provides ready access to any recorded knowledge that will assist or improve its technical programs. In the same way, the external information requirements which NASA must satisfy can only be met by a system that insures ready access—for science, for industry, for the educational world, and for the general public—to NASA-sponsored scientific knowledge appropriate to a given need.

The extent to which such information is made usefully available to the several "publics" which NASA serves is therefore a major measure of NASA's effectiveness. The key word here, of course, is "usefully." Mere availability of a vast and varied collection of data is plainly not enough at a time when the communication of scientific knowledge is, in itself, a most pressing scientific problem. To fulfill the functions assigned by Space Act of 1958, and to meet its responsibility to the Nation, NASA must insure that its work and its findings are reported both comprehensively and selectively, that *all* suitable information is provided to organizations and interests that can properly utilize it, and that *any* of its scientific information can be identified and made available, in a meaningful form, to specialized endeavors that in any way promote the national aeronautics and space programs.

Finally, to avoid further compounding the scientific communication problem, the NASA program for meeting the foregoing goals must be coherently related to the many other existing scientific information systems, both inside and outside the Government.

INTRODUCTION

The NASA scientific and technical information program is based upon five operating principles, which merit identification and explanation as background for subsequent discussion of the organization, program elements, and operating details of the NASA system.

Service designed for the ultimate consumer.—All products, tools, and services provided by the NASA program have as a primary design consideration their usefulness to the ultimate consumer of scientific information—the scientist, the technician, the laboratory worker. They can also, of course, be utilized by intermediate services—by technical libraries, or by information centers—wherever this is desirable, but the intent is to give the scientist and technician a free choice: to maintain his own current literature awareness, to make his own literature searches, and to obtain his own information, or to refer his requirements to information specialists or librarians whenever circumstances so dictate.

Timeliness—An essential.—With the current pace of technological progress, in which today's critical breakthrough is frequently tomorrow's commonly accepted fact, such a general principle probably needs no emphasis. It should be emphasized, however, that the NASA program is designed to insure maximum timeliness in all aspects of scientific information service: in the preparation and publication of reports on NASA undertakings; in the acquisition and processing of non-NASA information bearing on aeronautical and space programs; in the announcement of all materials produced by or flowing into the NASA scientific information system; and in the response to specific document requests or to bibliographic inquiries. It is in support of this principle that the NASA program is designed on an active rather than a passive footing—that is, available materials will in all possible cases be provided to NASA installations, major con-

tractors, and other participating organizations, either as original documents or in microform, concurrently with their announcement. This will permit a scientist or technician, noting an entry in a NASA announcement journal, to consult the document or documents concerned in his local reference facility without having to request the material from a central Government agency service point.

Reliance on existing systems.—The NASA program must profit from, not compete with or displace, other existing information systems and services. In the field of report literature, upon which NASA's internal bibliographic efforts must concentrate, this requires coordination, collaboration, and wherever possible system compatibility with all other major systems sharing this report-literature orientation. These are primarily Government or Government-sponsored activities such as the Armed Services Technical Information Agency of the Department of Defense; the Technical Information Division of the Atomic Energy Commission; the Office of Technical Services in the Department of Commerce; other agency information systems such as those in the Federal Aviation Agency and the National Institutes of Health; and major Government libraries, including the library of the Department of Agriculture, the Library of Congress, and the National Library of Medicine. Through general collaboration under the aegis of the National Science Foundation, and through specific collaboration with agencies whose information systems are directly related to NASA's, the policies and procedures of the NASA program are being keyed as directly as possible to those of all complementary systems. In most cases, this direct tie-in, and the resulting operational compatibility, will even permit direct interchange of machine-processed information between the NASA and related information systems.

Similar collaboration has already been established in many cases with abstracting, indexing, and related services that concentrate on the vast bulk of formally published journal literature. Through contact with professional societies such as the Institute of the Aerospace Sciences, and with other members of the National Federation of Science Abstracting and Indexing Services, arrangements are being made to promote and where possible improve existing coverage of journal literature through abstracting and indexing services in fields of concern to NASA. NASA support already extended to the American Meteorological Society and the Aerospace Medical Association provides a pattern for similar encouragement in other areas of NASA interest with the end aim of completely complementary services to cover today's vast bulk of aeronautical and space literature with maximum comprehensiveness and minimum overlap.

Centralization only when necessary.—In any large-scale information system, the concept of centralized processing and control is at least superficially attractive. More economical production-line operations, more effective control over the myriad details of a documentation service—these and other factors can be cited in support of a strongly centralized system. To do so, however, runs the hazard of rating the needs of the system, per se, above those of its customers, since no completely centralized system can ever be as rapidly and as flexibly responsive to local needs as those of a decentralized operation. The NASA program, in keeping with its first principle of customer orientation, is designed to restrict centralization to those areas where it is mandatory on economic or functional grounds—examples are in the preparation of indexes, the maintenance of distribution authority records, operation of the agency translation clearinghouse. In other respects, decentralization is the guiding premise of the NASA program. Even in the area of machine-search capability, computer tapes are being made available to cooperative activities, such as NASA field centers, so that machine searches can be carried out onsite at the point of actual need. As previously emphasized, all document materials in the NASA system are being made similarly available within the NASA community. Through arrangements with other information systems and through a major depository library program, the same principle is being applied to information requirements external to the NASA community.

A variety of products and tools for a variety of "publics."—As a principle unto itself, and in support of those outlined in the preceding paragraphs, the NASA program recognizes that no one type of service, no one reference tool, and no one bibliographic pattern can ever satisfy the multiple "publics"—the multiple needs of thousands of organizations and hundreds of thousands of individual scientists and technicians—which the NASA scientific and technical information program must serve. The NASA publication program must obviously produce technical reports as primary records of NASA undertakings, but it must also produce many other secondary publications which collate, resynthesize, integrate, or repackage the mass of material contained in such basic records. Its bibli-

ographic services must provide announcement journals and indexes to serve the widest possible need, but there must also be provided a wide range of continuing and demand bibliographies, an extensive and flexible reference service, and a machine-search capability to satisfy specific requirements in the greatest depth possible. The NASA dissemination program must satisfy in advance, wherever possible, known requirements of participants in the NASA aeronautics and space programs; but provision must also be made for rapid satisfaction of additional or new requirements on a request basis, for the same audience or for other audiences. In all these ways, and others, the NASA program must continually strive to satisfy efficiently and economically the widest variety of needs with the widest practicable variety of products, tools, and services.

ORGANIZATION

As illustrated in the accompanying organization chart, the NASA Office of Scientific and Technical Information is responsible to the Assistant Administrator for Public Affairs, who, in turn, is directly responsible to the Administrator of NASA. Normal staff relationships between the Office of Scientific and Technical Information and the technical, managerial, and administrative elements of NASA Headquarters are supplemented by a system of technical information coordinators—individuals designated by the other headquarters elements to act as focal points for the effective handling of all technical information considerations that are of direct concern to the office represented. Similarly, relationships with NASA field elements are handled either through usual command channels or—on operating and procedural questions—directly with personnel in the scientific and technical information function maintained at each of the major field installations.

Through these staff arrangements, and through the establishment of a contractor operated facility (Scientific and Technical Information Facility), it is possible for the Office of Scientific and Technical Information to concentrate its in-house efforts and resources on program planning, management, and administration, rather than building up the large operationally oriented staff that would otherwise be required.

The following outline summarizes the major functions of the three principal divisions of the office—the Technical Services Division, the Documentation Division, and the Technical Publications Division—and the branches established in each:

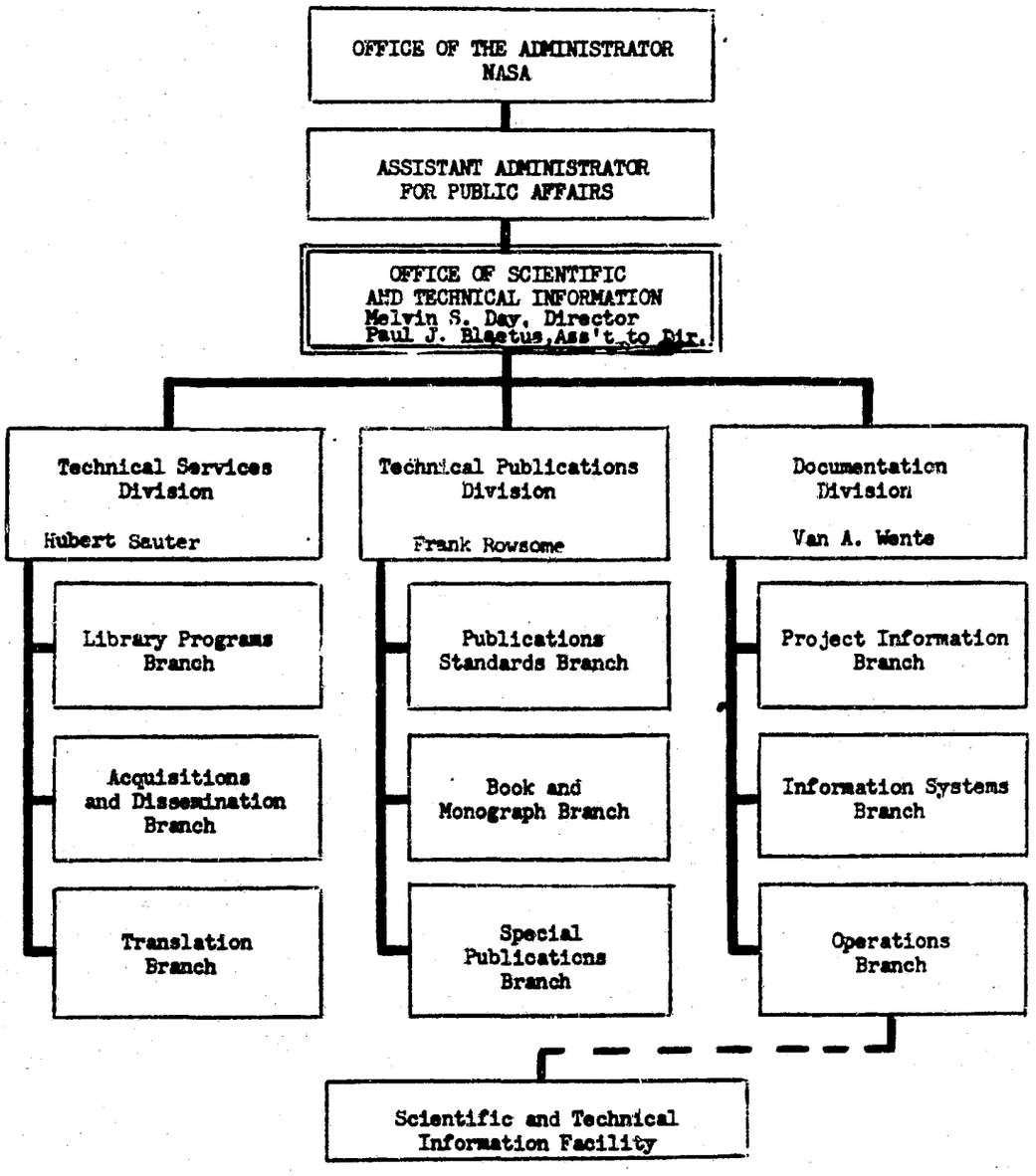
TECHNICAL SERVICES DIVISION

In general, this division has the responsibility for planning, managing, and monitoring the input and output aspects of the NASA scientific and technical information program.

Library Programs Branch.—This Branch is responsible for operating the NASA Headquarters Library—a specialized technical reference facility responsive to both the scientific and the managerial information requirements of the Headquarters staff. In extension of this facility, the Branch is also responsible for providing actual literature research assistance to Headquarters elements in three broad areas: life sciences, physical sciences, and applied sciences or engineering. Finally, the technical personnel who provide this research assistance are also responsible for monitoring and evaluating all products, tools, and services of the NASA scientific and technical information program. Through their own technical capabilities, and through direct and continuing liaison with the user areas which they represent, they provide a feedback mechanism to insure that all of the programs efforts are consumer oriented in practice as well as in principle.

Acquisition and Dissemination Branch.—Responsibilities assigned here include the establishment and maintenance of acquisition criteria which govern the selection of material to be included in the program, and the establishment and maintenance of the standards and procedures under which materials in the system are distributed within the NASA community as well as to activities and interests external to NASA. In specific support of these responsibilities, the Branch directs NASA's comprehensive exchange program—through which NASA information materials are traded on a worldwide basis for materials produced by other aeronautical and space activities—and the NASA depository library program, which insures the availability of reference collections of NASA publications wherever necessary to satisfy recognized needs.

Translations Branch.—This Branch maintains a clearinghouse for NASA translation requirements, providing close liaison with other translation activities to guard against any unnecessary duplication in NASA's efforts, and provides translation capability to meet NASA requirements not satisfied elsewhere. The in-house capability is small, concentrating on correspondence and other matters of immediate concern, but is supplemented through contracts with translating activities known to have special competence in the scientific and technical areas of primary concern to NASA.



DOCUMENTATION DIVISION

This Division, generally, is responsible for information processing and related capabilities within the NASA program.

Project Information Branch.—This Branch is responsible for establishing and maintaining a system whereby information regarding current NASA research and development activities is identified and recorded before the activities reach the stage of documentary reports. Information on who is doing what work where must be obtained from management and administrative reporting systems, and then organized, stored, and retrieved at need. This storage and retrieval process has to be integrally related to the documentary retrieval system, to the

end that the total response to any information inquiry will include both citations of all known documents that may be pertinent as well as all citations of current or projected research and development activities. (A further function of the project information system is to provide an acquisition control mechanism to insure receipt of all NASA scientific and technical reports on current research activities as soon as they are available.)

Information Systems Branch.—Here is assigned responsibility for identifying, analyzing, and evaluating all new methods, systems, techniques, and equipment in the field of scientific communication. Based upon such investigation and evaluation, the Branch is responsible for recommending the adoption or adaptation, wherever appropriate, of new equipment or techniques that may in any way aid any aspect of the overall NASA scientific and technical information program; in terms of efficiency, economy, and effectiveness.

Operations Branch.—This element has as its central responsibility the administration and management of NASA's contract-operated scientific and technical information facility. Branch personnel provide or monitor all administrative and functional liaison between NASA and the contractor to insure effective satisfaction of all recognized requirements in terms of the criteria, standards, and procedures determined by NASA. (Details of this contract operation are presented in a later section of this report.)

TECHNICAL PUBLICATIONS DIVISION

The responsibilities of this Division fall into two quite distinct categories: the processing for publication of the technical report literature which comprises NASA's primary information material, and the preparation and publication of a wide variety of so-called secondary publications designed to integrate, or resynthesize, the information contained in basic NASA publications.

Publications Standards Branch.—One of the two major functions of this Branch comprises the establishment and maintenance of the editorial and related standards under with all NASA technical publications are prepared. The second function involves the control—from administrative and logistic standpoints—of NASA's basic technical report output. This function includes responsibility for assuring proper technical approval of all such NASA products, but specifically excludes approval authority as such, since this resides with the NASA technical program offices or, in the case of contract reports, the technical project offices.

Special Publications Branch.—This Branch is responsible for the preparation of all secondary publications which are of a continuing or serial nature, as well as such one-time publishing products as symposium proceedings and the like. Other examples of the Branch's responsibilities includes periodic technical reviews, and continuing state-of-the-art summaries. (Both this Branch and the Book and Monograph Branch will have limited in-house capability for the preparation of appropriate publications, and must depend largely upon contract efforts through the professional societies, universities and research groups, and commercial activities.)

Book and Monograph Branch.—Basically, the functions performed here are similar to those in the Special Publications Branch, except that they cover a periodic, or monographic, publication, such as handbooks and data compilations, state-of-knowledge compendiums, and the like.

One essential publications function, not yet assigned to the Technical Publications Division, is being handled as a staff function of the Office of Scientific and Technical Information itself, primarily because of the developing nature of the initial effort. This function concerns the identification, collation, and appropriate publication of information deriving from NASA's scientific and technical program which is particularly susceptible to industrial or commerical application. This function must of necessity be carried out in close coordination with NASA's Office of Applications.

PROGRAM ELEMENTS

The preceding section has treated responsibilities and functions of NASA's scientific and technical information program in organizational terms. At risk of repetition, the chart headings and notes on this and succeeding pages treat the same functions as component parts of basic program elements:

1. Publication.
2. Collection and Bibliographic Control.
3. Dissemination.
4. Project Information.

These headings pertain to the documentary portion of the program. While each represents a relatively well defined area of endeavor, it should be clearly recognized that in practice they interlock and interact at too many points to permit their consideration as truly discrete entities.

This element of the program, still in initial stages of its development, concerns the records of current research—research in progress, or projected.

PUBLICATION

1. NASA's technical results and findings:
   - NASA technical reports.
   - NASA technical notes.
   - NASA technical reprints.
   - NASA technical memorandums.
   - Contractor reports.

This part of the publications effort comprises basic reporting, in approximately the forms indicated, of work performed under NASA technical programs. Reports and notes are, respectively, interim and final statements of results and findings; memorandums carry distribution limitations, for security reasons; reprints present NASA information published in journals; contractor reports record the results of extramural effort. Emphasis is on high technical quality, but also speedy publication and distribution. To overcome the limitations inherent in the extreme specialization of such reports, they are thereafter used as input for the "secondary" publications described below.

2. Related information and "repackaged" products:
   - Conference and symposium proceedings.
   - State-of-art monographs.
   - Technical reviews.
   - Technical translations.
   - Handbooks and data compilations.
   - Dictionaries.

Publications of the general types indicated here are designed to integrate and resynthesize information derived from NASA programs and related activities. The effort will eventually involve a variety of forms to insure the widest possible utility of the information presented. Preparation of these materials is being very largely handled through contracts or other external arrangements to insure the highest degree of technical competence in the publications. With the exception of symposium proceedings and technical translations, periodicty of publication will be determined by the level of activity in particular subject areas of coverage.

COLLECTION AND BIBLIOGRAPHIC CONTROL—INPUT

1. Acquisition:

   All NASA publications.
   Report inflow from non-NASA R. & D. activities:
      Interagency agreements.
      Exchange arrangements.
   Books.
   Journal subscriptions.

2. Evaluation:

   Check for duplicates.
   Review for relevancy.
   Coverage of given subjects.
   Scanning for special treatment (express announcement, bibliography entries).
   Exchange benefits.

3. Abstracting:

   Review and editing of author abstracts.
   Preparation of abstracts where necessary.
   Precise translation.

4. Indexing:

   Preparation of descriptive entry.
   Preparation of subject entry.
   Selection of subject terms for journal index.
   Selection of subject terms for machine retrieval.

These headings identify, in self-explanatory detail, the input functions of the documentation system. However, in the acquisition phase it is important to note that the system will concentrate almost entirely upon report literature; books and journals will be obtained for reference use, but will not be included in subsequent processing. All four phases are the operational responsibility of the scientific and technical information facility, but all are being conducted under precise NASA guidance and control in terms of the standards on procedures to be observed. Under acquisition, particularly, NASA itself will act in making all contacts and arrangements necessary to insure adequate receipt. In the first year of operation, it is estimated that some 20,000 reports will flow into the system. A final point worthy of note is to be found in the indexing phase. Here, under the selection of subject terms, appears the two-level search capability which the documentation system will provide: one level for direct use by consumers in the journal index, and a second level—in far greater depth than the first—for literature searching and bibliographic preparation by the computer system. (The first, or journal index level, will provide an average of four access points per item because of the size limitations inherent in a printed index: for machine retrieval, where greater depth of indexing and retrieval is optimized by the machine capacity, the average will be 20 or even more access points.)

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COLLECTION AND BIBLIOGRAPHIC CONTROL—OUTPUT

1. Reference and retrieval:
   - Identification of requested items.
   - Performance of literature searches.
   - Provision of specific data.

2. Abstract journals and indexes:
   - Categorization of abstracts.
   - Assembly and publication of journal sections.
   - Preparation of indexes—Subject, author, source.
   - Publication of cumulated indexes.

3. Bibliographies:
   - Preparation and publication of continuing bibliographies.
   - Preparation of demand bibliographies.
   - Provision of "express" announcements.

These "Output" headings are again largely self-explanatory, but certain items justify particular mention. Under Reference and retrieval, the identification and literature search functions are performed by machine in most cases (except for special search requirements, such as for reports under a given contract, where manual methods are far more effective). The provision of specific data requires human endeavor to provide factual answers until such time as the system can be refined to permit actual data storage, either comprehensively or in particularly susceptible fields. Under Abstract journals and indexes, the time cycle is of particular interest. The journals are published semimonthly, complete with four indexes, with a maximum 4- to 6-week time lag between receipt of reports and their announcement. Cumulated indexes are prepared quarterly, semiannually, and annually, with a lag of no more than 4 weeks after the conclusion of the period covered. Two items in the bibliographic area deserve mention. First is the fact that continuing bibliographies in selected subject areas permit a form of specialized reference and announcement service in any terms that NASA's interests dictate, whether disciplinary, programatic, or other; this provides flexible bibliographic service that can be tailored to any specific need. The second point concerns "express" announcements: geared to the continuing bibliographies, or to other identifiable requirements, receipts can be identified and circulated as frequently as necessary (weekly, or even daily) to those with pressing interests in particularly active fields.

DISSEMINATION

1. NASA publications to widest possible audience:

   Depository libraries.
   Exchange programs.
   Other systems: OTS (public), ASTIA (DOD), AEC.
   Automatic distribution.
   Request distribution.

2. Non-NASA reports in the system to NASA and its contractors:

   Request distribution.
   Automatic distribution.
   Microform.

Two distribution systems, as indicated, are provided: one to disseminate NASA publications, the other to disseminate non-NASA reports. In the first category, the depository library entry includes both the Government Research Reports Regional Reference Centers being established by the National Science Foundation and the Office of Technical Services, as well as complementary depository libraries established by NASA itself. Both the depository and exchange programs are international in scope. Dissemination to other systems, of course, includes not only those specifically identified here but others with comprehensive or selective interests in NASA publications. Automatic distribution to satisfy the foregoing requirements is supplemented by satisfaction of specific requests wherever necessary. Automatic distribution and request distribution also form a part of the system whereby non-NASA materials are disseminated within the NASA community itself. Either microform copies of such reports, or full-size copies if available, are being distributed to NASA Centers and contractors shortly before their announcement. This is to insure availability, on a decentralized basis, of all materials needed by any user at the earliest possible time. Although not so indicated in the headings as given, microform copies of NASA publications are available to any recipient who has a need for such a medium for reference or reproduction.

PROJECT INFORMATION

1. Collection and bibliographic control:

   Acquisition: From all NASA activities.

   Evaluation: For relevancy, adequacy, clarity.

   Abstracting: Extracting necessary data from reporting forms.

   Indexing: Coding data for machine input and search.

   Reference and retrieval: Machine search for technical, managerial, or analytical purposes.

2. Dissemination:

   Compilation: Preparation of printouts on continuing or demand basis.

   Distribution of selected compilations.

   Provisions of machine records to cooperating systems.

These headings identify the functions necessary to the centralized processing of the records of current research. Although there are minor differences between procedures identified here and those of the related portions of the documentary program, basically similar procedures are involved, and they have been stated in common terms to illustrate the integral relationship between the two portions of the NASA scientific and technical information program. The two principal aims of the project information program are, first, to provide a capability of identifying and collating the who-what-where data on current research in response to any informational inquiry; and, second, to provide a ready means of identifying and acquiring all relevant NASA documentary reports as soon as they emerge from current research efforts. The indexing, as well as the reference and retrieval aspects of this program element, are as nearly identical as possible to their counterparts in the documentary system, subject only to the possibly more stringent requirement for controlled output of information to suit the varying needs of technical or managerial customers, within or outside NASA.

CONTRACT EFFORTS

As indicated elsewhere in this report, the NASA scientific and technical information program is designed to rely heavily on external assistance, obtained through contracts, rather than trying to develop a large in-house operational capability. Contractual efforts in these terms are required in several areas of the program—translations, preparation of publications, information research, and documentation.

The most significant single contract now existing or contemplated is one in the documentation area. Since this contract provides for products and services that underlie and support all phases of the program, it deserves description in some detail before proceeding to more general description of the contract arrangements being made or planned for other portions of the program.

SCIENTIFIC AND TECHNICAL INFORMATION FACILITY

To provide assistance in collecting information and developing bibliographic controls, NASA has contracted for the operation of a central scientific and technical information facility in the Washington metropolitan area. The contractor is Documentation, Inc., Bethesda, Md., an information system organization with wide experience in the abstracting and indexing of scientific documents. Under the close technical direction of NASA and employing special facilities for processing information by advanced techniques, the contractor acquires and selects documentary materials to be added to the NASA collection, abstracts and indexes these materials as appropriate, prepares announcements and indexes for the newly acquired materials, provides concurrent and continuing dissemination service, provides a supporting reference service, and compiles bibliographies in specialized subject areas. These activities are described in the following paragraphs.

Acquisition and selection.—The facility automatically receives all significant scientific and technical documents that result from NASA-supported investigations. Such documents, which include those written at NASA Centers as well as those by NASA contractors, subcontractors, and grantees, are cataloged.

The facility also receives documents derived from NASA interagency agreements and from NASA exchange arrangements with domestic and foreign organizations. In this regard, it is sufficient to note that the facility provides assistance both in requesting documents or exchanges and in locating organizations that may be engaged in work related to NASA's space and aeronautical programs. Generally, the process of locating such information consists of automatically scanning current literature and reports for references to those potential sources. Every document received is reviewed for relevancy to NASA programs. Those of potential use to a scientist or engineer working in NASA related fields are selected for cataloging and announcing. Individual exchange arrangments are periodically reviewed for possible termination in the event no useful material has resulted.

Abstracting and indexing.—The facility utilizes the accepted medium of a short abstract to communicate scientific information in a convenient and economical form. Abstracts of an informative and specific nature are provided insofar as possible. Those received with the documents are frequently suitable for this purpose, but if not, they serve as a basis for the preparation of a proper abstract.

To provide for subsequent retrieval of the abstracts and the information which they describe, all documents selected for the collection are indexed in depth. A printed index is prepared as part of the abstract journal to permit retrieval of the information on a broadly decentralized basis. At the same time, magnetic tapes are prepared to permit more effective computer-based retrieval at the facility and at field locations having access to computer equipment.

Indexing is provided at two levels so that both retrieval systems may be used at maximum efficiency. In the case of the printed index, documents are analyzed to determine the four or five most significant index points—the limitation is necessitated by the sheer bulk and awkwardness of the index if it carries a greater number of index entries. In the case of a computer tape, the fundamental manipulative ability of the computer permits an almost unlimited number of index entries—the number to fully characterize a document is usually in the range of 20.

The indexing language or vocabulary for both purposes is carefully controlled. Special attention is given to providing enough flexibility for the vocabulary to grow with scientific and technological advances, while at the same time placing the index terms in an ordered system so that all users—indexers, documentalists, librarians, and scientists alike—may receive full benefit from the retrieval devices.

Announcements and indexes.—Abstracts prepared by the facility are published biweekly in an announcement journal. The publication cycle is such that all items received within any 2-week period are announced within 4 to 6 weeks. While the basic announcement journal is unclassified, a classified version is published on the same schedule to list all receipts which require security classification.

For the present, the announcement journal is a continuation of Technical Publications Announcements (TPA)—the publication used heretofore by NASA to announce new NASA publications and a few other selected report categories. TPA has been greatly expanded so as to provide adequate coverage for the thousands of NASA and non-NASA technical reports now being issued in the aerospace areas. TPA has also been revised in format and typography to insure greater ease of use.

The facility prepares four indexes to Technical Publications Announcements: subject, corporate source, personal author, and report number. All four indexes appear in each issue of the journal, and are being cumulated quarterly, semiannually, and annually. The cumulations are within 2 weeks after the close of the period covered by the cumulation. Each item announced is given a specially prepared notation of content which the computer manipulates and reproduces at appropriate points in the indexes.

For an initial period, NASA is issuing a single announcement journal, with the abstracts appearing in each issue categorized by general subjects to simplify scanning and location. This does produce an effective but rather bulky journal. Future plans, therefore, call for separation of the single journal into several sections, each one designed to cover a discrete area within the broad field of aeronautical and space sciences. Indexes and their cumulations will cover all sections and will thus serve as a unified reference mechanism for the entire series.

Dissemination service.—The facility is responsible for automatic dissemination of all documents accepted into the collection to official users, including NASA field installations, contractors, and grantees, to other Government agencies and their contractors, and to any other recognized participants in the NASA scientific and technical information program. This automatic dissemination is being accomplished within 10 days after new materials are received. It is either comprehensive or selective, according to subject categories, depending upon the stated needs and interests of individual recipients.

The dissemination program is designed to assure availability of documents on a broadly decentralized basis concurrent with the announcement of these documents. Its objective is to provide immediate access to reports of interest to any user without the delays imposed by having to request them from geographically removed points of service. Documents are being disseminated in full-sized copies when supplies permit. All documents, however, are also available for distribution in microform.

After initial automatic dissemination, the facility is responsible for satisfying specific requests. Individual documents—again in full size or microform—are provided to qualified requestors.

The microform dissemination employs a 5- by 8-inch diazo transparency which represents a departure from, and a compromise with, other existing microform programs. The 5- by 8-inch transparency was selected because it embodies a high degree of compatibility with other programs and because it provides a unitized record with extremely high readability and reproducibility qualities. Each microform, using a reduction ratio of 15.4 to 1, may record up to 75 standard page images. An estimated 80 percent of the documents in NASA's collection comprise fewer than 75 pages each and so can fit on a single microform unit; all but an insignificant portion of the remaining 20 percent can fit on 2 units. The microform can be viewed in most existing film readers, and can be reproduced on almost all available reader printers. Although the basic microform selected is a 5- by 8-inch film sheet, it has been engineered to permit easy conversion to a tab-card microform size should future developments render this desirable.

Reference service.—The facility provides three categories of reference service. One of these satisfies a requirement to identify specific documents requested by users who do not know—or do not use—a precise title or number for the document they need. A second type of service provides literature search reference assistance to satisfy requests for documents bearing on a given subject, produced under a given contract, written by a given author, etc. The third type is designed to provide factual answers—instead of bibliographic citations—wherever the nature of the question and the capabilities of the facility's staff permit.

Computer techniques provide the basis for literature searches that require more than a simple look up in a manual file. Use is made of the indexing-in-depth described previously. This information, recorded in computer language on magnetic tape, is manipulated by the computer to provide the necessary coordinations. As the computer also manipulates descriptive information already recorded on tapes, the product is a rapidly prepared literature search that requires no additional labor over that which went initially into the key punching of the document citations and descriptive entries for Technical Publications Announcements.

Bibliographies.—Using computer techniques, the facility prepares continuing bibliographies in selected subject areas. As noted elsewhere in this report, the preparation and publication of such bibliographies provides specialized reference tools which can also be used as a current awareness announcement mechanism.

Where activity in any given area or known needs on the part of any participant in the program require it, the continuing bibliographies prepared by the facility also provide a capability for "express" announcement service. In other words, new items identified as appropriate to a bibliography are flagged for special dissemination in advance of the announcement journal.

Supplementing the continuing bibliographies are bibliographies prepared on demand. Again, the computer capability is utilized to the greatest possible extent so as to insure timely response.

OTHER CONTRACTUAL AREAS

As previously noted, contractual assistance is required for translations, for the preparation of publications, and for information systems research. In all these areas, scientific and technical competence as well as economy and speed are the

primary requirements. While each contract for information systems research and development is tailored to the individual project because of the diverse nature of activities of this type, a basic pattern has been adapted for translations and publications undertakings.

Using the translations field as an example, NASA prepared and circulated a request for proposal (RFP) identifying seven broad subject areas of primary interest. Rather than relying upon a single "generalist" contract for across-the-board coverage, this approach permitted the selection of as many contractors as necessary to insure the highest degree of competence, both technical and linguistic, in these principal fields. Cost was, of course, a factor in selection, but chief stress will be placed upon the prospective contractor's demonstrated competence, preferably with in-house talent, to provide high quality service.

A similar approach is being developed for the preparation of publications. In this field, however, unlike translations, every reliance can be placed upon the professional societies. In many cases, they represent a concentration of scientific and technical talent that cannot be matched by any commercial organization or service. The types of direct publications desired—source books, technical reviews, state-of-the-art monographs, etc.—are described elsewhere in this report, but two other areas should be mentioned.

One concerns contract assistance to abstracting and indexing services maintained by professional societies. The second contract approach concerns possible support to new, and possibly novel publications by professional societies or other substantive groups which might expedite or broaden the dissemination of information of concern to aeronautical and space programs.

Relationships

Like the space program itself, NASA's scientific and technical information program is so broad that it necessarily cuts across all normal dividing lines—organizational, disciplinary, and geographic. This condition requires direct or indirect contact and working arrangements with a wide variety of other information services and interests, both domestic and international.

The following sections outline major relationships of this nature as they now exist or are being developed. First, however, it may be well to explain at least the general categories into which these relationships fall. One such category involves merely coordination, in an informational sense, to the end that NASA and some other activity keep each other fully and mutually informed of policies and operations to avoid duplication or conflict and to insure maximum joint benefits. A second category involves outright collaboration—where NASA and some other activity actually work together in developing or refining their operations to achieve the closest possible degree of working compatibility. A third category involves the exchange of informational materials—either technical documents or the bibliographic tools and products concerned with such documents. A fourth category deals with dissemination—that is, some other activity accepts NASA information for the purpose of disseminating it, or making it available, to a wider audience than NASA itself can reach. A fifth and final category involves relationships in which NASA provides actual monetary support to another activity to develop or assist in information programs that relate directly to NASA's interests.

As the following discussion and the accompanying chart demonstrates, these categories frequently overlap; relationships with any one agency or activity may involve two, or three, or all of the cited categories with varying degrees of emphasis on each. It should also be noted that this brief presentation does not comprehensively cover the exchange and dissemination of information, which involves scores of organizations in this country and abroad.

Finally, it is important to recognize that the relationships described here are only those in which a definite technical-information linkage exists as such. There has been no attempt made to identify or enumerate activities with which technical elements of NASA maintain constant working contacts—even though such contacts almost always involve the exchange of technical data. Examples of these—given only for illustration—include the Interagency Committee on Radiological Assistance; the NASA–DOD Aeronautics and Astronautics Coordinating Board; the Telecommunications Coordinating Committee of the Department of State; the Joint Meteorological Satellite Advisory Committee; and several committees of the Space Science Board.

RELATIONSHIPS MAINTAINED BY THE NASA SCIENTIFIC AND TECHNICAL INFORMATION PROGRAM

Domestic

Government Agencies

Library of Congress Science Information Exchange	1,2,3,4,5
Armed Services Technical Information Agency Atomic Energy Commission Federal Aviation Agency	1,2,3,4
Office of Technical Services	1,2,3
Department of Agriculture Library Department of the Air Force (AFOSR) National Bureau of Standards National Institutes of Health National Library of Medicine National Science Foundation Veterans Administration	1,2

Government-Sponsored Activities

Liquid Propellant Information Agency Power Information Center Radiation Effects Information Center Solid Propellant Information Agency	3,4,5

Non-Government Activities

Aerospace Medical Society American Meteorological Society	1,2,3,5
Inst. of the Aerospace Sciences American Rocket Society	1,2, and proposals for 3,5
National Federation of Science Abstracting and Indexing Services	1
Depository arrangements with 20 organizations	3
Exchange arrangements with 103 organizations	4

International

Advisory Group for Aeronautical Research and Development (AGARD)	1,2,3,4
Space Commissions (or counterparts) in 7 countries	2,3,4
Euratom Eurospace	2,4
Depository arrangements with 12 organizations in 12 foreign countries	3
Exchange arrangements with 98 organizations in 33 foreign countries and with 12 international aerospace and astronautical societies	4

Legend: (See text for explanation of terms)

1 - Coordination
2 - Collaboration
3 - Dissemination
4 - Exchange
5 - Funding

The chart displays only relationships that currently exist in formal or substantial terms. It does not list routine or potential relationships: exchange of materials, for example, routinely takes place in some degree with almost all other Government agencies, and informal coordination is widespread.

DOMESTIC

Government agencies

Of primary concern in the domestic field are NASA's working arrangements with other Government agencies active in the aeronautical and space sciences or in related scientific areas, as well as with those Government organizations concerned with all aspects of scientific communications. These include:

National Science Foundation.—Beyond general coordination on all aspects of the NASA information program, present arrangements include specific collaboration in efforts to improve the coordination of multiple-agency funding of abstracting and indexing services, such as those provided by the American Meteorological Society and, in the field of aerospace medicine, by the Library of Congress. NASA is a primary participant in the Federal System of Regional Technical Report Centers sponsored by NSF and being implemented through the Office of Technical Services. Similarly, NASA will be a primary contributor to the new program, also being implemented through the Office of Technical Services, de-

signed to provide a central permuted-title index to all Government research and development reports. On a less direct operational level, NASA participates in the NSF-sponsored effort carried on by the National Bureau of Standards in the coordination of machine storage and retrieval developments. Other areas of direct NASA–NSF collaboration include foreign translations; publications policy (particularly with respect to such questions as page charges to professional journals and reprint procedures); and ad hoc joint review of unsolicited proposals for information research or services.

Office of Technical Services.—In addition to the arrangements outlined immediately above, which involve both general coordination and specific collaboration with OTS, NASA provides its unclassified publications (except those necessarily handled through the Superintendent of Documents) to OTS for public announcement and sale. Documents are provided in multiple copies, through initial print overruns, to make them available at the lowest possible cost to the public. Under the developing NASA documentation program, all appropriate documents are being provided in microform for use by OTS as well as directly to the 12 libraries initially identified as Federal Regional Technical Report Centers. In contributing to the new central premuted-title index, NASA is providing basic cataloging information direct to OTS to avoid any duplicative processing costs. On a more general level, NASA is maintaining coordination with OTS and the Small Business Administration in developing new methods of identifying and disseminating information deriving from NASA programs which may have direct or potential industrial applications.

Armed Services Technical Information Agency.—Because of the similar nature of the NASA and ASTIA programs, and because of the broad commonality of interests between NASA and the Department of Defense, the closest possible degree of coordination and collaboration is maintained with ASTIA. Completely reciprocal service is maintained. ASTIA services are available to and used by NASA installations, contractors, and grantees. Department of Defense installations, contractors, and grantees can and do receive similar service from the NASA scientific and technical information program. This reciprocal service, of course, supplements the interlocking primary distribution mechanisms of NASA and the three military departments, by which originating agencies contribute technical reports directly to other interested activities regardless of their agency affiliations. The developing NASA documentation program is being geared very closely to the existing ASTIA system at all operational levels—from basic cataloging through specialized dissemination techniques such as microform or microfilm—to insure the greatest degree of compatibility throughout the two programs. NASA is participating directly in the present cooperative revision of the ASTIA Thesaurus, and is using the experience thus gained to assure the highest possible degree of compatibility in the essential area of retrieval vocabulary. Since all NASA reports feed into the ASTIA system, and since many military reports will of necessity feed into both systems, all possible steps are being taken to permit the utilization by either agency of the machined products of the other; with the exchange of abstracts and indexing information and with machine output from one being direct input to the other, duplicative processing of common materials is minimal.

Atomic Energy Commission.—Again, because of common interests and procedures, close working relationships are maintained between the NASA scientific and technical information program and its counterparts in the AEC. Reciprocal document and bibliographic service is maintained, and the NASA documentation system is recognizing points requiring compatibility wherever possible. Here also all possible steps are being taken to permit the utilization by either agency of the working materials of the other in order to eliminate duplicate processing.

Library of Congress.—Relationships with the Library of Congress, maintained primarily through the Library's Science and Technology Division, include both general coordination and specific collaboration. Aside from the provision of all unclassified NASA publications to the Library, specific arrangements include NASA funding for the preparation, by Library personnel, of both current abstracts and retrospective bibliographies in the field of aerospace medicine. The bibliographies resulting from this continuing effort are published by NASA; the current abstracts are published in the journal of the Aerospace Medical Society. NASA has also supported the Library's preparation of a biographical compendium of individuals publishing papers in the space sciences.

Science Information Exchange.—NASA is represented on the SIE Board of Governors, and, with the other agencies concerned, contributes financially to

the support of SIE. Up to the present, NASA contributions of information to the SIE system have been largely limited to published listings of NASA research grants and contracts. It is recognized, however, that the breadth of NASA's research and development effort requires a substantial expansion of its contribution to the SIE program. This is being accomplished by the provision to SIE of output from the project-information system established as an integral part of the overall NASA scientific and technical information system. As SIE's collections and capabilities expand through this and other contributions, increased utilization of SIE by NASA should result.

National Library of Medicine.—Principal emphasis in the NASA–NLM relationship rests on coordination. This is because the NASA scientific and technical information program—particularly in its documentation aspects—is still in the process of development, while the same condition is true for NLM, through MEDLARS and associated efforts. Since both systems will rely heavily upon machine processing of information, every effort is being made through reciprocal briefings and consultations to maintain mutual awareness of all developments in either of the two systems. One area of particular joint interest is in the evolution or development of printing output devices designed to provide acceptable bibliographic products directly from machine-processing systems.

Federal Aviation Agency.—Like NASA, the FAA is in the midst of developing a new and expanded scientific and technical information program. While reciprocal document and bibliographic service is of course maintained, chief emphasis is placed upon coordination and collaboration as the two systems develop. As examples of this effort, the NASA microform program has been presented to FAA officials in detail for their adoption or adaptation as desired, and arrangements have been made for direct working interchange in the development of NASA and FAA retrieval vocabularies.

Other Government agencies.—Liaison in some degree is maintained with several other Government agencies, either directly or through interagency efforts such as those of the National Science Foundation and the National Bureau of Standards. These agencies include the Department of Agriculture, the Patent Office, the Veterans' Administration (which has been of direct assistance to NASA on several aspects of its microform system), as well as many elements of the Department of Defense, the Air Force Office of Scientific Research, the Army's Office of Research and Development, etc.

GOVERNMENT-SUPPORTED INFORMATION ACTIVITIES

A variety of specialized technical information centers or activities are supported, in whole or in part, by the different Government agencies. Where the subject or services of these specialized activities pertain directly to the NASA program, working arrangements ranging from coordination through actual funding support are maintained. Major examples are:

Power Information Center (at the University of Pennsylvania) may be considered as the secretariat of the Interagency Advanced Power Group of which a member of the NASA staff is chairman for 1962. The Army, Navy, Air Force, Advanced Research Projects Agency, Atomic Energy Commission, and NASA jointly contribute to the support of this activity which supplies information on new power concepts.

Radiation Effects Information Center (at Battelle Memorial Institute) which serves designers of nuclear-powered equipment, is another group with which the NASA is cooperating, and to which funds were contributed by NASA in 1962.

NASA, together with the Army, Navy, Air Force, and Advanced Research Projects Agency share equally in the technical management and financial support of the Liquid Propellant Information Agency (at Johns Hopkins Applied Physics Laboratory). This group collects and disseminates material of interest to those concerned with liquid-fueled rockets. The Solid Propellant Information Agency (also at the Applied Physics Laboratory) is a similar organization in the field of solid propellants.

NON-GOVERNMENT ACTIVITIES

The National Federation of Science Abstracting and Indexing Services represents a point of focus for many of the informational relationships which NASA maintains or contemplates with nongovernmental activities. Aside from exchange and depository agreements—which, as already noted, are too numerous

to be discussed in detail here—these relationships are designed to concentrate on two objectives: the first is the achievement of the best possible coverage, in a bibliographic sense, of journal literature in the aeronautical and space sciences; the second is to develop input from professional societies and other qualified organizations for the "repackaging" portion of the NASA publication program.

Although primary emphasis has been placed on development of the NASA documentation system and its esssential intragovernment relationships, definite arrangements in the nongovernmental area have already been achieved and several others are under active discussion.

Of those that do exist, one—with the American Meteorological Society—exemplifies the first of the two cited objectives. In this relationship, NASA contributes—along with six other Government activities—to the financial support of "Meteorological and Geoastrophysical Abstracts." By carefully specifying its own subject requirements, and in cooperation with the other Government agencies concerned, NASA hopes to relate the coverage of this publication to that of others which may merit NASA support in a pattern that will insure maximum comprehensivity and minimum overlap.

A recent agreement between NASA and the Institute of the Aerospace Sciences illustrates that coordination and collaboration necessary for full coverage of the expanding body of information in the airspace sciences. Historically, the IAS published a monthly abstract journal which provided partial coverage of the report and published literature. With the vast expansion in published literature both at home and abroad, it was recognized that this mass of information must be intelligently divided if comprehensive coverage and service requirements were to be achieved. Therefore, beginning in January 1963, the IAS will extend its efforts to provide coverage in depth of the published literature while the NASA program will concentrate on similar coverage of the vast report literature. Both the NASA and the IAS journals will utilize the same indexing system and will be issued twice a month on alternate weeks.

Another somewhat similar arrangement has already been indirectly identified—that involving NASA support of the publication of current abstracts by the journal of the Aerospace Medical Society. Here, again, NASA intends to promote defined coverage for optimum relationship with other abstracting or indexing services in medical or bioscience fields.

As a preliminary step toward obtaining guidance and input for the "repackaging" publications program, NASA has initiated study grants with the Midwest Research Institute, and with the Association of Rocky Mountain Universities, which include in their requirements the exploration of informational needs in the geographic areas in which the two organizations are located. One particular aim of these efforts is to identify actual or potential need for informational materials of industrial significance, and to determine methods of publication or dissemination of this information.

INTERNATIONAL

The keystone of NASA's international relationships in the field of scientific and technical information is to be found in the agency's exchange and depository library programs. These programs assume far more importance in foreign countries than they do domestically because, in many cases, they represent the only feasible means of insuring ready availability of NASA materials to scientists abroad, as well as the only means of insuring NASA acquisition of much unpublished or unpublicized scientific information of foreign origin.

As explained elsewhere in this report, exchange agreements are negotiated with any scientific or technical activity which can properly utilize NASA publications and which in turn can contribute similar materials of interest and value to NASA's technical programs. Depository library agreements are negotiated with organizations which undertake to receive NASA publications and thereafter make them freely available to the scientific and technical community in the geographic area concerned. Exchange arrangements are very frequently specialized as to subject, whereas depository library arrangements involve the full scope of NASA publications.

Either exchange or depository arrangements can be, and are, negotiated with organizations in any foreign country recognized by the U.S. Government. At the present time, there are approximately 155 exchange arrangements with organizations in 33 countries, and approximately 12 depository arrangements with organizations in 12 countries. In both categories, comprehensive review and evalua-

tion is in process, both to insure maximum utility of existing agreements and to permit major expansion as rapidly as possible.

Supplementing this broad foundation, several special relationships exist:

Space commissions.—Arrangements have been made to provide to the national space commissions, or their counterpart organizations that have been established in seven foreign countries, NASA technical reports and bibliographic tools pertinent to their official concerns. Although exchange and depository considerations are implicit in the initial arrangement, it is NASA's intent to formalize these considerations in all possible cases. As rapidly as other nations establish counterpart organizations, also, NASA intends to extend this pattern of direct informational linkage.

Advisory Group for Aeronautical Research and Development (AGARD).—Through representation on the Documentation Committee of AGARD, NASA maintains close working relationships with the AGARD organization itself, as well as with the major technical information activities of all other member nations. By long-standing agreement, NASA acts as the central U.S. depository, and distributor, of AGARD publications.

Euratom and Eurospace.—Collaborative arrangements have been made with Euratom, the cooperative European center for atomic energy programs, and with Eurospace, a cooperative group for space research studies. Initial discussions have been held with officials responsible for Euratom's developing documentation program, and with the Eurospace documentation panel, looking toward the establishment of common or related procedures to permit maximum interchange of information.

RESOURCES

The accompanying table provides a general indication of the dollar resources allocated by NASA to its scientific and technical information requirements. The indication cannot be precise, because of the number of unknowns involved in any calculation of technical information functions in their broad sense, and because of the difficulty of compiling meaningful data, on completely congruent bases, across the broad scope of a program as large, as varied, and as rapidly expanding as NASA's.

The table shows estimated obligations, for NASA Headquarters and its major field installations, for technical information services in fiscal year 1962 and fiscal year 1963. For the convenience of this presentation, the three categories used—primary production and distribution, bibliography and reference services, and scientific symposia and technical meetings—are comparable to those used in the annual reporting to the National Science Foundation for its publication "Federal Funds for Science." These categories do not necessarily correspond to the budget schedules used in NASA's formal fiscal reporting. (A fourth NSF category—research and development in scientific communication and documentation—has not been used in the table. Rather, the 1963 planned activity has been subsumed under "Bibliographic and reference services of headquarters," since present study plans are more related to improvement of bibliographic and reference services than to the furthering of fundamental knowledge.)

The figures present only the direct costs identified with scientific and technical information services per se. No attempt has been made to include the tremendous indirect cost of information gathering and assimilation inherent in the research and development activities of the agency and its contractors. (For example, the figures do not take into account the time of technical program personnel who write or review technical reports.)

The CHAIRMAN. Mr. Hammill has another question, Doctor, then I think we will adjourn until Tuesday next.

Mr. HAMMILL. Just one short question.

I know your responsibility is not in the manned area but the unmanned area.

But I noticed something in one of the trade publications that struck my interest.

Dr. von Braun was quoted as having said something to the effect that if we were to place on the surface of the Moon a highly trained chemist or physicist or some other type scientist, that such a person could find out an enormous amount of information and data of a basic

nature which would be of special interest to your space sciences program. I wonder if you have any views on the question of how well the astronauts who will participate in the Apollo program should be trained in science?

I think the implication of Dr. von Braun's statement was that there really is not very much a test pilot can do once he gets to the Moon, except roam around perhaps, and make some very superficial observations, and then bring back inconclusive information.

Put another way: why not send somebody who really knows his stuff?

Dr. NEWELL. This is a very difficult question.

It is awfully easy to give a superficial answer and say, of course you have got to get a scientist there right away, but it does not work out that easily.

We are working with the manned space flight people to try to develop the best approach to this problem. Questions that we have to consider are:

Should the first crews to the Moon include a scientist, or should they be composed only of astronauts who develop the technique of getting men on the Moon?

If they are composed only of astronauts, should one or more of those astronauts be given scientific training to do as much as he can; or should scientist-astronaut teams be developed in which the astronaut carries along with him television and radio to communicate to the scientist back on the Earth? Or should one wait until later and carry a scientist along as a passenger after the technique of flying men to the Moon has been developed to the point where you need only two fully qualified astronauts. The scientist could then help out but not to be relied on as an astronaut.

The scientist then would do his job after he has been conveyed to the Moon.

All of these things we have to work out. They are not easy to work out, because just as the astronauts have a job that requires a tremendous amount of training, past experience, development of reaction times, and trained judgment in the face of emergencies, so the scientist needs a tremendous amount of training to understand what he is looking at.

It is not easy to bring the two together.

We are working on it as one of the major problems we have to solve.

The CHAIRMAN. Are there any further questions?

If not, we will adjourn until Tuesday at 10 o'clock.

(Whereupon, at 12:05 p.m., the committee was adjourned, to reconvene at 10 a.m., on Tuesday, March 19, 1963.)

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1964 NASA AUTHORIZATION

TUESDAY, MARCH 19, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMWITTEE ON SPACE SCIENCES
AND ADVANCED RESEARCH AND TECHNOLOGY,
Washington, D.C.

The subcommittee met at 10 a.m., pursuant to adjournment, in room 304, Cannon Building, Hon. Joseph E. Karth (chairman of the subcommittee) presiding.

The CHAIRMAN. The meeting will be in order, gentlemen.

Mr. Brackett, we want to welcome you before the subcommittee, and we are anxious to learn more about how NASA goes about procuring the items they need.

I see that you have a prepared statement?

Mr. BRACKETT. Yes, sir.

The CHAIRMAN. Would you proceed, please. At the conclusion of your statement the members of the committee may have some questions they would like to pose.

STATEMENT OF ERNEST W. BRACKETT, DIRECTOR, PROCUREMENT AND SUPPLY, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. BRACKETT. Mr. Chairman and members of the subcommittee, since NASA became an operating agency its procurement functions have become increasingly important. During fiscal year 1962, approximately 90 percent of funds appropriated by the Congress were spent by contracts, as compared to 64 percent in fiscal year 1960. In fiscal year 1964, the percentage of funds going to contractors may increase further. NASA appreciates its responsibility to see that this money is spent prudently, economically, and in accordance with the intent and policies laid down by the Congress and the President.

DECENTRALIZATION OF NASA'S PROCUREMENT OPERATIONS

Each of NASA's centers places contracts in support of the projects assigned to their cognizance. Four other NASA offices also do contracting for the agency. In addition, the Jet Propulsion Laboratory, which is operated under a contract by the California Institute of Technology, spent over 60 percent of the dollars provided by NASA in fiscal year 1962 on contracts with business firms.

Procurement policies and procedures are issued by NASA headquarters. These follow quite closely those promulgated by the Armed Services Procurement Regulation. We are facing many of the same

procurement problems faced by the military departments, our basic statutory authority is the same as theirs—the Armed Service Procurement Act of 1947—and we are dealing with much of the same segments of industry. This uniformity is advantageous to industry as it simplifies contract systems and contractual provisions.

Major contracts are reviewed and approved by NASA headquarters. This includes a review by the Office of General Counsel for legal sufficiency. Authority is delegated to the Marshall Space Flight Center, the Manned Spacecraft Center, and the Western Operations Office, those being the procurement offices which place most of the larger contracts, to issue contracts up to $1 million without headquarters approval. The other procurement offices have lower maximum contracting authority without headquarters approval. The reasons for review and approval by headquarters is to assure compliance with NASA's procurement policies, contractual provisions, and sound business principles. The reason for the different limitation amounts is to assure a review of a representative number of contracts from each procurement office.

METHODS OF COMPETITION

The most difficult part of procurement is the selection of contractors. It is our policy to advertise formally for items we procure whenever this is possible. This is where there are adequate detailed technical or performance specifications available so that all bidders will understand and bid on the same thing.

However, NASA is predominantly procuring research and development items, things which have never been made before such as the Apollo spacecraft, where there are no specifications and various engineering designs should be considered. For this reason most of our contract dollars go into contracts which must be negotiated. In fiscal year 1962, 64 percent of our contracts were negotiated under the authority of 10 U.S. Code 2304(a)(11), which authorizes procurement by negotiation for research and development. Fourteen percent of our contracts were negotiated with educational institutions under the authority of 10 U.S. Code 2304(a)(5). This includes the contract for operation of the Jet Propulsion Laboratory.

When a contract is negotiated it does not mean that competition is waived; usually it is just as possible to get competition by negotiation as it is by formal advertising. Our policy is to obtain competition whenever it is feasible and possible under a negotiated procurement. There are instances when clearly one company should be chosen, and it would be a disservice to other companies to invite competition. An example is the contract for development of the Gemini spacecraft which is a follow-on to the Mercury spacecraft. In this case the contract was let to the same contractor because of similarity in design, the technical experience of the contractor on the Mercury project, and because the Gemini project is planned to follow the Mercury flights with little intermittent time delay. However, it should be noted that this contractor secured the Mercury contract competitively.

NASA procurements for research and development of over $100,000 start with a procurement plan which sets up the method, steps to be taken, type of contract which will be used, and other details. In instances where the estimated cost is over $5 million the plan is

submitted to the NASA Associate Administrator for approval; if under that amount, the center director approves the plan.

SOURCE EVALUATION PROCEDURES

In nearly all of the competitive research and development procurements, a Source Evaluation Board is appointed to evaluate the proposals submitted. The Board is made up predominantly of technical members with representatives from business management offices. This Board determines the criteria which will be used in the evaluation, and these points are then set forth in the requests for proposals. Usually a technical and a business committee are appointed by the Board who do much of the detailed examination of proposals. The Board makes its report to the director of the center, if the estimated cost is under $5 million, who selects the company with which a contract will be placed if satisfactory terms can be negotiated. If the estimated cost is over $5 million, NASA's general management at headquarters makes the choice.

Companies which are considered to have the capability to perform the work are invited to submit proposals; however, any company may submit a proposal which will be evaluated on the same basis as those invited. During evaluation companies which submit proposals are checked to determine their performance on work done for other Government agencies and in some instances for commercial customers. The results of this system are competition, which gives all interested companies an equal opportunity, impartial evaluations, and selection by high-level responsible officials within NASA of contractors who are considered to have the best chance of successfully accomplishing the work at a reasonable cost.

TYPES OF CONTRACTS

NASA uses the fixed-price form of contract whenever it is possible to fairly determine what the cost should be. This can be done where standard items are purchased or there is a basis for determining price. However, in most research and development projects, this is not the case and cost-plus-fixed-fee contracts are usually made. The fee for the work is fixed in advance, but the contractor's actual costs necessary to perform the work are paid as they accrue. The fees on our contracts in fiscal year 1962 ranged from 1.85 percent to 9.65 percent, with the average being 6.33 percent, which is slightly less than the year before when fees averaged 6.65 percent. Forty percent of the fees are between 6 and 7 percent.

The cost type contract does not give a contractor a real incentive to hold down costs, and NASA is trying to find other ways of contracting which will encourage economy. One way is to enter into a design contract, and when the design is completed and detailed specifications are known, to enter into a fiixed price contract for production of the end item. A second way is to place provisions in research and development contracts which give contractors a financial incentive to reduce costs and to produce articles which will perform in a superior manner. The conventional incentive type contracts have a formula by which the fee or profit is computed. This formula sets the fixed cost or performance targets with a premium fee or profit

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paid for completion of work below the target cost or for performance of the article better than the target specification. I might add that a lower fee or profit is paid if the costs exceed the target or performance does not meet the target. The difficulty NASA is experiencing with this type of incentive contract is that our projects are so new that there is no history of cost or performance on which to base a fair target.

On the other hand, NASA is trying a new contract system which we hope will accomplish the incentive objectives. The base fee in the contract will be lower than the usual fee. Criteria will be set up in the contract for evaluation of the contractor's performance. These criteria may include reduction and control of costs, excellence of performance, delivery on schedule, and other points. Periodically, a NASA board, also specified in the contract, will evaluate the contractor's performance and may award some higher fee, up to a set maximum, if the facts justify an increase.

CONTRACT ADMINISTRATION

After a contract is placed it must be managed and monitored during its performance. There must be close technical checks maintained to assure quality control and to obtain the best possible performance. Much of this is done by NASA engineers assigned to the contractor's plant. Also, such things as audit of vouchers, keeping accountability of Government property in the hands of the contractor, approval of overtime, and other contract administration work must be performed. NASA has an agreement with each of the military departments to do a major part of this work for us. These agreements save the Government the cost of setting up duplicate organizations, and efficiency is obtained by having the contractor transacting this type of day-to-day business with one Government agent. In plants where NASA has all or substantially all of the contract work, its administers its own contracts.

CONTRACTS MADE BY OTHER AGENCIES FOR NASA

Other Government agencies, largely the military, contract for some of NASA's requirements where they are contracting for the same items or services for their own requirements. For instance, the Air Force bought the Atlas boosters used in Project Mercury. In the last fiscal year approximately 21 percent of NASA's contract dollars were expended through other Government agencies. These contracts are the contracts of the procuring agent, including such details as selection of source, pricing, and contract provisions.

DOLLAR DISTRIBUTION OF NASA CONTRACTS AND SUBCONTRACTS

NASA appreciates the increasing impact of its contracts on the national economy, and is attempting to see that consideration is given in placing its contracts so that they will aid the economy while at the same time bearing in mind its duty to carry out the civil space program in a timely, efficient, and economical manner. It is the judgment of management throughout NASA that the ultimate success of the program depends to a large extent on placing contracts with companies

which are found best qualified to perform the work. It should be recognized that certain companies have successfully performed similar work and have acquired unique technical experience, facilities, and equipment, which would cost hundreds of millions of dollars to duplicate. It is technically and economically advisable to utilize the services of such companies wherever they are located or whatever their size.

However, the fact that one of these companies receives a prime contract does not mean that the money obligated on the contract is spent in that company's plants. We estimate that at least half, on the average, is spent in subcontracts. We requested nine of the largest NASA prime contractors to report on the volume and place of their first tier subcontracts. They reported that they had subcontracted 50 percent of the dollars to approximately 10,000 first tier subcontractors in 46 States.

By permission of the Bureau of the Budget, we have recently initiated a simple report by postal card of the placement of the larger first and second tier subcontracts placed by 12 of our larger prime contractors. Reports are starting to come in and the early returns already show 2,172 subcontracts totaling $427,196,444 placed in 37 States. It is interesting to note that during the last fiscal year, 40 percent of NASA prime contracts, by dollars, were placed in labor surplus areas.

In order to assist companies, both large and small business concerns, in knowing where to solicit subcontract work, NASA synopsizes in the Department of Commerce Business Daily all pending procurements for research and development where the estimated cost is $100,000 or more, listing the names and addresses of the companies which are being invited to submit proposals.

SMALL BUSINESS PARTICIPATION

Small business concerns also have participated substantially in NASA's prime contracts. They received 16 percent in dollars of new contracts placed in fiscal year 1962. Of a total of approximately 118,000 contractual transactions, large and small, small business companies received 66 percent. In procurements where small business companies bid for prime contracts they were successful in obtaining contracts for 57 percent of the dollars. Of the 100 companies which received the largest dollar amount of NASA contracts in fiscal year 1962, 24 were small business concerns. The above facts apply only to prime contracts and it is probable the participation of small business concerns in NASA subcontracts is somewhat larger.

IMPROVEMENT IN CONTRACT SYSTEM

We are constantly trying to further improve our procurement practices and procedures. The Administrator has appointed a committee to study NASA's source selection procedures, means of using incentive-type contracts, and a system of evaluating contractor performance. It is anticipated that constructive innovations will be made as a result of its efforts. NASA recognizes its responsibility in the expenditure of the money appropriated by the Congress and will con-

tinue to exert its best efforts to see this trust is properly carried out.

The CHAIRMAN. Does that conclude your statement at this time, Mr. Brackett?

Mr. BRACKETT. Yes, sir.

The CHAIRMAN. Thank you very much, Mr. Brackett.

On page No. 1, Mr. Brackett, the first sentence under "Decentralization of NASA's Procurement Operations," states: "Each of NASA's Centers places contracts in support of the projects assigned to their cognizance."

Who, specifically, within the Center, has this authority, or this responsibility?

Mr. BRACKETT. The contracting officer has the authority to enter into the contract.

The CHAIRMAN. There is a contracting officer at each one of these centers?

Mr. BRACKETT. That is correct, sir.

The CHAIRMAN. And what liaison is there between that contracting officer and you as director of procurement, or the top administrative officers of NASA?

Mr. BRACKETT. We are, according to our regulations, the functional managers of procurement, and they have direct access to our office, and we to them, on questions of policy or questions of contract provisions. For instance, we have a standard set of contract clauses and provisions which are supposed to go in each contract, or in selected contracts. In case they want to deviate from these clauses they have to come to our office for authority.

If they wish to enter into a letter contract they must come to our office for authority to do so.

The CHAIRMAN. So, unless they want to go outside the authority that has been specifically stated in that contract procedure, they have complete authority to make and enter contracts; is that right?

Mr. BRACKETT. Yes, that's right.

The CHAIRMAN. Without coming to you?

Mr. BRACKETT. Yes, within the regulations.

The CHAIRMAN. Unless it is over $5 million?

Mr. BRACKETT. Well no, $5 million is for approval of the procurement plan. This is before the contract or the procurement has started.

The CHAIRMAN. But this is after the negotiations have been conducted, is it not?

Mr. BRACKETT. Well, they have authority, without our approval, for the three centers, the Manned Space Flight Center, the Marshall Center, and the Western Operations Office, up to $1 million. Anything over a million dollars has to come into our office for review and approval.

The CHAIRMAN. I see.

Mr. BRACKETT. Now, the Lewis Center, the Langley Center, and the Goddard Center, also have $1 million and anything beyond that has to come in to our office for approval.

The CHAIRMAN. How many of these Centers do we have now?

Mr. BRACKETT. We have eight Centers.

The CHAIRMAN. Eight. Would you care to list them, for the record?

Mr. BRACKETT. Yes, sir. There is the Goddard Space Flight Center at Greenbelt, Md., the Launch Operations Center at Cape Canaveral, Fla.

Mr. MORRIS. What about the Launch Operations Center at Cape Canaveral—is this a $1 million ceiling?

Mr. BRACKETT. They have authority up to $250,000, sir, and anything above that has to come to our office.

Mr. MORRIS. Well, don't they have the same authority as Goddard? They are a very important installation. More important than Goddard, are they not?

Mr. BRACKETT. Well, they are not making as many contracts, or as large contracts, sir. And one of the purposes of having the contracts come in for review is so that we will get a representative number of contracts from each Center.

The CHAIRMAN. Would you give us the eight, then, so that we will have it for the record?

Mr. BRACKETT. Yes, sir.

There is the Langley Research Center, at Hampton, Va., the Marshall Space Flight Center at Huntsville, Ala., the Manned Spacecraft Center, at Houston, Tex., then we have the Western Operations Office, and we have a small office at headquarters that makes contracts where a project will be monitored by headquarters people.

Then we have the Ames Research Center, at Moffett Field, in California and the Lewis Research Center, at Cleveland, Ohio, and Flight Research Center, Edwards, Calif.

Then there is the Jet Propulsion Laboratory, which is operated for NASA by the California Institute of Technology.

The CHAIRMAN. Now I have nine.

Mr. BRACKETT. Well, I don't consider the Jet Propulsion Laboratory technically as a center because they are under contract to Cal Tech.

The CHAIRMAN. What do they come under?

Mr. BRACKETT. Well, sir, they report directly to Dr. Seamans, the Associate Administrator.

The CHAIRMAN. Do they have authority to enter into and negotiate contracts?

Mr. BRACKETT. So far, from a contracting point of view, it is nothing over $25,000, and subject to approval of the Western Operations Office.

The CHAIRMAN. Well, the JPL is a part of NASA, is it not?

Mr. BRACKETT. It is a NASA installation, but it is operated for NASA under a cost-type contract, by the California Institute of Technology.

The CHAIRMAN. But they do have certain contracting authority?

Mr. BRACKETT. They do. They make some subcontracts, just as NASA made a contract for the lunar excursion module. A contract has just been received for LEM.

The CHAIRMAN. So, to that extent, they have contracting authority, is that correct?

Mr. BRACKETT. That is correct.

The CHAIRMAN. Is there anything else, other than the NASA centers that have this authority—namely, the authority to go out and contract with private contractors?

Mr. BRACKETT. Not a Government contract.

The CHAIRMAN. Other than on a subcontract basis.

Mr. BRACKETT. No, sir.

The CHAIRMAN. The eight centers, then, are the only NASA installations who have this authority?

Mr. BRACKETT. No, sir, there is the Western Operations Office, which is not a center, and headquarters.

Then, we do have a joint office with the Atomic Energy Commission, located physically at the Lewis Research Center in Cleveland, Ohio, which does make some contracts for the joint projects, such as the Rover and the Nerva projects, under which NASA is developing a nuclear rocket engine, and they have authority there.

The CHAIRMAN. I think Mr. Morris has a point.

Mr. MORRIS. I just have a question about this Launch Center at Cape Canaveral.

You only have $250,000, for the Launch Center in Florida, and yet Greenbelt has a million dollars.

Mr. BRACKETT. Well, the reason is that their contracts, for the most part, Mr. Morris, are smaller, at the Launch Operations Center.

Mr. MORRIS. What about this $450 million project at Launching Operations? That is a pretty good sized project, is it not?

Mr. BRACKETT. I think, sir, that you would want to know that that is under the Corps of Engineers, and NASA wouldn't have anything to do with that.

If we ask another Government agency to make a procurement for us, they would make the contract.

Mr. MORRIS. The Corps of Engineers is handling all of the facilities at the Launching Operations Center?

Mr. BRACKETT. That's right. Practically all of them.

Mr. MORRIS. Yes, I see.

Mr. BRACKETT. There may be some minor exceptions.

Mr. MORRIS. Yes. On the interpretation I have made—and I beg your pardon for interrupting you——

Mr. BRACKETT. That's all right, sir.

Mr. MORRIS. I am confused about another matter and I would like you to answer this question:

Would you just run through for me again, the Launching Operations Center authority, and why it does not have a larger authority?

Mr. BRACKETT. Yes, sir.

Part of the reason for our review and approval at headquarters is to monitor operations of the field centers, as to whether they are applying the directions and complying with our regulations, and that their contracts are adequately priced. And in other words, that they are doing a good procurement job.

Part of the way we can evaluate this is to see a representative number of contracts. We can't see them all, but we can see a representative number of them.

I believe in the last year, from all the centers that have sent us contract for reviews and approval, there have been less than 300, but this gives us a picture of how things are being done in the field. And, in order to get a representative picture, we have different levels of approval.

Now, we will see more contracts from Marshall at the minimum level of a million dollars than we will see from Launch Operations Center at $250,000. This latter, of course, is just coming into being, and we wanted to be sure that they are capable of doing a good job.

Mr. MORRIS. I am very happy to hear that.

I haven't visited all of the NASA installations, but I have visited some of them, and the ones I have visited included the Launch Opera-

tions Center at Cape Canaveral, which impressed me as having the best people and the best management, and running a more economical and better operation then any of your other Centers.

Now, that may be just an impression that I got, and it may not be accurate. However, it was my impression.

Mr. BRACKETT. Well, I don't question it at all, sir, but we will still like to see a representative number of these contracts from down there. That is the way we do it, and we won't see too many from the $250,000 Centers.

Mr. MORRIS. You could, though, as head of the procurement division, just say to any center, or any contractual authority in NASA, that you wanted to see the contract that is being let?

Mr. BRACKETT. Oh, yes, sir, we can.

Mr. MORRIS. And you can say to them: "Bring it up here"?

Mr. BRACKETT. Yes. But this makes for a more or less uniform system.

Now, as the quality of this procurement goes up, and as their dollars get more under these contracts, we have, and we will continue, to raise the level and quite possibly the next time that there is a change, and we made one this last year, the Launch Operations Center will be one where the authority will be increased.

Mr. MORRIS. Well, I am not questioning whether it is right or wrong, at the Launch Operations Center, but it seems to me that uniformity is not what you want in checking on contracts.

You still have a set pattern of checking on contracts, and I am wondering whether or not this is the best method. I am not at all certain that it is.

Mr. BRACKETT. Well, we also have other methods of checking, sir.

We send out teams; we go out to the various Centers and work with them on particular projects, to check to see how they are coming.

As a matter of fact, I was down a week ago yesterday, at Launch Operations Center myself, and I worked all day with the procurement people.

The CHAIRMAN. I have one question on these eight Centers that you have listed for the record.

Could you tell us the maximum authority at each one of those Centers?

Mr. BRACKETT. Surely.

Two hundred and fifty thousand dollars for Launch Operations Center.

One million dollars for Goddard.

One million for Lewis.

One million for Langley.

One million for Western Operations Office.

And we have two places that I have failed to mention; Wallops Island Test Site, which has $100,000 limitation, and the other one is a research center at Edwards Air Force Base at California, which has $100,000 limitation.

Then there is the headquarters office which has $1 million limitation.

Lewis has $1 million, and Ames has $500,000.

The CHAIRMAN. And would you give us Marshall?

Mr. BRACKETT. Marshall Spacecraft Center, and Western Operations have one million, each.

The CHAIRMAN. And Ames—could you give me that—I am sorry, but I missed it.

Mr. BRACKETT. I think Ames has $250,000—no, one-half million, I am sorry.

I may have misstated the Launch Operations Center. That has $500,000 instead of $250,000. It formerly had $250,000.

Mr. MOSHER. Mr. Chairman, may I ask a question?

The CHAIRMAN. Yes, certainly, Mr. Mosher.

Mr. MOSHER. Do you know of any tendency on the part of the field centers to attempt to avoid the trouble of being monitored by the central office by using some techniques of breaking contracts up to get them within the limits, so that, instead of having one contract which would be more than the limit, they can break it up and have two contracts?

Mr. BRACKETT. I know what you mean. I have seen it done.

Mr. MOSHER. Yes.

Mr. BRACKETT. But I am pleased to say, Mr. Mosher, that we have not noticed that happening in NASA. I would not say it has not happened, but we don't run into it.

Mr. MOSHER. Well, in local governments and city councils where they have a limit, within which they can make a contract they frequently do this, and I wonder if it were true here. You do not notice this tendency, however, sir?

Mr. BRACKETT. We have not noticed it, sir.

In fact, I sort of feel that our relationship with the Centers, between our Office and the Centers, is pretty good, and they sort of welcome our assistance.

Mr. MOSHER. So this would be a matter of integrity to a degree?

Mr. BRACKETT. Yes.

Mr. MOSHER. And you have no reason to suspect such a thing?

Mr. BRACKETT. No.

Mr. MOSHER. Although there may be a temptation, not so much based on integrity, but there may be a temptation to try to get on with the job as quickly as possible.

Mr. BRACKETT. Or perhaps just making a contract just under the ceiling amount.

Mr. MOSHER. Yes, to avoid red tape. But you don't see this?

Mr. BRACKETT. I haven't seen it, Mr. Mosher.

Mr. STAEBLER. May I ask a question, Mr. Chairman?

The CHAIRMAN. Yes, certainly, Mr. Staebler.

Mr. STAEBLER. I would like to explore this question of changes in the contract and overruns.

Mr. BRACKETT. Yes?

Mr. STAEBLER. Are changes frequent on your contracts?

I am thinking as of in the case of many military procurement contracts. What is the policy on changes?

Mr. BRACKETT. Well, when a change may be made, sir—is that what you mean, or the pricing, or what?

Mr. STAEBLER. Well, pricing changes and approval.

Mr. BRACKETT. Well, the system is that when the engineer, the technical man, determines that a change is necessary, he directs our contracting officer, asks him to direct the change, and then the change may be made.

Or, the change may be one which the engineer, our NASA engineer, thinks is necessary, or it may be a change that the contractor has recommended. But it is never directed until our NASA engineer so directs the contracting officer.

When he tells our contracting officer: "You direct this change," a direction in writing is given to the company to start to make that change. The company has a period of 60 days in which to submit its claim for an adjustment in the contract amount.

One more thing: There is an estimated cost of what this change will amount to.

Mr. STAEBLER. Who makes the estimate?

Mr. BRACKETT. If the contractor comes in with his suggestion, he estimates it. This is not accepted by us, however, unless our engineer concurs.

Our engineers also make an estimate. And, as when one of the military departments is doing inplant work, the contract administration work for us, our engineers might request the pricing people in the military department to come up with their estimate.

Now, again, this is before the change is made.

After the change is authorized, the contractor has, in most of our contract provisions, as I say, 60 days to come in with a detailed breakdown of what this change will cost. This cost is analyzed. Frequently we send—NASA has the military administer these contracts under agreements with the military—the figures to the military contract administrator, and a detailed audit, or analysis, is made, and it comes back with a recommendation.

Then a supplemental agreement is negotiated formalizing this change in the contract, and the additional amount of money is added to the contract to cover the cost of the change.

Mr. STAEBLER. Now, you are describing the changes where the authorization precedes the actual physical incorporation of the change in the contract?

Mr. BRACKETT. That's right.

Mr. STAEBLER. Will there not be frequent instances also where the change is authorized before the price is agreed upon?

Mr. BRACKETT. This is the case, sir.

This is where we have estimated what we expect the cost of the change will be. Our own people, usually with the help of the military, have determined that this probably is going to be the amount. Although it is not fixed and the contractor has not agreed to it, the change is immediately ordered so as not to hold up the project.

The CHAIRMAN. But an estimate is given?

Mr. BRACKETT. The estimate is given, and this money is available before we order the change. One of the factors is that we have to be sure we have the money to cover it.

The CHAIRMAN. If the gentleman will yield——

Mr. STAEBLER. Yes, Mr. Chairman.

The CHAIRMAN. Say the actual cost exceeds the estimate by 300 or 400 percent, and you don't have the money. Is this where a reprograming system comes into effect?

Mr. BRACKETT. This usually doesn't happen, sir.

The CHAIRMAN. But what if it did happen?

Mr. BRACKETT. Well, sometimes it does exceed the estimate, and sometimes it is less.

The CHAIRMAN. But if it does this would really necessitate reprograming?

Mr. BRACKETT. It would all depend on the amount.

Usually if it is a change of that magnitude, it would not be directed ahead of fund availability; perhaps, it would be included for the first time in an amendment to the contract.

Then there are some minor types of changes, which we call within the scope of the contract, and these changes are the ones I have been describing, and usually bear a fee. This may not be the same fee as the basic contract bears, but the contractor is entitled to ask a fee, which is negotiated.

The CHAIRMAN. Well, these changes, on many occasions, really keep the contractor alive; do they not?

Mr. BRACKETT. Well, they amount to a substantial amount during the performance of a contract, quite frequently.

Mr. STAEBLER. Just pursuing that point, on the substantial amounts involved. Do you have any compilation of the number of instances in which the changes concerned materially affect the amount of the contract, say, exceeding 10 percent of the value, the total value of the original contract? Is that readily available?

Mr. BRACKETT. I don't have any figures, sir—no definite statistics on it—but I think that we will find that in most of these major development contracts, particularly something that has never been made before, that they will go much higher than 10 percent. Sometimes a great deal higher.

Mr. STAEBLER. Well, what I am trying to get at, without requiring a special study to be made, is whether we have any off-the-cuff estimates of the number of instances in which such changes occur. Does it occur in the case of half the contracts?

Mr. BRACKETT. Well, this is again an estimate, but I would think, Mr. Staebler, this would happen in almost every one of these large development contracts.

Mr. STAEBLER. So that the changes are an almost inevitable occurrence in contracts?

Mr. BRACKETT. Yes, sir.

The CHAIRMAN. On this very point, Mr. Brackett, is this not one way that the companies who severely underestimate the cost of a program when they make their bids are able to justify substantially greater costs than they originally estimated, by later on saying: "Well, there were so many changes that had to be made." How are you going to keep these people honest?

Mr. BRACKETT. Well, part of our job in procurement is to analyze the cost of these changes, and to see whether the amount that is added to the contract represents no more than the cost of making that change.

Now, there are changes that are made that will decrease the cost, also.

The CHAIRMAN. What has our experience been with overestimating in contract bidding?

Mr. BRACKETT. We have not yet completed—and I assume that you are talking about a comparison of the original amount when we start the contract out, with what it costs when completed.

The CHAIRMAN. Yes; what has our experience been in those circumstances?

Mr. BRACKETT. We have not yet completed any of our major contracts—very few of them, anyway—even the Mercury contract has not been completed yet.

The CHAIRMAN. How about Mercury; that has been a major one?

Mr. BRACKETT. That is not completed yet, so we have not accumulated in NASA statistics on this, but I think we are going to find that, as compared with the original cost, the ultimate cost is going to be considerably more.

The CHAIRMAN. I see. I would like you to do this, then, for the record.

Would you provide for the record as much information as you do have on this point, on these major contracts, and the overages that you are estimating at this point in the contract.

We may want to take a look at that sometime this year.

(The information requested is as follows:)

Attached hereto are tables summarizing by NASA installations increases in the contract amounts of major contracts from date of award to approximately March 31, 1963. Major contracts have been generally defined for this purpose as those which at the time of award had a contract amount of $5 million or more. Increases in contract amounts since award are set forth in two categories, namely, (*a*) those due to the inclusion in the contract of additional work, which for the purposes of this presentation include increases due to changes within the existing scope of work as well as those due to additions of new scope of work to the contract, and (*b*) those due to cost overruns. Where the contract is a letter contract, the dollar amount set forth is the amount funded under the letter contract as of March 31, 1963, rather than an estimate of what the amount of the definitive contract may be, because of the potential for inaccuracy in any estimate developed prior to agreement between the parties on the scope of work for the definitive contract and because of the undesirability of publicizing information on the estimated amount of a contract prior to its definitization.

Summary of increases in contract amounts of major contracts

GODDARD SPACE FLIGHT CENTER

Contractor	Contract No.	Description of work	Total contract amount at time of award	Actual increases to date		Total contract amount to date
				Due to additional work	Due to cost overruns	
Grumman Aircraft Engineering Corp	NAS5-814	Orbiting astronomical observatory	$32,050,000	$1,593,096	$23,666,062	$57,309,158
Space Technology Laboratories, Inc	NAS5-899	Orbiting geophysical observatory	24,334,108	319,280	10,228,695	34,882,083
Hughes Aircraft Co	NAS5-1560	Syncom I	4,889,000	2,825,936	2,150,000	9,864,936
Philco Corp	NAS5-1757	40-foot X-Y tracking antenna systems	5,462,689	351,955		5,814,644
RCA	NAS5-1272	Relay	4,990,060	2,441,000	4,125,801	11,556,801
RCA	NAS5-877	Nimbus	2,127,500	1,744,187	5,419,031	9,290,718
Bendix Field Engineering Corp	NAS5-734	Minitrack maintenance and operation	11,026,108			11,026,108
Do	NAS5-1426	Mercury network	5,767,637	6,966,360		12,733,997
General Electric Co	NAS5-978	Nimbus	8,482,185	2,062,225	4,000,000	14,594,410
Do	NAS5-746	Integration of Nimbus subsystem	1,515,710	574,872	5,257,259	7,347,841
Motorola, Inc	NAS5-1926	Goddard range and range rate system	4,261,058	312,130	501,000	5,074,188
Space Technology Laboratories, Inc	NAS5-1302	Systems coordination and planning for Project Relay	4,836,528	130,275		4,966,803
HEADQUARTERS PROCUREMENT BRANCH						
Bellcomm, Inc	NASw-417	Provision of systems analysis and study, planning, and technical support to Office of Manned Space Flight, Headquarters, NASA.	$8,562,000			$8,562,000
General Electric Co., Apollo Support Department.	NASw-410 [1]	Provision of integration, reliability, and checkout support for Apollo program.	[2] 16,398,500			[2] 16,398,500
LANGLEY RESEARCH CENTER						
Republic Aviation Corp	NAS1-1945	Research, develop, design, fabricate and support launch operations of reentry package subsystem for Project FIRE.	$5,000,000	$21,062		$5,021,062
Western Electric Co., Inc	NAS1-430	Project Mercury tracking and ground instrumentation system.	33,058,690	20,708,938	$15,192,610	68,960,238
Chance Vought Corp., Division of Ling-Temco-Vought, Inc.	NAS1-1295	Design, fabricate, ground test, and assembly of 14 Scout research vehicles.	8,651,000	8,889,368		17,540,368
Do	NAS1-900	Design, fabricate, ground test, instrument assemble and prepare for launch of 5 Scout research vehicles.	5,557,017	1,722,754	442,384	7,722,155

LEWIS RESEARCH CENTER

General Dynamics Corp., Astronautics Division.	NAS3-3232 [1]	Fabricate and deliver certain development vehicles and support equipment; flight readiness programs; support and sustain a development program and systems integration.	[2] $20,413,000			[2] $20,413,000
Do	NAS10-16 [1]	Services, material, equipment, and facilities necessary to activate Launch Complex 36-B, Atlantic Missile Range, to a configuration capable of accommodating and launching Atlas D 1st stage and Centaur 2d stage vehicles.	[2] 2,300,000			[2] 2,300,000
Aerojet-General Corp	NAS8-4014 [1]	Design, development, and testing of a 500,000-pound thrust liquid hydrogen-liquid oxygen engine.	[2] 30,400,000			[2] 30,400,000
Do	NAS8-4015 [1]	Design, fabrication, and acquisition of facilities required for M-1 engine development program.	[2] 13,200,000			[2] 13,200,000
Do	NAS5-417	Research and development program to obtain a SNAP-8 electrical generating system.	8,233,425	$5,210,961	$6,941,614	20,386,000

MANNED SPACECRAFT CENTER

North American Aviation, Inc	NAS9-150 [1]	Apollo command and service module	[2] $260,000,000			[2] $260,000,000
McDonnell Aircraft Corp	NAS9-170	Gemini spacecraft and auxiliary equipment	456,650,062			456,650,062
General Dynamics Corp., Convair Division.	NAS9-492	Apollo solid suborbital vehicle	6,322,643			6,322,643
North American Aviation, Inc	NAS7-90(F) [1]	Downey facility contract for Apollo command and service module.	[2] 6,191,800			[2] 6,191,800
Kollsman Instruments	NAS9-499	Optical subsystem for Apollo navigation and guidance system.	7,658,000			7,658,000
Raytheon Co	NAS9-498	Computer for Apollo navigation and guidance system	15,029,420			15,029,420
A.C. Spark Plug	NAS9-497	Apollo system assembly and test for navigation and guidance.	35,845,000			35,845,000
Massachusetts Institute of Technology	NAS9-153	Apollo navigation and guidance system	4,375,000	10,500,000		14,875,000
Grumman Aircraft Engineering Corp	NAS9-1100	Apollo lunar excursion module	387,900,000			387,900,000
McDonnell Aircraft Corp	NAS5-59	Mercury manned space capsule	19,500,000	70,000,000	50,000,000	139,500,000
International Business Machines Corp	NAS9-996 [1]	Integrated mission control center—Real time computer complex.	[2] 3,000,000			[2] 3,000,000
Philco Corp	NAS9-1261	Integrated mission control center—Implementation	33,797,565			33,797,565

See footnotes at end of table, p. 1768.

Summary of increases in contract amounts of major contracts—Continued

MARSHALL SPACE FLIGHT CENTER

Contractor	Contract No.	Description of work	Total contract amount at time of award	Actual increases to date		Total contract amount to date
				Due to additional work	Due to cost overruns	
Douglas Aircraft Co., Inc	NAS7-101	Design, development, and manufacture of S-IVB stages of Saturn IB and Saturn V.	$999,939	$142,362,779		$143,362,718
Chrysler Corp	NAS8-6	Engineering services—Saturn, Mercury, and Juno	7,609,987	6,755,219		14,365,206
Brown Engineering Co., Inc	NAS8-20	Engineering, fabrication, and services—Saturn	5,719,534	2,356,435		8,075,969
Do	NAS8-2485	do	5,268,235	11,399,853		16,668,088
Chrysler Corp	NAS8-2483	Engineering services—Saturn program	9,149,665	1,034,901		10,184,566
Mason-Rust Co., Inc	NAS8-4004	Support services for Michoud plant	1,215,128	14,821,572	$283,999	16,320,699
Boeing, Inc	NAS8-2577	Preparatory effort on S-IC stage development for Saturn V	8,910,962	39,569,838		48,480,800
Do	NAS8-5606(F)	Facilities for S-IC stages	7,736,371	43,100		7,779,471
Do	NAS8-5608	Design, development, and manufacture of S-IC stages	418,820,967			418,820,967
Chrysler Corp	NAS8-4016	Fabrication of S-I stages for Saturn I and Saturn IB	215,502,744	3,952,744		219,455,488
Do	NAS8-2576	Preparatory effort on S-I stage development	10,779,408	3,015,146		13,794,554
Do	NAS8-5602(F)	Facilities for S-I stages	7,102,322	37,497		7,139,819
North American Aviation, Inc., Rocketdyne Division.	NASw-16	Development of F-1 engine	102,471,761	133,451,211	17,140,193	258,063,165
Do	NAS8-5604 [1]	Production of F-1 engines	[2] 16,000,000			[2] 16,000,000
Do	NAS8-19	Development of J-2 engine	44,700,000	29,150,666		73,850,666
Do	NAS8-5603 [1]	Production of J-2 engines	[2] 7,950,000			[2] 7,950,000
Do	NAS7-190 [1]	Development of H-1 engine	[2] 4,500,000			[2] 4,500,000
Do	NAS7-162 [1]	Production of H-1 engines	[2] 2,588,230			[2] 2,588,230
Do	NAS7-3	Development and production of H-1 engines	30,517,857	7,640,680		38,158,537
Do	NAS7-4	Production of H-1 engines	4,040,000	1,060,050	517,816	5,617,866
Pratt & Whitney Aircraft	NAS8-2690	Development and production of RL-10 engines	28,971,000	57,322,087	6,806,543	93,099,630
Do	NAS8-5605 [1]	Development of throttleable version of RL-10 engine	[2] 3,485,000			[2] 3,485,000
Do	NAS8-2691	Development and production of RL-10 engines	22,890,000	17,774,304	13,741,248	54,405,552
Do	NAS8-5607 [1]	Production of RL-10 engines	[2] 1,800,000			[2] 1,800,000
Douglas Aircraft Co., Inc	NAS7-1	Design, development, manufacture, checkout, delivery, and launch support—for flight stages—of S-IV stages of Saturn I.	68,838,160	31,372,832	25,500,000	125,710,992

[1] Letter contract funding as of Mar. 31, 1963.

Mr. BRACKETT. Could we define what we mean by "major contract"—anything over $5 million, or something like that?

The CHAIRMAN. I would say that would be a good place to start, yes.

Mr. MORRIS: In order that the witness fully understands, and just so that there will be no mistake, does the $5 million mean the total estimated amount for the contract that is signed?

Is this to be a signed contract, now, or is this $5 million for a fiscal year?

Mr. BRACKETT. No; it would have to be the complete contract.

The CHAIRMAN. That is the total contract.

Mr. BRACKETT. I may say we have not completed many of these contracts, so it will be an indefinite figure. But we will surely get it for you.

The CHAIRMAN. Let me pursue this, then, for just another minute, if I may.

You said before that you were checking these things and paying a great deal of attention to this question of the changes that were made, and adding up these changes so that later on you could subtract them from the original costs; and that would give you an idea as to how much increased cost came about without any changes having been made, or without taking into consideration any changes.

Now, you say you have not done any of this, and you haven't carried it to conclusion, apparently, in any major contract; is this true because we have not completed any major contracts?

Mr. BRACKETT. Well, you see, sir, we have been checking, Mr. Chairman, each time one of these changes is made, the cost of that particular change. But so far as the total number of them, adding them all up, is concerned, we have not done that.

The CHAIRMAN. But you check very closely on these changes to see that the estimated cost is a good estimate, compared with what you actually get?

Mr. BRACKETT. That's correct. That is part of the procurement job, Mr. Chairman.

The CHAIRMAN. And you follow that change through to completion to see whether it did cost that much, or whether it cost more or less? Or does the estimate, thereafter, stand on its own weight, regardless of what the facts are?

Mr. BRACKETT. Some of this is very difficult to track down, because part of it is overhead; part of it is mingled in with other things; and so to just actually segregate what it did cost to make one of these changes out of the total after it was done would be rather difficult to do, but it possibly can be done. I think it would be rather difficult, and I don't think this is done.

The CHAIRMAN. Well, then, it probably may be true that it is these changes that make the gravy in these things; is that correct?

Mr. BRACKETT. It is an element of increase in fee.

Now, we have just entered into a contract with the Grumman company for the development of the Lunar Excursion Module, and we have a rather unusual thing here. There will be no fee paid on changes where the estimated cost is under $100,000—they will get no additional fee.

This would not mean if we were ordering another capsule, or spare parts, or something in addition, within the scope of the contract, that

there would not be a fee paid, but there will not be a fee paid where the estimate is under $100,000.

Now, if I may, Mr. Chairman, I would like to elaborate on one thing a little more.

The CHAIRMAN. Yes, sir.

Mr. BRACKETT. There are two reasons why things cost more than the original price or estimate; one of them is the changes, of course, and one of them is the fact that it did actually cost more than what was originally contemplated. In the latter case, we will have a cost overrun, assuming that there have been no changes at all.

A cost overrun sometimes happens, as in one case where we had a contract that was estimated to cost us $5 million, but by the time everything was added up it came to $7 million. Now, the $2 million is what we would call a cost overrun.

If there was a change made in the specifications that cost more money, that is what we would term a change.

Mr. STAEBLER. My next question was: Do you keep records of separate items of cost overrun and changes on each contract?

Mr. BRACKETT. Well, this is part of the contract file, yes, sir. Also where we have a supplemental agreement for the change, that is also part of the contract itself.

Mr. STAEBLER. Are your contractors graded as to their performance on overruns?

Mr. BRACKETT. This is one of the elements that is taken into consideration as to future contracts—did they stay within the estimated cost?

The CHAIRMAN. Have you completed any of these projects?

Mr. BRACKETT. We haven't completed any of our major projects yet, sir; but, for instance, with the Delta space vehicle contract—I have checked some of these, but I haven't checked this one—I have been told that, outside of the changes, the cost of the Delta was within around 5 percent of what it was originally estimated it would be.

In other words, there was no more than that percentage of cost overrun.

This is one of the subjects for which Mr. Webb has set up a committee to see what can be done, and how we can do a better job of coming up with this kind of evaluation of the contractors and their performance. This evaluation would include living within their costs, reliability, lack of failures, delivery on time, and things like that.

When we started to do this, we found that the Department of Defense was doing the same thing, so we have joined with them, and we expect that within a period of a few months we will have a unified system where the military departments, as well as ourselves, will be continuously evaluating what the companies are doing. There will be written reports that will be available to our agency.

In other words, if we are going to make a contract with a company that had some previous Government contract experience, we will say: "How did they do?" And the evaluation would include cost overruns, and things like that. This is what we are working on right now.

The CHAIRMAN. But do we have any way of spanking these people who continously underestimate, and so forth? I presume that they are pretty much in the same boat, are they not?

If you spank one, you have to spank another. What are we doing about them?

Let us say we know they are doing it from the records, we know that their record has been rather poor, and I suppose most of them are—now what do we do about spanking them?

Mr. BRACKETT. Well, of course, one of the things we have to remember is the incentive that a company has to obtain future business, and they are quite sensitive about cost overruns.

The CHAIRMAN. Well, let me ask you this question: Have you ever denied a company any business as a result of their previous overestimates, or underestimates?

Mr. BRACKETT. I recall no specific ones, Mr. Chairman.

The CHAIRMAN. Well, we are not spanking them that way, are we?

Mr. BRACKETT. We tell them what we think about it, definitely.

The CHAIRMAN. Well, that really doesn't hurt their pocketbook, just to tell them what you think about it.

Mr. BRACKETT. Well then they get no additional fee on cost overruns; they have to do this work without any additional profit. If this happens they are just working for nothing, so there is no incentive on their part to have a cost overrun. The fact is, they accuse us many times——

The CHAIRMAN. Excuse me, before you go on to this other point, I want to finish this inquiry.

It is better, is it not, to make 6 percent on $10 million, even though the contract will involve costs running up to $20 million, rather than get no contract at all?

Mr. BRACKETT. Yes, sir.

The CHAIRMAN. So that you get 6 percent on $10 million, and that is 3 percent of $20 million. That is better than nothing, isn't it?

Mr. BRACKETT. Yes, it certainly is.

The CHAIRMAN. And if they had not underestimated what it would cost, perhaps they never would have gotten it.

Mr. BRACKETT. Well, of course, they accuse us many times of contributing to these cost overruns because they say that when we come to negotiate the contract, we negotiate them down to an unrealistic cost.

Of course, this is not our objective. Our objective is to have a contract which we consider to include a realistic cost of what the job should be.

The CHAIRMAN. I think you have done a better job in the particular area of the small business firms than you seem to do with the giants, and I suppose it is only reasonable. But you could do a better job. When dealing with small firms, normally the contracts are small ones and the hardware is not so sophisticated, or whatever the situation may happen to be, so it is easier for you people to give an accurate estimate or to check on estimates that have been furnished by the companies.

Mr. BRACKETT. That is true.

The CHAIRMAN. And I have heard from some of the small firms, that NASA is rather severe in their estimating the costs.

But, without exclusion, it has been in the small contract cost area, rather than in the large ones.

Mr. BRACKETT. Well, I have heard more from the large ones than I have from the small ones, Mr. Chairman, that we are tough.

The CHAIRMAN. The record doesn't indicate that they have too much to complain about.

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Mr. BRACKETT. It is a good sized contract.

Mr. STAEBLER. Mr. Chairman, would it be appropriate to suggest that when some of these contracts of substantial size are completed that NASA review the details with the committee, and demonstrate how it methods operate?

The CHAIRMAN. I think that is a very good suggestion. But one of these things that I have been asking for is an evaluation of this kind.

If I understand correctly, none of these have yet been completed because none of the major projects have been completed, but it seems to me that we were not thinking very well when we suggested a $5 million figure as being a criteria.

We have completed a lot of the vehicle programs, for example, and we have some additions to them. But, without those additions, it seems to me that we have a pretty good idea.

Mr. BRACKETT. Well, we have the Delta and the Scout, and I think we could come up with some figures there.

Incidentally, you might be interested in knowing that today there is a negotiation going on down at Langley for the purchase of more Scouts, and this will be on a fixed-price type contract basis.

We are at the point now on Scout where we can negotiate a fixed price.

The CHAIRMAN. You see, the thing that really concerns me is that a company may very well find that it is extremely advantageous to underestimate.

This subcommittee looked into one of these projects last year, and found that a prime contractor very grossly underestimated the cost of the program, and ever since then, we have been pumping money into that program. We have given it about four shots in the arm, and the company is doing very well.

Now, how often does this happen, and does this happen on all of the major contracts?

This is my concern, and I think it is the concern of the committee.

We would like to have a little bit better estimate, you see, and I am sure you would like that also.

I know that you can appreciate the reason is because we have to justify these things to the taxpayers.

Mr. BRACKETT. Yes; that's right.

The CHAIRMAN. And when NASA says, "Well, now, we are proposing about $17 million for XYZ program," we would like to have something to justify it. Instead of having $57 million, rather than $17 as the actual cost, we would like to have some realistic figures when we attempt to justify these programs, on the basis of estimated cost. It seems to me that we have not been very accurate, at least not in any program that I know of.

Mr. STAEBLER. Mr. Chairman, may I add to the implications of the point that you are making, that it is not merely because of the company that gets the contract where a bad estimate is made, but it is the effect that it has on the whole competition in other instances, and competition in the future.

Nothing is so discouraging to good estimates as the acceptance of bad ones.

The CHAIRMAN. That's right.

Mr. STAEBLER. And when everybody says: "Well, let's do this in the future, if that is the way we have to operate to get the business."

Then we have a really delicate and valuable part of the competitive system threatened.

If we are really going to make competition work here, we have to get a good relationship between the Government and private industry, and if we allow that relationship to deteriorate, then all sorts of defects creep into the relationship and reduce the value of competition, reduce the incentives for all, and then everyone recognizes all these consequences.

The CHAIRMAN. Yes, that is the point, exactly. I was getting at the implications involved in these overruns.

Not only are the overruns bad in and of themselves, but in addition to that, so many changes are made to hide the facts of the cost itself, that the people who knew that they were bidding wrong to begin with actually come out very well, and they can almost hide the overbid, while other people who feel that they made a fair and reasonable and accurate bid, complain because they say that this is one way in which the favored contractor can get out of his responsibility of justifying his estimate.

That is why I am wondering if there is not some other way we can get around this, to effectuate these changes without these difficulties creeping in. I don't know, and of course, these people here are the experts. But it does look rather bad.

Mr. MOSHER. I wonder if Mr. Brackett, Mr. Chairman, would want to repeat, or add to what he has said about the penalties of the system. Are there any ways which exist to guard against this abuse and to guard against consciously underbidding, or things of that nature?

Mr. BRACKETT. Well, I would like to say a couple of things about this. In the first place, we don't want companies to come in with unrealistically low estimates on cost, and a built-in overrun. We want to have them come in with realistic costs and what they think the job is going to be. In our source-evaluation procedure, one of the elements which is taken into consideration is: Is this company coming in with such a low estimate that it does not realize the complexity of the job to be done?

The estimate of cost is only one of the factors that is taken into consideration in selecting contractors for technical developments. The technical part is usually the part that has the most bearing.

I think one of the best things we can do is to offer an incentive to companies, a monetary incentive, to hold down their costs, and that is what we are trying to do right now. A year ago now, we had no incentive contracts at all, today we have eight of them. We are negotiating one on the Scout, right now. We have another contract that will be going into effect within a very short time, with an incentive in it, a penalty for late delivery, and a penalty for overrun costs, also.

We are doing everything that we can to put this into effect to hold down costs, and to give the companies a monetary incentive to hold down costs.

The CHAIRMAN. What is the penalty you put in for overrun. What does that amount to?

Mr. BRACKETT. Each one is separately negotiated, Mr. Chairman, depending upon what we are doing. There is no format or set percentage.

The CHAIRMAN. Well, what form do these penalties take?

Do you chop a certain percentage off of the price of the contract; do you reduce the fee?

Mr. BRACKETT. The fee is reduced.

The CHAIRMAN. Or is it negotiated?

Mr. BRACKETT. Well, we have one right now with General Electric for one of the components of the Nimbus satellite. I think I have the figures right here with me, and I can give them to you. This contract can get down to a cost-sharing arrangement.

Mr. CORTRIGHT. Mr. Chairman, while Mr. Brackett is looking for that, you may be interested in learning about an interesting development that is taking place today.

Many contractors are now approaching us about the contract situation, and suggesting incentive provisions for their contracts. They are, you might say, following the lead established by the Government. They are trying to find ways of coming in with honest estimates and are willing to accept incentives based on their estimates. This is a very encouraging turn of events.

Mr. BRACKETT. We have a contract with the Space Technology Labs, which is an experimental organization, for something that has never been tried before, where we have an incentive on their overhead. If they reduce their overhead, their fee will go up, and if their overhead exceeds what it should be, their fee goes down. It looks today as though they are going to lose some of their fee here.

The CHAIRMAN. One question on this point: Doesn't this really encourage them to come in with a very high estimate, because they know that if they do the job and keep their overhead down, they have an incentive in a higher fee?

Mr. BRACKETT. Well, the facts here show that they are losing money on the contract, which has a fixed overhead.

The CHAIRMAN. Yes, but once you generally accept this concept, aren't you opening yourself up to this kind of thing?

Mr. BRACKETT. It is one of the weaknesses.

The CHAIRMAN. At a fixed price incentive bid, aren't they going to think—well, they can come in with a fairly high fixed price, and then reduce it in the course of the contract quite substantially, and they have done such a good job that you will increase the fee?

Mr. BRACKETT. It is one of the weaknesses. Yes, sir.

The CHAIRMAN. Probably they will do better profitwise than if they had come in with an accurate bid in the first place.

Mr. BRACKETT. Well, it is one of the weaknesses, and at this time it is very difficult for us to tell in the case of something that has never been done before, and where there are no past cost histories on which to base a contract target.

The CHAIRMAN. Oh, I know it is very difficult.

Mr. BRACKETT. That is why we are trying a sort of incentive award, where we will start the fee at a lower level, a base level; but that will be the floor. The reason we don't have any penalty below that is that most of the companies have said: "We are not interested in this base fee; the evaluation is not going to be based on a formula but is going to be made entirely by Government boards who give awards of more fees, if they think we are entitled to it; nevertheless, we have to make statements to our banks and stockholders, and we have to declare dividends, and so we need to have some base fee."

So there are all these things to be taken into consideration—the delivery schedule, cost control, the overrun situation, reliability—and under this type of contract, it will be done without a formula. Periodically, probably each year, the board would meet—it would be a high level board—and it would determine whether the contractor had succeeded in doing these things, and if so, what award of additional fee should be made.

We have two of these contracts in effect now, and we will be placing some more. We feel that there is some incentive to companies to hold down costs in this arrangement.

As I was saying, another type of incentive contract is the one with the General Electric Co., which is for a stabilization and control subsystem for the Nimbus Weather Satellite. We have an estimate that it is going to cost $6,350,000, and if it goes up to $7,500,000 there would be no fee at all—the fee would be wiped out.

The CHAIRMAN. What is the fee?

Mr. BRACKETT. I don't know the percentage. I think it is around 6 percent, but I am not sure.

Now, above that amount, the cost will be shared 10 percent by GE and 90 percent by the Government; and if it gets up to $8,200,000, for each $100,000 it goes above the $7,500,000, there will be an extra 5 percent paid toward the cost by General Electric, and 5 percent less paid by the Government, until it gets up to $8,200,000. From that point on, half the cost will be paid by GE and we will pay the other half. Now there is certainly an incentive to hold down the cost, because their fee will be wiped out when they get to $7,500,000.

Mr. CHENOWETH. Is that a typical contract?

Mr. BRACKETT. No, sir; that is unusual.

Mr. CHENOWETH. I recall the Martin Co. came in here before the committee—not this particular committee, but it may have been the whole committee—and they were trying to reduce their costs to 40 percent, and I don't know how they succeeded in that area.

Mr. BRACKETT. I don't know, sir, I don't recall.

Mr. CHENOWETH. I don't know if it was 40 percent exactly, but I know they wanted to reduce it.

That was on the Titan.

Mr. BRACKETT. Yes, they were making the Titan II.

Mr. CHENOWETH. Titan II.

Mr. BRACKETT. Well, that's right. The Air Force is doing some procuring for us, and the Titan II will be used as a booster for the Gemini program. But this is a contract that is made for us by the Air Force.

The CHAIRMAN. Will this contract with the GE Co., to which you have just referred, be competitive—was it competitive to begin with, or was it not competitive?

Mr. BRACKETT. I don't know the answer, Mr. Chairman.

The CHAIRMAN. But if it was not competitive they probably would never have experienced an overrun. Maybe it is too high to begin with—that is my point.

What are your plans for the future programs?

Are you going to open them up for competitive bid, or are you just going to negotiate these things across the board, and forget about competitive bidding?

Mr. BRACKETT. We are going in for competition, Mr. Chairman, every time we possibly can; we are going in for competitive negotiation.

The CHAIRMAN. Now, competitive negotiation, what do you mean by that?

Mr. BRACKETT. Well, these are not formally advertised. These are development contracts for something that has never been made before, and we have no specifications for them. In other words, we want to ask companies for competitive proposals, and although I am not familiar with this one, this is the usual rule.

The CHAIRMAN. Well, do you conduct competitive negotiations, as you call them, only when you are trying to find something that has never been done before, or how widespread is the practice of competitive negotiation, as opposed to competitive bid, and then negotiation after the contract has been accepted?

Mr. BRACKETT. Well, we formally advertise whenever we have detailed specifications, or even performance specifications which are so definite that every company is bidding exactly on the same thing. However, if we are going to put up a new satellite, there may be many different approaches, from an engineering point of view, as to how this could be done, and it may be well to get various companies to come in with their different engineering proposals and approaches. This means that everyone is not bidding on exactly the same specifications, and this is the type of item that I have in mind. This is where most of our dollars are going, like the Mercury capsule. When we first started the Mercury spacecraft——

The CHAIRMAN. Well, may I just ask you this:

What percentage of our contracts during the calendar year 1962, for example, if you can get these figures, were competitive bid contracts, as opposed to all others?

Mr. BRACKETT. Formal advertising. Is that what you are speaking about?

The CHAIRMAN. Yes.

Mr. BRACKETT. I think it is 6 percent, approximately of our contracts during fiscal year 1962, 6 percent were formally advertised. This is where we had definite standard items, so we knew what was involved, or where we had adequate specifications.

The CHAIRMAN. You mean 6 percent in total dollars?

Mr. BRACKETT. Yes.

The CHAIRMAN. Or 6 percent of the price of the contracts?

Mr. BRACKETT. Dollars.

The CHAIRMAN. Dollars?

Mr. BRACKETT. Yes. Now, many of the things that are susceptible to formal advertising, such as construction work, are done for us by other Government agencies, like the Corps of Engineers, and these are not included in our program. NASA formal advertising is just for supplies.

Mr. MORRIS. Is Western Operations using the Corps of Engineers?

Mr. BRACKETT. Western Operations Office—No, I don't think they have any construction work under their jurisdiction.

Mr. MORRIS. Well, what about the Jet Propulsion Laboratories project?

Mr. BRACKETT. I don't know for sure about that. I doubt that they are using them.

Mr. MORRIS. Well, how are they handling any construction. Do you know whether they are using them?

Mr. BRACKETT. Well, they have some construction, but whether they are using the Corps of Engineers, I don't know.

Mr. MORRIS. Well, why wouldn't they use the Corps of Engineers?

Mr. BRACKETT. Why?

Mr. MORRIS. Yes. Why wouldn't the Jet Propulsion Laboratory people use the Corps of Engineers?

Mr. BRACKETT. Well, for one thing, they are able to do their own construction work. They do have construction work out at Goddard, Lewis, and Langley. Where there is construction, it is on a formally advertised basis.

Mr. MORRIS. Would you not use the Corps of Engineers if it could be done cheaper?

Mr. BRACKETT. Well, I don't know that it could be done cheaper. They have overhead expenses, and whatever has to be done——

Mr. MORRIS. But have you ever given them a chance so that you know whether it would be cheaper or not. How can you tell if you haven't given them the chance to estimate the cost?

Mr. BRACKETT. They are doing the majority of our construction work right now.

Mr. MORRIS. But not in the west coast?

Mr. BRACKETT. I don't think they are doing any. As far as I know, they are not doing anything out there for the Jet Propulsion Laboratory.

Mr. MORRIS. When did you sign the contract for the Gemini project, do you remember?

Mr. BRACKETT. The Gemini contract was signed, I would say, 2 weeks ago. It has not yet been approved, but it is in our office for review, and it is now being studied.

Mr. MORRIS. Didn't you solicit proposals on the Gemini?

Mr. BRACKETT. No, sir.

Mr. MORRIS. Well, how about the lunar excursion module. I just noticed a flyer the other day, that you had signed a contract. Was it a formal contract?

Mr. BRACKETT. That's right.

Mr. MORRIS. And you solicited proposals on the lunar excursion module, as I recall it, about September?

Mr. BRACKETT. Yes.

Mr. MORRIS. Last September?

Mr. BRACKETT. That's right.

Mr. MORRIS. When did you solicit proposals on the Apollo?

Mr. BRACKETT. I am not sure, but that was over a year ago, sir.

Mr. MORRIS. When did you sign the contract on Apollo?

Mr. BRACKETT. That contract, they are working on a letter contract there.

Mr. MORRIS. What is Grumman working under?

Mr. BRACKETT. Oh, not Grumman—they didn't have a letter contract. That was a definitive contract.

Mr. MORRIS. Could you explain what difference there is in procedure?

Mr. BRACKETT. Well, this is getting a little out of my line. This is in the technical side. But it is my understanding——

Mr. MORRIS. No, I don't want you to go outside your jurisdiction.

Mr. BRACKETT. I will be glad to tell you what my understanding about it is.

Mr. MORRIS. Well, I would be happy to hear it, but I want you to understand that I am not trying to get you outside of your field.

Mr. BRACKETT. From my understanding, after the proposals were received, our technical people decided that it would be well to take more time in order to come up with a better working statement and specifications. That is what held Apollo up.

Mr. MORRIS. In other words, it is not the company; it is NASA itself that changed its mind and made these adjustments?

Mr. BRACKETT. After the changes in specifications are completed the contractor would have to have a reasonable time to come up with a new estimate of cost on the basis of the new specifications.

Mr. MORRIS. Well is that not the case in most of the contracts where you have overruns and changes—that they are the result of NASA changing their specifications or changing their engineering?

Mr. BRACKETT. At times it contributes to it.

Mr. MORRIS. Do you have any idea of what the percentage would be?

Mr. BRACKETT. No. I don't know, sir.

Mr. MORRIS. When a development contract is changed, does NASA change it, or does the contractor change it?

Mr. BRACKETT. It can come both ways. The contractor may suggest a change, but he cannot order it—he cannot make the change. He can just suggest it. Or, our own engineers can direct it. But if the contractor suggests it, it still won't go into effect unless the engineer directs it.

Mr. MORRIS. Your engineer?

Mr. BRACKETT. Our engineer; yes, sir.

Mr. MORRIS. In other words, all changes that are made on contracts are approved by NASA—they have to be approved by NASA and they are put into effect or negotiated by NASA?

Mr. BRACKETT. Technically, yes. They may be suggested by the company, but they are negotiated, and the order goes to the contracting officer from the technical man. Then the contracting officer directs the company to make the change.

Mr. MORRIS. If we could go off the record, Mr. Chairman?

The CHAIRMAN. Off the record.

(Discussion off the record.)

The CHAIRMAN. Back on the record.

Mr. MORRIS. Has your office ever made any estimate of the number of changed orders in contracts or revisions that have taken place in your major contracts, for instance take the Mercury project—you have no idea of how many engineering changes were made in the Mercury contract?

Mr. BRACKETT. I do not have it here, sir, but that is available.

Mr. MORRIS. And those changes contributed to the cost of the program.

Mr. BRACKETT. Yes, sir. That is available.

Mr. MORRIS. Could you furnish that figure?

Mr. BRACKETT. That is right. I think that is in what the chairman has asked us to furnish—I think it will be a portion of that information.

Mr. MORRIS. All right.

How many other projects, if you can recall, are operating under this letter contract arrangement?

Mr. BRACKETT. Right now?

Mr. MORRIS. Yes.

Mr. BRACKETT. The Mercury capsule——

Mr. MORRIS. Are they operating under letter contract?

Mr. BRACKETT. They are operating under letter contract.

Mr. MORRIS. In other words, you have never had a definitive contract for Mercury?

Mr. BRACKETT. No. That is not Mercury. This is Apollo. It is Apollo spacecraft. Did I say Mercury? I am sorry; I meant Apollo.

Mr. MORRIS. Yes.

Mr. BRACKETT. On Mercury, I don't think we ever had a letter contract.

Mr. MORRIS. Did you have a definitive project contract for that project?

Mr. BRACKETT. Right. We did not have a letter contract there. That was definitive, as I recall.

Mr. MORRIS. But you have been operating under letter contract for Gemini.

Mr. BRACKETT. Yes; we have.

Mr. MORRIS. In fact you still are?

Mr. BRACKETT. Yes, today.

Mr. MORRIS. Yes.

Mr. BRACKETT. That will probably be stopped in a few days now.

The CHAIRMAN. Will the gentleman yield?

Mr. MORRIS. Yes, Mr. Chairman.

The CHAIRMAN. Why, after we have had this experience with the Mercury, do we enter into a letter contract on Gemini?

Mr. BRACKETT. Well, it is entirely different sir. In my understanding, it is an entirely different specification.

The CHAIRMAN. Well, it is not so different that you blindly accepted the same contractor because he had had the experience.

Mr. BRACKETT. Well, that is true, sir, but the specification itself and the cost of it is somewhat different.

The CHAIRMAN. Well, even though the specifications are different——

Mr. BRACKETT. This is a two-man capsule.

The CHAIRMAN. That's right—it is a larger one. It is a two-man instead of one-man—just like a four-door automobile versus a two-door.

Mr. BRACKETT. Well, the difficulty here again is that we have had the delay in getting the detailed work statement and specifications and the price so that we could finalize it.

The CHAIRMAN. Well, you have all the technique that was used in Mercury and that would give you an idea in adapting it for Gemini, would it not?

Mr. BRACKETT. That is correct.

The CHAIRMAN. And in the Mercury you didn't use the letter contract—you had a definitive contract.

Mr. BRACKETT. Right.

The CHAIRMAN. And with Gemini, which is a follow-on program, and where we have had just scads of experience in comparison, here

you operate on a letter contract. I wonder if you could just give for the record the reasons, one, two, three, four, five, why you did this?

Mr. BRACKETT. Well, Mr. Chairman, again we are getting into the technical area and I can only give you my understanding of it.

The CHAIRMAN. Well, suppose you supply that information for the record, then, so that it is in there, because I think that this is very important. At least, I would not have thought it was so important, maybe, if I had not paid particular attention to your testimony at page 3, where you said:

Our policy is to obtain competition wherever it is feasible and possible under a negotiated procurement.

(The information requested is as follows:)

A letter contract was used to initiate the Gemini spacecraft program because:

(1) It was urgent to start the contractor effort at the earliest possible date, in order to meet the astringent schedule requirements.

(2) Although the Gemini spacecraft is based upon Mercury technology, the program envisioned many new techniques and equipments that, in December 1961, required additional time for specification; i.e., rendezvous, long-duration flight, maneuvering in orbit, rendezvous guidance, maneuvering reentry, and paraglider recovery. A letter contract provided the means of starting work at McDonnell immediately, while elements of the program continued in the process of complete definition.

(3) In comparison with the Mercury procedure, whereby the original contract had to be revised in scope and cost by a series of more than 300 contract change proposals, NASA anticipated improved program and contractor control from a comprehensive Gemini contract based upon relatively complete specifications. As it turned out, the final contract was supported by 38 books of specifications, which were developed while spacecraft work was proceeding at an optimum pace under letter contract.

(Statement furnished by Col. D. D. McKee, assistant director, manned satellite programs, Code MSS.)

As I understand it, we have only been competitive in 6 percent of the dollar totals, and that means that 94 percent has not been competitive in these contracts, and someone has been using their judgment.

Mr. BRACKETT. May I say that the 6 percent covers the so-called formally advertised contracts, but we do have negotiated contracts which are competitive. For instance, the lunar excursion module was competitive, and the Apollo spacecraft was competitive.

The CHAIRMAN. Well, that is my question—you said 6 percent, and I was confused with the definition as opposed to what I thought it was, so I wonder if you could supply for the record what the percentage was in fiscal year 1962 and 1963.

(The information requested is as follows:)

The percentages of the net value of NASA awards that were competitive and noncompetitive in fiscal year 1962 and fiscal year 1963 are set forth below:

	Fiscal year 1962	Fiscal year 1963 (1st 6 months)
	Percent	*Percent*
Formally advertised	6	5
Competitive negotiation	49	51
Total	55	56
Noncompetitive negotiation	45	44

Mr. BRACKETT. Yes, sir.

The CHAIRMAN. And let me just finish this—you continue to say:

There are instances when clearly one company should be chosen, and it would be a disservice to other companies to invite competition.

Mr. BRACKETT. Right.

The CHAIRMAN. You see that?

Now, as an example, there is the contract for the development of the Gemini spacecraft which was a follow-on to the Mercury spacecraft, but it is a letter contract; it is not a definitized one. You say:

In this case the contract was let to the same contractor because of similarity in design, the technical experience of the contractor on the Mercury project, and because the Gemini project is planned to follow the Mercury flights with little intermittent time delay.

You seem to indicate that this was so similar that it would be a disservice to the country and to the other companies to make it competitive and then we let it on an open-letter-contract basis and I just can't understand it. These two thoughts are not compatible with one another, in my opinion.

Mr. MOSHER. Did I understand correctly that the letter contract was a very temporary thing, and that the actual contract will be signed within the next 2 or 3 days, however?

Mr. BRACKETT. The actual contract is signed today, Mr. Mosher.

The CHAIRMAN. How long have we been engaged in the Gemini project, so I can understand what temporary is.

Mr. BRACKETT. I have that here, I think, somewhere, Mr. Chairman.

The CHAIRMAN. When did we first sign a contract for Gemini—the first contract?

Mr. BRACKETT. December 15, 1961.

The CHAIRMAN. That is a year and a half ago.

Mr. BRACKETT. A year ago December.

The CHAIRMAN. Well, 1961, you said?

Mr. MOSHER. I will take back the word "temporary."

Mr. BRACKETT. Yes; that is what I said, Mr. Chairman.

The CHAIRMAN. Well, I am trying to ascertain what is the reason why we are doing some of the things we are doing and I thought I had a reasonably good explanation for why we selected the contractor in Gemini and chose to forgo the competition, but now I am not so sure that I was right.

Mr. BRACKETT. I think, Mr. Chairman, that there are two aspects, really. One is the selection of the company, which had to do with McDonnell's experience, tooling, facilities and their engineering experience. This was a good follow-on and I agree it is still the difference between buying, let us say, a passenger car and a truck.

The CHAIRMAN. Well, Mr. Brackett, my objection really has not so much to do with the selection process, and certainly not the selection of McDonnell; my objection is that you have negotiated with these people and then you give them a letter contract. I think you should have made them define it.

Mr. BRACKETT. This is what we are doing.

The CHAIRMAN. Well, with all of the experience you had with the Mercury project, I think that it could have been much closer, probably, on the Gemini. I think, at least, this should be subject to a very close check——

Mr. BRACKETT. What we are trying to do, Mr. Chairman, is to avoid the use of letter contracts, and an illustration of this is the lunar excursion module where Grumman was chosen and where we would not give them a letter contract, but insisted on a definitive contract. This has been negotiated and now Grumman is working on it.

The CHAIRMAN. Well, a letter contract there would have made more sense to me, actually.

Mr. BRACKETT. Yes, sir.

The CHAIRMAN. I mean I could have justified that, I think, but it is very difficult for me to justify the Gemini one.

One other question and then I will yield the floor. Who has got the Apollo contract?

Mr. BRACKETT. North American.

The CHAIRMAN. The same reasoning apparently did not exist when you went from Gemini to Apollo as when you went from Mercury to Gemini?

Mr. BRACKETT. This is again quite out of my field. It is in the technical field, but my understanding is that this is an entirely different type of spacecraft.

The CHAIRMAN. Well, I am not even sure that it is good to have just one capability in this country, no matter what the discipline might be. I think it is rather dangerous.

Mr. BRACKETT. If I recall, Mr. Chairman, McDonnell was one of the competitors on the Apollo.

The CHAIRMAN. It seems to me I read something about that. I will yield.

Mr. MORRIS. You are not leaving the impression with us that NASA alone insisted on the definitized contract on the lunar excursion module, are you Mr. Brackett?

Mr. BRACKETT. That we alone——

Mr. MORRIS. Yes, sir.

Mr. BRACKETT (continuing). Insisted on it. As far as I know, we were the ones who insisted on it.

Mr. MORRIS. Well, didn't Grumman also want the contract signed?

Mr. BRACKETT. I don't recall, sir.

Mr. MORRIS. So that the work would be defined?

Mr. BRACKETT. I don't know that Mr. Morris. I know that the rule was, right from the top, that we would not use a letter contract, and we would get a definitive contract, which we did.

Mr. MORRIS. With the advertising of proposals, does the company acquire a proprietory right in any part or all parts of their proposals—whether or not they are selected finally?

Mr. BRACKETT. You mean if they include in their proposals some proprietory design or something, does it remain their property?

Mr. MORRIS. Could they have a proprietory design?

Mr. BRACKETT. At times, and I am not sure but that the lunar excursion module was one of those, we provide in the request for proposal that any design that was submitted would be considered to be—well, we could use it, as we need to, I mean. At other times, if they mark it that this is their design and they consider it proprietory, then we will not use it.

Mr. MORRIS. Well is it not NASA's policy, and was it not the policy on the lunar excursion module, that no company would have a propri-

etory right to any part of their proposals; did I not understand that correctly, sir?

Mr. BRACKETT. I think it was the lunar excursion module. It was about that time that there was one, anyway—that had this provision.

Mr. MORRIS. Well this, then, leaves me with the impression—and I am not trying to put words in your mouth, Mr. Brackett——

Mr. BRACKETT. No, sir.

Mr. MORRIS. That you don't do it or that you have not done it on other contracts?

Mr. BRACKETT. I think you are correct, sir, and that is why we placed it in the requests for proposals. Incidentally, this was so there would be no question in the minds of any company coming in, that we might use the information submitted.

Mr. MORRIS. All right. In other words, this lunar excursion module contractor will in all probability have access to all the proposals that were submitted by the other companies?

Mr. BRACKETT. No, sir. That is not the way it works out.

Mr. MORRIS. Now how is NASA going to know; are they going to go through the proposals and pick out parts of them and select the pieces that they are going to give to the contractor who was awarded the contract?

Mr. BRACKETT. It may be that we would check the ideas in the competitive proposals and pick them out and incorporate them in the final work statement; but it is not our policy to show a competitor's proposal to another company.

The CHAIRMAN. Well you say it is your policy to do that?

Mr. BRACKETT. It is not our policy, sir, to do that.

The CHAIRMAN. And you never do it?

Mr. BRACKETT. No, we do not do that.

Mr. MORRIS. Then, after the contract has been awarded that is the only one of its kind?

Mr. BRACKETT. That is true.

Now, two things. I have heard of companies sending to the successful company their proposals. It may be because of friendship for the other company, or, maybe, they feel this is a public service. But they have gone to the successful company and said: "Here are some of the ideas that we had in ours; you may like to consider them."

Mr. MORRIS. They might like to have a subcontract, too—that might be a reason?

Mr. BRACKETT. Well, yes; certainly. They may very well.

Mr. MORRIS. That would be logical.

Mr. BRACKETT. Yes, right. This has happened occasionally; and then, another thing, we at times—quite frequently we do this, not generally, but frequently—go out with a study or design contract. We may go out to two or three companies and we will pay them usually up to a ceiling amount for these designs. Anything that they submit in the way of designs we consider our property. We have paid for it, and the contract so provides.

Mr. MORRIS. In other words, you have mentioned the lunar excursion module; let us take that for example. Have you issued any study contracts for the lunar excursion module?

Mr. BRACKETT. Not to my knowledge, sir. We did on the Apollo spacecraft.

Mr. MORRIS. You did on the Apollo?

Mr. BRACKETT. Yes.

Mr. MORRIS. Who did you issue them to; do you recall?

Mr. BRACKETT. Martin Co. is one, and I think General Dynamics, and there was a third company that I don't remember. There was a question of designs there. In fact, as these designs were made available to the competitors, information came in as a result of their submissions. I guess these were what we would call feasibility studies more than designs.

Mr. MORRIS. Is this NASA policy on all contracts?

Mr. BRACKETT. Not on all contracts, but it is on selective ones. It depends. Perhaps this could be something that was so far out, it is questionable as to whether it is something we should go into or not, and then a feasibility study can be made as to the feasibility of going into it.

Mr. MORRIS. Is it your policy then that after you issue the feasibility or study contracts these would be returned to the agency and the agency then decides if it is feasible to issue a contract and they would advertise for proposals formally; and do you always make this information available to the companies who have submitted proposals. Is that your policy?

Mr. BRACKETT. I can't say absolutely, but to my knowledge, we have done this, Mr. Morris. As far as I know we have—I can't say consistently.

Mr. MORRIS. At the end of your statement, sir, you mention that the Administrator has appointed a committee to study NASA's selection procedures.

Mr. BRACKETT. Yes, sir.

Mr. MORRIS. How many people comprise this committee, Mr. Brackett?

Mr. BRACKETT. I believe there are eight on the committee, and I think I can name them. Mr. Cortright is on it, and I am on it; Mr. Bothmer is on it, and Mr. Sohier, Mr. Dembling, and Dr. Kelley, and Mr. Low. Mr. Sohier is of the General Counsel's Office. I think those are all the members.

Mr. MORRIS. Well, this is an inhouse committee?

Mr. BRACKETT. Yes, sir.

Mr. MORRIS. They already work with NASA now.

Mr. BRACKETT. Well, yes, that is true. But this was constituted to make a special study. We also have worked with Harbridge House.

Mr. MORRIS. Who are they?

Mr. BRACKETT. Harbridge House is a group in Cambridge.

Mr. MORRIS. Is that a competitive contract?

Mr. BRACKETT. Well, it was competitive to the extent that we considered several companies, Rand and Harbridge House and some others, and it was decided that the Harbridge House people should be chosen because they had been conducting some courses on procurement for NASA, so that they had some familiarity with our procurement concepts, and so on.

Mr. MORRIS. It was not a competitive contract?

Mr. BRACKETT. No, not in that sense. Not in the sense that we went out and solicited proposals.

Mr. MORRIS. Did they come up with a conclusion that this inhouse committee was the best way to handle it?

Mr. BRACKETT. It was Mr. Webb's decision, sir.

We talked about it with Mr. Webb's consultants, Dr. Draper and Mr. Godsey, and so on. We have done that, and we have talked with about 12 large companies, very frankly across the table, about how we could do our job better. What are their suggestions. We have talked with various organizational people. We have read different reports—the Sherrick report and cost reduction reports—as to different changes we might make in relation to the big objectives of our source selection procedure.

Not only this, but when these proposals from these companies come in, they involve very extensive work and they take a great many engineering man-hours of some of the best engineers of these companies, so we have tried to figure out how we could still keep fair competition and give these companies an equal opportunity and yet cut down on this expense to the country and the companies in these engineering man-hours and other costs. We have come up with some ideas, if you would like to hear about them.

Mr. MORRIS. I would if the chairman would have no objection.

The CHAIRMAN. I wonder if the gentleman could submit them for the record?

Mr. BRACKETT. We don't have anything written but I can supply some.

The CHAIRMAN. Please do that.

(The information requested is as follows:)

NASA CIRCULAR	BR PROCUREMENT AND SUPPLY (STUCKEYER)	No. 231
		Reference 3-3
		DATE May 29, 1962

SUBJECT: SPECIAL PROCUREMENT STUDY

1. PURPOSE

This Circular sets forth the Special Procurement Study Group for NASA. its functions and the procedures for Headquarters and field personnel for furnishing assistance to such groups in connection with the study which is being undertaken at the Administrator's direction.

2. APPLICABILITY

This Circular is applicable to NASA Headquarters and Field Installations.

3. BACKGROUND

a. On April 3, 1962, the Administrator established a procurement study group to assist in the conduct of a special procurement study.

b. On May 4, 1962, the Administrator designated a Study Director of this project with the responsibility for carrying out the study over a six-month period utilizing the services of the procurement study group.

c. The Administrator also approved the use of Harbridge House, under contract, to assist in the study.

4. STUDY DIRECTOR AND GROUP STAFF

Study Director:	Walter Sohier	Office of General Counsel
Study Group:		
Chairman:	Ernest W. Brackett	Procurement and Supply Division
Members:	Clyde Bothmer	Office of Manned Space Flight
	Edgar M. Cortright	Office of Space Sciences
	Paul G. Dembling	Office of Legislative Affairs
	Albert J. Kelley	Office of Advanced Research and Technology
	George M. Low	Office of Manned Space Flight
	Walter D. Sohier	Office of General Counsel

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Harbridge House Staff:

Members: Mr. William Allison
Mr. Henry Norwood
Mr. William Colvin
Mr. Michael Bergner

5. AREAS OF RESPONSIBILITY

Among the broad subject areas to be given intensive study and analysis are:

a. NASA's current source evaluation procedures;

b. Methods of improving contractor performance through contract incentives and other management devices;

c. Methods of utilizing, more effectively, performance data regarding contractor performance in the selection of sources.

6. COOPERATION AND ASSISTANCE

a. Headquarters Staff and Program Offices and field installations will cooperate with and assist the study group (including members of the Harbridge House staff) in carrying out its task.

b. NASA personnel will:

(1) Make freely available, upon request, to the study group (including members of the Harbridge House staff) the complete files of past source selections.

(2) Cooperate in supplying additional information and data requested.

In connection with this study, it is desired that NASA personnel freely express whatever personal opinions they may have regarding the matters under inquiry.

Robert C. Seamans, Jr.

Associate Administrator

Mr. BRACKETT. Let me say this: We have not as yet formalized anything specific. These are ideas that we are considering.

The CHAIRMAN. If you could supply those for the record that would be appreciated.

(The information requested is as follows:

Several ideas relative to source evaluation board procedures, which are under study in NASA at the present time, have as their principal objectives the reduction of the costs of such procedures to industry and the Government without impairment of fair competition among the participating companies.

In order to reduce the amount of technical effort and consequently the cost involved in the preparation of proposals early in the evaluation procedure, consideration is being given to the phasing of proposals. In this way, companies that do not have a reasonable chance of being awarded the contract will be eliminated from the competition following the submission of a first-phase proposal and the determination by the selecting authority that they do not meet the overriding criteria necessary to be competitive.

In order to reduce the cost involved in preparing proposals at any stage of the evaluation procedure, consideration is being given to reducing the requirements for information to be included in a proposal. The tendency in the past has been to require a full-fledged design effort on the part of every potential source as well as extensive data regarding the business aspects of each company. Consideration is now being given to requesting no more data or material than is necessary to evaluate the companies in competition. This is consistent with the concept that the source evaluation process is concerned more with the evaluation of companies than with the evaluation of proposals.

In order to harness competition more effectively in defining the work to be done and in costing it out on a realistic basis, consideration is being given to the placing of fully funded contracts with each company surviving a first-phase evaluation for the conduct of any required feasibility studies and for the detailed design effort. The detailed costing of a project would be postponed until late in the competition when the design would be fairly well established and while there were still several companies in competition. In this way, more realism in costing should be possible and there should be a more meaningful basis for selecting a source since the performance of several competitive companies under contract could be observed and evaluated.

Mr. MORRIS. I don't want to monopolize this discussion, Mr. Chairman.

The CHAIRMAN. Unless the other members have some questions, go right ahead.

Mr. MORRIS. It would seem to me, getting back to how you make these decisions, that a certain contract is going to be handled say in respect of the Manned Space Flight Center at Houston. All right—then you ask for proposals and I assume that they reach a pretty large amount, a contract of, let us say, fifty to a hundred million dollars.

Now then, I assume they have a contracting board or some advisory people who assist this contracting officer do they not?

Mr. BRACKETT. Well, if this is the intent—let us take a substantial one of $5 million—over 5 million.

Mr. MORRIS. I want to know how it gets up through the channels of bureaucracy and then who makes the final decision and why he decides on that decision.

Mr. BRACKETT. All right. It starts out by the contracting officer, working with the technical people in charge of the program at the Center, writing up the so-called procurement plan. In that plan, he says what kind or type of contract he thinks should be used.

Mr. MORRIS. He would define the type of contract?

Mr. BRACKETT. He says, perhaps, "I believe this should be an incentive type" or "It must be a cost-plus-fixed-fee type," or some kind of fixed price. This is part of the plan.

Then there is the question of time, a time for each step of the procurement. He will suggest, what our regulations provide, that there be a source evaluation board appointed to review the proposals.

Mr. MORRIS. Is this the Manned Space Flight Center at Houston?

Mr. BRACKETT. He will put in his plan everything the board can use, and the plan will come up to our office. We will present a copy of this to the program office at headquarters, to General Counsel, to the reliability office, and get their comments.

After we have gotten their comments, the plan goes up to Dr. Seamans' office, the Associate Administrator, who either approves the plan or makes suggestions, or, once in a while, disapproves it.

Mr. MORRIS. Has he ever disapproved one?

Mr. BRACKETT. I think we have had some, sir, where it was decided when they got to headquarters that this whole project should be wiped out. This is taken very seriously by Dr. Seamans personally. He reads these plans and takes them up, at times, with Dr. Dryden and Mr. Webb. I would say that it is at this headquarters level, particularly, that the big majority of them get changed in some detail. This is the plan.

After the plan is approved if there is to be a board, he appoints the board. Nominations of the members of the board come from the Center, and it is usual, with very rare exceptions, that there would be a technical man, an engineer usually closely connected with the project, who is chairman of the board.

The majority of the board are technical people and there is always one technical person from the program office at headquarters, and there is one business management representative. Usually there are others on the board from headquarters, and at times members of the board come from the other centers if they have particular knowledge.

Dr. Seamans appoints the board. The board convenes and decides what are the main points that should be used in the evaluation of this particular project. These would be in two divisions—there would be a technical side, and there would be a business side. These points are given by the board to the contracting officer who writes the request for proposal and outlines the criteria on which the evaluation will be based.

The contracting officer sends out the request for proposals to the companies that have been indicated on the plan as being those to be invited. These are the companies who are considered to be in a competitive position to obtain the contract and perform it. Even though a company may not be invited, however, and they wish to submit a proposal, they may do so and their proposal, when it comes in, will be considered on an equal basis.

Now we have a technical committee and a business committee appointed by the board, and when the proposals come in these will be considered in light of the business points and technical points, the facilities available, costs, and things like that.

Usually before the requests for proposal are sent out, there is a bidder's conference and the companies come in and they are told what the procurement is going to be about. They may ask questions. Sometimes that goes on for 2 days. This gives the companies an opportunity to clarify the technical details.

The companies go back and submit their proposals and any company that submits a proposal may also come in and within a limited time, maybe 1 or 2 hours, make a presentation to the board explaining different things they wish about their proposals. These proposals, all these proposals, are opened at the same time.

Mr. MORRIS. Where are they opened?

Mr. BRACKETT. At the center where the contract will be made.

They are then divided up between the two committees and evaluated and sometimes this takes 3 weeks. It has taken as much as 6 weeks for detailed evaluation.

Mr. MORRIS. Would that be because there are some occasions where you might want more information about certain parts of the proposal?

Mr. BRACKETT. Well, rarely.

Mr. MORRIS. Do they go back to ask the companies for other explanations?

Mr. BRACKETT. Very rarely does this happen. You see this could give a company an advantage, that is, to allow the company an opportunity to amplify its proposal after it has submitted it. However, they do have the privilege of coming in and making an oral presentation, and sometimes questions are asked them.

Mr. MORRIS. Don't they have the privilege of coming in with additions after that?

Mr. BRACKETT. No, sir. Once they have submitted their proposal, that is it.

Some other agencies, AEC or the military departments, probably have had contracts with these companies before, too. So, one thing the Board does is to check their experience with this company. Has it had cost overruns? Has it been behind in schedules? Has it made technical mistakes? And so forth.

Now one of the things the special study committee has recommended, and we started to do this with the lunar excursion module, is to send two or three people out as a team to visit the companies and talk with the engineers who will perform the work. That is a part of the evaluation.

Then the committees give their detailed evaluations to the Board, and the Board writes up its report. When the procurement is over $5 million, the Board makes an oral presentation to the Administrator, the Deputy Administrator, and the Associate Administrator.

Mr. MORRIS. What about the project officer?

Mr. BRACKETT. The project officer usually comes along with the Board and is available to answer any questions. These three top men in the management of NASA hear the evaluation. The report may sometimes take 2 hours or more, and then they make a decision as to the choice of company with which the contract will be negotiated, and to which a contract will be awarded, provided satisfactory terms can be negotiated.

The CHAIRMAN. How often do they not accept the recommendation of the Board?

Mr. BRACKETT. Well this doesn't exactly come under the heading, Mr. Chairman, of a recommendation. This is an evaluation, of how the proposals stand up. But, from the evaluation, they can tell—it is, in fact, usually quite easy to see—which company they consider in a better position to perform the contract.

Mr. MORRIS. But they are not ranked?

Mr. BRACKETT. Well, I will say this: They do not. There has not been any numerical grading. They don't rate one "1," and the next "2," or "3," "4," and so on, although usually from the presentation you know they would consider the best company No. 1, and, in fact, they are quite frank about it. But this is not a recommendation in that sense.

The CHAIRMAN. Well, now—would you yield?

Mr. MORRIS. Yes, Mr. Chairman.

The CHAIRMAN. Do we understand that sometimes up to 6 weeks are taken up in evaluating these proposals and attempting to ascertain on a technical basis and on a business basis which one makes the most sense?

Mr. BRACKETT. Yes; business and technical basis.

The CHAIRMAN. And then they don't make this recommendation to these three officers as to whom to make the award?

Mr. BRACKETT. Well, this is more an attempt to see whether—well, as I say, this is an evaluation more than a recommendation.

The CHAIRMAN. Well now, I don't care what you call it. Do they suggest in any way, shape, or form to these three top officers of NASA that they should make the final decision for company A, B, or C, in their opinion? That such company is best qualified to receive the contract, in other words?

Mr. BRACKETT. Yes; they do.

The CHAIRMAN. They do?

Mr. BRACKETT. Yes, sir.

The CHAIRMAN. All right.

Mr. BRACKETT. And then, there is a written statement made and signed by these three top men in NASA giving their reasons for the selection, as part of the contract file. This file, and the file of the Board, are available to GAO or any congressional committee that wishes to see it.

The CHAIRMAN. Then, on page 7, I would like a little further amplification. The first sentence at the top of the page there says:

> It is the judgment of management throughout NASA that the ultimate success of the program depends to a large extent on placing contracts with companies which are found best qualified to perform the work.

Is not a substantial portion of the total NASA budget taken out of competition right there?

Mr. BRACKETT. No. This does not mean that there won't be competition, but this means technically the best one will be selected.

The CHAIRMAN. But that is not what you said.

Mr. BRACKETT. This is trying to find the best contractor. Take the lunar excursion module, for example. I have forgotten how many proposals were received—eight or something like that. They tried to get the company they thought was best qualified to perform the work.

The CHAIRMAN. Well, was this on the basis of proposals submitted?

Mr. BRACKETT. Yes, sir.

The CHAIRMAN. It was?

Mr. BRACKETT. Yes, sir.

The CHAIRMAN. You see, there is one thing that disturbs me and I am not sure that it fits in with the intent of that sentence, although I think that sentence probably has several different meanings.

If, for example, we are going to have any method that stifles competition and causes the companies who are not looked upon as preeminent in their field not to have the opportunity to become involved in some of these programs, I think in that case what we are going to continue to do is make the giants even larger giants and have a greater accumulation of dollars in a few pockets than you have today. As time goes on this is what is going to happen and it will get worse and worse instead of better.

Now I interrupted you; but I wanted to know how we could get away from this.

Mr. BRACKETT. It is not our policy, Mr. Chairman, to stifle competition. In fact we sponsor competition. I might give you an example of two or three companies that perhaps 2 or 3 years ago were rather small and are now getting to be substantial in our program. They usually start at the subcontract level.

The CHAIRMAN. Where are those?

Mr. BRACKETT. Well, I can think of one or two offhand—Ball Bros. is one, and there is another one that I do not recall down in Florida. Those are two I just happened to think of now. The one down in Florida was a small business in 1961 and is doing very well. Ball Bros. is another one that was a small business and is now handling some of our substantial contracts. They have moved up from the subcontract level, and this is how we are bringing more and more companies into our program—through the subcontract route.

The CHAIRMAN. Well, I am very happy to hear that. I thought it was only 8 that you said, of the 100 companies, which received the largest dollar amount in NASA contracts for the fiscal year 1962, and 24 were small business concerns.

The only point I wanted to make is that there are so many more small business concerns than large ones and with 75 percent of the total dollar amount going to the larger ones, it seems to me that we are in a situation where we ought to be making an effort to distribute some of this to the smaller firms which of course we all know are really the backbone of our competitive system. That really isn't what might appear on the surface here, however.

Mr. BRACKETT. Mr. Chairman, I think we have done a great deal for these small concerns and I think the Small Business Administration will bear me out on this. We have created many opportunities for small business.

The CHAIRMAN. That again, I suppose, can get to be intolerable too. You have some problems, don't you, setting aside work I think they call it?

Mr. BRACKETT. Oh yes, yes. We had last year some 700 set-asides for small business. I think we had well over double what we had the previous year.

You may be interested to know, Mr. Chairman, that through the postal card report we have just started to find out where the first and second tier subs are. I might mention this, too: We found that Minnesota is about fifth or sixth on the list of States that are getting subcontract work. These cards are beginning to come in now.

The CHAIRMAN. I would like to take a look at them.

Mr. BRACKETT. I will show them to you.

The CHAIRMAN. Minneapolis-Honeywell, I suppose, would be a large one.

Mr. BRACKETT. Yes; that is one of them, I expect.

The CHAIRMAN. That is a large corporation again, as opposed to small business though.

Mr. BRACKETT. This company in Florida that I mentioned was the Electrical & Mechanical Research Corp. of Sarasota, Fla. In 1960 or 1961, it was just a small business concern, and now, with about 2 years of working with us, they have a contract that amounts to about $7

million, and I know of one subcontract that is about $12 million. That is no longer a small business.

The CHAIRMAN. About 50 percent of the work you say is subcontract work.

Mr. BRACKETT. This is what we are taking from the reports we receive. They show 50 percent is subcontracted.

The CHAIRMAN. If this trend holds true then, and if Congress provides the dollar amount requested by NASA nearly the whole $3 billion will go to the prime contractors?

Mr. BRACKETT. And they will subcontract 50 percent of it.

The CHAIRMAN. Then all of the rest of the people in this country who participate in the space program will divide the other 3 billion—right?

Mr. MOSHER. On page 5, Mr. Brackett, where you refer to new contracts and systems, you say:

> Periodically a NASA board, also specified in the contract, will evaluate the contractor's performance and may award some higher fee, up to a set maximum, if the facts justify an increase.

What do you mean by "periodically"—how often?

Mr. BRACKETT. Well this is on that incentive award business I referred to.

Mr. MOSHER. Yes.

Mr. BRACKETT. This would be, Mr. Mosher, negotiated as I said, differently in each contract, but for the ones that we have had so far, it is on an annual basis.

Mr. MOSHER. One other question if I may, Mr. Chairman: On page 6 where you talk about contracts made by other agencies, you give an instance buying the Atlas booster.

Two things about that type of arrangement: How do you assure yourself that this is the best way to do it? I suppose NASA has to have some way of deciding that the Air Force procedures are up to your standards and that there is an advantage to NASA to do it this way.

Mr. BRACKETT. Well of course, we are all part of the Government.

Mr. MOSHER. Yes.

Mr. BRACKETT. We have confidence in the other departments of the Government, that the military departments do a good contracting job. If anyone asks us to buy things for them—for instance we are buying the Scout vehicles, space vehicles, for the military departments. One of the advantages of buying it this way is that we don't interfere with each other's programs.

Mr. MOSHER. I can see the obvious advantages, but are the Air Force procedures similar to yours?

Mr. BRACKETT. Very similar.

Mr. MOSHER. Similar to those you have described?

Mr. BRACKETT. Very similar. We are under the same statute and our procedures are—in fact we coordinate with them quite closely.

Mr. MOSHER. Is there an overhead fee of some sort charged in those instances?

Mr. BRACKETT. No—none at all. None at all.

In those instances, where we place a contract with the Douglas Co., for example, we will ask the Air Force to do the so-called inplant administration, take care of property, accounting, security, auditing

of vouchers, and so on. We pay their additional contract administration cost, that's all.

Mr. MOSHER. Out-of pocket expenses?

Mr. BRACKETT. Out of pocket expenses for the additional people they have to have—no overhead.

The CHAIRMAN. So that I should not mistake what you have said here, and if I didn't ask this question the people back in Minnesota wouldn't like it, what were you talking about in dollar amounts?

Mr. BRACKETT. I have it here.

The CHAIRMAN. If you would give us that, please.

Mr. MOSHER. Did the gentleman prepare these figures for the States of each member of this committee?

The CHAIRMAN. It has been prepared for every State in the Union.

Mr. BRACKETT. It goes into 37 different States.

The CHAIRMAN. I wonder if the gentleman would supply that for the record.

Mr. BRACKETT. Yes, sir.

The CHAIRMAN. We would appreciate that very much—I think, if there is no objection to that?

(No response.)

Mr. BRACKETT. Surely, sir.

(The information requested is as follows:)

1st-tier subcontracts of $10,000 and over awarded by 12 major prime contractors (period: Jan. 1, 1962, through Feb. 28, 1963)

States	February	Percent	Grand total, September–February	Percent
Alabama [1]	74,302	0.27	556,720	0.13
Arizona	1,348,750	4.99	4,094,723	.96
Arkansas			145,058	.03
California [1]	18,353,663	67.89	180,866,615	42.33
Colorado	129,858	.48	2,026,102	.47
Connecticut [1]	706,516	2.61	13,868,982	3.25
Florida [1]	108,765	.40	35,239,620	8.25
Georgia			82,219	.02
Illinois	548,765	2.03	6,701,422	1.57
Indiana	196,856	.73	907,930	.21
Iowa	163,930	.61	12,885,548	3.02
Kansas	15,924	.06	789,209	.18
Louisiana [1]	218,682	.81	4,774,415	1.12
Maryland	60,137	.22	13,018,687	3.05
Massachusetts	910,043	3.37	18,557,094	4.34
Michigan	188,304	.70	3,557,237	.83
Minnesota	530,640	1.96	26,277,864	6.15
Mississippi			28,415	.01
Missouri [1]	180,828	.67	29,990,584	7.02
New Hampshire	19,332	.07	19,332	.01
New Jersey	1,029,377	3.80	9,325,393	2.18
New Mexico			15,576	.01
New York [1]	678,433	2.51	35,743,728	8.37
North Carolina			547,888	.13
Ohio	245,665	.91	4,588,727	1.07
Oklahoma	435,364	1.61	452,113	.11
Oregon	10,349	.04	271,967	.06
Pennsylvania	448,232	1.66	16,968,824	3.97
Rhode Island			68,503	.02
Tennessee			57,216	.01
Texas [1]	273,294	1.01	2,153,184	.50
Utah	109,574	.41	256,801	.06
Virginia			114,397	.03
Vermont			41,589	.01
Washington	22,816	.08	73,689	.02
West Virginia			724,699	.17
Wisconsin	25,726	.10	1,404,374	.33
Total	27,034,125	100.00	427,196,444	100.00

[1] States in which 1 or more of the 12 reporting prime contractors are located.

NOTE.—Total number of subcontracts (1st-tier), 2,172.

1st-tier subcontracts of $10,000 and over awarded by 12 major prime contractors (period: Jan. 1, 1962, through Jan. 31, 1963)

State	October 1962	Percent	November 1962	Percent	December 1962	Percent	January 1963	Percent	Grand total	Percent
Alabama [1]			$26,842	0.05	$297,092	0.16	$158,484	0.11	$482,418	0.12
Arizona	$167,884	0.69	1,415,698	2.75	275,260	.15	887,131	.63	2,745,973	.68
Arkansas			145,058	.28					145,058	.03
California [1]	12,091,500	49.89	27,569,837	53.60	83,174,985	45.22	39,676,630	28.23	162,512,952	40.61
Colorado	14,531	.06					1,881,713	1.34	1,896,244	.47
Connecticut [1]	364,099	1.50	314,501	.61	775,830	.42	11,708,636	8.33	13,162,466	3.29
Florida [1]	79,574	.33	910,711	1.77	33,923,510	18.44	217,060	.15	35,130,855	8.78
Georgia	58,993	.24			23,226	.01			82,219	.02
Illinois	1,193,879	4.93	588,550	1.15	1,023,616	.56	3,346,612	2.38	6,152,657	1.54
Indiana	345,986	1.43	204,935	.40	81,197	.04	78,956	.06	711,074	.17
Iowa	346,747	1.43	254,157	.49	1,475,348	.80	10,645,366	7.57	12,721,618	3.18
Kansas	79,334	.33	45,310	.09			648,641	.46	773,285	.19
Louisiana [1]					606,614	.33	3,949,119	2.81	4,555,733	1.14
Maryland	44,050	.18	1,480,494	2.88	116,806	.06	11,317,200	8.05	12,958,550	3.24
Massachusetts	392,349	1.62	776,068	1.51	9,840,132	5.35	6,638,502	4.72	17,647,051	4.41
Michigan	323,628	1.34	30,392	.06	2,052,742	1.12	962,171	.68	3,368,933	.84
Minnesota	3,081,237	12.71	2,242,664	4.36	7,562,639	4.11	12,860,684	9.15	25,747,224	6.43
Mississippi			15,320	.03	13,095	.01			28,415	.01
Missouri [1]			83,890	.16	765,497	.42	28,960,369	20.61	29,809,756	7.45
New Jersey	2,682,640	11.07	1,828,305	3.55	2,302,018	1.25	1,483,053	1.06	8,296,016	2.07
New Mexico					15,576	.01			15,576	.01
New York [1]	1,148,207	4.74	6,327,571	12.30	26,875,612	14.61	713,905	.51	35,065,295	8.76
North Carolina	38,888	.16	509,000	.99					547,888	.14
Ohio	441,422	1.82	98,072	.19	583,651	.32	3,219,917	2.29	4,343,062	1.09
Oklahoma	16,749	.07							16,749	.01
Oregon	61,155	.25			36,133	.02	164,330	.12	261,618	.07
Pennsylvania	171,191	.71	5,683,591	11.05	10,076,701	5.48	589,109	.42	16,520,592	4.13
Rhode Island					68,503	.04			68,503	.02
Tennessee					37,230	.02	19,986	.01	57,216	.02
Texas [1]	442,678	1.82	772,151	1.50	570,851	.31	94,210	.07	1,879,890	.47
Utah	52,375	.22	10,000	.02	84,852	.05			147,227	.04
Vermont							41,589	.03	41,589	.01
Virginia	10,205	.04	24,192	.05			80,000	.06	114,397	.03
Washington			13,364	.03	37,509	.02			50,873	.01
West Virginia	563,632	2.32	43,094	.08			117,973	.08	724,699	.18
Wisconsin	24,765	.10	23,448	.05	1,238,600	.67	91,835	.07	1,378,648	.34
Total	24,237,698	100.00	51,437,215	100.00	183,934,825	100.00	140,552,581	100.00	400,162,319	100.00

[1] States in which 1 or more of the 12 reporting prime contractors are located.

You might be interested in this report form that we have. It is a very simple one—this self-addressed postal card, which just has a few questions on the back—there are no records to keep, no reports to be made. They just fill this out and mail it in to us when they let a subcontract and that is all there is to it.

The dollar amount for Minnesota is $26,277,864.

(The exhibit referred to appears on the following pages.)

The CHAIRMAN. What percentage is this?

Mr. BRACKETT. That represents 6.15 percent, sir, of the total dollars that we have had reported.

The CHAIRMAN. Six point of what?

Mr. BRACKETT. Six point fifteen percent of the total dollars that have been let under these first- and second-tier subcontracts.

The CHAIRMAN. Oh, yes; but what percentage of the grand total?

Mr. BRACKETT. Six point one five of the grand total went into Minnesota.

The CHAIRMAN. Of all NASA dollars?

Mr. BRACKETT. That is the subcontracts—first and second tier.

The CHAIRMAN. Oh, yes; I know—that's right, but my point is: What percentage is it of all NASA dollars?

Mr. BRACKETT. I don't have that, sir.

The CHAIRMAN. Well that, of course, tells the story. One prime contract, for example, might be worth more than all the subcontracts of a particular State—right?

Mr. BRACKETT. That is true, sir.

The CHAIRMAN. Right.

Mr. MOSHER. Are these statistics collected on a voluntary participation basis—by sending these cards back, or do you require it?

Mr. BRACKETT. It is required by their contract, to do this. Of course, this only applies to our 12 major contractors. We have gotten the permission to do this from the Bureau of the Budget, and they have given us permission to try this with the 12 major contractors for a period of 15 months in order to get the picture of just what is going on.

The CHAIRMAN. Are there any other questions?

Mr. STAEBLER. I would like to inquire specifically about the research or these contracts where no material is involved. Are these all handled by negotation?

Mr. BRACKETT. Yes, they are.

Mr. STAEBLER. Is there some method of determination by a board, then?

Mr. BRACKETT. Well, these for the most part, sir, are smaller study or basic research contracts, with small money involved, you see. I doubt if there would be a board on many of these. I have never heard of any.

Mr. STAEBLER. These are just within the discretion of the contracting officer then——

Mr. BRACKETT. Yes.

Mr. STAEBLER (continuing). Aided by some technical people.

Mr. BRACKETT. Many of these are with colleges and universities and nonprofit institutions, sir. Dr. Thomas Smull is in charge of the office that handles the college and nonprofit institution contracts.

SECTION I.	1. PRIME CONTRACT NO.			*Form Approved Budget Bureau No. 104-R012*	*For NASA Use Only*
	2. PRIME CONTRACTOR				A.
	3. ADDRESS				B.
II. FIRST-TIER SUBCONTRACT	4. SUBCONTRACTOR				C.
	5. ADDRESS				D.
	6. SMALL BUSINESS ☐ YES ☐ NO	7. SUBCONTRACT NO.	8. SUBCONTRACT AMT. $	9. ☐ NEW CONTRACT 10. ☐ MODIFICATION	
	11. PRINCIPAL PLACE OF PERFORMANCE *(If known)*				E.
	12. DESCRIPTION OF WORK				F.
III. SECOND-TIER SUBCONTRACT	13. SUBCONTRACTOR				G.
	14. ADDRESS				H.
	15. SMALL BUSINESS ☐ YES ☐ NO	16. SUBCONTRACT NO.	17. SUBCONTRACT AMT. $	18. ☐ NEW CONTRACT 19. ☐ MODIFICATION	
	20. PRINCIPAL PLACE OF PERFORMANCE *(If known)*				I.
	21. DESCRIPTION OF WORK				J.
	22. COMPANY SUBMITTING REPORT		23. SIGNATURE	24. DATE	

NASA FORM 667 AUG 62 GPO : 1962 O - 655168

REPORT ON NASA SUBCONTRACTS

FIGURE 76

INSTRUCTIONS

GENERAL

A. This report form is for use by NASA prime contractors and first-tier subcontractors participating in the NASA subcontracting reporting program. Parts I and II of the form are for use by the prime contractors; Parts I, II and III are for use by the first-tier subcontractors.

B. NASA prime contractors will complete and submit Parts I and II of the form for each subcontract *(as defined in paragraph D below)* placed by them which is estimated will exceed $10,000 and for each action *(modification)* in excess of $10,000 on such subcontract. Modifications to be reported include actions which result in the decommitment of funds as well as commitments.

C. First-tier subcontractors having any subcontracts which are estimated will exceed $10,000 will complete and submit the form in entirety for each subcontract *(as defined in paragraph D below)* placed by them which is estimated will exceed $10,000 and for each action *(modification)* in excess of $10,000 on such subcontract. Modifications to be reported include actions which result in the decommitment of funds as well as commitments.

D. The term *"subcontract"* as used herein means procurement in excess of $10,000 by the prime contractor or first-tier subcontractor of articles, materials, or services entering into the performance of a specific NASA prime contract. It does not include purchases, regardless of amount, of stock items, materials, or services which cannot be identified with a specific NASA prime contract.

E. NASA prime contractors will provide the number of the NASA prime contract to their first-tier subcontractors for entry on the reports.

F. The report is to be submitted as soon as possible after placement of the subcontract to the National Aeronautics and Space Administration, Procurement and Supply Division, Code BRP, Washington 25, D. C.

G. Prime contractors will obtain a supply of the forms from their NASA Contracting Officer. Subcontractors will obtain the forms from the prime contractor.

SPECIFIC

Item 1. Enter the NASA prime contract number.

Item 2. Enter name, and division if applicable, of the prime contractor.

Item 3. Enter address *(City and State only)* of the prime contractor.

Item 4. Enter name, and division if applicable, of the subcontractor.

Item 5. Enter address *(City and State only)* of the subcontractor.

Item 6. Enter a check in the applicable box.

Item 7. Enter subcontract or purchase order number specified by the contractor initiating the action.

Item 8. Enter in terms of commitments, to the nearest dollar, the amount of the subcontract, or amount of modification to the subcontract. Modifications resulting in decommitments are to be enclosed in parentheses.

Item 9. Enter a check if this report is the first report submitted on the subcontract.

Item 10. Enter a check if this report is for a modification of a previously reported subcontract.

Item 11. Enter the location *(City and State only)* of the principal plant or place of business, where the items will be produced or supplied from stock or where the work will be performed, if known. For construction subcontracts enter the site of construction.

Item 12. Enter a brief description of the item to be furnished or the work to be performed under the subcontract. *(For example: Environmental control system for Apollo Spacecraft, Fuel Pumps, etc.)*

Items 13 thru 21. See Items 4 thru 12.

Item 22. Enter the name of the company submitting the report. This should be the name of the prime contractor for reports on first-tier subcontracts; it should be the name of the first-tier subcontractor for reports on second-tier subcontracts.

Item 23. To be signed by the company individual submitting the report.

Item 24. Enter the date of signature.

FIGURE 77

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON 25, D. C.

OFFICIAL BUSINESS

POSTAGE AND FEES PAID
NATIONAL AERONAUTICS
AND SPACE ADMINISTRATION

National Aeronautics and Space Administration
Procurement & Supply Division (Code BRP)
Washington 25, D. C.

FIGURE 78

Mr. STAEBLER. What is the aggregate dollar volume of the contracts of this type—not material, just research?

Mr. BRACKETT. I don't know, sir. We have not broken it down that way, I don't think—perhaps so. I think that Dr. Smull can tell us, perhaps, the amount of the contracts, and these of course include grants, too.

Dr. THOMAS L. K. SMULL (Director, Office of Grants and Research Contracts, NASA). In this last fiscal year this would be approximately $40 million.

This is a question of definition. Certainly the feasibility studies that Mr. Brackett spoke about are study contracts. These could be rather substantial—for example, for something like the Apollo.

This figure is for the more generalized basic research programs as opposed to studies which are directed to specific matters.

Mr. STAEBLER. Well, instead of having me cut across your categories, what are the categories you establish inside NASA?

Dr. SMULL. I don't think I quite understand.

Mr. STAEBLER. What categories of contracts are there within NASA?

Dr. SMULL. For the basic research activities?

Mr. STAEBLER. Yes.

Dr. SMULL. Grants are the principal form of agreement for the support of research at educational institutions. In some instances we use fixed-price contracts, and in other cases cost-type contracts.

Mr. STAEBLER. All of these covering pure research?

Dr. SMULL. Yes, sir, depending on the nature of the investigation. If it is at a nonprofit research organization, it is usually a contractural arrangement. With a university, if it is what you would call a basic, very basic investigation, of the paper type, we use a grant agreement, inevitably.

In those situations where there are flight programs in which the university is participating which require a piece of their experiment of necessity to be somewhere at a given place and time, such as Cape Canaveral, as a part of a satellite study, this will usually be handled by—the development of this piece of instrumentation—will be handled by the cost-type contract.

Mr. STAEBLER. What kind of follow-up do you utilize in this case—how deeply does NASA go into the question of cost? Does it simply take the figures submitted by the institution or is there any follow-up?

Dr. SMULL. No; we use the established Government audit services to look into these questions and to follow up on costs.

Mr. STAEBLER. You said most of this was with the universities?

Dr. SMULL. Yes, sir.

In NASA's structuring of its organization for the procuring of things, the establishment of policies and procedures for dealing with the universities and nonprofit organizations has been the responsibility of my office. Such determinations of the industrial or profit type are in Mr. Brackett's organization. The larger measure of the basic research is handled by the universities and nonprofit research organizations.

Mr. STAEBLER. How large a dollar volume for basic research is involved and handled by the profit institutions?

Dr. SMULL. I don't think we have a figure on that, sir. This, again, is a question of definition. But it is not large.

Mr. STAEBLER. So that it is safe to say that practically all of the work done by companies is done for you toward the developing of some particular material or project?

Dr. SMULL. Yes, sir; the industrial activity is largely for services in developmental and operational programs.

Mr. BRACKETT. Quite a bit of research work is done in our own laboratories by our own people.

The CHAIRMAN. May I interrupt for a moment? You are talking about basic research, are you not, Mr. Brackett? Just basic research?

Mr. BRACKETT. Well, of course, they do some.

The CHAIRMAN. But I suspect a sizable portion of your budget is for research and development is it not, and I assume that you are talking about basic research when you are discussing the universities and educational establishments and inhouse activities. It is pretty much basic research.

Mr. BRACKETT. Yes.

The CHAIRMAN. And I think industry does the majority of the applied research don't they?

Mr. BRACKETT. Yes. When it comes to the development of the hardware that is where it goes to industry.

The CHAIRMAN. Yes. I just wanted to have the gentleman understand that.

Mr. STAEBLER. Yes. One question, not along that line we have just discussed: Are the contracts with NASA subject to approval by the Renegotiation Board?

Mr. BRACKETT. Yes, they are.

Mr. STAEBLER. Thank you, that is all.

The CHAIRMAN. Mr. Hammill, do you have any questions?

Mr. HAMMILL. Just one, sir.

This subcommittee is specifically responsible for reviewing requests of both the Office of Space Sciences and the Office of Advanced Research and Technology. I am just curious as to whether you have come across some procurement problems that are peculiar to those areas?

Mr. BRACKETT. None that I know of, Mr. Hammill.

The CHAIRMAN. If there are no further questions we will adjourn but it may be that some members may have some questions of you later, after studying the submissions, Mr. Brackett.

Mr. BRACKETT. Yes, sir.

The CHAIRMAN. We will perhaps impose on you for some further information. We thank you very much and appreciate your appearing here today.

(Whereupon, at 12:20 p.m., the committee was adjourned, to reconvene at 10 a.m. on Wednesday, March 20, 1963.)

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1964 NASA AUTHORIZATION

WEDNESDAY, MARCH 20, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS
SUBCOMMITTEE ON SPACE SCIENCES
AND ADVANCED RESEARCH AND TECHNOLOGY,
Washington, D.C.

The subcommittee met, pursuant to adjournment, at 10 a.m., in room 304, Cannon Building, Hon. Joseph E. Karth (chairman of the subcommittee) presiding.

Mr. KARTH. The committee will be in order. Dr. Silverstein, we take a great deal of pleasure in welcoming you before the subcommittee to talk to us about Centaur. As you know, this subcommittee has been extremely interested in the Centaur launch-vehicle development program, and after substantial inquiry last year, we feel that the Centaur program is on the path to recuperation or whatever, under your direction. Today we would like to have you tell us what is happening to Centaur and what your pet theories might be as to its chances of success. We also want to know how vital you think the Centaur vehicle is to the total space sciences program, and when you think this vehicle is going to be operational.

If you have a prepared statement, we would be very happy to have you read directly from it or summarize it. You may proceed in any manner that you like.

STATEMENT OF DR. ABE SILVERSTEIN, DIRECTOR, LEWIS RESEARCH CENTER, NASA; ACCOMPANIED BY V. L. JOHNSON, CENTAUR PROGRAM MANAGER, NASA HEADQUARTERS, AND EDGAR CORTRIGHT, DEPUTY DIRECTOR, OFFICE OF SPACE SCIENCES, NASA HEADQUARTERS

Dr. SILVERSTEIN. Thank you very much.

It is a pleasure to be back with this committee to testify before it and talk about the Centaur vehicle which I consider to be one of the most important vehicles in our space science program. It is through the Agena vehicle and Centaur vehicle that the major elements of our lunar and interplanetary science program will be conducted, and, therefore, it is extremely important for the program that we do provide a successful vehicle.

This is the approach we have taken. We are bending every effort to provide success. There is, I think, a general philosophy with which we are working, one which I think is appropriate to the space vehicle area, and is different than the philosophy that has been used in the past, in, for example, the area of missiles.

96-504 O—63—pt. 3a——23

I picked up the Washington Post this morning and was very pleased to find in it a talk by Dr. Getting of the Aerospace Corp., which he just made yesterday, which expressed my philosophy so completely that I was very pleased to find that our distinguished Dr. Getting was actually moving down the same path I am.

It is quite true, I think, in space vehicles that the approach we must take has got to be one where everything that can be done on the ground in the way of test and checkout must be done perfectly on the ground, and in this way I think we can find 95 percent of the problems that we will later encounter in flight, and solve these problems on the ground before flight testing.

This philosophy is one which we have adopted in the Centaur program. Since taking over the program in October, we have increased the ground test program on the Centaur by perhaps 500 to 800 percent, depending on how you evaluate it.

Another major philosophy I have is that a program such as Centaur needs strong central project management from both a technical and business administration point of view. These programs are tremendously complex; they involve new technology. In the case of Centaur, of course, it is the hydrogen technology which has evolved out of a number of years of research, but has not as yet been applied, and in its application there are many new technologies and many new applications that need to be developed before we can hope for a successful flight.

In the same way the industrial organizations that are working in the field without previous experience encounter problems in which they need help from organizations such as the Lewis Center, who have been engaged in hydrogen technology for the past 15 years.

Secondly, in the business administration point of view, it is necessary, I think, to get project teams, strongly manned and strongly led, oriented with the project with the idea that day by day and week by week, throughout the period, there will be people in each area of technology and each area of business administration who are carefully following each aspect of the program and making sure that the program is being funded as intelligently as good engineering know-how and business techniques will enable it to be. It has been on the basis of these two philosophies that we have established the Centaur program at the Lewis Center.

I propose now to tell you a bit about the administrative setup that we have arranged with the General Dynamics organization, our own in-house organization and the relationships we have established at the range for the flight of these birds.

I will follow that with some discussion of the technical considerations of the problem and some of the problems that we have been attempting to solve and are solving, and I will mention a bit the test program that has been amplified and give you some feeling as to schedules.

First, perhaps I should show a picture of the Centaur. Most of you are familiar with it and there isn't much need for me to go into background because I find in this report of the Committee on Science and Astronautics, dated July 2, the background of the Centaur program has been well covered.

May I have the first chart that shows the general layout of the Centaur vehicle (fig. 78a)?

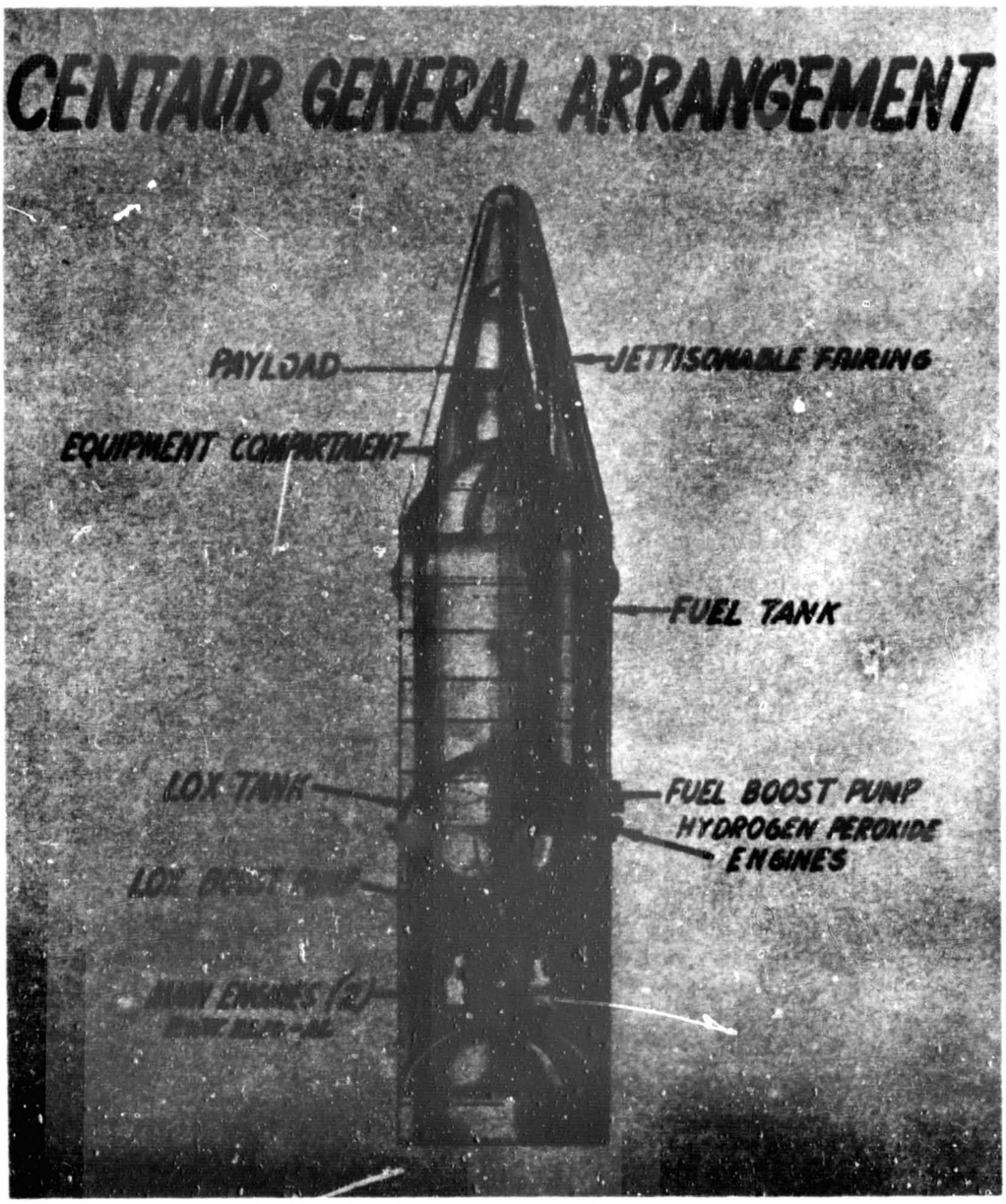

FIGURE 78a

I will move over here to explain it.

This is the Centaur stage from here to here. The payload is mounted on top of the stage. This is the nose cone. The overall length from the Atlas booster to the peak of the nose cone is some 47 feet. The stage is powered by two engines that are produced by the Pratt & Whitney Aircraft Corp., each with 15,000 pounds of thrust. Stage weight is about 38,000 pounds, loaded with fuel, and the payload on top weighs 2,100 pounds. The Centaur is boosted by the Atlas, having a total thrust of 367,000 pounds.

The vehicle at this position carries its guidance system and associated equipment required for flight performance. In our earlier tests with the vehicle, the first flight was a failure. You recall it was associated with a failure in this area of the tank, and it was believed to be

due to the weather shield around the top of the tank coming off under the aerodynamic loads experienced in the flight at a time of about 54 seconds after launch.

I will show a slide later to indicate what we are doing in this area.

May I have the next chart (fig. 78b)? This shows the location within the General Dynamics organization of the Centaur project group, headed by Mr. Hansen, who reports directly to the president of the General Dynamics/Astronautics organization in San Diego, Mr. Dempsey. So we see within the organization we have a project team at General Dynamics/Astronautics, and all of the Centaur work is directly through this project team which is composed of some 1,500 scientific and technical and supporting personnel.

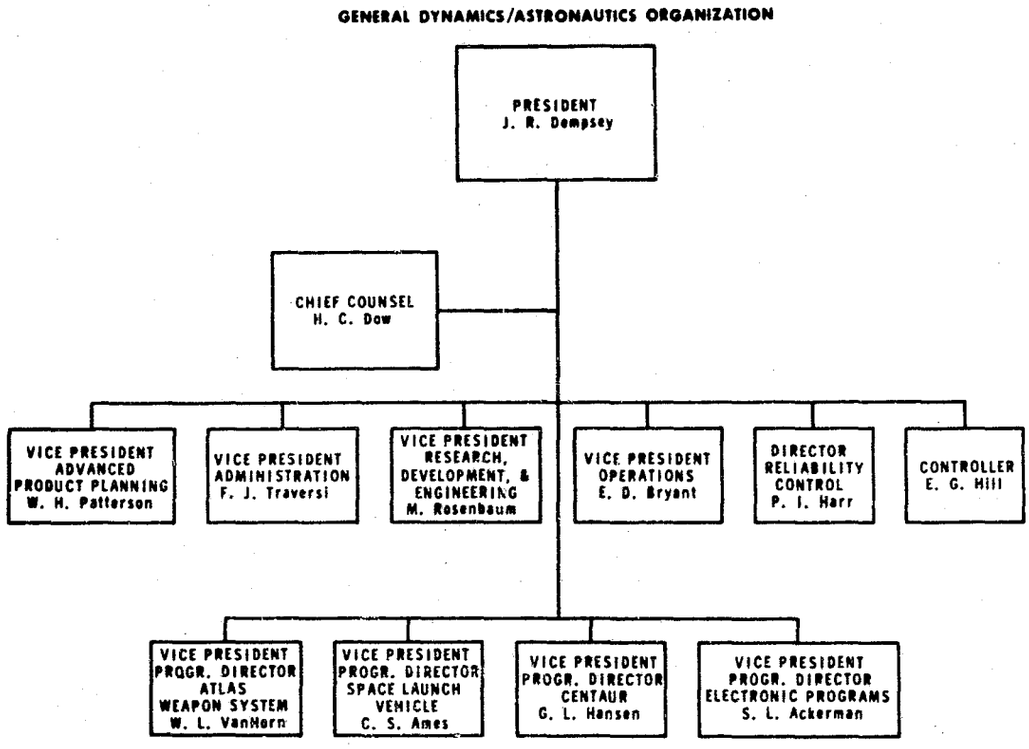

FIGURE 78b

They are supported within the organization by others, for example, in development and engineering and other groups by an additional thousand personnel of the organization. The work is carried out at San Diego, Point Loma, Edwards Air Force Base, Sycamore Canyon, and at Cape Canaveral. That work is all directed by Mr. Hansen, so we do have a project organization here which is well centered, and peaks to a point where direction can be given from our project management team to the Centaur organization.

The next chart (fig. 79a) shows the project organization within General Dynamics/Astronautics led by Hansen and has two major divisions, one in engineering, and the other in operations. As you can see the organization is divided up into systems management, analysis, and design on the engineering side and, under operations, materials, manufacture, test operations, and launch operations supported by staff

GENERAL DYNAMICS/ASTRONAUTICS ORGANIZATION

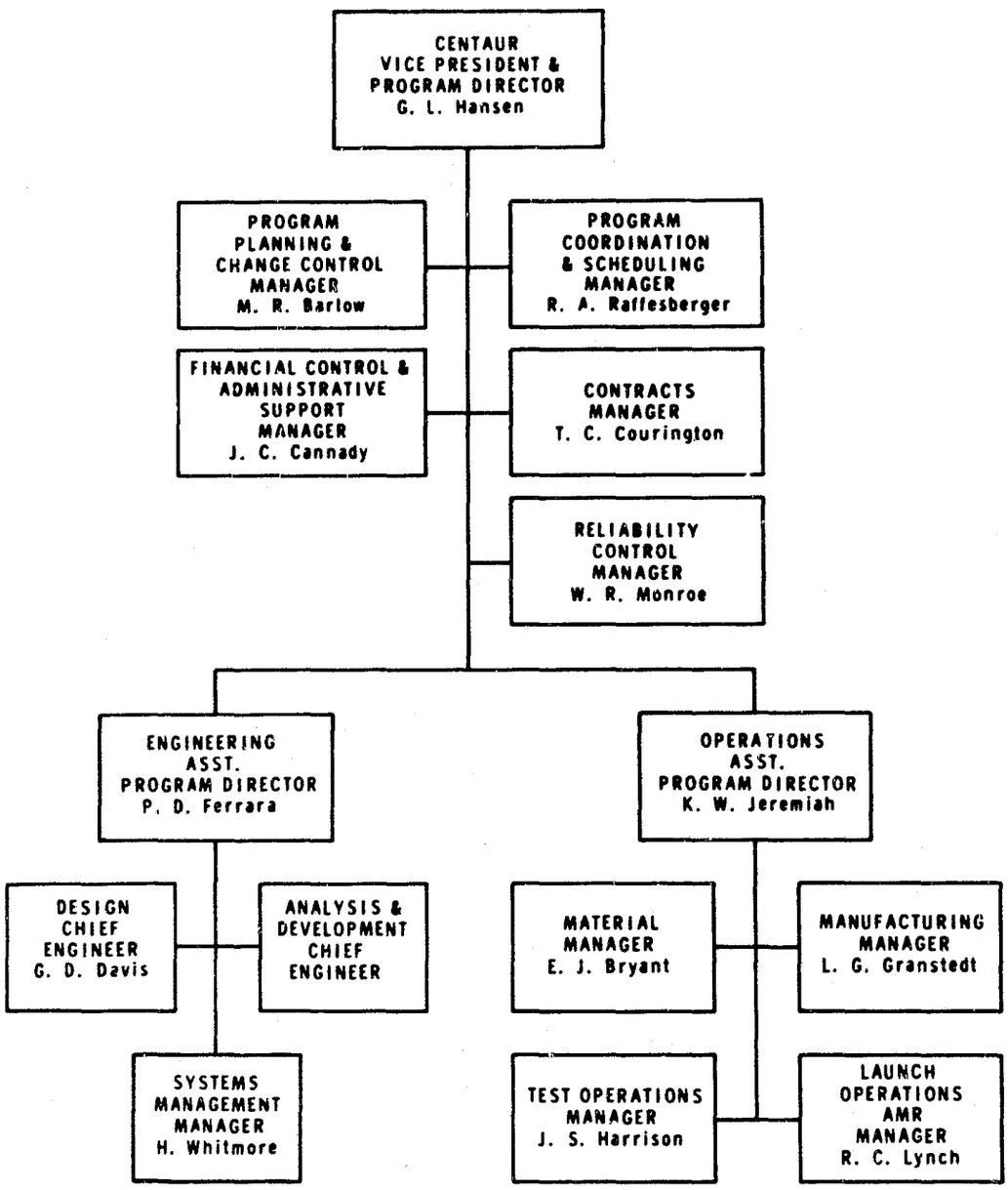

FIGURE 79a

groups that deal with financing, scheduling, programing, and so forth.

We feel that this is an organization that can provide very strong control of the program both technically and administratively.

May I have the next chart (fig. 80a)?

At Lewis we have organized the project team into a Centaur Project Office led by Mr. Gabriel, which is divided into a group handling system integration and performance and a group that deals with various aspects of guidance, contracting facilities, instruments and electrical, launch operations and a group for contractors' activity in propellent systems, propulsion and tests.

We have a field projects branch which is led by Mr. Gray. He is the man that has been leading the group at Canaveral that is re-

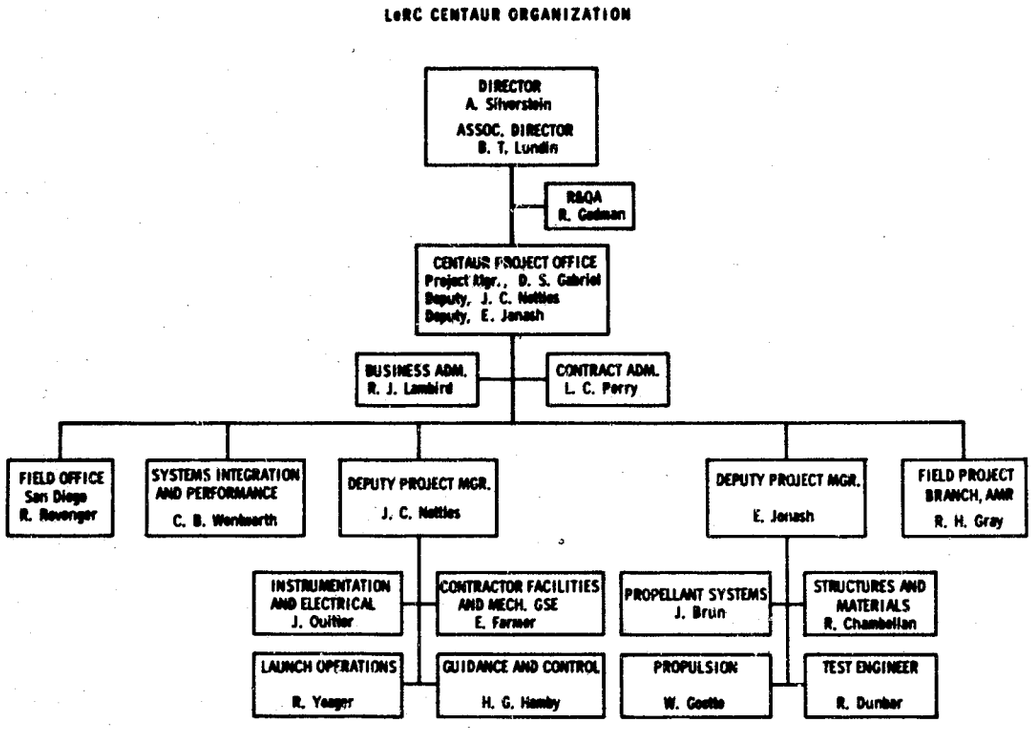

FIGURE 80a

sponsible for the successful flight program of the Thor-Delta vehicle. As you know, the Delta vehicle has been the most successful vehicle that has been flown in this country or elsewhere with a success record of 15 out of 16. His techniques are ones we are trying to adapt into the flight operation of Centaur, so we have expanded this team at the cape under his leadership to provide us, we hope, a record of at least 15 out of 15.

May I have the next chart (fig. 81a)?

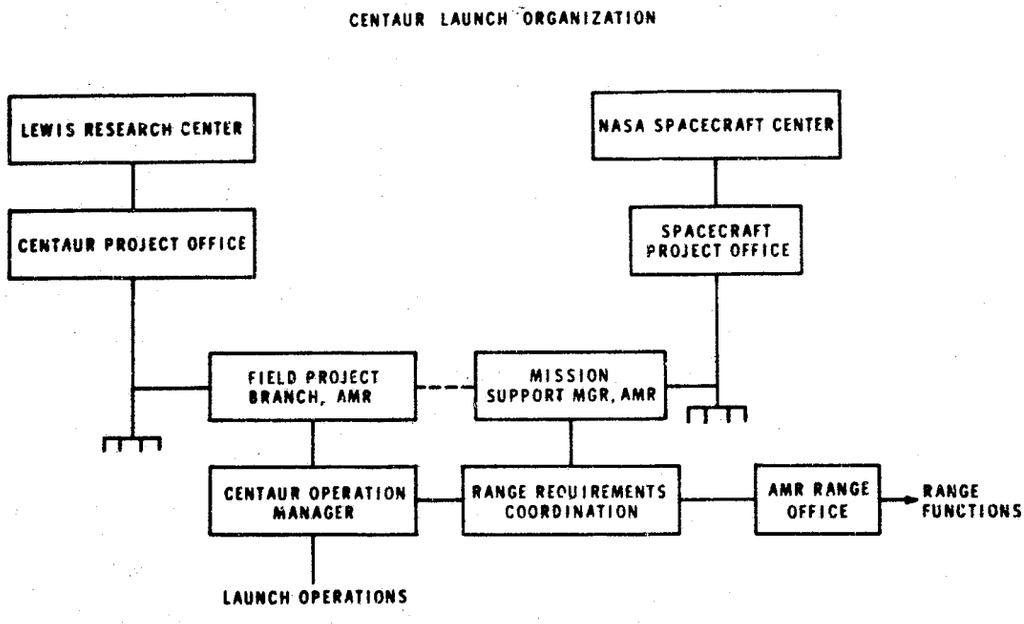

FIGURE 81a

Mr. KARTH. I wonder if you would provide for the record copies of those organizational charts?

Dr. SILVERSTEIN. I will provide copies of all of my charts.

This is a breakdown of the relationship established between the Lewis group in the Centaur Project Office and the field project branch led by Mr. Gray. There is a direct route from the project office to Mr. Gray for technical direction.

Since the vehicle will carry spacecraft, the spacecraft centers, such as the Goddard Center and the Jet Propulsion Laboratory, will feed into this same project branch the coordination between the launch vehicle team and the spacecraft team.

There will be a branch of this office both at the Atlantic Missile Range and the Pacific Missile Range, so I think we have here both a good organizational configuration to carry out the launches and the team which is, I think, the best team in the country to do it.

Now let me consider with you for a few minutes some of the problems that we are tackling in Centaur. These are some of the technical problems which we reviewed intensively for the first 2 months after taking on the project in October by assembling together a team of some 80 men, technical expects in all of the problem areas where we expected difficulty.

We brought this team together and assigned to them the task of studying, for example, guidance, trajectories, propulsion, and structures. Each of these areas was tackled by a strong team which came up with certain recommendations for either changes or, after review of the problem areas, suggested that the vehicle not be altered.

This has led us and our staff, in subsequent studies of the work they did and the work we had done, to make certain changes in the way in which the vehicle would fly and in the characteristics of the vehicles.

May I have the next chart (fig. 82a)?

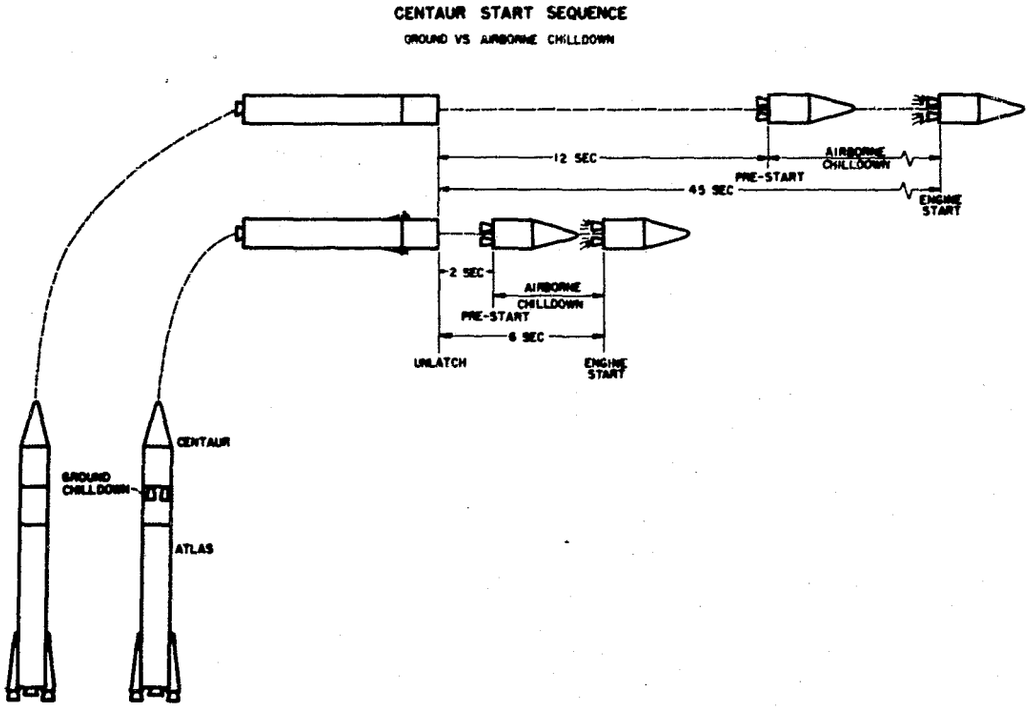

FIGURE 82a

For example, one of the things we are going to provide in Centaur is a very much shorter period of time between the end of burning in the first stage Atlas and the time in which we ignite the Centaur. In the previous design, this time was some 45 seconds, and we are reducing it to 6 seconds.

There are a number of reasons for this. One, we gain some hundred pounds of payload by doing this. During this time of 45 seconds of time, each second is worth 3 pounds of payload because the vehicle is simply coasting upward against the action of gravity and is losing energy in the process so we are trying to reduce this to a minimum.

Mr. KARTH. Was this a secret before you took over the program? Why did we originally make the decision to coast 45 seconds before re-ignition?

Dr. SILVERSTEIN. In order to accomplish this, there are some other processes that have to take place, and as you well know various groups of engineers who design any system will come up with different solutions. This solution was one that became apparent to our group.

I think it is a better solution, but I think you must recognize the fact that if you put 10 engineering groups to work on a system, that you will get 10 engineering answers, and some are better than others. I think this is a bit better.

Mr. KARTH. This is true, but hasn't it always been a top consideration when you are talking especially about escape, to build your vehicles so that you get the best possible benefits ratio?

Dr. SILVERSTEIN. I think that has been the principle.

Mr. KARTH. I understand that escape costs run to $10,000, or $15,000, or $20,000 a pound. You mean that hasn't been taken into consideration in this?

Dr. SILVERSTEIN. I must say this is a change we were putting into the program as a result of our studies and that it was not in before. Different groups will put different design features into a vehicle and——

Mr. KARTH. Doctor, what is the change in its capabilities now from what it could put into escape as opposed to what it now will be able to put into escape? What could it do under the old configuration as opposed to what it will now?

Dr. SILVERSTEIN. I will have to give a round number on this. I would say the changes we have been making will increase its capability by 250 pounds. We have, in some places, of course, increased the weight of the vehicle to take care of other problems. For example, I will mention the structural problem later which we recognize as being serious from the standpoint of the structure of the vehicle and here we are taking care of it.

The effects are both plus and minus.

Mr. KARTH. Yes, but the overall pluses overbalance the minuses.

Dr. SILVERSTEIN. The overall effect is plus.

Mr. KARTH. You put more in the escape feature despite the added weight?

Dr. SILVERSTEIN. Yes, sir. There is one feature, of course, that we have been trying to accomplish and that is to avoid the zero G situation that occurs with this long coast before we light the engines and that is another reason we wanted to go for a shorter time. Between

the time that the booster separates and the time that the Centaur engines ignite, Centaur could be in zero G, and to avoid that there are several small rockets that burn fuel to give a small push on the rocket. By keeping this time short we burn less fuel here and we don't have to worry about the fuel being at the pump when we get ready to start the engine.

Another change we have made in this same area has been the development of an entirely new separation system which is geared toward insuring successful vehicle flights and also reducing the weight. Previously the vehicle took about 12 seconds to come out of the transition section between the Atlas vehicle and the Centaur stage.

We rearranged the sequence to accelerate the Atlas backwards away from the Centaur rather than attempting to accelerate the Centaur. This was done because the Atlas at this point in its flight has burned off its fuel so that it only weighs about 10,000 pounds, whereas the Centaur weighs 38,000 pounds at this time. It was easier to accelerate the lighter vehicle away from the Centaur than to accelerate the Centaur forward as was being done in the previous design, so we have changed this situation.

May I have the next chart please (fig. 82b)?

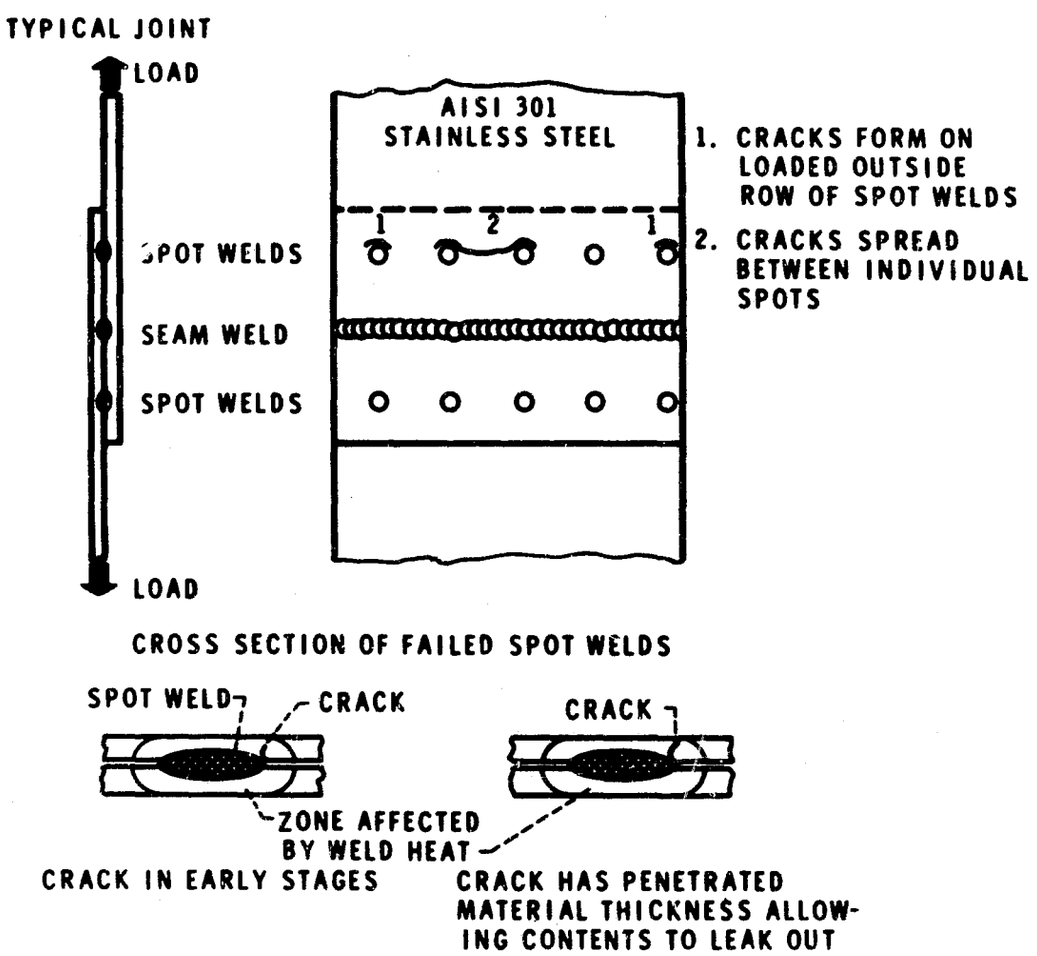

FIGURE 82b

This problem is a structural problem associated with the fact that Centaur carries liquid hydrogen. As you know there have been problems with leaking diaphragms which prevented the vacuum in the intermediate bulkhead from reaching the low value required to insulate the hydrogen tank from the oxygen tank.

Also there was some question about the integrity of the spot welds in the thin 301 stainless steel that makes up the shell of the vehicle. You may recall that there is a seam weld at the joints with spot welds in this area.

Studies have revealed that cracks occurred around these spot welds associated with the rise in temperature of the material during the welding process, and that there is an actual phase change in the material which leads to the brittleness of the weld.

When hydrogen is added to the tank, the thermal shock tends to expand the cracks and, because hydrogen has a low molecular weight, it will creep out of almost any crack of any size. It was necessary to do something about the spot welds. We have taken two approaches, an intermediate and final approach. The next chart will help develop this point (fig. 83a).

CAUSES OF FAILURE

1. STRESS CONCENTRATION AT SPOT WELD
2. LACK OF DUCTILITY IN WELD ZONE

REMEDIAL ACTIONS POSSIBLE

1. REDUCE STRESS CONCENTRATION BY DESIGN MODIFICATION AND MATERIAL CHANGE
2. INCREASE DUCTILITY OF WELDS BY CHANGING COMPOSITION OF WELDS

DUCTILE WELDS PRODUCED BY ADDING NICKEL FOIL REDUCE TENDENCY TO CRACK

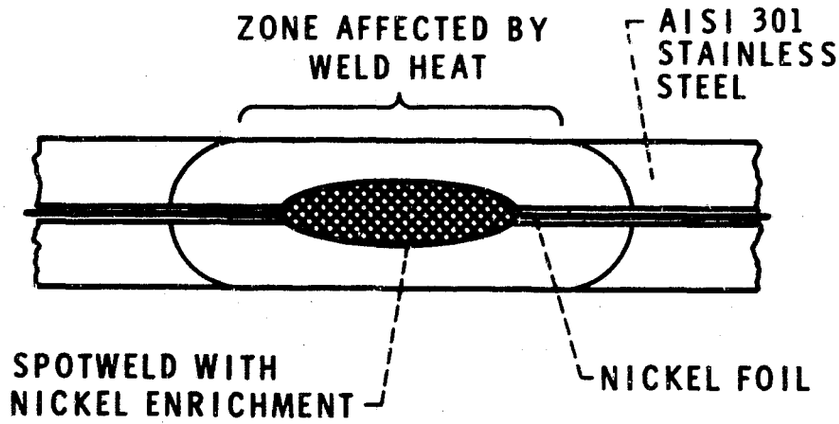

FIGURE 83a

The causes of cracks are stress concentration and lack of ductility. There are remedial actions that can be taken. One is to reduce stress concentration and another to increase the ductility of the welds. The stress concentrations can be reduced by reworking of the weld pattern; the ductility can be improved in two ways, one by changing materials and the other by the addition of an intermediate material between the two pieces of material to be welded.

The GD/A Corp. came up with the idea of adding nickel to the welds. Now nickel, as you know, increases the ductility of steel and tests have shown that the addition of nickel does make these spot welds more ductile and stronger.

On this chart (fig. 84a) you can see a comparison between the result obtained on spot welds of this type that were tested in shear and in cross tension. You will see that, whereas stainless steel 301 has in cross tension only a load-carrying capability of 65 pounds and failed after 633 cycles, the addition of nickel to the weld more than doubled the strength and the test proceeded to more than 2,000 cycles.

TYPICAL PROPERTIES OF RESISTANCE WELDS
IN 0.010 INCH THICK STEEL

	FATIGUE TEST 0 -.140,000 PSI - 423° F	SHEAR STRENGTH SINGLE SPOT		CROSS TENSION SINGLE SPOT	
		POUNDS		POUNDS	
		75° F	-423° F	75° F	-423° F
AISI 301 STAINLESS STEEL	633 CYCLES	390	379	213	65
AISI 310 STAINLESS STEEL	OVER 2000 CYCLES	293	464	168	232
AISI 301 STAINLESS STEEL WITH NICKEL ENRICHED WELDS	OVER 2000 CYCLES	371	615	209	131

FIGURE 84a

The intermediate solution we are going to use is the addition of nickel and we are going to carry on a very heavy program of structural development and structural testing of the vehicle with these welds. We are also investigating the use of stainless 310 which does not become brittle at the low temperatures associated with liquid hydrogen. As you can see the 310 has a value of 232 pounds. This is a technical point that I think is extremely important to the success of the vehicle and its structural integrity.

Another problem that has been encountered in recent months has been that associated with the slosh of the liquid oxygen in the oxygen tank (fig. 85a). This tank contains over 20,000 pounds of liquid oxygen. When the vehicle moves under the influence of the winds and

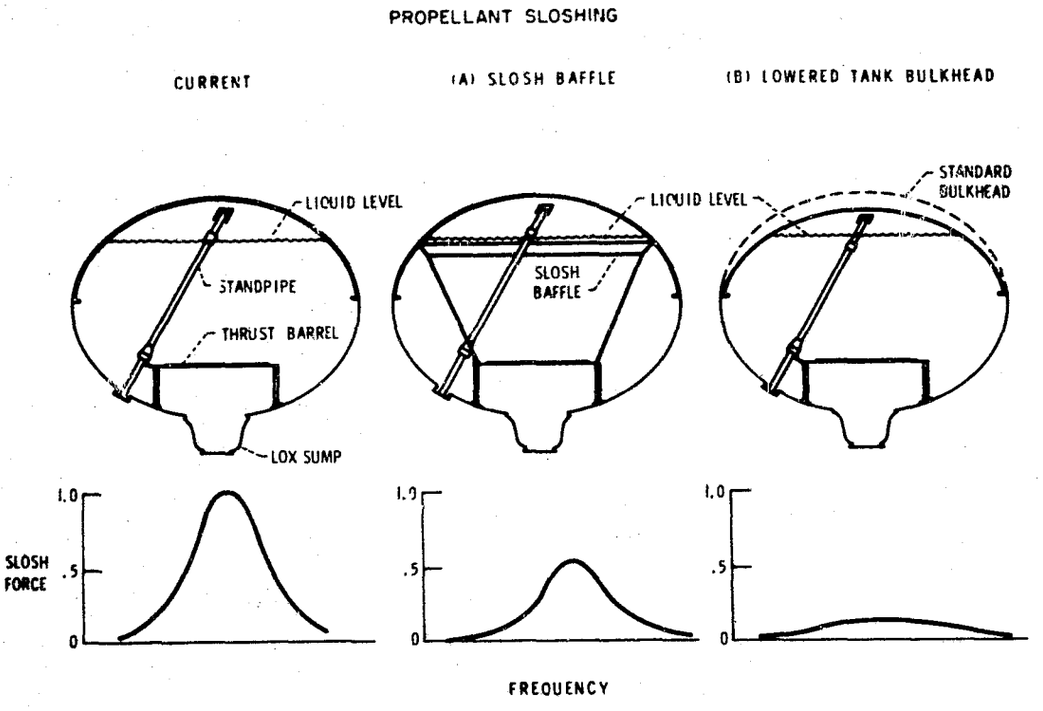

FIGURE 85a

atmosphere, the liquid starts a sloshing motion and the forces developed under the sloshing motion can become high enough to be destructive to the vehicle.

It might be difficult to imagine, but I think the calculated and measured forces can be as high as 8 to 12,000 pounds sideways on the vehicle because of the slosh. We found it necessary to do something about it.

Mr. KARTH. Wouldn't this be true of every liquid-fuel engine?

Dr. SILVERSTEIN. It is true and has been true of most of our vehicles. You will find most of them have slosh baffles. Now, the solution to this problem that we are——

Mr. KARTH. My point is that this should not have been a unique problem of Centaur, that we should have had experience with this before, inasmuch as most of our experience has been with liquid fuel vehicles.

Dr. SILVERSTEIN. I think the early calculations of this slosh indicated it was not critical, but later examination has shown this problem must be corrected to prevent possible flight failure. We are taking the intermediate step of adding a baffle in the oxygen tank and, in the final vehicle, modifying it to lower the bulkhead so the volume for the liquid to slosh in is reduced. We find for a liquid configuration of this type that the sloshing force shown here which peaks at a certain frequency has a value of this amount relatively for this tank configuration whereas it has a value of this amount in this configuration and here we find the problem is not serious. So by simply lowering the bulkhead and raising the level of the oxygen with reference to the top of the tank we can solve the slosh problem.

Mr. KARTH. Have you reduced it by a factor of 10, would you say?

Dr. SILVERSTEIN. In that order, yes, sir. May I have the next chart (fig. 86a)?

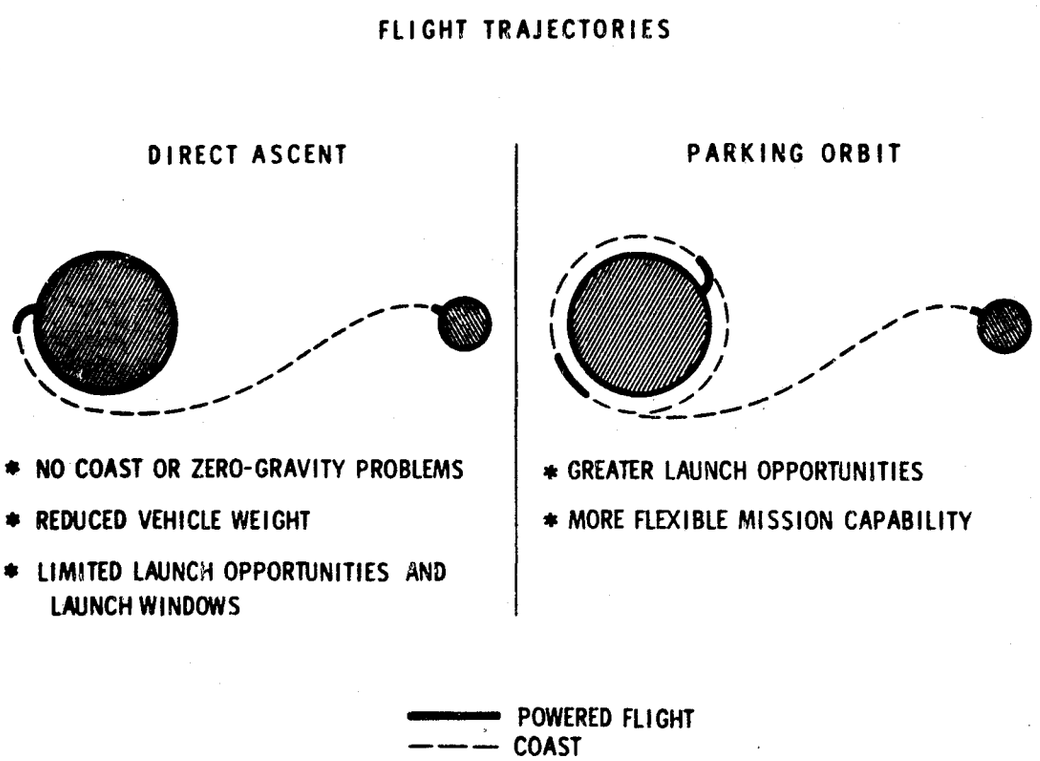

FIGURE 86a

Another step we are taking to get at some of the flight problems on Centaur is to start our flight program with a method called direct ascent as contrasted with a flight program called parking orbit. I think these terms have become familiar to you as a result of the many times they have appeared. The parking orbit is the case in which the vehicle first goes into an Earth orbit and then refires out of the orbit to the target. The direct ascent is a case where the vehicle heads toward the objective directly without going into orbit first, and requires only one firing of the Centaur engines. Our calculations show that we can achieve our development objectives by such a single firing thereby avoiding the long zero G period between the first firing and the second firing. We are going to set up a flight program to first carry out the direct ascent to the Moon and go to parking orbits later. The limitations of this method are shown here.

The launch opportunities to land on the Moon are limited if you use the direct ascent because you have one degree of freedom taken away. However, during the periods of the early flights, we have shown that we will have the capability of going to the lunar surface with the payload we are going to carry.

Mr. KARTH. Does it adversely affect the ability of the vehicle with the greater number of pounds to escape?

Dr. SILVERSTEIN. No, actually it is slightly improved. You get a slightly higher payload with direct ascent.

Mr. KARTH. How much does this increase the reliability of your flight?

Dr. SILVERSTEIN. The early flight reliability will be greatly increased. We feel that we have enough problems in our early flights

in studying the overall flight problems, structural, separation, and engine problems without taking aboard the additional problems introduced by the parking orbit including zero gravity, boil off of fuel during coast, and so on. So we start the program this way and clear out the development problems in certain areas, and then proceed to the additional problems of the parking orbit.

Mr. KARTH. Actually, what you are saying is you are going to be building two different Centaurs?

Dr. SILVERSTEIN. No; actually the change involved here is not a change in the Centaur. It involves only the flight program of the vehicle. The instrumentation compartment of Centaur contains a flight programer which signals the engine when to start and when to stop. We will program initially just one engine start and the vehicle will burn all of its fuel in a single firing. When we go to parking orbits, we will put into the programer the information to turn the engines on, off, coast, and restart. Thus, it doesn't really involve a change in the vehicle but involves only a change in the programing of the vehicle.

Mr. STAEBLER. Mr. Chairman?

Mr. KARTH. Mr. Staebler.

Mr. STAEBLER. May I ask an elementary question? What are the mechanics of restart?

Dr. SILVERSTEIN. Each engine, of course, has a somewhat different system and the engine we have has a start cycle which has two parts to it. There is a so-called prestart cycle in which the engine system comes up to speed. I don't know if you know how this particular engine system operates but it is a so-called regenerating system in which the heat that is in the engine system, such as in the nozzle of the engine, is used to heat hydrogen and then this hydrogen with the heat added is expanded through a turbine to do work. This turbine drives the pump which pumps the liquid from the tank to the engine. In other engine systems you don't use this regenerating cycle of using heat within the engine to get work from the turbine but you use other fuels—for example, you carry along another supply of fuel, run it through a combustion chamber to drive the turbine. Thus this engine has a prestart cycle of propellant flow through the system to engage the turbine and bring up the speed and then a start cycle which allows the fuel to go into the engine and start combustion.

Mr. STAEBLER. Do you have a pilot flame?

Dr. SILVERSTEIN. There is an ignition system which is energized at the time of start. It is a spark system such as in your automobile.

Mr. RANDALL. That sounds a little like some other phase of work. Is that what you refer to as bootstrap?

Dr. SILVERSTEIN. That is the regenerating bootstrap system.

Mr. KARTH. Have you changed that at all, Doctor, in this field?

Dr. SILVERSTEIN. We have not changed the bootstrap system because I think myself that, as a part of this engine, it is an excellent invention. It has some advantages from the standpoint of getting the maximum impulse out of the system. We have been carrying on one activity which is related again to the maximizing of the payload; that is, in the prestart cycle we are prechilling on the ground so that the hot metal that is in and around the pump will not vaporize the liquid hydrogen coming to the pump and therefore prevent the pump

from starting. You see, if you get gas into a pump trying to pump a liquid it won't pump well. So we have to be sure liquid comes into the pump. We are doing this on the ground and therefore not wasting the fuel that would be expended in flight to chill the pump.

Mr. KARTH. If you were starting from scratch would you use the bootstrap principle? You are stuck with it now, I believe.

Dr. SILVERSTEIN. No; I wouldn't put it that way. Again I come back to my point that good engineers do things different ways. If you look at bridges, each bridge you pass across looks different because a different engineer might have worked on it and there are certain bridges more appropriate for their location. The same is true of engines.

Mr. KARTH. Except this is an experiment matter. Your bootstrap system doesn't have much growth potential. It has some, perhaps. It could possibly grow into a J–2 engine.

Dr. SILVERSTEIN. I think it could. We are getting very excellent performance on this engine. It has some advantages, quite clearly, and it does have the possibility of giving a little more specific impulse because there is no fuel wasted such as you waste in a gas generator system. You don't entirely waste the energy in the gas generator system because you expel the gas downward; however, I think there is possibly a two-point-impulse gain that can be associated with the bootstrap principle.

Mr. KARTH. You are satisfied that you have improved this?

Dr. SILVERSTEIN. Very much so. I think this engine has been a very fine piece of work. I think in a sense it justifies Centaur almost by itself because this engine, as you know, is being used in the S–IV vehicle and it has demonstrated very clearly that we can build a hydrogen engine, make it work, and get good performance from it.

Mr. KARTH. Isn't the J–2 engine a liquid hydrogen, liquid oxygen?

Dr. SILVERSTEIN. It is.

Mr. KARTH. That is a 200,000-pound-thrust engine; is it not?

Dr. SILVERSTEIN. Yes, sir.

Mr. KARTH. How far down the road is the development of the J–2?

Dr. SILVERSTEIN. It is several years past this development.

Mr. KARTH. Behind?

Dr. SILVERSTEIN. Behind because it was started long afterward.

Mr. KARTH. The technological advances we are making in this area—is this technology being applied in the development of the J–2?

Dr. SILVERSTEIN. I am sure it is. Beyond that it is being applied to engines such as the M–1 which are even larger. For example, we have the development of the M–1 engine and this is a million and a half pounds of thrust, so the steps we are taking of going from 15,000 to 200,000 to a million and a half are actually building blocks in knowledge and building blocks in technology to give you confidence to take a bigger step.

Mr. KARTH. I am not sure I understand this boiloff problem. Is it possible to boil off hydrogen fuel if you have no cracks at all or no leaks, no place for it to escape? Is it just a matter of changing from a liquid to a gaseous form? What is this boiloff you are talking about?

Dr. SILVERSTEIN. I think you are referring to my statement on the pump.

Mr. KARTH. No, boiloff in the flight, during coast periods.

Dr. SILVERSTEIN. In the flight, of course, when the vehicle is in space, the hydrogen is down to minus 423° F., the sun is shining on the tank and it is radiating to the earth with a temperature of 400° Rankine, so heat is being added to the hydrogen. It takes a certain amount to vaporize the hydrogen and as soon as that much heat gets into it, it goes into a vapor and this tends to put the pressure up in the tank because vapor tries to find a place to live. The pressure goes up. So this tank has a vent on it which prevents the pressure rising above a certain amount.

Mr. KARTH. If you didn't vent it, it would explode?

Dr. SILVERSTEIN. If you didn't vent it, the pressure would get too high and it would explode. You don't want to vent more than you have to because that is thrown away. So our whole effort is to prevent heat getting to the fuel and actually throwing it away.

Mr. KARTH. Thank you.

Dr. SILVERSTEIN. You recall we had this problem with F–1, the first flight in which this weather shield was purported to have come off due to the fact that the pressure underneath these panels here was somewhat higher than anticipated in the design and it was a failure. In my review of this material and looking at all of the data that is available, I am not sure that this is the origin of the failure at all. I don't think there is enough data to be sure exactly what was the origin of the F–1 failure. Certainly the analysis of the data and analysis of the structure would indicate you would do something to it and we have. However, whether or not in truth this is the difficulty, I am not prepared to say.

May I have the next chart, please (fig. 87a)?

CENTAUR F-1 JETTISONABLE INSULATION SYSTEM

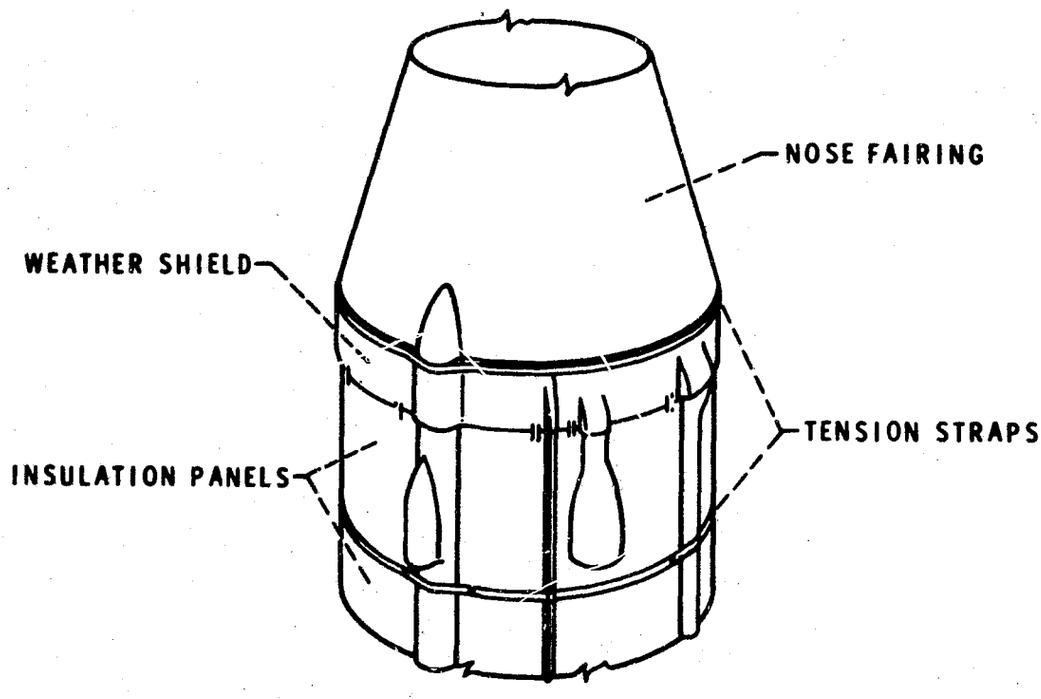

FIGURE 87a

Mr. KARTH. Isn't there a report out that indicates this is a problem area and something can be done about it and something should be?

Dr. SILVERSTEIN. Yes, sir.

Mr. KARTH. What is the name of the report?

Dr. SILVERSTEIN. There are several reports in this area. One is a technical report that refers to pressures——

Mr. KARTH. The one that calls specific attention to this problem that you had with the first launch.

Dr. SILVERSTEIN. Was this the Fleming report?

Mr. KARTH. Was the Fleming report issued before the first flight or after?

Dr. SILVERSTEIN. That was after. That was a review report. I think that I must admit that all of us are smarter in retrospect than we are sometimes initially, and possibly there was a design error made here and I think possibly this area of the vehicle was not strong enough. However, in order to have enough evidence to prove this, a great deal more data will be needed. In any event, we are greatly reinforcing this area and making a great many changes over the flight operation. We have set up a system at Lewis with a series of five different programs in which we are studying pressure on the body, loads on the body, loads on the panels in this area, and hope at least in this area to avoid any future difficulties.

May I have the next chart (fig. 88a)?

CENTAUR F-1 AND AC-2 WEATHER SHIELD DESIGNS

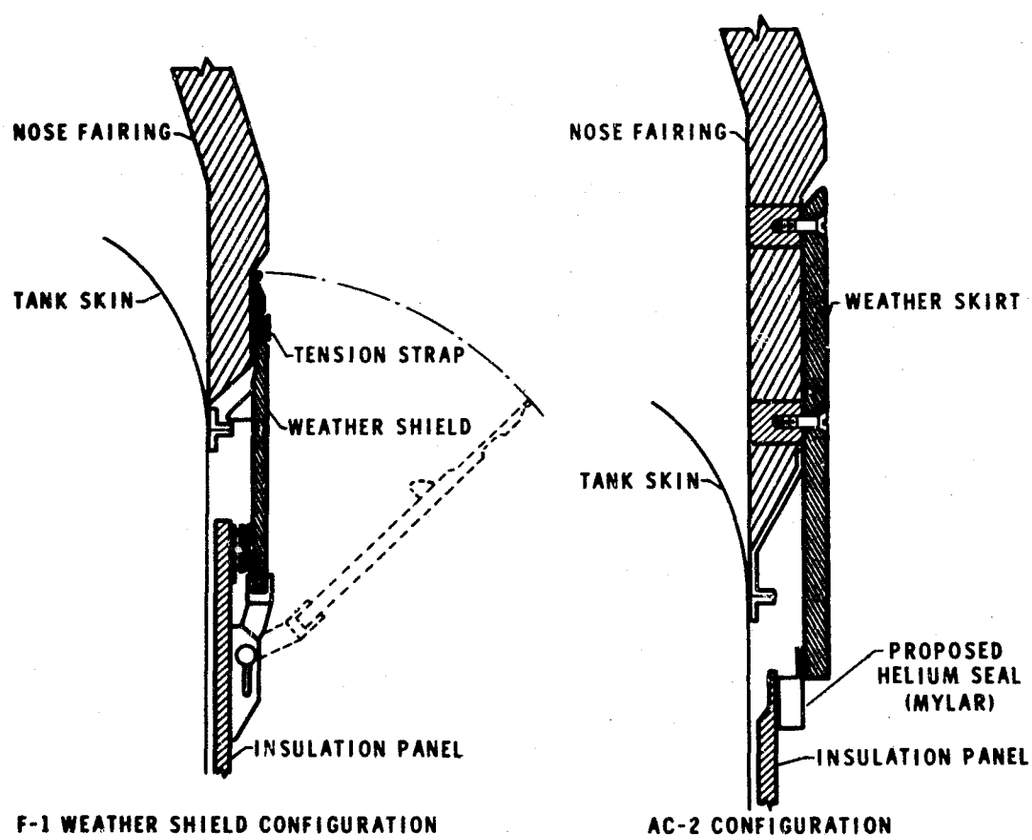

FIGURE 88a

96-504 O—63—pt. 3a——24

Now, I don't think I will go over any more of the technical problems. There are others and I could spend a great deal of the morning discussing them. I will be glad to answer questions in any particular area that is of interest to you.

Mr. KARTH. I think for the record, Doctor, I would like very much for you to at least mention all of the technical areas where changes have been made.

Dr. SILVERSTEIN. I will be very happy to.

I emphasized in my initial remarks the area of tests, and this is an area in which my philosophy is so thoroughly established that I, perhaps, lean over backwards here because I feel that if we are ever to succeed in space it is absolutely essential that we properly study these vehicles on the ground. It is quite amazing when you actually dig into the details how many techniques there are on the ground for studying the problems. One of them we are going to add to the test program on the Centaur is a complete vibrational analysis of the vehicle. We do this by installing the booster, transition stage, Centaur stage and in the spacecraft within this tall building, supported with cables on the bottom so it is free to move—we call it a free-free suspension—and then we shake it and we find throughout the whole vehicle what the frequencies are, what the stresses are that can be calculated and associated with those frequencies, whether there are any particular resonances; that is, if there are any sympathetic vibrations with the motions of another part. We have modified one of our existing stands by adding this little cupola on top. We weren't quite high enough to take the vehicle. We are installing the cable supports that are required to suspend the vehicle in this free condition and putting instrumentation in so as to do a complete vibration analysis of the Centaur flight vehicle (fig. 88b).

Another area of test we are initiating is that of adapting the philosophy of spacecraft to vehicles. You know in all of our spacecraft, almost since the beginning of our program, we take the spacecraft and put them into thermal vacuum tests and cycle through the temperature ranges and through the pressure ranges that will be encountered by the vehicle in flight. We do this because we know that there are many pieces in the system that are sensitive to the environment of space. They are either sensitive to the vacuum space or sensitive to the effect of solar radiation in space. They heat up. They can't get rid of the heat by normal methods. They have to radiate. If you prevent the body from radiating and heat is added, it burns up. If you look at our records for spacecraft and compare that with the records on vehicles, you will find that we have an amazingly good record. Once we get a spacecraft into space, we have had very fine success. We are going to adapt some of the things we did in spacecraft and put Centaur into a tank where we can simulate the problems we have in space. This program is underway. Again, because of the length of the stage, we have had to modify the test chamber by adding a dome and we are making this modification now (fig. 88c).

Mr. RANDALL. Mr. Chairman, the comment about the production of heat in space. How do you handle that? You say put it through these ranges in temperature and then you say there is no way to get rid of it.

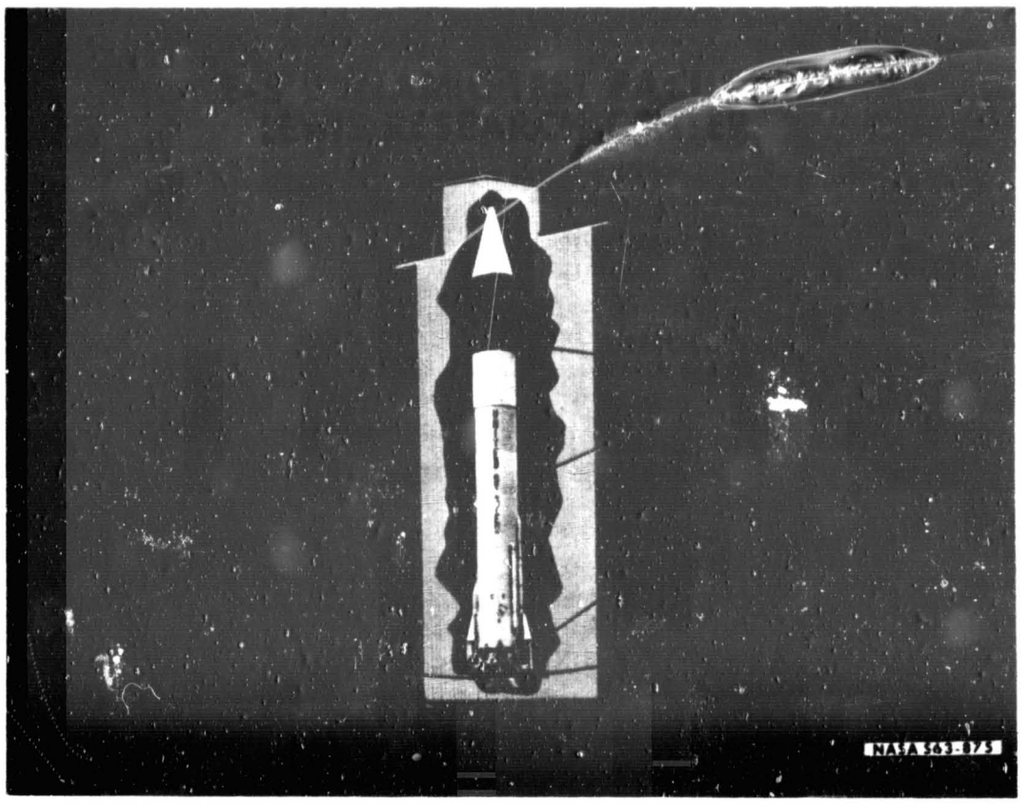

FIGURE 88b

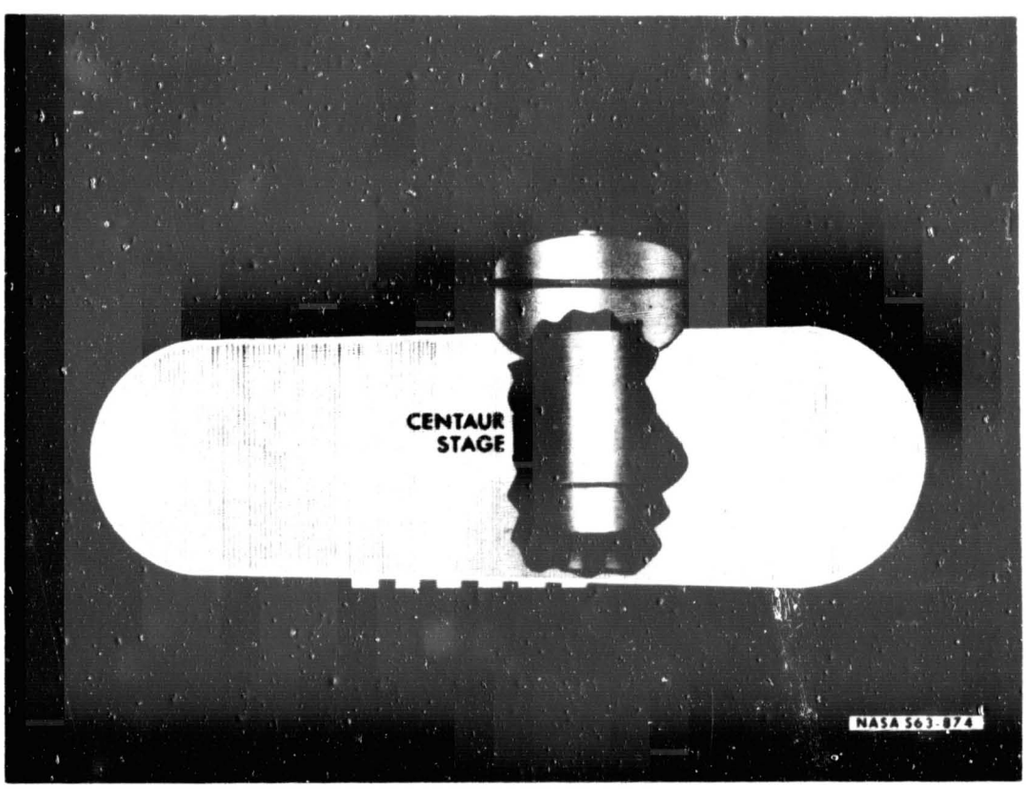

FIGURE 88c

Dr. SILVERSTEIN. There is no way by conduction. There are different ways of getting rid of heat. On the ground most of the heat removed from hot bodies is by conduction. But in space, with no air, you can't use conduction to get rid of the heat, so you have to get rid of it by radiation. Getting rid of heat by radiation becomes progressively more difficult as the temperature of the body that you are trying to remove the heat from approaches the temperature of the body that it is radiating to, so in outer space we get different temperatures. For example, if a satellite is going around the Earth and close to the Earth, it looks largely at the Earth from the bottom side and largely at space from the top side. Looking at the Earth, there is only about 103° temperature difference to get rid of the heat out of the spacecraft, so you have a problem getting rid of it. If you are looking into space where the temperature is close to absolute zero, then there is no difficulty in getting rid of the heat. We have had problems in all of the satellites as to how you take the heat out and keep them from burning up. All of the pieces of equipment are very sensitive to the addition of heat.

The test program, of course, is very much more extensive than illustrated in these two charts. I think we have something like 30 different test facilities that we use in this program of greater or lesser complexity in addition to the wind tunnel program I described. In addition to these programs I have described, we have various stands at Lewis and General Dynamics, and a stand at Edwards Air Force Base that we are using to test the combination of the tanks and engine system. We are going to test in the San Diego area the prototype of our flight vehicle and run through a complete hot firing, so that we have a very extensive program. The tests of the guidance equipment have been augmented about fivefold over the previous program so as to assure ourselves that we have adequate quality and reliability in the system.

Mr. KARTH. How many additional vehicles do you need to conduct this kind of a test program?

Dr. SILVERSTEIN. We are building extra tanks and some extra equipment to take care of these test programs, but the expensive part of flight testing comes down to a combination of the booster vehicle, the upper stage and the spacecraft and, as you know, in some of our flights we have investments of $25 million or more. There is hardly a limit to the amount of ground testing that you can do. You save one flight and pay for a tremendous amount of ground testing. It is our objective, of course, in all of our programs to have 100 percent success in flight and we set that as our goal and hope to achieve it. We probably won't achieve it, but we will always aim for it.

The next slide (fig. 89a) shows a current schedule for Centaur presented for the flights in order, and it shows the program as best we can establish it at this time.

I think it is realistic within the framework of the problems we have encountered and the problems that we anticipate. It is subject, however, as all flight programs are, to being changed. You see we are flying a vehicle in each quarter.

This quarter we fly two and we continue into 1965.

Mr. KARTH. Your next flight will go when—in July?

Dr. SILVERSTEIN. The next flight will be someplace in the third quarter. It has not been pinned down yet. We are studying right

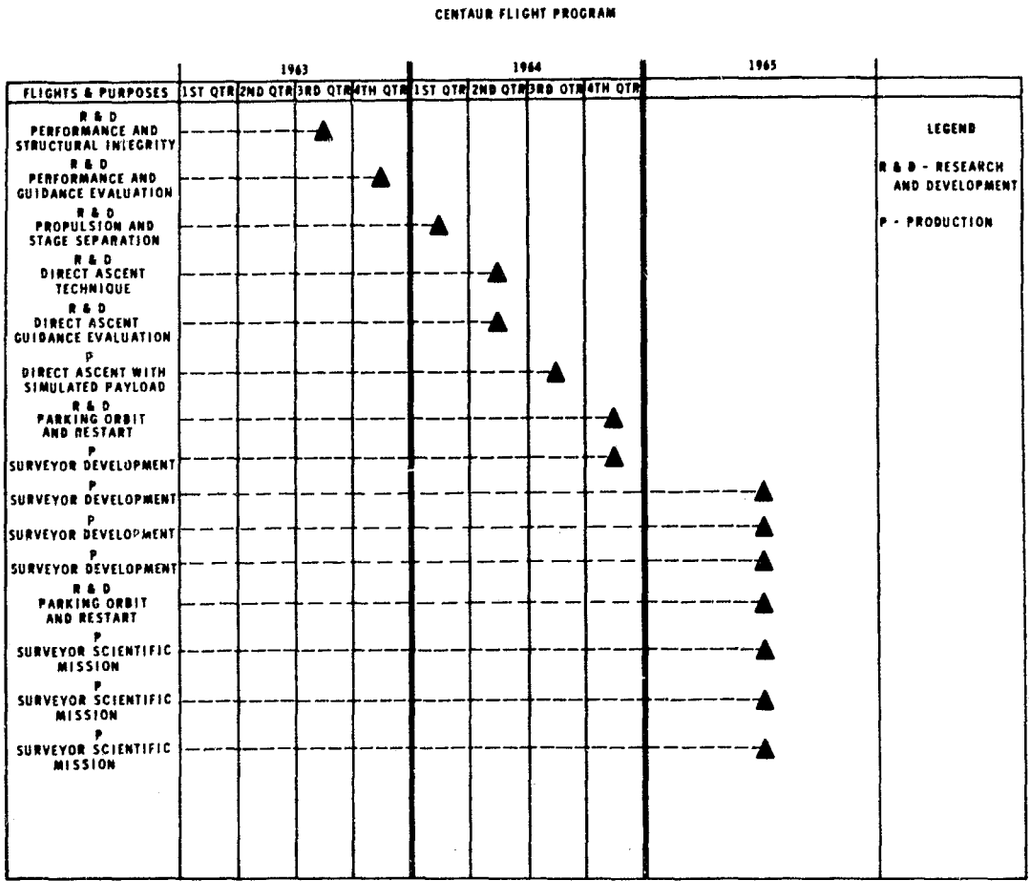

FIGURE 89a

now the availability of support equipment for the flight. One of the problems, of course, in setting up a program of this type is establishing the pipeline of equipment that is required.

There are thousands of parts in these vehicles and each part has to be in the pipeline. We are trying to find out now exactly what we have as to parts to make possible the scheduling.

Mr. KARTH. Doctor, your chart tells part of the story as to why we need the Centaur launch vehicle. I see there is the Surveyor development program, and Surveyor scientific missions are included. I wonder if you would for the record list the programs that are entirely dependent upon Centaur.

Dr. SILVERSTEIN. Yes, sir; I will do that for the record. I can mention them now.

Mr. KARTH. Would you mention them briefly?

Dr. SILVERSTEIN. Yes. The Surveyor, of course, we all consider to be a key program of NASA to provide us at the earliest time a landing on the lunar surface. There are a number of problems that are associated with manned landing on the lunar surface, and the understanding of the lunar surface is keyed to the success of the program. I think the urgency for getting an early landing on the lunar surface is recognized.

This, I think, is a basic drive in the Surveyor program and a basic drive in the Centaur program. That is the reason that we at our

Center and throughout NASA are pushing as hard as we know how to get this accomplished. The lunar program, of course, is followed by the interplanetary program and Centaur is scheduled to fly the interplanetary flights in 1966 and beyond. As we make these flights to Venus and Mars, there is currently no other vehicle in the program that will carry an adequate weight of spacecraft to Mars and Venus.

Mr. KARTH. Are you talking about the Voyager program?

Dr. SILVERSTEIN. No; I am talking about the advanced Mariner programs.

Mr. KARTH. How about Voyager?

Dr. SILVERSTEIN. Voyager as yet has not been established technically as a program. I will ask Mr. Cortright to add to that, or Mr. Johnson.

Mr. CORTRIGHT. The Centaur will make possible the landing of instrumented capsules on both Mars and Venus between 1966 and 1970. We hope to get the Saturn into the program by about 1969.

Mr. KARTH. I understand that the Office of Space Sciences is talking about a vehicle other than Centaur for this Voyager program, is that true?

Mr. CORTRIGHT. That is true, the Saturn, but the time period would be 1969 for our first mission.

Mr. RANDALL. Mr. Chairman, we went through quite an inquiry on Centaur last year as you well know. Dr. Silverstein, you made the comment here, I think, that no other vehicle in the program will do what we are talking about.

Dr. SILVERSTEIN. No other vehicle will carry it in the time period.

Mr. RANDALL. Just in the time period. We do have vehicles right now that if we had to use them we don't have to wait for Centaur?

Dr. SILVERSTEIN. Which ones?

Mr. RANDALL. You mentioned Saturn is down the road.

Dr. SILVERSTEIN. Saturn does not have stages yet that will accomplish the Surveyor mission. It will in time.

Mr. RANDALL. Perhaps not in NASA itself, but somewhere in the Air Force there is a stable of vehicles.

Dr. SILVERSTEIN. If there were, we would use them.

Mr. RANDALL. I thought so. I just wanted to be sure I got your statement correct. No other vehicle can do what we are talking about in the time range.

Dr. SILVERSTEIN. That is exactly correct.

Mr. KARTH. Mr. Randall's question does cause, I think, some concern about other facets of the first stage vehicles. There has been a little talk about that. Is there a possibility that Titan II may be used as the first stage for the Centaur? If this is true, what changes will have to be made in Centaur?

Dr. SILVERSTEIN. Currently, as you know, we are looking at this problem in our Center to examine the possibilities of using the Titan with the Centaur, and what additional payload it will provide and how you would optimize the Centaur to work with the Titan.

However, this program, if it were initiated tomorrow, would be later than the Atlas-Centaur because it is a whole new program and, for example, creating a launch stand that will even launch this system is a 3-year program.

Mr. KARTH. If you went down the Titan-Centaur road rather than the Atlas-Centaur road, then the vehicle would not be ready for the first Surveyor shots, would it?

Dr. SILVERSTEIN. Absolutely not.

Mr. CORTRIGHT. I would like to add to that, Mr. Chairman, if I may. We are looking at the Titan-Centaur simply because should we decide we need it we want to know what is involved. There is no plan or requirement at the moment which makes it absolutely necessary that we develop this vehicle combination. However, we are interested in what the Centaur could do, on top of a better first stage. That is why we are looking at it.

This is the status of the study at this time. It is strictly a study.

Mr. KARTH. Thank you.

Back to that Voyager one more time. Centaur would be used with what first-stage vehicle?

Mr. CORTRIGHT. Atlas-Centaur will be used in the Mariner B program. For Voyager we require a Saturn 1–B with a third stage. That third stage is not yet determined and we have not come to Congress with a request for funds to develop such a stage.

Mr. KARTH. That was my question before and I was confused with your answer. The plan right now is to use Centaur as a third stage vehicle on Saturn for the Voyager program; isn't that correct?

Mr. CORTRIGHT. No, sir. The third stage for the Saturn to make a booster suitable for the Voyager program has not been determined yet.

Mr. KARTH. What are the alternatives? The alternative is 1, Centaur; 2, a brand new vehicle which hasn't yet been conceived perhaps; and 3, what other vehicle do we have today that might be used?

Mr. CORTRIGHT. Those are the alternatives, the Centaur on top of the Saturn, or a new stage on top of the Saturn for use in the 1969 program.

Mr. KARTH. Hasn't there been some discussion about that new third stage that emanated as a result of consideration of the lunar logistics vehicle?

Mr. CORTRIGHT. Yes, sir. You recall we discussed this in an earlier hearing this year. This is one of the new stages that has been proposed as a third stage for the Saturn 1B.

Mr. KARTH. This is the new stage we just discussed as one of the two alternatives, is that correct?

Mr. CORTRIGHT. Yes.

Mr. KARTH. Then really I guess we are talking about the advanced Mariner and Surveyor program as being the only two programs we absolutely need for Centaur, is that right?

Mr. CORTRIGHT. The Mariner and Surveyor.

Dr. SILVERSTEIN. However, there are other uses I might mention.

Mr. KARTH. Voyager is a possibility.

Mr. CORTRIGHT. Voyager may use the Centaur stage if it is adapted to the Saturn. I think that is where we had a misunderstanding.

Dr. SILVERSTEIN. Not in the science program, but in the applications program we are looking at the 24-hour orbit for the synchronized satellites and there are indications that they will be used in this area. How these will actually develop as a result of studies and requirements in the area of our Office of Applications have not been finalized.

Mr. KARTH. Thank you, Doctor.

Mr. CORTRIGHT. One other quick point. There are other potential missions in addition to those Dr. Silverstein mentioned which we have

really not discussed because they are in the study phase. The Atlas-Centaur is capable of deep space probes which we can't make with other vehicles such as probes close to the sun.

Dr. SILVERSTEIN. That concludes the material I prepared for showing on charts. I will be happy to answer questions with reference to this material or any other questions you may have.

Mr. KARTH. Doctor, how much engineering would you say needs to be done yet on Centaur? The reason I ask the question is because I notice that one of the daily publications carried information to the effect that Space Technology Laboratories was just granted a half million dollar contract for additional study program.

I am not sure just exactly what that means. Certain other contracts have been let for engineering studies in support of the Centaur program. I am not sure what that means. Certain other contracts have been let for flight readiness programs and support of the development programs and systems integration.

I am not quite sure what that means. I wonder if you could tell us how far away we really are from having a Centaur vehicle that works?

Dr. SILVERSTEIN. The basic ingredients of the program I think are well established. However, in a development program which is creating a vehicle or an engine or any sort of system, if you plot the engineering requirements against time in the program and engineering costs against time in the program, you will find a typical distribution for the job which shows an increase in requirements in the program usually up through the first 3 years or sometimes 3½ years, if it was a 5-year development program, which most of our vehicles and engine systems are, and then perhaps leveling off at the last year. You might ask why you have to carry this total staff that builds up and levels off through the whole program.

It is because it is a development program. It is because as you successively go from basic layouts in the system which your engineers are working on to detailed design drawings and creation of first hardware through first tests, failures in first tests because it is a development program, reengineering to take care of failures, retests, qualification of all hardware that is on the bench and in the laboratory for production, assembly of systems, complete systems checkout, checkout of the birds as they are prepared for the launch stand, and work at the launch stand, you will find that if you integrate these totals over these years you do end up with the same kind of curve and although at first glance you might say you have designed something and your engineering department built it, this is not the case.

Mr. KARTH. You say you have about 80 people working on this project?

Dr. SILVERSTEIN. We have 80 key people. Actually at Lewis right now we have key people plus others for a total of some 320 people.

Mr. KARTH. How many of these people are from Marshall Space Flight Center?

Dr. SILVERSTEIN. None of them.

Mr. KARTH. None at all?

Dr. SILVERSTEIN. Pardon me, I made a mistake here. I should have mentioned the fact that within the Centaur staff I counted the people out at the General Dynamics/Astronautics plant who are on the job

and some 15 of these were transferred from Marshall. They had been on Marshall's rolls before. They are not physically at Lewis but are at San Diego and are part of the Centaur team.

Mr. KARTH. None of the actual team are from Marshall?

Dr. SILVERSTEIN. No.

Mr. KARTH. I assume that these people have been assigned to some other program?

Dr. SILVERSTEIN. I assume they have.

Mr. KARTH. They haven't been laid off, have they?

Dr. SILVERSTEIN. I have not followed these people particularly. They were with us for the first 2 months in making the transfer and as soon as we——

Mr. KARTH. They worked for 2 years on this program. What happens to all of their experience?

Dr. SILVERSTEIN. I think that we, during the 2-month period interchange, got on board about as effectively as we could have and I think that our basic experience is adequate because of our background to handle it. You see, our background is in this area.

Mr. RANDALL. With reference to General Dynamics/Astronautics, I assume you meant General Dynamics out in California.

Dr. SILVERSTEIN. Yes.

Mr. RANDALL. They came with you for 2 months and then they are gone. You said you had none from Marshall.

Dr. SILVERSTEIN. I said during the first 2 months of the transfer of the program from Marshall to Lewis the management team from Marshall were with us. They were mostly all at Lewis and as we picked up information from different pieces of the team we let them return.

Mr. RANDALL. I thought you said there were none with you now.

Dr. SILVERSTEIN. There are none with us now.

Mr. RANDALL. Then you said some came from San Diego, I thought?

Dr. SILVERSTEIN. I was not very clear. Our team has a group now of some 28, building up to 34 people, that are at the General Dynamics plant. These people are responsible for monitoring the General Dynamics work in the plant, providing for rapid response to procurement requirements. They have certain procurement authority at a low level so that the program is not delayed. Since it has a DX priority, it is not delayed because of the time it takes paper work to get back and forth from Cleveland to San Diego. We have a small group there. There are 15 of these people that came with us at the time of the transfer of the program from Marshall to Lewis.

Mr. KARTH. Doctor, Titan II-Centaur, if I may refer to it as such, would have pretty much the same capability as the Titan III, would it not, or is that an improper assumption?

Dr. SILVERSTEIN. I would guess that it would have less capability than Titan III, although I would much prefer to go through these calculations in detail to see—I would guess it would be less for some missions. It would have more for others.

Mr. KARTH. It would be pretty close?

Dr. SILVERSTEIN. I would say in the orbit mission it would have less. I think in the more distant missions I would say it may have the same, depending on what third stage is used with the Titan III, but I would prefer to go through the calculations.

Mr. KARTH. Do you recall how much money has been spent on Centaur up to this time?

Dr. SILVERSTEIN. Yes, up through 1963, from 1959 when the program was started, it is about $280 million. I might want to correct this one way or the other.

Mr. KARTH. How many vehicles do you have in the program?

Dr. SILVERSTEIN. The current program that I showed had some 15 vehicles through 1965, but subsequent to that time there will be approximately 7 to 8 vehicles a year flown for the next 4 years.

Mr. KARTH. How much additional money will it take to complete the Centaur development program?

Dr. SILVERSTEIN. We are estimating currently that it will take between $425 and $450 million for the total cost of the program, including engine vehicle development and the early launches.

Mr. KARTH. That is for the first 10 vehicles?

Dr. SILVERSTEIN. The first 10, yes.

Mr. KARTH. Do you happen to recall what the original estimates by General Dynamics/Astronautics were when they made their proposal?

Dr. SILVERSTEIN. I don't recall because their original proposals were made to the Defense Department. You recall the program was started through the Defense Department, and the original proposals were made to them, and I wasn't a party to it at that time.

Mr. KARTH. Mr. Cortright, do you happen to recall those figures?

Mr. CORTRIGHT. We have that information. I will ask Mr. Johnson to read it.

Mr. JOHNSON. As Dr. Silverstein said, the original estimates didn't apply to the complete program, because it started out as a technological program. At the time it was first conceived of as a 10-vehicle development program for missions, the best estimate we had was about $270 or $280 million for the first 10 vehicles. This was about the middle of 1961 when the program took shape in this form.

Mr. KARTH. Doctor, in addition to the 15 men from Marshall Space Flight Center who still have some quality control responsibilities at General Dynamics/Astronautics, do you have any of your men assigned to the contractor as quality control people?

Dr. SILVERSTEIN. Yes, sir.

Mr. KARTH. How many technical people are assigned to General Dynamics/Astronautics to see that this program functions properly?

Dr. SILVERSTEIN. At that plant there currently are 28 total, and there are going to be some slight increases before the end of this fiscal year, which we estimate will bring it to 34. These are not all technical people, however. These people have secretaries and others. I think the total technical people are close to 20, and some of these people are reliability and quality control people, and some are procurement people. The head of the group is an assistant project manager who is the voice and arm of the project management in Cleveland at General Dynamics/Astronautics.

Mr. KARTH. I wonder for the record if you could tell us what the performance capabilities are for Centaur as you see it now, since, as I understood you during your chart talk, you have increased its capability by 200 pounds or 250 pounds. Is this true?

Dr. SILVERSTEIN. Yes, sir. Our initial requirement, of course, is to carry a 2,100-pound Surveyor to the lunar surface, and we are directing our attention to providing that.

We want to have a margin of 250 pounds, and our goal is around 2,350 pounds.

Mr. KARTH. One of our Centaur vehicles was destroyed on the test stand at Sycamore Canyon. Has this situation been changed and the test stand removed?

Dr. SILVERSTEIN. Well, the test stand isn't activated, and because of the difficulty it has never been rebuilt so there is no current hazard. The Atlas stand is simply not functioning.

Mr. KARTH. You don't anticipate conducting tests on that?

Dr. SILVERSTEIN. We are conducting tests on our stand, but the Atlas stand is decommissioned.

Mr. MOSHER. I would like to ask this question. Is there any degree of doubt remaining in your mind concerning the ultimate success of the hydrogen technology? Are you completely confident now that you will succeed in the hydrogen technology and it won't have to be discarded?

Dr. SILVERSTEIN. Without question I am sure that hydrogen is an excellent fuel for space application and will be used in the future for space vehicles.

Mr. MOSHER. Wasn't there quite a little talk in this committee last year about the possibility that hydrogen would have to be discarded and some other more exotic fuel used? You don't have any doubt on that score yourself?

Dr. SILVERSTEIN. No, sir; we will continue to use hydrogen, and the problem is simply one of creating the technology that enables you to use it successfully. Every time we take a step of this type we go through it, we live through it, and, depending on how able we are and how smart, and how we anticipate our problems, we do better or worse. Sometimes in retrospect you see mistakes you have made which you try to correct the next time around, but sometimes you don't do it then either. It is a problem of anticipating problems in a new area.

Mr. MOSHER. Hydrogen is not the ultimate in itself, probably. Some generations ahead we may look back on hydrogen as less than perfect.

Dr. SILVERSTEIN. In chemical fuels, as you know, hydrogen is in the most favored position in the atomic chart. The oxidizers to go with it can be varied, but it is not anticipated we are going to get any better chemical fuels than hydrogen; and in the nuclear systems, hydrogen is the key material as the fuel because of its low molecular weight. The most important characteristic of an engine from the standpoint of accomplishing difficult space missions is the thing we call specific impulse, which is essentially the same as miles per gallon on your automobile; only the impulse is pounds of thrust per pound of fuel burned per second. The more thrust you get out of each pound of fuel you burn the better. Well, this term is dependent upon basically two things: one, the temperature at which you burn it and, secondly, the molecular weight. The equation is very simple—it is simply the square root of the temperature divided by the molecular weight—so what we are after is a fuel with a low molecular weight.

Mr. KARTH. So there is nothing better from that standpoint. There has been some talk by members of the committee that maybe we are traveling the wrong road in putting most of our eggs in the hydrogen basket, and it may be well worth our while to increase the research in the diborane field and fluorine, I think.

Dr. SILVERSTEIN. I think you are right.

Mr. KARTH. The specific impulse, quite frankly, is greater.

Dr. SILVERSTEIN. With fluorine as an oxidizer, yes. Let me first agree with your statement that there is a need for a continuing effort in chemical propellants. Take the fluorine case first. We are and have been working with fluorine for years, as you know, not for application directly in a development vehicle but rather from a research point of view to develop backgrounds of ideas. We have tested, for example, fluorine-hydrogen systems which give you theoretically almost the highest impulse of any chemical fuels. There are a few other much more exotic combinations that give you higher values. We have gotten values of the specific impulse as high as 480 in our program which is a very high value. In the boron area, as you know, Congress last year appropriated a million dollars for special attention to this area which we are expanding in an effort to increase the basic knowledge in this area. The laboratory in Lewis has worked in the boron field for many years. We have a program we are initiating with the combination of the OF_2, which is a mixture of oxygen and fluorine—actually it is a chemical combination—and diborane, which gives a specific impulse less than hydrogen and oxygen but, since these materials are quite dense, the loss of the specific impulse is somewhat compensated for in some missions by the increased density of the system.

Mr. KARTH. How about cesium?

Dr. SILVERSTEIN. Cesium is a possibility for some applications as an additive, but most particularly cesium becomes of interest in our electric propulsion area.

Mr. KARTH. There has been a running argument for several years between two divergent theories. One is that the liquid makes the best prime booster system and the other is that the solids do. I wonder if you care to address yourself to this question, and tell us what group do you agree with and why.

Dr. SILVERSTEIN. Well, the fact is that there are some areas where it is quite clear that solids are best and there are some where it is quite clear that liquids are best and there are other areas that you can use either.

Mr. KARTH. If there are some areas where solids are best, why isn't NASA doing anything on solids? Technically they are not doing anything on solids.

Dr. SILVERSTEIN. Solids happen to be best in the area where rapid response and readiness are the most important ingredients. This brings it most definitely into the Defense Department area, and you will find the Defense Department in their missile program and in advanced booster programs where readiness is of more importance are the ones sponsoring the solid work. The fact that the solid rocket is always ready to go is an important feature from the defense point of view. In the liquid area where you hope to get extremely high impulse, say, of the order of 480 that I mentioned earlier or 470, as yet

there are no solid combinations that have been developed that will give specific impulse of this amount. More than that, we cannot yet throttle the solid engine and provide a degree of flexibility such as required in, say, landing of the vehicle on a surface, whether it be the lunar surface or planet surface, where you want to be able to modulate the thrust in very fine amounts. There has been some work done to try to stop them and it has been successful, but modulation has not been accomplished. This is a goal of the liquid field that will let you hover above the surface and build up and increase the thrust, so in these areas it is quite clear the liquid is superior. There are other areas where you can take your choice. If you recall, years ago there were many arguments between those that build in-line engines and radial engines and I think it came out that they are both good. I think that is true of the liquids and solids in this intermediate area.

Mr. KARTH. Do you feel as far as the deep space probes are concerned that the solid fuel is not nearly as applicable to that kind of a program as is a liquid; is that correct?

Dr. SILVERSTEIN. There is one function that can be performed by a solid even in that mission and that is a function of a retrorocket which has one job to perform, which is to slow down the vehicle, say, from one velocity to another. In this case you can show that a well-developed solid rocket can be competitive. Then you get into other things and you begin to talk not now about performance but the trade-off factors that you always have in design.

Mr. KARTH. You don't see much likelihood of our developing the 10 or 15 or 20 million pounds thrust solid booster engines?

Dr. SILVERSTEIN. The studies or the basic technological developments are underway for fairly large segments and whenever that occurs, I don't attempt to be a prophet. Since this program is underway I am willing to wait to see how these things develop.

I think they can be developed, but there are other factors that you get into. From an economical point of view the question at this point is whether we will be able to develop reusable boosters by returning first stages. The advantage would return to the liquid boosters very quickly for reusable boosters because in a solid rocket the thing that is expensive is the propellant, whereas in the liquid rocket the thing that is expensive is the hardware, so if you can return the hardware in a liquid rocket it is quite attractive and I am sure in time we will learn how to develop it. This remains open as a development and I think we ought to continue to develop both the liquid and solid rockets for the time being.

Mr. CORTRIGHT. Mr. Chairman, to illustrate where we do use solid rockets when we think they have a particular advantage, the Scout vehicle, as you know, has four high-energy solid propellent stages. Also, we have used solid propellent retrorockets on both the Ranger and Surveyor. These are a far cry from the 10-million-pound rockets you were talking about, but they are advantageous in those applications.

Mr. RANDALL. I thought all along that our big problem is to get more pounds thrust. That is the whole thing we are seeking, isn't it? If there is any head start in our adversary, it is for that reason. We talk about the valuation boards, and so forth, at all levels and we know or at least I assume that we know, that NASA is doing nothing on solids; is that right? Except the Scout which we use——

Dr. SILVERSTEIN. I think you will find within our budget small sums of money associated with the technology of applying solids rather than carrying on the major study on it.

Mr. RANDALL. I think you said some slight amount of money was given to study.

Dr. SILVERSTEIN. Yes.

Mr. RANDALL. Outside of NASA or in the Defense Department, is there any continued valuation in going ahead with solids?

Dr. SILVERSTEIN. The solids area is being pushed quite vigorously.

Mr. RANDALL. In the Defense Department?

Dr. SILVERSTEIN. Yes.

Mr. RANDALL. Is there any panel or commission or board that is constantly on top of that?

Dr. SILVERSTEIN. Do you want to answer that, Homer? You know there is a coordinating board between NASA and the Department of Defense; yes, sir.

Mr. RANDALL. That is what I am talking about.

Dr. SILVERSTEIN. The Aeronautics and Astronautics Coordination Board which is an interagency organization, cochaired by Dr. Seamans, of NASA, and Dr. Brown, of the Defense Department. One of the agreements, of course, that they have is the vehicle agreement which has been arranged between NASA and the Defense Department in which discussions and agreements are reached on all new vehicle developments and a continuous survey of the propulsion field is maintained through a panel of this coordinating board which is directed at the propulsion problem particularly. They are propulsion experts from NASA and DOD.

Mr. KARTH. What about concepts? Do the two agencies of Government get together and discuss those? I understand that the Defense Department was quite surprised about the M-2 concept that NASA came out with a few days ago or a couple of weeks ago.

Dr. SILVERSTEIN. I wasn't informed that they were surprised. Concepts, of course, can arise anywhere and I think it is very difficult to control in an organization the size of NASA with the many people that are entitled to speak their minds regarding concepts—concepts seems to be an area of utter freedom so anybody can have a concept. Until it becomes a program that is funded it isn't too important in the national scene. Every morning, I have more concepts that I can handle.

Mr. KARTH. What about when it gets into a feasibility study stage? Is it still a concept then or something else?

Dr. SILVERSTEIN. A feasibility study stage is really the analysis of a concept to find out if it has meaning.

Mr. KARTH. Then should there be cooperation or coordination between the two organizations to eliminate overlapping and duplication?

Dr. SILVERSTEIN. I think there should be and is at this point. In our propulsion panel that works under the coordinating board, any new studies that are created in this area are mutually discussed, so that there is an interchange.

Mr. RANDALL. Doctor, you may not be the proper witness and I am the worst layman of them all in this, but is there any work being done, or is it feasible to combine stages of solids and liquids. Now, you mentioned here this question of flexibility to modulate the thrust like

landing. Well, there is no problem in the original getaway. You want all you have got on the original getaway and I want to say as has been said before and some of the members are not on the committee any more but I feel that is the answer, a big, big thrust on the getaway. Is there anything being done along that line?

Dr. SILVERSTEIN. Yes, sir.

Mr. RANDALL. There is no control there except just to get away; isn't that it? You are talking about recovery of the vehicle, and so forth. Have you gone into the poor man's version of binding together these segments? There is nothing to save there. That is going to be jettisoned and that is it.

Dr. SILVERSTEIN. There was a report in the paper the other day about a flight which is exactly this combination in which a Thor liquid vehicle was augmented by solids.

Mr. RANDALL. I don't know that you are the proper one to go into it but we are making some progress on that?

Dr. SILVERSTEIN. I think this flight was a definite piece of progress and I think that there isn't any question but that you can use solids, say, for initial boost. This method has been used for years at our Wallops Island station for augmenting the thrust at takeoff of sounding rockets with solids. It is the same concept used in the whole JATO system on aircraft. It can be developed for space very extensively.

Mr. RANDALL. And get into the flexibility you talk about in the upper stages, and so forth?

Dr. SILVERSTEIN. Yes, sir.

Mr. KARTH. But the development of large first-stage solid boosters is a long way off in the future if we delop them at all. Isn't that true? What are we doing in this area? When, if we are going to have them at all, will we have them?

Dr. SILVERSTEIN. I might suggest it would be more appropriate in this area for you to discuss this with the people in Brainerd Holmes' shop because they are the people familiar with it.

Mr. KARTH. Some members of this committee like to explore the question with other people. Some believe in liquids, period, and some believe in solids, period, and we would like to have an objective viewpoint.

Dr. SILVERSTEIN. Yes. I am perfectly willing to discuss it. I might point out that mine might not be the official voice. The augmenting of liquid rockets with solids is very appropriate and can be done and is being done and done successfully.

Mr. KARTH. But you don't see in the near future NASA's [illegible] large, tremendously large, first-stage solid boosters, do you?

Dr. SILVERSTEIN. This is not the way the program is currently headed. In other words, to develop a booster we know it takes 5 or 6 years so that nothing that we do not have in the mill right now is going to be developed before 5 or 6 years and we have the S–1 and S–5 liquid boosters under development.

Mr. KARTH. On the basis of what we have in the mill we couldn't possibly have a large solid booster that the gentleman has in mind before this decade is passed, could we, because we don't have anything like this under study?

Dr. SILVERSTEIN. In the national program, you are familiar with the Titan III program which does utilize solids in combination with the Titan.

Mr. KARTH. I remember that. There was a great deal of thought that that might be canceled, too.

Dr. SILVERSTEIN. This I don't know about.

Mr. KARTH. The point is we have no feasibility studies now being made as to the practicability of 15 or 20 million pound solid boosters, do we?

Dr. SILVERSTEIN. There have been feasibility studies made already and I think there are in progress other studies relating to the uses of solids. These are studies.

Mr. KARTH. But there are no programs or no plans in NASA's table of plans to use this kind of a vehicle, is there?

Dr. SILVERSTEIN. I would have to say not to my knowledge.

Mr. KARTH. Mr. Hammill?

Mr. HAMMILL. Going back to Mr. Mosher's question on the use of hydrogen as a fuel, isn't it true that the essential question is the storability of hydrogen in space? You brought out earlier in your testimony the fact it is sensitive to temperature changes which causes boiloff. How are we going to lick that problem?

Dr. SILVERSTEIN. This is a basic problem, storability, and currently work is underway on insulations for tanks. As you know, there have been rather substantial gains made in this area in recent years through the use of the very thin foil insulator materials built up alternately of aluminum reflectors where you keep the radiation down from the tanks. We are working with these and other people are working with them. Insulation of tanks to avoid boiloff is underway. I believe this problem will be solved.

Mr. HAMMILL. Another point. Last year when Dr. von Braun testified before the subcommittee he mentioned differences between the design philosophies of Marshall and General Dynamics/Astronautics and specifically it was brought out that the so-called margin of safety built into the vehicles produced at Marshall was 35 percent, whereas General Dynamics/Astronautics used a 25-percent margin of safety.

Now, are there any differences in design philosophy between Lewis and General Dynamics/Astronautics on the Centaur vehicle?

Dr. SILVERSTEIN. Well, I think that I better put it another way around. It is our intent to approve the design of the vehicle so that we will have a common philosophy. I think that we must be responsible for the design and so we will intend to approve whatever design philosophy is used, so there will be a common one.

Mr. HAMMILL. There will be, or there is now? Isn't the thing so far along that we know that there is a common design philosophy?

Dr. SILVERSTEIN. There is a common design philosophy since we will approve the design, so there can't be room for discrepancy.

In other words, if it doesn't satisfy us from the standpoint of strength, we will make it stronger.

Mr. KARTH. You have beefed this thing up quite substantially haven't you, Doctor?

Dr. SILVERSTEIN. Yes, sir.

Mr. HAMMILL. One other thing: During the course of last year's hearings it was brought out that Mr. Hueter from Marshall had written a letter to Mr. Dempsey of General Dynamics/Astronautics

and in this letter he had mentioned that in his opinion the staff at General Dynamics/Astronautics working on Centaur was not sufficient in number and quality.

I wonder if you are satisfied with the number and quality of personnel assigned to this program by General Dynamics/Astronautics at this time?

Dr. SILVERSTEIN. There has been, as you know, a rather substantial increase in the level of the people at General Dynamics/Astronautics. When you discuss the quality of an organization, you are dealing with intangibles. One man's evaluation of this is hardly adequate.

I think that the people we have been doing business with generally are of the same quality as those that exist in most of the organizations in this country. You plot a standard distribution curve, and I think you will get the same kind of a curve in this organization as you get in any other organization.

Mr. HAMMILL. That is true, but if there is anybody that has to be satisfied with the number and quality of personnel in General Dynamics/Astronautics, it is you.

Dr. SILVERSTEIN. That is true, and if I feel they are not adequate, I know how to take care of it.

Mr. KARTH. We think you are doing a real good job, I might say, Dr. Silverstein. We have a great deal of faith in your running this program.

Mr. STAEBLER. Mr. Chairman, the Russians are ahead of us in capacity to develop larger vehicles. What have they learned that we haven't yet understood? In what phases do they excell—the parts of the program?

What are our limiting factors to date?

Dr. SILVERSTEIN. I can't answer your question on the basis of knowledge that I hold about their vehicles, because in fact I have never seen one of their vehicles, and the information I have obtained has been quite sketchy, and certainly not authentic data, so that I cannot answer your question accurately.

I can answer this question in the most general way by saying that they started earlier, and had their requirements for a larger vehicle, which we do know to be the fact. So they built a bigger vehicle.

Our efforts in the ballistic missile program, from which we moved to carry on the space work, using the ballistic missiles as the first stage was aimed at building the smallest ballistic missile we could, and we in fact didn't go ahead to build the ballistic missile until our weapons work was far enough along so we could have a small ballistic missile. So we inherited the smaller ballistic missile as our first stage for our space boosters. Really the only vehicle that might be considered to have been designed wholly for space use is the Saturn C–1, which as you know is just going through the early flight test.

I am talking about the bigger vehicles. Of course, Scout was created especially for the space missions.

Mr. STAEBLER. What problems did they encounter and solve that we are still working on?

Dr. SILVERSTEIN. They just started earlier, I think, and by starting several years earlier with a bigger vehicle, they had it available when they needed it. I think it is largely that, but of course this is an area in which you must obviously make guesses, and I think you will have to classify my answer as a guess.

Mr. STAEBLER. With Saturn then, we have the solution to problems of size in hand?

Dr. SILVERSTEIN. Not knowing, of course, exactly what the Russians are planning as the next step, it would be very difficult to prove that Saturn I, or Saturn V was bigger than what the Russians are going to build. These are big vehicles that will meet the requirements of our program in the next decade. If the Russians choose to build a big vehicle, I feel fairly sure they can—but whether they are or not, I don't know.

Mr. KARTH. Would the gentleman yield?

Mr. STAEBLER. Surely.

Mr. KARTH. Do we have any evidence that the Russians are building a bigger basic booster than they have been using?

Dr. SILVERSTEIN. I have none, sir. I don't know. I would be very much surprised if they weren't, but I don't know for a fact.

Mr. KARTH. You are not aware of any evidence that we have as to that?

Dr. SILVERSTEIN. I am not aware of it. There may be evidence, but I am not aware of it.

Mr. STAEBLER. Are there any bottlenecks that lie ahead in the development of larger vehicles?

Dr. SILVERSTEIN. There are many problems, tremendous problems. However, they in general are what I classify as engineering problems that are amenable to good engineering judgment and hard work.

Mr. STAEBLER. There is no blockade ahead?

Dr. SILVERSTEIN. I see no place where a real conceptual breakthrough will have to occur.

Mr. STAEBLER. Thank you, Mr. Chairman.

Mr. KARTH. Any further questions?

Mr. HAMMILL. I have one.

Mr. KARTH. Mr. Hammill.

Mr. HAMMILL. Early in your testimony, Dr. Silverstein, you spoke about your philosophy of ground testing. In essence it seems to me that you are saying that it is more economical in the long run to have extensive testing on the ground to avoid flight test failures.

Now is this a novel or unique approach in NASA? Is this not the way the rest of the vehicle development programs are going?

Dr. SILVERSTEIN. It is a somewhat novel thing in the Centaur program, and it is somewhat novel in fact in the vehicle program, although this philosophy, I am sure, is shared by our Marshall people. In the development of Saturn they have taken as many steps as they could to achieve similar purposes.

As vehicles get bigger, your facility limitations get bigger so it prevents you from putting the entire vehicle in the space chambers. Our problem in the past has been there are no facilities large enough to handle them. They are just too big.

I do think as we move ahead in our whole space effort that a key element in it is building the ground facilities that will enable us to test our vehicles as best we can in an environment simulating space.

Mr. KARTH. Do we have vacuum chambers large enough to put the electronic equipment in and keep them under those conditions for substantial periods of time?

Dr. SILVERSTEIN. This we have done, and are doing. It is necessary, though, that you start at the component level and check out this equip-

ment and qualify it for space use, and then you qualify the subsystems in which these are grouped, and then you qualify the systems and then you must qualify the vehicle, because many of the problems we encounter for the first time in flight are due to the interaction of subsystems within the whole system and many of the failures are associated with the environment that the whole system finds itself in when it is operating as a system.

Mr. HAMMILL. What other vehicle development programs do you have under your direction at Lewis?

Dr. SILVERSTEIN. We are now following the Agena program and the program associated with the M–1 engine involvement is currently at Lewis.

We have no other vehicle programs.

Mr. KARTH. Has Pratt, Whitney's work on the engine been satisfactory, on the Centaur engine?

Dr. SILVERSTEIN. In my opinion it has been quite good.

Mr. MOSHER. Dr. Silverstein mentioned the necessity for hard work a moment ago. I wonder if you want to characterize your intensity or your lack of it in your work at Lewis? Under what type of head of steam are they working there? Is it a fairly routine and leisurely fashion, or do you feel as though you have fire underneath you all of the time and you are driving and driving?

Which is it?

Dr. SILVERSTEIN. I think we characterize it in the latter fashion.

Mr. MOSHER. You feel as though there is tremendous drive behind most of the people working there?

Dr. SILVERSTEIN. I know there is, and these people are dedicated and are devoting not just an 8-hour day to this, but the number of hours it takes to get the job done that particular day, and of course the work requires—I dare say there isn't a weekend that is not almost encompassed by the working effort of our people in the program.

Mr. MOSHER. They are not working on time and a half and double-time basis?

Dr. SILVERSTEIN. They are not earning overtime in that sense. They are working the hours to get the job done. They are professional people, and work whatever time it takes to get the job done.

Mr. MOSHER. You are satisfied with the motivation?

Dr. SILVERSTEIN. I think everyone realizes this is an important program.

Mr. MOSHER. Well, I am basically impressed by the magnitude of the scientific problems you are undertaking, not only here, but elsewhere, and usually when you have a crash program, there is a lot of hit and miss, but you are resolving a lot of the misses, and having the hits.

Dr. SILVERSTEIN. We think so.

Mr. KARTH. Doctor, that is all for today. We thank you very much for coming down. We sincerely appreciate it.

As I said before, I think I can speak for the committee on this, that we have a great deal of confidence in you and your team assigned to the problem, and the will that you have apparently to make this a success.

Thank you very much. The meeting is adjourned.

Dr. SILVERSTEIN. Thank you.

(Whereupon, at 12:10 p.m., the subcommittee adjourned.)

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1964 NASA AUTHORIZATION

THURSDAY, MARCH 21, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SPACE SCIENCES
AND ADVANCED RESEARCH AND TECHNOLOGY,
Washington, D.C.

The subcommittee met, pursuant to adjournment, at 10 a.m., in room 304, Old House Office Building, Hon. Joseph E. Karth (chairman of the subcommittee) presiding.

Mr. KARTH. The subcommittee will be in order. Doctor Newell, today we will go into the construction of facilities program for the Office of Space Sciences, and you may proceed in any manner you would like.

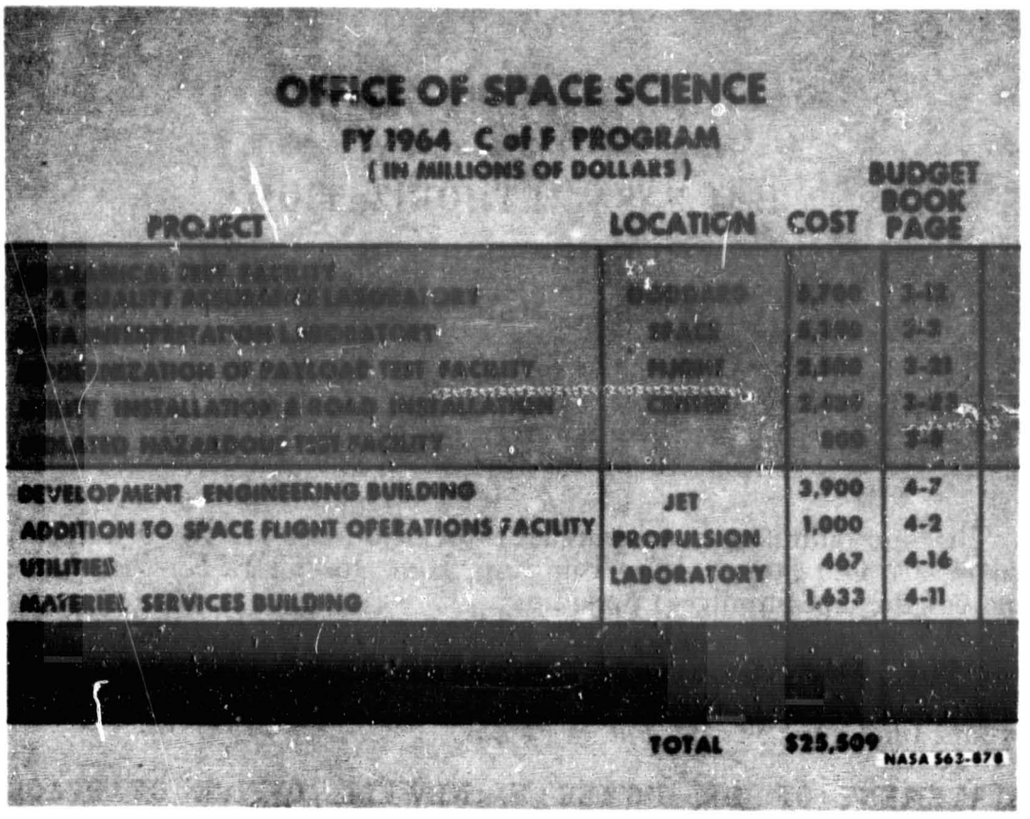
STATEMENT OF DR. HOMER E. NEWELL, OFFICE OF SPACE SCIENCES, NASA; ACCOMPANIED BY EDGAR M. CORTRIGHT, DEPUTY DIRECTOR

Dr. NEWELL. Thank you, Mr. Chairman, the Office of Space Sciences has assembled a few notes on this. I would like to ask Mr. Cortright to run through them for you with explanations of what our needs are in construction of these facilities.

Mr. KARTH. Mr. Cortright.

Mr. CORTRIGHT. Mr. Chairman, the construction of facilities program for fiscal year 1964 at the NASA field centers responsible for the space sciences program is summarized on this chart (fig. 79, Office of Space Sciences). We are requesting a total of $25,509,000 to construct four facilities at the Goddard Space Flight Center, Greenbelt, Md., three at the Jet Propulsion Laboratory, Pasadena, Calif., and one at the Launch Operations Center, Cape Canaveral, Fla. This total represents approximately 3 percent of the space sciences budget for this year.

As the space sciences program has developed over the past few years, the technical difficulty of flight projects has created the need for ground testing and laboratory facilities which approach the complexity of the spacecraft themselves. For example, the complexity of a space environment facility is illustrated by this photograph behind us (fig. 80, Space Environment Simulator). Requirements for extreme low pressures, solar simulation, and cryogenic wall temperatures present difficult design and development problems which must be solved in a timely manner. This type of technical facility must be available on the ground to test flight hardware in order to insure reliability and long lifetime in space.



PROJECT	LOCATION	COST	BUDGET BOOK PAGE
DEVELOPMENT ENGINEERING BUILDING	JET PROPULSION LABORATORY	3,900	4-7
ADDITION TO SPACE FLIGHT OPERATIONS FACILITY		1,000	4-2
UTILITIES		467	4-16
MATERIEL SERVICES BUILDING		1,633	4-11
TOTAL		$25,509	

NASA 563-878

FIGURE 79

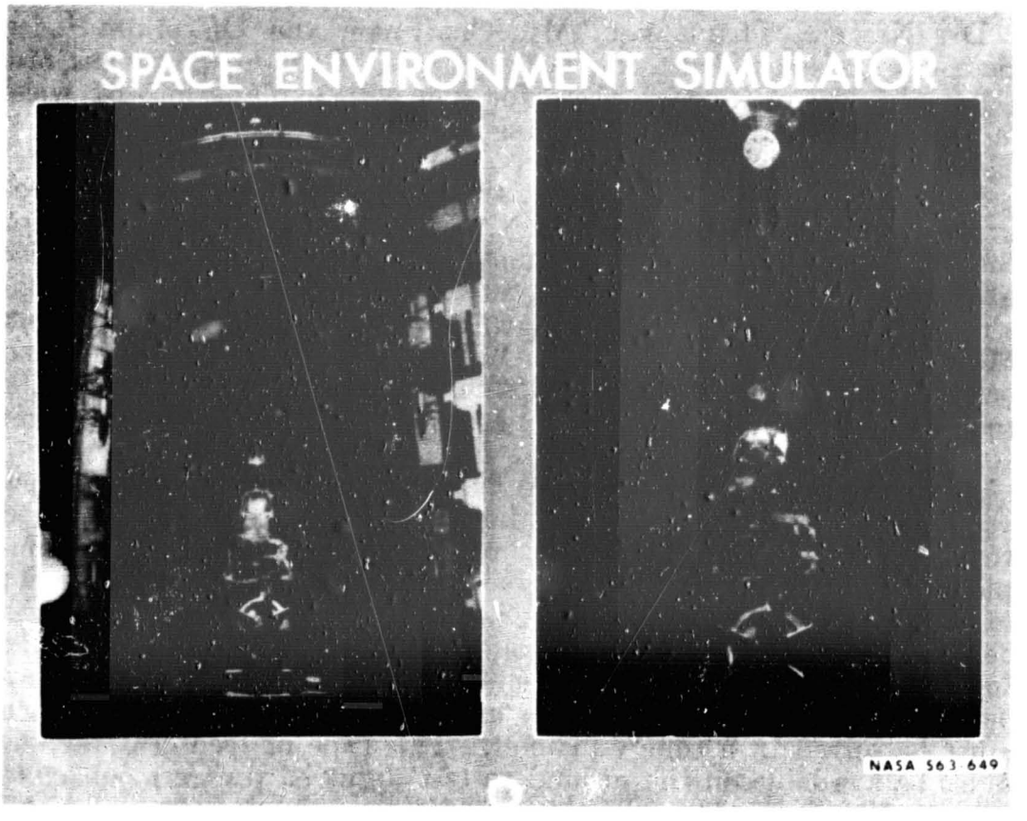


FIGURE 80

I just would like to mention, this is not a facility we are asking for (fig. 81, Spacecraft Development Facilities). I have shown it on the screen simply to illustrate the kind of facilities you have been providing for us up through this past year so that we can get our job done.

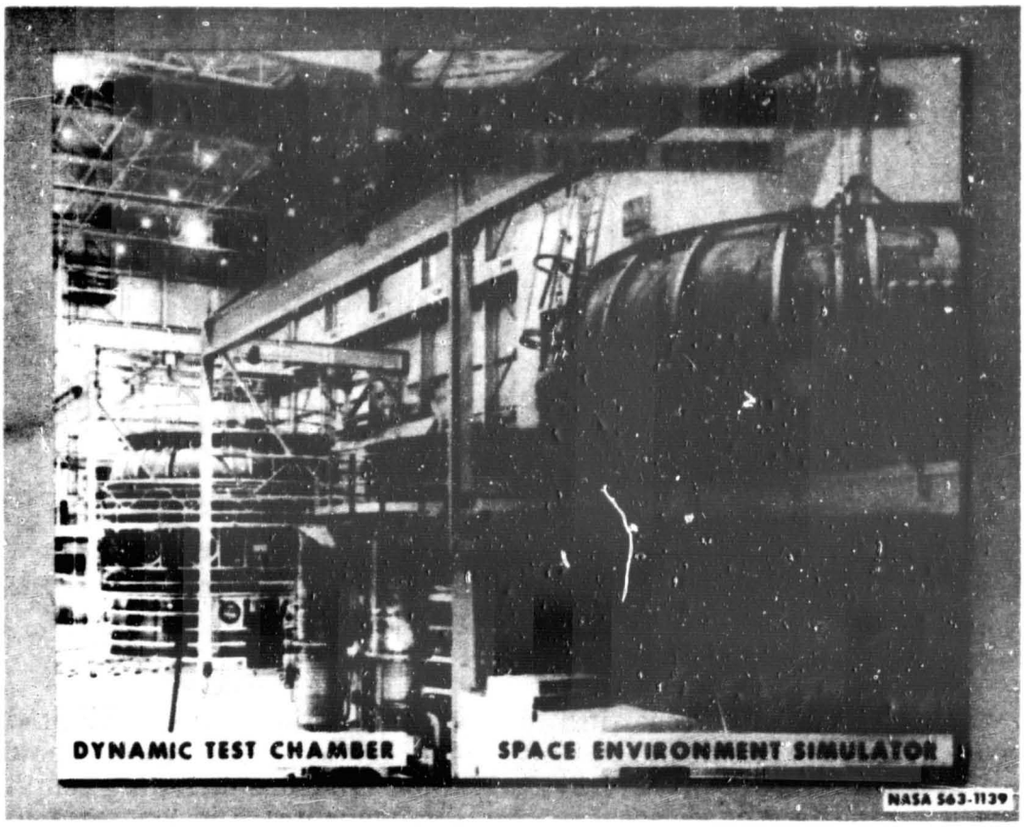


FIGURE 81

The next slide (fig. 82, Goddard Space Flight Center) shows the four fiscal year 1964 projects proposed for construction at the Goddard Space Flight Center.

The mechanical test facility and quality assurance laboratory shown in the upper left will provide a large 30- by 40-foot) vacuum test chamber and the necessary laboratory equipment to perform failure analysis, calibration, and quality assurance testing. This facility will permit testing of components, systems and complete spacecraft of our largest variety from the standpoint of reliability and quality control.

To repeat myself, increased reliability is the key to successful spacecraft development programs; and best achieved by complete ground testing prior to flight. It we have learned one thing, this is it.

The data interpretation laboratory is shown in the lower left. This facility is required to provide for centralization of laboratory effort in the design and development of spacecraft and ground telemetry systems; the location of computing, data processing, and data reduction equipment; and real-time data handling for satellite control. This consolidation is necessary for three reasons. First, the

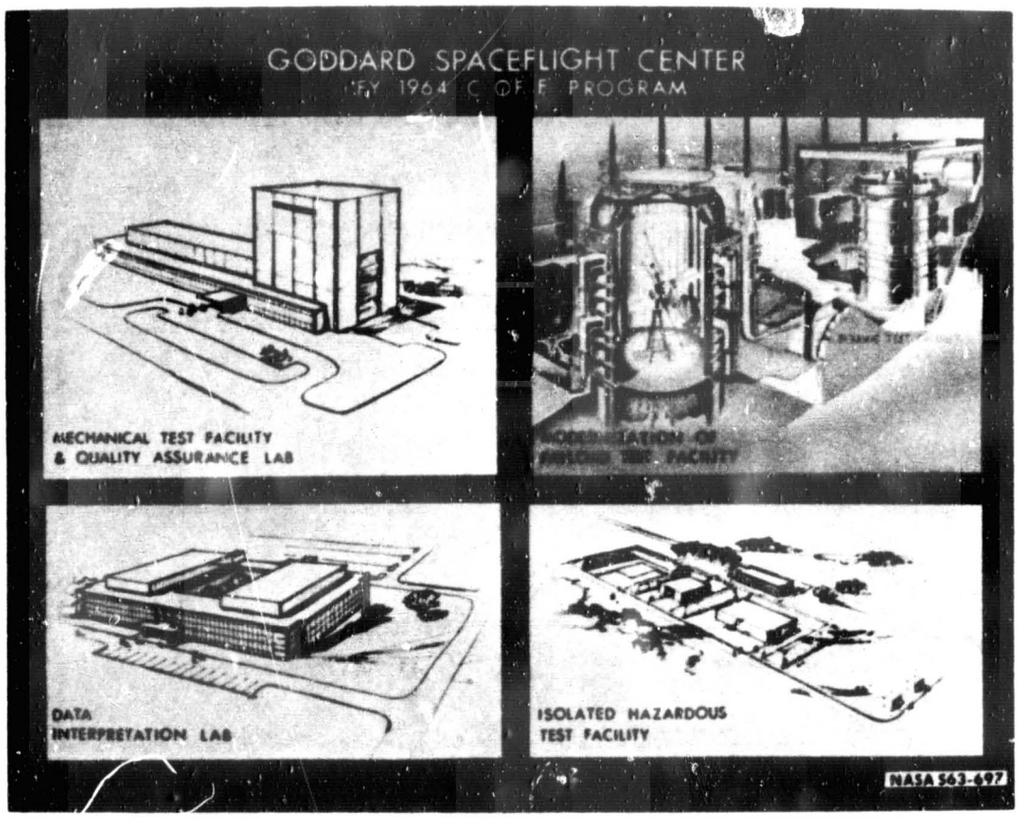


FIGURE 82

requirement for data processing and analysis has outgrown the limited space available for this purpose. Second, the data system groups now working are spread over several geographic locations including rental space. Finally, the co-location of developmental and operational groups will permit rapid interchange of information on mutual problems. Since this laboratory will house existing organizational units, most of the large data processing systems will be in existence prior to the completion of the building and need merely to be transferred into the new building.

The planned modernization in the payload test facility shown in the upper right on this slide will provide for the upgrading of existing equipment and the addition of test equipment having increased capability.

We plan to add solar simulation to the existing 12- by 15-foot thermal-vacuum chamber for example.

This improvement will provide an improved capability for simulating the space environment. Equipment will be added to the mechanical test laboratory to extend its present limit of 1,000 pound spacecraft to 4,000 pounds. Also, the central data collection and analysis system which supports the facilities will be expanded to permit experimenters to observe and monitor experiments undergoing test. This is necessary, I might point out, because our new spacecrafts, instead of carrying 5 or 6 experiments carry 20 to 40.

The isolated hazardous test facility shown in lower right will be located on a remote site off the Center proper. This facility will be

composed of two hazardous laboratory-type buildings, a concrete test pad separated by earth bunkers, a central control building and two storage bunker buildings. This facility will provide a safe means for conducting investigations of damage resulting from simulated space radiation and for containment of blast and fragmentation particles caused by detonation of pyrotechnic equipment.

The next slide (fig. 83, Jet Propulsion Laboratory) shows sketches of the three facilities proposed in the fiscal year 1964 construction program for the Jet Propulsion Laboratory.

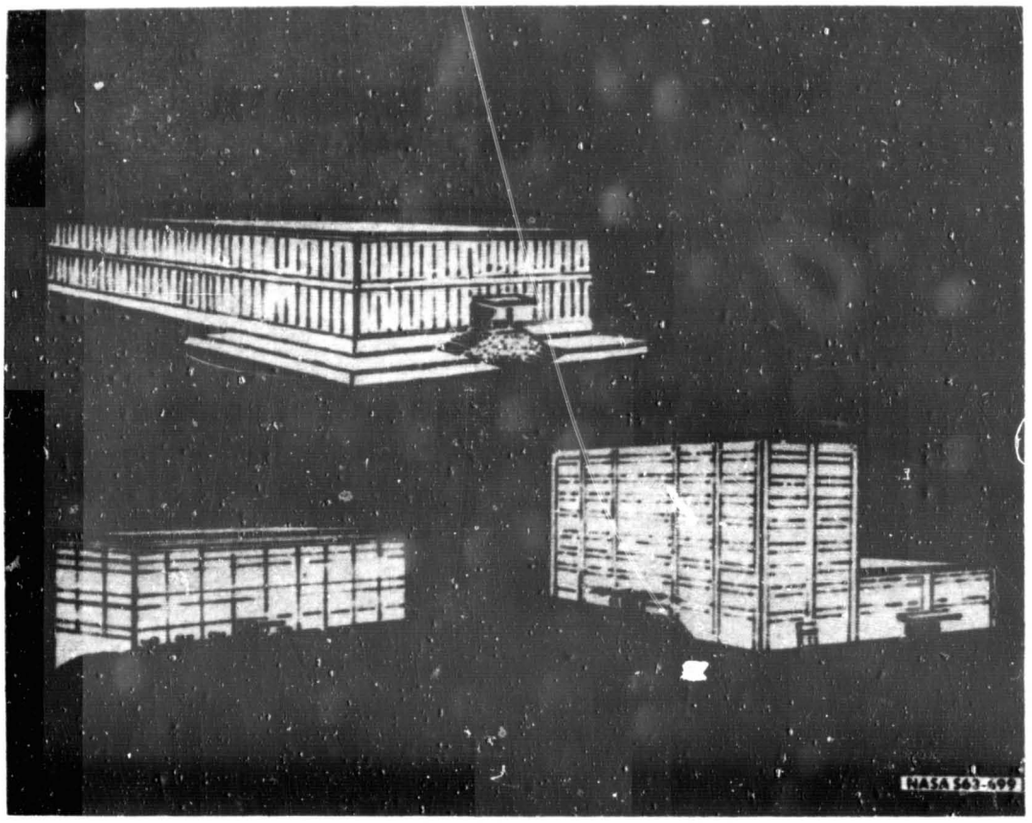


FIGURE 83

The planned addition to space flight operations facility will permit continuous and simultaneous communications with spacecraft during a lunar mission lifetime of from 3 to 60 days and a planetary mission's lifetime of from 3 to 8 months. The need for a multiple flight control capability will begin in the last quarter of 1964 with concurrent Ranger, Surveyor, and Mariner flight operations. The addition will be used to house new analog and digital data processing equipment and provide operational space for the technical personnel involved in around-the-clock space flight operations supporting these projects.

The Development Engineering Building is shown in lower right. The office and laboratory space will provide for technical laboratories, a machine shop, stockroom storage, and a high-bay developmental area. The Engineering Mechanics Division is now scattered through 10 different buildings, 12 trailers, and 2 leased facilities off the Jet Propulsion Laboratory premises. This group will primarily occupy

this facility. The present decentralization of division activity has separated the engineers from developmental laboratories and shops, in which much of their work is carried on, and has proven to be a serious handicap to efficient and effective work.

The Materiel Services Building will provide for a consolidation of support and service functions; service, inventory control, central stores warehousing, shipping, receiving, inspection, property accounting, and Materiel Services Division offices.

The location of these activities within a centralized area will bring together personnel now occupying trailers and off-laboratory leased space.

The last slide (fig. 84) is an artist's sketch of the unmanned satellite operations facility planned at the Launch Operation Center. This facility will provide the necessary working space for the preflight

FIGURE 84

preparation, system testing, and final assembly of unmanned satellites such as OGO, OAO, and Surveyor under closely controlled environments of temperature, humidity, pressure, fungus and spore-free ambients conditions, and radiation to permit close calibration of engineering test and scientific instrumentation.

In summary, it should be noted that although these facilities represent only a small part of our proposed program for the coming year, they are an extremely important and integral part of our total R. & D. effort. It is only by thorough and adequate proof testing of our flight

hardware that we can approach the reliability and mission lifetimes required of our flight projects.

Those are the prepared remarks, Mr. Chairman.

Mr. KARTH. Anything further you would like to add, Mr. Cortright, or Dr. Newell?

Dr. NEWELL. Now, as Mr. Cortright has said, these facilities are essential to our developing and maintaining the high reliability we feel we have to maintain in the space program. We, therefore, strongly request your support of these facilities.

Mr. KARTH. Colonel Gould?

Colonel GOULD. I have a few general questions, Dr. Newell, I'd like to ask. Possibly some of these are across-the-board questions. Maybe Mr. Ulmer might be able to provide the answers.

I'd like to have you outline for the committee the programing and budgeting cycle that NASA follows in developing its construction program from the time a requirement becomes known at a given field installation until the facility comes into being.

Could you do that for us, please?

Mr. CORTRIGHT. I think Mr. Ulmer is most qualified to do this. Mr. Ulmer is Director of Facilities Coordination in the NASA's Office of Programs. He has been kind enough to come with us today.

Mr. KARTH. Welcome, Mr. Ulmer. Why don't you take a seat at the witness table.

Mr. ULMER. Colonel Gould, the budgeting for facilities follows the regular budget cycle with respect to the R. & D. programs in that the total requirements come from the field centers as a package to a particular program office.

Now, facility requirements are generated in the field in two ways:

One, by virtue of the knowledge of the field people, particularly in the advance research areas, of the facilities they might require in the future to carry out their programs.

The other way a facility requirement is generated is by a program director laying on a program to a field center for work that has to be done in carrying out an approved mission and a facility requirement may generate from that assignment of work.

This may put a particular field center in a situation where it is developing requirements to handle the workload of more than one program office.

The field center director then has the responsibility of working with both program offices to fit the facility requirements into his overall long-range plan.

The facility requests are prepared in the form of project requests consisting of a description, justification, cost estimate, and construction schedule.

The cost estimates are based on preliminary engineering studies made by staffs at the center. These are estimates, it is true, but they are well-founded estimates in that these staffs have had long experience over the years in building the types of facilities required in carrying on our work. They are not final estimates and they are not estimates based on complete architectural engineering designs.

The projects are then submitted together with the R.D. & O. requirements to a program director like Dr. Newell who then has the responsibility for melding the overall requirements in his program

area into whatever constraints the management may have placed on him with respect to the overall agency budget.

I am sure you are aware this process goes on in every agency.

The final agency budget is then established by the program directors sitting down with the Associate Administrator, the Deputy Administrator, and with Mr. Webb and reviewing in detail each facility item and its relationship to the program and why the facility is necessary in carrying out the program.

After discussions with the Bureau of the Budget we get a Bureau of the Budget markup, which results in the submission to the Congress.

I do want to emphasize the fact that the facility cost estimates are not just guesses. They are what we consider reasonable estimates based on preliminary engineering studies by our field people.

Colonel GOULD. What is the timetable from the time the requirements become known in the field until the facility is complete? (This, I realize, depends on the complexity of the facility to a certain extent.)

Mr. ULMER. It would vary between about 18 months, to perhaps, in some cases, 4 or 5 years. Right now we are generating requirements that will be going into fiscal year 1965 budget, some of which will take 3 to 4 years to complete in the construction phase.

Colonel GOULD. Then the programing cycle within NASA, is about 2 years?

Mr. ULMER. Yes, sir, 18 months to 2 years.

Colonel GOULD. Do you think the length of this cycle is incompatible with the pace at which the space program is proceeding?

Mr. ULMER. No, sir, I do not, provided the agency is given a reasonable flexibility to adjust its program to meet changing requirements.

This flexibility is a key element in this kind of business.

Colonel GOULD. Does the reprograming authority that you now have for construction of facilities, help to reduce this cycle?

Mr. ULMER. It helps to reduce the cycle where a program change makes a changed cycle necessary, Colonel.

For the majority of our facilities we carry out the construction of the facility generally in the manner and the timetable in which it was presented to the Congress.

If a change in the R. & D. program makes it necessary to start a new facility, to change the scope of an authorized facility, or to change the construction timetable for a facility, the reprograming authority may be absolutely essential to allow those actions to be taken.

Colonel GOULD. I notice that in the past years, the amount of advance planning funds that have been made available to NASA has been somewhat limited considering the size of your construction program.

Would more liberal use of advance design funds assist in cutting down the cycle to any great extent?

Mr. ULMER. Yes, perhaps it could, Colonel.

It's hard to speak of this in generalities though. You really have to look at the individual facility requirements.

If you have very good planning in a program where there is relatively little change, advance design money is not necessarily helpful in that you can plan your facilities early enough so that the regular budget cycle takes care of it.

The advance facility planning and design is particularly desirable in the phases of the program that change rapidly.

This year we have a total of $8 million for advance facility planning and design. We have allocated the entire amount.

Under the reprograming authority you people have given us in the authorization act, we can allocate additional funds to the advance facility planning and design account and we are in the process now of making such a recommendation. A modest reprograming action in that direction will be coming before you soon.

The advance design account is a very helpful item. We are glad we have it.

You can't advance design everything because the technical characteristics of many of the facilities, must proceed in relationship to the development of the R. & D. program. You couldn't now, for example, sit down and design every facility you might need 4 years from now.

Certain facility requirements might look quite different at that time, depending on the progress of the R. & D. effort.

Colonel GOULD. But it would appear that if you had enough advance design money in fiscal year 1963, for example, to design at least to preliminary stage all the facilities you are asking for in the 1964 program, your estimates and your requirements would be firmer when you submitted your authorization request this year. Is that not correct?

Mr. ULMER. I think that's a fair statement, Colonel.

There would be a tendency to have firmer estimates based on more engineering studies.

Colonel GOULD. Doctor Newell, your program this year, your authorization request for construction, totals $25.5 million. Is this all you asked for initially?

Mr. CORTRIGHT. The total construction of facilities program within NASA is put together as a single entity within NASA but with recommendations from all of the directors' offices.

We were not denied facilities that we thought must go forward this year.

Colonel GOULD. Under Public Law 87–584, NASA is authorized to use R. & D. funds for the purpose of providing for construction of contractor facilities.

Do you have any such contracts within the Office of Space Sciences wherein construction was provided for contracts?

Dr. NEWELL. From R. & D. funds?

Colonel GOULD. Yes, sir.

Mr. ULMER. Colonel, I believe that the section 1(c) authority has not been exercised for any facility required in the Space Sciences area except for a university facility grant.

Colonel GOULD. I have noted at certain NASA installations in the field that construction design and management are accomplished by one of three means—either with an in-house capability, by a construction management contract, or in some instances by the U.S. Army Corps of Engineers.

At those installations falling under your jurisdiction, how do you accomplish these services?

Mr. ULMER. I'd be happy to answer that, sir.

At the Jet Propulsion Laboratory and at the Goddard Space Flight Center, which constitute the centers primarily concerned with the Space Science effort, the service you speak of is normally accomplished

by an in-house staff. This is generally the procedure that has been followed in the older of the NASA centers, the Langley, Ames, Lewis, and Flight Centers. They have their own staffs and the selection of architect engineers and the construction management is done by in-house personnel.

At the newer centers which resulted from the very rapid expansion of NASA, it was not feasible in the time frame available to build this in-house capability. I believe the Government was very fortunate at that time in getting the services of the Army Corps of Engineers during a period when their military construction program was diminishing with respect to the missile activity. They were able to throw into our work a very fine capability in a very short period of time.

They have been extremely helpful.

The other type of procedure that you mentioned, the construction management contract, is a very rare case and I'd say hasn't been used more than three or four times in the agency. It's only used for a very special type of facility.

Colonel GOULD. Do you have any idea of the relative costs of using these three means to accomplish design, supervision, and inspection?

Mr. ULMER. I don't have those figures available. I would estimate there would probably be relatively little difference in cost between having people on the NASA staff do this or reimbursing the Corps of Engineers for the same service. The costs may be comparable.

Mr. KARTH. Mr. Ulmer, I wonder if you would provide those figures for the record.

Mr. ULMER. I'll try. I don't know whether I can, because the in-house cost for NASA is made up of people on our payroll and those costs may not be segregated against individual construction projects.

We have inspectors, design engineers, and people in our procurement division engaged in the construction management effort. It may be very difficult to make the comparison you have requested.

Mr. KARTH. There is no way this committee could determine whether there is a possible way of saving money in this area. Is that correct?

Mr. ULMER. It could be done. I believe it would take a great deal of accounting work.

Mr. KARTH. If your construction people are working 8 hours a day, 5 days a week, that's one thing.

Mr. ULMER. Our situation is made a little more difficult because of the fact that the people engaged in modification and repair work at our centers are also used in conjunction with the construction programs.

It may be a difficult accounting task to develop the figures for the portion of people's time devoted exclusively to the facility program when you have an in-house group doing it.

Mr. CORTRIGHT. If you want us to make a stab at this, we will do so.

Mr. KARTH. Well, I guess a "stab" at it probably wouldn't give us too much information.

However, why don't you take a look at it, Mr. Ulmer?

If it's practical, it might enlighten us a bit.

Mr. ULMER. All right, sir.

(The following was submitted for the record:)

Time was insufficient to conduct an adequate analysis of comparative costs of in-house versus Corps of Engineers construction supervision and management. A spot check of several projects, however, indicates that NASA and Corps of Engineers costs for construction supervision and management are approximately the same when all cost elements are included.

Mr. KARTH. Mr. Ulmer, a few moments ago you were talking about the firmness of your estimates.

Mr. ULMER. Yes, sir.

Mr. KARTH. Estimates for construction of facilities.

I wonder if you could tell us how unfirm our previous estimates have been? Have they been within the ball park?

How far off have we, in 5 percent, 10 percent, 60 percent, been right on the nose or what?

Mr. ULMER. I think I can probably give you an example to fit every figure you mentioned, sir, because a great deal depends on the status of the construction industry at the time a project is released for bid.

Mr. KARTH. I see.

Mr. ULMER. We have had some very fine bids. We have had some that have been very unfortunate in the respect that we have underestimated the cost of projects.

Mr. KARTH. This isn't true in buildings, is it?

Mr. ULMER. Yes.

Mr. KARTH. You mean brick and mortar?

Mr. ULMER. Brick and mortar. We have been pleasantly surprised, for example, at a particular center to solicit bids for a $3 million building and receive about 10 bids on that building with a spread of less than $100,000 and with the low bid coming in considerably below the estimate. In this case the overall construction industry in the area was in a situation where they were really looking for work. They sharpened their pencils.

We have had the reverse situation where we've gone considerably over the estimate, and it's for this very reason that we feel it essential that we have some flexibility within the construction appropriation to take care of any kind of contingency.

Mr. KARTH. What do you do when you go over the estimate?

Mr. ULMER. Well, we do one of several things.

We may cut the funding for some other project, we reduce the technical capability of the project, or we may transfer funds from the R.D. & O. appropriation.

Mr. KARTH. But you don't relet the bid, for example?

Mr. ULMER. We have on occasion, yes.

If the situation requires a severe downgrading of the technical capability of the facility, we may have to redesign the facility.

Mr. KARTH. At Cape Canaveral, they relet the bid and were generous enough to increase the dollar amount allowed in certain areas.

I don't have the particular facility in mind at the moment.

Mr. ULMER. I'm not familiar with the case you are speaking of.

Mr. KARTH. Seems to me, if my recollection serves me properly, they went back to a bridge contractor and said, "Gentlemen, we're sorry, but you didn't charge us enough for this. We think maybe you should revise your bid."

I think he did just that after this pretty generous offer.

Mr. ULMER. I'd have to know the particulars of the case.

I feel the competitive bid basis for construction work is a very fine thing, and we attempt wherever possible to conduct our construction program on this basis. We get bids in excess of our estimates, and we get them below the estimates; and, with the reprograming authorities that you have provided in our authorization act, we have been able to meet nearly all of the difficult situations that have arisen.

Mr. KARTH. What is the normal process in Government when all of the bids are in excess of what your professional people have told you they should be?

Let's say that you've estimated cost to be $2 million and the bids are all around $3 million?

What do you do about it?

Mr. ULMER. We would sit down and take a very hard look at what the effect on the whole program would be if we need to provide an additional million dollars for that facility. We have to evaluate the effect on the entire agency program.

It may be that the facility is so essential we have to cut out some other facility or reduce some research and development effort to provide money.

We also have to look at the facility itself. Perhaps there is some way we could cut some corners, or perhaps downgrade the technical capability slightly.

All of these things are examined in that type of case.

It's a very difficult decision.

We don't have a pot of money to take care of that kind of situation. If something goes higher something else gives.

Mr. KARTH. Is there a possibility of price rigging on competitive bids?

Mr. ULMER. I imagine it would be very difficult on a competitive bid involving facility construction.

Mr. KARTH. Thank you.

Colonel Gould?

Colonel GOULD. Are all your facilities contracts awarded on a competitive-bid basis?

Mr. ULMER. No, I wouldn't say all of them.

I'd like to have Mr. Brackett provide the exact figure. He's not here today, but he could provide that for the record. The bulk of them are.

Colonel GOULD. Would you provide that for the record, please?

Mr. ULMER. Yes, sir.

(The material referred to is as follows:)

The following table presents the status of NASA obligations through January 1963 under the "Construction of facilities" appropriation for those projects where construction management and supervision is performed by the NASA staff.

Fiscal year	Obligations (in millions)	Percent obligations by competitive bid	Percent obligations by noncompetitive procedures
1961	$58,495	84.1	[1] 15.9
1962	74,221	72.9	[1] 27.1
1963	36,453	70.6	[1] 29.4

[1] Includes obligations for design and engineering services which are traditionally contracted for on a noncompetitive basis.

In addition, the following data is presented for the same 3 fiscal years on the obligations through December 1962 under the "Construction of facilities" appropriation for those projects where construction management and supervision is performed by the U.S. Army Corps of Engineers as agents for NASA:

Fiscal year	Obligations (in millions)	Percent obligations by competitive bid	Percent obligations by noncompetitive procedures
Total for fiscal years 1961, 1962, and 1963	[1] $206,400	81.5	[2] 18.5

[1] Does not include obligations totalling $96.8 million for land acquisition.
[2] Includes obligations for design and engineering services which are traditionally contracted for on a noncompetitive basis.

Colonel GOULD. Doctor Newell, I note the facilities construction for 1964 are projected only through 1964. Do you have a long-range plan of construction to meet all known requirements at each installation?

Dr. NEWELL. All known requirements?

Colonel GOULD. Yes, sir.

Dr. NEWELL. Yes. Put in that word "known."

We are continually reviewing our needs at the various centers both from an installation point of view and from a program point of view and we have in mind the things that we would like to do.

These are included in our long-range thinking.

If you mean, do we have a firm written handbook, long-range plan, we do not have that.

Mr. CORTRIGHT. I'd like to amplify on that just a little bit. Basically we have submitted from NASA centers in the budgeting cycle far more requests for construction of facilities than we choose to support within NASA headquarters.

In fact, the normal situation is that about one-half end up as being deemed essential. This is why I answered the previous question as I did, namely, we were not denied facilities that we deemed essential to the program.

We go through quite a severe editing process ourselves.

Colonel GOULD. Well, for example at the Goddard Space Center, what is the total value of your plant at the present time? Do you know offhand?

This year you have asked for $16,829,000. How much more construction do you have to accomplish at Goddard, based upon your known requirements as of today?

Dr. NEWELL. As of June 30, 1962, the plant value was $67,722,000.

Colonel GOULD. Does that include authorized projects not yet completed?

Mr. ULMER. No, that is only work that is completed.

Colonel GOULD. How much outstanding authorization do you have at Goddard that is not yet completed?

Mr. ULMER. Somewhere in the neighborhood of $15 million.

Colonel GOULD. Would you verify that, please, and furnish it for the record?

Mr. ULMER. Yes, I will.

(The following was subsequently supplied for the record:)

The outstanding construction of facilities authorization at the Goddard Center is $17,866,800.

Colonel GOULD. This year's program requests $16.8 million, $4.1 million of which, I believe, is in support of the Office of Applications; is that correct?

Mr. ULMER. That is correct.

Colonel GOULD. This then, would give you a total of somewhere around $95 million in place and programed for Goddard.

Now, beyond 1964, what are your known facilities requirements at Goddard?

Mr. CORTRIGHT. Well, we are just going through that evaluation now.

We have a list of Goddard proposals for fiscal 1965 and have not completed the evaluation and have not made any proposal to the Administrator as to what he should support for 1965.

I would not like to say more than that some additional expansion is required.

As you noticed in the personnel, Goddard is not through growing yet. There still is a little way to go before Goddard is a fully sized laboratory. This will require additional facilities to support the work these people are doing and to give them housing.

There will be additional Goddard facilities in fiscal 1965, perhaps of the same order of magnitude as this year's construction.

Colonel GOULD. Are you telling us that your master plan is firm only through fiscal year 1965?

Mr. ULMER. Colonel, may I make this observation?

This depends on what you call a master plan. We do have a master plan for the Center that envisions growth for a period of perhaps 6, 7, 8 years, but this doesn't mean that all of the facilities that we will be requesting are known in detail for that period.

In other words, when we build a facility now we want to build it in a way that would not preempt good usable space for future facilities; yet we are not exactly sure of the details of those future facilities.

Mr. Cortright mentioned that they are now reviewing what facilities might be required in 1965. The people at Goddard are looking well beyond that in how they may wish to cite the 1965 facilities.

Colonel GOULD. The only thing I was trying to get in the record, just using Goddard as an example here, is how far in advance your master plan is firm and what are your firm requirements; things you know you are going to build sometime between now and the year X.

Mr. ULMER. I don't think that figure is available, Colonel, because a great deal depends on what the program content will be in the years beyond 1964.

Mr. CORTRIGHT. A great deal depends on how large a program the Congress and our own Administrator will support.

I think the Goddard planners and Jet Propulsion Laboratory planners and all our center planners put together what it defines as "long-range thinking" which includes center expansion, maybe up to 5,000 or 6,000 people. But that's not the level being supported by the current administration within NASA or by the Congress.

Colonel GOULD. Don't misunderstand me. I'm not trying to pin you down for a given fiscal year. I'm just trying to find out what the long range plan is for Goddard, how much it's going to cost, and whether it's going to be programed in 2 or 20 years.

Mr. CORTRIGHT. I don't believe either the growth or the changes within the Goddard Center will be completed in a few years. The growth may be largely complete in 3 years, but there will be changes probably within the whole 20 years you are referring to, simply because these are not static programs.

Mr. KARTH. The fact of the matter is, you don't have a long-range plan for construction of facilities at Goddard. Isn't this right?

Dr. NEWELL. We do not have a written handbook type long-range plan.

We have a process of long-range planning in which we look at the likely avenues of development of the different programs and the likely centers at which these programs would be taken up for project management execution.

Out of that, as we go into this budgeting process for each fiscal year, we make our selections and choices.

Mr. CORTRIGHT. There is a master planning board at each center which insures the centers do not grow in a haphazard fashion. Siting is considered well in advance.

This is the point Mr. Ulmer brought out.

Mr. KARTH. Dr. Newell, the 1964 budget request includes $5.7 million for a mechanical test facility and quality assurance laboratories, I guess you call it.

What is the major purpose of this facility?

Mr. CORTRIGHT. This facility contains a large 30- by 40-foot vacuum chamber in which we can put spacecraft and make them go through their electromechanical tests.

Tests of this sort have to be performed frequently over and over again in a vacuum condition to insure the parts will, in fact, function virtually 100 percent of the time.

All we need is one solar panel to hang up and we have lost the mission.

The nature of these tests require that you be able to pump down the facility rapidly, that you can inject gas and not destroy the vacuum completely. The pumping capability is high.

We don't ask for quite as low pressures as we do on thermal vacuum chambers where we soak spacecrafts for days and weeks on end.

Some people refer to this as a "dirty vacuum chamber." In other words, it's not quite as high a vacuum as the others, but it's good enough to check out the electromechanical functions of a spacecraft.

The spacecraft in prior years, which have been the Explorers and Monitors, have been small and they actually have not had many moving parts. Where they have had moving parts such as extendable panels, they have been small and we've been able to accommodate them without the solar array by only exercising the linkages.

This facility is for the larger spacecraft of the OAO and OGO variety.

Mr. KARTH. The one you are requesting now?

Mr. CORTRIGHT. Yes.

Mr. KARTH. What size was that, Mr. Cortright?

Mr. CORTRIGHT. Thirty by forty feet.

Mr. KARTH. I was informed it was 40 by 50.

Mr. CORTRIGHT. This is a clear space——

Mr. KARTH. You might doublecheck.

Mr. CORTRIGHT. This is the clear space inside which is available for spacecraft and booms.

The exterior dimensions of the tank may be more like what you are describing.

Mr. KARTH. OK. Well, I'm not sure whether I'm talking about the exterior dimensions, and you are referring to interior dimensions, or what; but I'm sure that we are in the same ball park.

The reason I ask the question is because we already have four vacuum chambers out at Goddard and they range in size from 12 by 15 feet to 35 by 60.

Now, we need one 30 by 40 feet.

Can't we use the 35 by 60 for these tests? Or one of the others? Is this impossible?

Mr. CORTRIGHT. Virtually.

They are used for different purposes.

As I say, this is a "dirty vacuum chamber" in which you can——

Mr. KARTH. Can we conduct tests in a clean vacuum chamber on a dirty piece of equipment?

Mr. CORTRIGHT. If they weren't being used for other tests we might. In this case, I think, to exercise all of the mechanical and electromechanical extension equipment on OAO and OGO, you need this increased size.

If you attempt to run this in a smaller chamber, you would simply cut down on the lengths of the booms and not do a complete job.

Mr. KARTH. Except that we have one chamber that is larger than the one you are requesting.

Mr. CORTRIGHT. Yes, sir; the other chambers are being utilized for things like thermal vacuum soak and experiments where you have to run the pressures to 10^{-5} or 10^{-6} millimeters of mercury—very, very low pressures.

You have solar simulators wherein you have a columnated beam of light representing the Sun and you have cryogenic walls.

These are really instruments, and you have to treat them like instruments and perform the type of tests in them which require that capability.

The type of tests we would perform in this facility do not require all that refinement. They do require volume.

We have loading schedules which I could show you. I don't have them with me today.

Mr. KARTH. Would you supply for the record the tests that have been made or the tests that are being made at the present time and that you look forward to——

Mr. CORTRIGHT. I can provide——

Mr. KARTH (continuing). Being made in these chambers that would accommodate your OGO and OAO?

Mr. CORTRIGHT. I'd be happy to supply that for the record.

(The information referred to is as follows:)

Summary of Goddard vacuum test chambers

Chambers	Type	Feature	Usage history		Usage projection (2 years)					
			Time [1]	Programs	Setup	Test	Teardown	Maintenance	Total	Program
Bell jars (3)	General-purpose research.	Ultrahigh vacuum	75 percent (1 shift)	ART/SRT	15	40	5	15	75 percent (1 shift).	Research, ART; selected subassemblies, SRT.
Under 6 feet (9)	Subassembly tests.	4 with solar; 5 without.	50 percent (3 shifts).	OGO, S-3, S-51, S-52, S-3a, S-3b, P-14.	10	40	5	20	75 percent (3 shifts).	Experimental and subassemblies, S-52, S-74, OGO, OAO; S-57, IMS.
7 by 8 feet	Delta-size spacecraft.	Solar simulation	60 percent (3 shifts).	S-3b, OGO; experimental S-52.	15	25	10	25	75 percent (3 shifts).	S-52, S-74, OGO experimental.
8 by 8 feet	Delta-size spacecraft.	Wall temperature −65° C. to +106° C., no solar.	60 percent (3 shifts).	S-3, S-3a, S-51, S-6, P-21, S-48.	10	40	5	20	75 percent (3 shifts).	S-52, S-74, OGO experimental, sounding rockets.
12 by 15 feet	Agena spacecraft and research.	Ultrahigh vacuum adaptable to solar.	Due on line July 1, 1963.		20	15	10	30	75 percent (3 shifts).	OAO experimental and research.
Space environment simulator.	Agena spacecraft.	30- by 40-foot workspace. Solar due Jan. 1, 1964. Achieved 2 by 10^{-9} torr.	Due on line Apr. 1, 1963, without solar.		15	25	10	30	80 percent (3 shifts).	OAO spacecraft EOGO.
Dynamic test chamber.	Mechanical tests in vacuum.	SS vessel. Convertible to high vacuum.	100 percent first shift, 30 percent second shift.	Echo, S-3b, S-51, S-52, sounding rockets.	30	30	20	10	90 percent (2 shifts).	Many small jobs on most GSFC programs.
Vacuum optical bench.	Special purpose.	Including optical bench.	Due on line June 1, 1963.		30	10	10	10	60 percent (1 shift).	OAO.
10 by 15 feet	Thermal design research.	Solar simulation	Contract let February 1963.		20	15	10	25	70 percent (2 shifts).	ART, SRT, selected projects.

[1] Includes setup, test, teardown, and maintenance.

Mr. KARTH. The next 6 months or whatever the situation might be.

Mr. CORTRIGHT. Probably for the next 2 years.

Mr. KARTH. Let me ask you this. Are there no private industries in this country that can take care of the experimentation you say is necessary?

There are deep vacuum chambers all over this country. Maybe they don't fit your requirement.

Mr. CORTRIGHT. I'd like to discuss that. I'd like to complete the answer on an earlier question which I forgot to mention.

Whenever you perform so-called dirty tests in a clean tank it may take days or even weeks to pump down to where it can operate at 10 to the minus 6 or 7 millimeters of mercury. Just, as I said, you have to treat the high vacuum tanks as instruments.

Now to discuss your other point, there are companies throughout the country that have developed vacuum facilities during the past 3 or 4 years contemplating Government business. In the majority of cases these facilities are being used.

For example, the Space Technology Laboratories, Inc. is just completing a vacuum chamber which they will use for certain tests on the OGO.

The Hughes Aircraft Co. has vacuum facilities. They have some small ones and are completing a large facility which will be used for the Surveyor tests. We will not duplicate this facility, we will let Hughes do all of the Surveyor tests.

In the case of the OAO, there are certain tests being planned at Grumman and certain tests being planned at Goddard by Goddard and Grumman which have worked out the best possible use of available facilities.

I have heard various companies say we are not making complete use of their facilities, but I believe that in virtually all cases we are making the most efficient use of facilities to complete the total job even though there might be a short period of time where company A has the vacuum tank unused.

Mr. KARTH. Is there any way in which NASA could check with the industry in this point in time, by saying the 4- or 5-month period between January and June of 1965 you will need a facility fitting this description with this capability, and ask if they can meet that requirement?

Is there any way of doing this, Mr. Cortright? If we could, we may over the long haul eliminate some very costly facilities?

Mr. CORTRIGHT. The Aeronautics and Astronautics Coordinating Board of NASA and DOD has a panel on supporting space research and technology which considers the total facilities of the country. Periodically this group reviews all the facilities existing under construction or contemplated facilities of the large vacuum chamber variety.

The reason for this group it that it was recognized that these large vacuum facilities become a national asset in the same manner the large wind tunnels were in prior years and that they should be coordinated.

There was a hazard that NASA and the Department of Defense would end up with duplication and that some of the industrial companies would do likewise.

What we are trying to do is keep abreast of all these facilities and make a determination whether the total facility complex is being well exercised.

Mr. KARTH. I see. The point you make is that NASA always looks at what the private industry capability will be at that time, and if it looks as if there might be available capability, you would then solicit those people. Is that correct?

Mr. CORTRIGHT. That is absolutely correct.

Mr. KARTH. How about the other agencies of Government now?

The Navy, I know, has some vacuum chambers, and I assume the Army has. The Air Force, I know, has.

Do you also solicit the help of other agencies of Government on these requirements you have in NASA?

Mr. CORTRIGHT. We look at the facilities that are available, but there is a point that should be brought out here, Mr. Chairman, and that is the following:

A spacecraft goes through essentially two phases of development.

When the contractor is working with the spacecraft he is getting the basic flight frame, what we used to call the airframe in the case of aircraft, to a point where it is deliverable to the Government.

At Goddard, for example, the next step which has to be done, is to take our 20 to 30 experiments on the OGO and integrate them into the spacecraft and still end up with a flightworthy system.

Now the Goddard facilities are uniquely designed to accept the space frame from the contractor in a flightworthy condition and integrate the experiments into it, provide the monitoring equipment for the experimenters to observe their experiments during thermal vacuum and prepare a final total instrumented spacecraft. So these are two phases of testing that are different.

The type of equipment is different and as I said, we have attempted to work with the contractors in such a way that their facilities are used to perform the functions they best are able to do and our facilities are used to perform what we must do.

Mr. STAEBLER. Mr. Chairman, may I ask a belated question?

Mr. KARTH. Mr. Staebler.

Mr. STAEBLER. When you put an instrument or a spacecraft into a vacuum chamber for testing, you have to go back to atmosphere to load it?

Mr. CORTRIGHT. Yes, sir.

Mr. STAEBLER. You lose all your vacuum?

Mr. CORTRIGHT. You do.

Mr. STAEBLER. What does it cost to evacuate a chamber?

I've often wondered what the expense might be.

Mr. CORTRIGHT. It is nominal in terms of electrical power to run the oil diffusion pumps. We evacuate them by two techniques, roughing pumps which work rapidly and oil diffusion pumps which work more slowly.

These pumps consume electrical power to run and it is a relatively small cost.

The biggest expense is the time that an expensive facility may be tied up and that is why we treat our very fine vacuum chambers so carefully.

We work in them with clean suits and use clean room procedures so there is little contamination that later might outgas and require several days rather than a day to pump it down.

Mr. STAEBLER. How long did you say it might take to pump down?

Mr. CORTRIGHT. If we are careful, I think we can get our vacuums in less than a day after having made a change. That would depend on the type of equipment they are putting in, however.

Mr. KARTH. What is the capability of the vacuum chamber that you request in this fiscal year's budget?

Mr. CORTRIGHT. In terms of pressure, I think it is about 10 to the minus 3 millimeters of mercury.

Our normal vacuum soaks are done at 10 to the minus 6 or 10 to the minus 8 millimeters of mercury.

Mr. KARTH. Mr. Mosher?

Mr. MOSHER. How is the proposed environmental tank at the Lewis Research Center related to these at Goddard?

What's the construction time schedule of that tank at Lewis?

Mr. CORTRIGHT. That's not under our cognizance and I'll have to ask Mr. Ulmer if he knows the answer to that question.

Mr. ULMER. You are speaking of the large $25 million facility?

Mr. MOSHER. Yes.

Mr. ULMER. That is being placed under construction now, sir. It is a facility that will permit testing of propulsion systems as distinct from the type of facility Mr. Cortright was mentioning which is for spacecraft.

I can give you the construction schedule on that for the record.

Mr. MOSHER. I'd like to have that, if I could.

Mr. ULMER. Yes.

(The information referred to is as follows:)

The Space Propulsion Facility at the Lewis Research Center is scheduled to be completed in November 1965.

Mr. MOSHER. There's no chance that could be used to relieve the pressure at Goddard and make unnecessary some of this construction at Goddard?

Mr. ULMER. I doubt it very much, sir, because the facility is just too large for the types of experiments that Mr. Cortright is speaking of. It would be something like using a 10-ton truck to do a half-ton truck's job.

Mr. CORTRIGHT. That particular facility, if I'm not mistaken, is for testing of electrical propulsion systems.

Mr. ULMER. That is correct.

Mr. CORTRIGHT. It is a propulsion facility.

Mr. ULMER. Yes; for a complete propulsion system.

Mr. KARTH. We do have a 25- by 25-foot chamber at JPL, don't we?

Mr. ULMER. I believe that's very close to the actual size of the area in the JPL facility in which solar simulation can be obtained The overall tank size is 25 feet in diameter and 50 feet high.

Mr. KARTH. Is this under constant use?

Mr. CORTRIGHT. We have a photograph of that, you might be interested in. That facility is under very heavy use.

Right now we are completing some tests on the Mariner.

You recall, we ran into an overheating problem on Mariner II. This facility was not available to qualify the Mariner II, so we designed the Mariner as best we could and later found we had neglected a few reflections.

In fact, you can't see it too well in the photograph but the conclusion was that a few of the polished structural members which had been inadequately allowed for in previous calculations and tests reflected enough solar light back up onto the main body of the spacecraft to cause overheating and we almost lost the Mariner from overheating.

This is the sort of thing we have to find out far in advance. This is a heavily used facility and probably will have to be supplemented at JPL in future years.

Mr. KARTH. Now getting back to my question existing facilities within other agencies of Government, you do make an effort to solicit information as to the availability of other facilities that you may be able to use.

Am I to understand that this is done?

Mr. CORTRIGHT. Yes, sir; although in all honesty, I think this is an informal process.

If it does not seem necessary to conduct a series of tests on site with our own people right there, which we normally like to do in our final qualification testing, we look elsewhere. We know where to look because we know of the large existing facilities in the country.

There are not that many of them that they are hard to keep track of.

Mr. KARTH. How many chambers do we have under construction or where funds have been requested for construction of the chamber facilities in the NASA budget this year?

How many of those do we have under construction from the moneys supplied for construction?

Mr. ULMER. I'd have to supply that for the record, Mr. Karth.

(The information referred to is as follows:)

NASA environmental chambers (6 feet or over in interior dimensions)

Center	Size	Significant characteristics	Construction status
Ames Research Center	16-foot diameter by 12 feet high	Temperature, none; vacuum, 10^{-7} torr; solar simulation, none; comments, man-rated chamber.	Fiscal year 1964 budget.
Do	5-foot diameter by 10 feet long	Temperature, to −320 F.; vacuum, 10^{-10} torr; solar simulation, yes; comments, includes particle accelerator for materials testing.	Do.
Do	12-foot sphere	Temperature, none; vacuum, 10^{-3} torr; solar simulation: yes; comments, platform with air bearing for attitude control system tests.	Do.
Goddard Space Flight Center	12 by 12 by 20 feet	Temperature, −65° C. to 150° C.; humidity, relative humidity 20 to 95 percent from 1.7° C. to 81° C. vacuum, none; solar simulation, no.	In operation.
Do	6 by 6 by 10 feet	Temperature, −65° C. to 150° C humidity, relative humidity 20 to 95 percent from 1.7° C. to 81° C., vacuum, none; solar simulation, no.	Do.
Do	8-foot diameter by 8 feet high	Temperature, −65° C. to 100° C.; vacuum, 5 x 10^{-9} torr; solar simulation, no.	Do.
Do	8-foot diameter by 7 feet high	Temperature, to −190° C. as a test point; vacuum, 5 x 10^{-9} torr; solar simulation, yes.	Under construction.
Do	12-foot diameter by 15 feet high	Temperature, −65° C. to 100° C.; vacuum, 1 x 10^{-9} torr; solar simulation, yes.	Do.
Do	27-foot diameter by 40 feet high	Temperature, −65° C. to 100° C.; vacuum, 2 x 10^{-9} torr; solar simulation, yes.	Do.
Do	27-foot diameter by 40 feet high	Temperature, −65° C. to 100° C.; vacuum, 6 x 10^{-3} torr; solar simulation, no.	In operation.
Do	10-foot diameter by 15 feet high	Temperature, from −200° C. to +260° C.; vacuum, 10^{-7} torr; solar simulation, yes.	Under construction.
Do	7-foot diameter by 25 feet high	Temperature, none; vacuum, 1 x 10^{-6} torr; solar simulation, no	Do.
Do	13 feet by 7.5 feet by 42 feet	Temperature, ambient to −60° C.; vacuum, none; solar simulation, no	Do.
Do	8-foot diameter by 7 feet high	Temperature, to −200° C.; vacuum, 10^{-4} to 10^{-6} torr; solar simulation, yes	Fiscal year 1964 budget.
Do	40-foot diameter by 30 feet high plus 20-foot hemispherical dome.	Temperature, none; vacuum, 6 x 10^{-3} torr; solar simulation, none	Do.
Jet Propulsion Laboratory	25-foot diameter by 50 feet high	Temperature, to −320° F.; vacuum, 10^{-6} torr; solar simulation, yes	In operation.
Do	7-foot diameter by 14 feet high	Temperature, from −320° F. to +200° F.; vacuum, 10^{-7} torr; solar simulation, no.	Do.
Do	6-foot diameter by 8 feet high	Temperature, −320° F. to +200° F.; vacuum, 10^{-7} torr; solar simulation, no	Do.
Langley Research Center	60-foot sphere	Temperature, none; vacuum, 10^{-1} torr; solar simulation, yes; comments, accommodates 4,000-pound test vehicle.	Under construction.
Do	60-foot diameter by 55 feet high	Temperature, man-rated; vacuum, 10^{-1} torr; solar simulation, no; comments, centrifuge 2,000-pound capacity.	Do.
Do	5½-foot diameter by 6 feet high	Temperature, to −450° F.; vacuum, 5 x 10^{-10} torr; solar simulation, yes	Do.
Do	41-foot sphere	Temperature, none; vacuum, 0.5 torr; solar simulation, no	In operation.
Do	60-foot sphere	Temperature, none; vacuum, 10^{-4} torr; solar simulation, no	Do.
Do	4-foot diameter by 6 feet high	Temperature, none; vacuum, 10^{-2} torr; solar simulation, no	Do.
Do	4-foot diameter by 6 feet high	Temperature, none; vacuum, 10^{-6} torr; solar simulation, no	Do.
Do	5-foot diameter by 10 feet high	Temperature, none; vacuum, 10^{-8} torr; solar simulation, no	Do.
Do	5-foot diameter by 18 feet high	Temperature, −200° F. to +360° F.; vacuum, 10^{-7} torr; solar simulation, no.	Authorized.

Launch Operations Center	31-foot diameter by 42 feet high	Temperature, none; vacuum, 10^{-4} torr; solar simulation, no; comments, top access capable of holding command module and lunar excursion module separately or simultaneously.	Fiscal year 1964 budget.
Do	31-foot diameter by 42 feet high	Temperature, none; vacuum, 10^{-4} torr; solar simulation, no; comments, top access capable of holding command module and lunar excursion module separately or simultaneously.	Do.
Lewis Research Center	100-foot diameter by 122 feet high	Temperature, to −320° F.; vacuum, 10^{-5} torr; solar simulation, no; comments, heavy shielding for nuclear research.	Under construction.
Do	30-foot diameter by 90 feet high	Temperature, none; vacuum, 10^{-6} torr; solar simulation, partial; comments, designed for vertical testing of Centaur.	Do.
Do	50-foot diameter by 60 feet high	Temperature, to −320° F.; vacuum, 10^{-7} torr; solar simulation, partial	In operation.
Do	25-foot diameter by 70 feet high	Temperature, to −320° F.; vacuum, 10^{-7} torr; solar simulation, no	Do.
Do	5-foot diameter by 16 feet high	Temperature, to −320° F.; vacuum, 10^{-6} torr; solar simulation, no	Do.
Do	5-foot diameter by 16 feet high	Temperature, to −320° F.; vacuum, 10^{-6} torr; solar simulation, no	Do.
Do	3.5-foot diameter by 7 feet high	Temperature, to −320° F.; vacuum, 10^{-6} torr; solar simulation, no	Do.
Do	6-foot diameter by 9 feet high	Temperature, to −450° F.; vacuum, 10^{-13} torr; solar simulation, yes	Do.
Do	5-foot diameter by 16 feet high	Temperature, none; vacuum, 10^{-6} torr; solar simulation, none	Do.
Do	8-foot diameter by 18 feet high	Temperature, none; vacuum, 10^{-3} torr; solar simulation, no; comments, to be equipped for liquid metal space radiation testing.	Authorized.
Do	3.5-foot diameter by 10 feet high	Temperature, none; vacuum, 10^{-6} torr; solar simulation no; comments, electronic beam welding and corrosion test preparation.	In operation.
Do	40-foot diameter by 100 feet long	Temperature, to −320° F; vacuum, 10^{-6} torr; solar simulation, partial; comments, exhaust pumping for chemical rocket firing.	Fiscal year 1964 budget.
Do	22-foot diameter by 50 feet long	Temperature, to −320° F for nitrogen cooling, to −453° F for helium cooling, vacuum, 10^{-8} torr; solar simulation, yes; comments, extended space soak and firing of 45,000-pound thrust rockets.	Do.
Do	20-foot diameter by 400 feet high	Temperature, ambient; vacuum, 10^{-3} torr; solar simulation, none; comments, vacuum used to reduce drag of dropped model to obtain zero g.	Do.
Do	65-foot diameter by 12 feet high	Temperature, to −320° F.; vacuum, 10^{-6} torr; solar simulation, yes; comments, has high voltage power sources for electromagnetic generator testing.	Do.
Do	4-foot diameter by 8 feet high	Temperature, to −320° F.; vacuum, 10^{-5} torr; solar simulation, partial; comments, for liquid metal instrumentation research.	Do.
Do	----do----	Temperature, to −320° F.; vacuum, 10^{-8} torr; solar simulation, partial; comments, for liquid metal instrumentation research.	Do.
Manned Spacecraft Center	65-foot diameter by 117 feet high	Temperature, man rated: vacuum, 10^{-5} torr; solar simulation, yes	Authorized.
Do	35-foot diameter by 45 feet high	Temperature, man rated; vacuum, 10^{-4} torr; solar simulation, yes	Do.
Do	6-foot diameter sphere	Temperature, none· vacuum, from 10^{-12} to 10^{-15} torr; solar simulation, yes	Fiscal year 1964 budget.
Marshall Space Flight Center	7-foot by 8 feet by 10 feet	Temperature, range from −100° F. to +350° F.; vacuum, altitude simulator to 200,000 feet; solar simulation, no.	In operation.
Do	6-foot diameter by 9 feet high	Temperature, from −150° F. to +259° F.; vacuum, 1 x 10^{-9} torr; solar simulation, no.	Do.

Mr. KARTH. We have two requests for facilities of this kind at Houston Spacecraft Center, in other words?

Mr. ULMER. Yes.

Mr. KARTH. Seems to me we had a request in for one at Ames.

Probably one for Langley and one for Goddard. That's about five.

Mr. ULMER. I think you will find this type of facilities at all the NASA centers, varying in size from the small type "bell jar" facility up to the large sizes you have been discussing here.

These facilities are in some ways the replacements for the wind tunnels you have known for so many years.

In fact, some people call them the "windless tunnels." They are the new tools of the trade in the space business.

I'd like to supplement what Mr. Cortright said about reviewing the need for these facilities.

There is an annual formal review of the facility budget proposals of the Department of Defense and NASA. This is done formally by a group from DOD and a group from NASA that sit down and review each facility proposed to be submitted in the budget to determine whether or not there is any duplication, or whether one facility could serve the purposes of both agencies. This is done very carefully and thoroughly and a report is issued.

Mr. KARTH. When a private contractor builds a facility of this kind, he generally tests a great many different vehicles, does he not?

He doesn't build one for every type of vehicle that he's under contract with NASA for, does he?

Mr. CORTRIGHT. He normally builds a general-purpose facility, but the impetus can be in two forms.

One, to be able to have an advantage over a competitor in bidding on a particular spacecraft. He can say, "I have this much equipment on hand and I'll be ready to do this much more testing earlier with company sponsored facilities."

I'd like to reemphasize that we cannot normally turn over to some contractor our final acceptance and check-out responsibility. This is a very grave responsibility, and we feel that in a great majority of our cases it should remain within the Government.

We don't insist on this in all cases. Sometimes we do make an arrangement with the contractor if the facility is developed to support a specific project such as the Surveyor. But where they have general purpose facilities, they just are not always suitable, without major modification, to do this final acceptance testing. If we were to attempt to use them it would be a severe handicap to performing good final testing in terms of dislocation of check-out gear and people. It isn't an efficient way to operate.

Incidentally, during the wind-tunnel days, there were a number of companies that saw fit to invest in their own wind tunnel rather than to make use of Government-owned wind tunnels and this worked out, more or less, successfully, depending on the particular instance.

The Government wind tunnels were always completely occupied both with Government research and with Government contractors.

Mr. MOSHER. Mr. Chairman?

Mr. KARTH. Mr. Mosher.

Mr. MOSHER. Are organizations such as the Cornell Laboratories in Buffalo building their own tanks nowadays?

Aren't they an example of an outfit that handled the wind tunnel at one time? Are they going to this new type of instrument?

Mr. CORTRIGHT. I don't think they have gone to any large vacuum facility.

Mr. ULMER. I am inclined to agree that they have not gone into the large vacuum facilities. At least, I am not aware of it.

Mr. CORTRIGHT. The fundamental science can be done in small chambers, usually. The checking of flight hardware simply cannot.

Mr. KARTH. The only thing we are trying to ascertain, I guess, Mr. Cortright, is whether or not we need to go first class all the time. I guess we could really boil it down to that.

Mr. CORTRIGHT. It is a general concern.

Mr. KARTH. I am sure everyone has the same desire, and that is to have the shiniest and newest piece of equipment to do the most modern type job that can possibly be done.

There are some, on the other hand, that feel that there may be ways that this can be done, that we really don't need to travel quite as first class as we'd like to and where the outcome would be substantially the same. If there's any possibility that this can be done without us traveling first class, this subcommittee would certainly urge the Office of Space Sciences, and the NASA centers for that matter, to take a real careful look at it.

I notice we need roughly five and a half million dollars for a data interpretation laboratory. Would you care to explain that requirement and tell why it's going to cost five and a half million dollars?

Mr. CORTRIGHT. The Data Interpretation Laboratory is designed to pull together, under one roof, some very important functions that go along with our advanced spacecraft.

The spacecraft and its mission require an integral data system which is highly complex. It involves first obtaining data, then conditioning the data within the spacecraft in a manner in which it can be transmitted.

It further involves data acquisition stations which are all over the world; the data transmission lines from those acquisition stations to Goddard; the electronic computer systems which take data and reduce it rapidly. I might point out that in the case of Mariner JPL set a fine example in being able to reduce data and supply it to the experimenters, sometimes within 20 minutes of receipt from Venus. This was only possible through a great deal of planning in advance.

The people who now do this work at Goddard are scattered in various locations, and the data flow has outgrown the capability of the equipment to handle it.

What we are doing here is pulling them together into an efficient space.

Now the space that they will vacate in turn will be utilized to house people as a part of this continuing growth of Goddard.

If we are to continue to support the growth of Goddard, and I think this year the requested increase in personnel allowance for Goddard is from 3,200 to 3,700, we have to house the staff. So, we are building facilities which mesh in with prior facilities in such a way to result in an optimum laboratory when it's all done. This is one such facility.

Colonel GOULD. Is it intended to carry on any electronic research in this facility?

Mr. CORTRIGHT. That's a question I'm not certain I can answer, positively. I think the answer is "Yes" only in the sense the research part of this activity deals with the design and layout of advanced data handling systems for second generation spacecraft. It's not electronic research in the sense I think you are using the words.

Colonel GOULD. I picked this out of your justification. This is why I was asking you the question. What is the relationship between this proposed facility and the tracking laboratory that was authorized in the fiscal year 1963.

Mr. CORTRIGHT. Can you describe that, Mr. Taylor?

Mr. TAYLOR. These two laboratories are actually complementary. The tracking laboratory that was previously authorized now houses data processing, analysis, and reduction function for the Goddard Center.

Just for example, there are two IBM 7090 computers tied in with the Mercury operation.

Now this building is very crowded at this point.

I don't have the exact numbers, but there are upwards to 100 or 150 over the design capacity for this building.

A segment of the people that are now in the tracking and telemetry laboratory will move to this new facility.

Also, people engaged in data processing effort who are located in rental housing will move to this new laboratory.

In this respect these two facilities are complementary.

Colonel GOULD. If this facility were not built, what impact would this have on the program at Goddard?

Mr. TAYLOR. I think one way to answer that would be in terms of housing people.

We would be forced to continue the inefficient location of people in rental space and overcrowding the facilities that now exist.

Also, concomitant to the housing problem is the requirement for additional computing equipment which will require space to house it.

Colonel GOULD. If you don't have the information on this next question, I wish you would provide it for the record, please.

Certain of the justification of projects at Goddard indicate that we will be releasing leased space. In the fiscal year 1963 program Congress authorized $23.7 million for facilities, many of which were intended to release leased space. In addition to this, NASA reprogramed $1.4 million for four multipurpose buildings, not previously authorized by Congress out of fiscal year 1963 funds.

Also I understand, you intended to relinquish leased space. Can you tell us how many square feet of space you are presently leasing offsite, what the annual cost of this is, and how much of this leased space will be released as a result of the fiscal year 1963 items now authorized and under construction at the Center?

Do you have that information?

Dr. NEWELL. We will have to supply that for the record.

(The material referred to is as follows:)

The Goddard Space Flight Center is leasing 145,000 square feet of off-laboratory space at an annual rental cost of $234,000. Personnel growth at this laboratory has increased at such a rate that the construction of facilities program for fiscal year 1963 and for fiscal year 1964 will not release any leased space.

Colonel GOULD. It's a little difficult to pull this out of your justification for the record.

Mr. KARTH. I see we have an $800,000 request for hazardous-test facilities.

I wonder if you could tell me how different that is from the mechanical test facilities which Congress is being requested to provide $6 million for? How different from other test facilities already on location?

Mr. CORTRIGHT. Should we put that slide up again?

Mr. KARTH. If you would, please (fig. 82, p. 1842).

Mr. CORTRIGHT. It is a completely different facility.

The one is at a remote location designed to handle radioactive sources with which we can expose spacecraft to simulated radiation, and also designed to permit us to check out the functioning of pyrotechnic devices such as shaped plastic charges to blow out panels——

Mr. KARTH. This is which one on the chart there, Mr. Cortright?

Mr. CORTRIGHT. The lower right is the isolated hazardous test facility.

Mr. KARTH. OK, and then the modernization of the payload test facility—I see that's two and a half million dollars.

I wonder if you can explain what we mean by "modernization," and how old is the payload test facility that we are going to modernize.

Mr. CORTRIGHT. The payload test facility we are going to modernize is quite new, actually. Simply stated, we are learning faster than our equipment can keep up with us.

The modernization includes a solar simulator for an existing 12- by 15-foot thermal-vacuum chamber.

Mr. KARTH. Pardon me?

Mr. CORTRIGHT. A solar simulator.

This is a combination of light sources which can duplicate the intensity and the light at distances ranging to Venus to something outside of Mars.

In addition, we must now accommodate spacecraft which carry 20 to 50 experiments such as the OGO.

Now, when these spacecraft are in thermal-vacuum test the experimenters have to monitor the functioning of their experiments. This requires more accessory equipment than we now have in support of our vacuum chambers.

Mr. KARTH. When was the payload test facility completed?

Mr. CORTRIGHT. We are discussing two things here. The payload test facility was completed about a year ago. The environmental chambers which are attached to this facility were only recently completed.

Mr. KARTH. Certainly OGO was well along the road of being an established part of our program at that time; wasn't it?

Mr. CORTRIGHT. I'm checking one point here to be sure. The two vacuum chambers without solar simulation were accepted this year.

Mr. KARTH. Pardon?

Mr. CORTRIGHT. There are two tanks that were just accepted.

I believe you saw these tanks on your visit to Goddard, Mr. Chairman.

They were the large ones, and they probably were under construction when you were there.

Yes, the OGO was under contract at the time these tanks were put under contract, and the timing is such that we are going to be able to use the tanks for the OGO.

When you don't have a solar simulator of the type you should have and need, you make do with something else.

You can do this by electric blankets or with batteries of lights within the tank on a temporary basis.

It's not too good. It gets us into trouble like we got into with the Mariner.

Mr. KARTH. Well, now, your payload test facility does what, essentially?

What is it?

What does it do the mechanical test facilities don't do or the quality assurance laboratory doesn't do?

Just so we have it for the record.

Mr. CORTRIGHT. The two large environmental chambers are for advanced spacecraft testing under accurate thermal-vacuum conditions of outer space. One of these previously authorized chambers will have solar simulation.

This means there is an artificial sun in the tank.

The walls are cryogenically cooled down to temperatures simulating the background temperatures of the outer space.

Mr. KARTH. This facility was originally built for these programs; wasn't it? To test the hardware pieces; wasn't it?

Mr. CORTRIGHT. Yes. You are asking——

Mr. KARTH. We just underestimated its need; is that right?

Mr. CORTRIGHT. I think what you are asking now is why do we need the solar simulator when the tank was fabricated without it? We will have solar simulation in one of the previously authorized large chambers. However, there is a need for solar simulation for component and systems testing and that is why we are requesting this capability for the 12-by-15-foot chamber.

Mr. KARTH. It's probably costing more to do it now than if we'd done it originally?

Mr. CORTRIGHT. Not necessarily.

The reason I answer it that way is that every company in the country with which I am familiar, that has been trying to develop solar simulators, has had trouble, including ourselves and our contractors. I think bringing this simulator along now will enable us to get a good one that will work the first time by drawing on prior experience.

Mr. KARTH. Are there similar solar simulators?

Mr. CORTRIGHT. Yes, Space Technology Laboratories has one in their tank.

Grumman has one.

Hughes will have one, and I think General Electric has one.

They all have had trouble.

Mr. KARTH. Couldn't we contract for the use of one of these if and when we needed it?

Mr. CORTRIGHT. Well, the point is, Mr. Chairman, we have, as the loading schedule I am going to submit for the record will show, continuous use for this tank with a simulator, not without.

In addition, the contractors' tanks by and large are being used although in some cases not as heavily as the contractor would like to see them used.

That is not untypical for contractors who make speculative investments.

We use them when we need them.

Colonel GOULD. Why couldn't the solar simulator at JPL be used to meet your schedule for the Ranger and Mariner?

Mr. CORTRIGHT. As I said, we are quite concerned with its loading, and I think we will have to build another tank.

Colonel GOULD. I notice in your cost estimate that no allowance for engineering service and design has been included for this facility. Has the design been completed?

Mr. ULMER. It may very well be, or we may be using a modification of an existing design.

Normally where you do not see an estimate for design in the budget year, advanced design funds have been allocated in the previous year.

Colonel GOULD. How are you going to cover the cost of supervision of the construction?

Mr. ULMER. This would be a case where it would be handled by our inhouse staff as I discussed in response to Mr. Karth's previous question. If it were to be handled by the corps, funding would have been requested for that purpose in the construction project.

Colonel GOULD. Mr. Chairman, I would like to go back to the project for the "Hazardous testing facilities," $800,000. As part of the fiscal year 1962 program, the Congress authorized the construction of Isolation Laboratory facilities at a cost of $755,000. According to the NASA status reports, this project was canceled at a later date. Does this request reinstate the original requirement for these facilities?

Mr. CORTRIGHT. You have that answer?

Mr. TAYLOR. No, these facilities are not identical.

The original concept of an isolation facility was merely to test pyrotechnics in a single building off the laboratory.

The concept embodied here is to test by arranging your structure so they will be correct, in terms of safety, not only the pyrotechnic devices but also radioactive sources and other chemical testing.

It's a more comprehensive facility than the one previously planned.

Colonel GOULD. The justification, however, that was presented in the record for the fiscal year 1962 item was very, very similar to what you are presenting here.

If this project was previously authorized by Congress despite a limited change in scope, why do we need new authorization this year?

Mr. ULMER. Well, Colonel, if there is no scope change in the project and if the authorization were still in existence, we would not be requesting a new authorization if funds were available for application against that authorization.

Colonel GOULD. Could you more clearly define the nature of the change in scope? You covered it rather generally.

Mr. KARTH. Was money appropriated for a $750,000 facility?

Was money ever appropriated? Where is it?

Mr. ULMER. It's been reprogramed.

Mr. KARTH. So, it's been spent.

Mr. ULMER. It was used for other purposes, yes, sir.

Mr. KARTH. Now before you can ask for an appropriation for a $800,000 facility, even though it would be identical, you have to get renewed authorization?

Mr. ULMER. In this case we would, yes, because we used the reprograming authority to apply the authorization for the Isolation Laboratory to two other new projects of higher priority.

Mr. ULMER. We can check the technical characteristics of the one in this budget with the one previously approved.

Colonel GOULD. Would you do so?

Mr. ULMER. We will do so.

(The information referred to is as follows:)

The fiscal year 1962 and 1964 isolation labs are essentially the same except for design and the fact that the 1964 project provides for radiation storage and exposure capabilities. The need for these increased capabilities resulted from requirements generated by the Van Allen belt effect, and the need for studies to replace solar cells with nuclear power supplies.

Mr. CORTRIGHT. I suspect you are correct. The work with radioactive substances would be different but this would not make great differences in the cost.

Colonel GOULD. Your justification states that existing facilities are inadequate at the present time.

How are you meeting this requirement now?

Mr. CORTRIGHT. To the best of my knowledge we are not making tests on the radiation damage, except on very small laboratory samples.

On the pyrotechnics—I can't answer that question. I don't know. I can certainly get the answer in short order.

Colonel GOULD. Are there not facilities at Plum Brook, for example, that could be used to carry on these hazardous tests?

Mr. CORTRIGHT. Colonel, there are many places around the country where you could ship a spacecraft and explode some pyrotechnics without hazard to people.

For example, at the Lewis Research Center in Cleveland, we have bunkers to protect operators from solid-propellant rockets.

The point is, Goddard is where we are building and testing these spacecraft, and that's why we need the facility there.

It would not be sensible to ship a complex spacecraft halfway across the country or wherever it might be and conduct these tests and bring it back.

This is a rather nominal facility, and I think the people developing the system should have it.

Mr. KARTH. Why was it canceled in 1962?

Did you have a change of heart, or did you need the money someplace else worse?

Mr. ULMER. I'd like to check the record.

I'm sure it was involved with new projects having higher priority.

Mr. KARTH. Suppose you do that?

Mr. ULMER. Notification letters were sent to the Congress explaining the need for the reprograming. I will supply the complete story for the record.

(The information referred to is as follows:)

Subsequent to enactment of the fiscal year 1962 authorization and appropriation acts it became apparent that requirements at the Goddard Space Flight Center for a magnetic fields component test facility and an antenna test range had advanced in importance to the extent that they were currently of a higher relative priority than the isolation laboratory approved in the 1962 program. The magnetic fields component test facility was required to permit better evaluation of magnetic instruments and the magnetic characteristics of small scientific spacecraft than was currently possible. The antenna test range was required for conducting research and development on antennas and their associate components. On December 13, 1961, the Administrator determined that the repro-

graming of fiscal year 1962 CoF funds to permit the construction of a magnetic fields component test facility and an antenna test range at the Goddard Space Flight Center was necessary because of changes in the national program of aeronautical and space activities and that deferral of such action until the next authorization act would be inconsistent with the interest of the Nation in aeronautical and space activities.

Pursuant to the reprograming authority authorized by section 3 of Public Law 87-98, funds for the isolation laboratory were reprogramed to assist in the funding of the magnetic fields component test facility and the antenna test range with the understanding that hazardous testing facilities similar to those proposed in the isolation laboratory would be requested in a subsequent budget. Notification letters regarding this reprograming action were submitted to the Congress on January 2, 1962.

Mr. KARTH. Anything in your list of requests this year that might be considered of a lower priority than something else so we might not have to appropriate the money for it?

Mr. ULMER. I know of none now.

We will have program changes in the coming year.

That is why the programing authority you have provided us has been so very helpful.

Mr. KARTH. If you do have some necessary changes where funds would have to be provided, which one would be your high priority item—would you probably take money from it to put it somewhere else?

Mr. ULMER. I do not have the Center priority list with me.

Mr. KARTH. Dr. Newell, you care to speculate on that a little bit?

Dr. NEWELL. We consider them all important.

I suppose if we didn't get all the money we'd have to order them and that would require a reevaluation——

Mr. CORTRIGHT. As I pointed out——

Mr. KARTH. Would you repeat that?

I'm not sure I understood.

Mr. CORTRIGHT. Yes.

We have not placed these in order of priority at this time, because these are the facilities which we considered essential. Among all the facilities that we considered that would help the program these are the ones which we believe are essential.

My final statement was, were these to be denied, we would then have to go back and examine the total facilities and see how to cope with it.

Mr. KARTH. But your authorizations last year were essential; weren't they?

Mr. CORTRIGHT. Yes, but changes came up in the year that caused us to reprogram.

Mr. KARTH. That is the reason for my question today.

Assuming history will repeat itself and we will probably appropriate funds in the coming year, what areas would we take them from?

Mr. CORTRIGHT. I'm sure it will come out of someone else's facilities, Mr. Chairman.

Mr. KARTH. Let the record so note.

Mr. CORTRIGHT. I should have said, "I hope."

I don't really know the answer to your question.

Mr. STAEBLER. Mr. Chairman, would it give us any notion of the thinking of NASA, if we were told some of the items that had been deferred in the decision to select these?

Can you tell us what some of these items are?

Mr. CORTRIGHT. Only the fiscal year 1962, isolation laboratory at Goddard Space Flight Center authorized by the committee was deferred.

Mr. STAEBLER. I think we are all puzzled by the question here and these all appear to be essential, and yet, when the following year comes around it turns out some of them weren't essential.

How can we tell?

Mr. KARTH. It merely turns out some were less essential.

Mr. CORTRIGHT. Some were less essential in terms of emergencies that came up during the year.

Dr. WEAVER. Dr. Newell, you have a total here of twenty-five and a half million dollars.

If you were told you had to get by on $20 million, what effect would you say this would have on the total space sciences program?

Dr. NEWELL. Well, we would have to review the total program, both R. & D. facilities and the R. & D. program, to go ahead with the facilities if we somehow or other could find the funding for it.

Dr. WEAVER. Would you feel handicapped?

Dr. NEWELL. Yes.

These are essential facilities of carrying on the program with the quality and viability and assurance for success we feel is necessary for the total program.

Dr. WEAVER. You would feel you would be definitely slowed down in your accomplishments?

Dr. NEWELL. It would be definitely slowed down because we have an ongoing program that relies on these things and the reliability of our spacecraft—the success rate of our spacecraft—would be affected.

Mr. CORTRIGHT. Also the housing problem. We have planned growth of personnel in the Centers to handle the projects we have undertaken or are starting, and if we don't provide office space for them we simply can't hire them, or we would have to hire them and put them into rental facilities.

Dr. WEAVER. If you cut each item 20 percent and still had your original basic items there, how badly would that affect you, rather than eliminating one item for another?

Mr. CORTRIGHT. Each one?

Dr. WEAVER. Each item you included in space sciences, construction——

Mr. CORTRIGHT. So much per construction?

Dr. WEAVER. For each of the facilities, yes.

Mr. CORTRIGHT. In some facilities you simply can't do that.

It would make more sense to drop the whole facility and keep one or two at the design values.

There are certain minimums.

I can't really answer that.

Dr. WEAVER. It's an unfair question, but at the same time, I wonder if you could cut each of these 15 percent, 20 percent and still carry on the basic effort you want, through that construction facility?

Mr. KARTH. I'd just like to point out to the gentlemen, usually we have had the reverse experience. If an estimate is for five and a half million dollars, usually it costs us approximately eight and a half to get the facility the NASA people made the design for.

Dr. Newell, or Mr. Cortright—the utility installation project, two and a half million dollars, what is this utility installation?

Mr. CORTRIGHT. I'd like Mr. Taylor to discuss that.

Mr. TAYLOR. Let me point out first the concept here. In each of the facilities projects that are presented, you will find a request for water lines, steam lines, and other utility items.

The concept is that each facility will provide the utilities which are unique to that building and the connecting links for control utilities.

It isn't practical in a total laboratory sense, say, to design power for a given facility. So, what we attempt to do in every instance is to provide central power, central heating, central water, air conditioning, et cetera.

This request is to supplement our utility system for fiscal year 1964 construction.

Mr. KARTH. Could you explain more thoroughly just exactly what that is?

In the first instance you build the powerplant large enough to take care of future needs, I suppose, for expansion.

Every time we authorize any new facilities we also have to increase utility installations. Why is that?

You talking about digging the trench between the main source of supply and the facility or what are you talking about.

Mr. CORTRIGHT. There is more.

Mr. KARTH. Will you itemize what you are talking about?

Mr. CORTRIGHT. I would like to read from the description of this project.

Mr. KARTH. Yes.

Mr. CORTRIGHT. Proposed to expand the utility installations to include in addition to the central heating and refrigeration plant the installation of 4,000 tons of refrigeration insulation, 33 pounds per hour steam generating boiler in the new addition, the installation of site-chilled-water lines and installation of gas mains.

In addition to run present 33-kilowatt line underground, from the present main substation westward to the perimeter fence, and the justification for this is also described at the bottom of the page and we can read through that if you choose.

Mr. KARTH. Really, you are providing your own air conditioning and heating and generating system for the new facility?

Mr. ULMER. Augmentation of the existing installations.

Mr. KARTH. You are calling them an augmentation of the existing facility. Is that correct?

Mr. ULMER. The costs could have been prorated among the several new facilities.

We thought it made a clearer picture this way.

Mr. KARTH. If we authorized the facilities we are talking about, and cut out the utilities, you'd melt in the summer and freeze to death in the wintertime.

Mr. ULMER. We'd be in a pretty difficult situation, yes.

Colonel GOULD. On the extensions of electrical feeders to new building sites, are the existing overhead feeders adequate to meet the additional new connected load?

Mr. ULMER. Yes. We are proposing, however, to route some of the existing overhead feeders underground.

Colonel GOULD. I noticed in the utilities project an amount, $730,000 for a new highway interchange over the Baltimore-Washington Parkway. Has the Bureau of Public Roads conducted an independent study of this requirement?

Mr. ULMER. It is my understanding they concur fully in this requirement.

Colonel GOULD. Have they published a report?

Mr. ULMER. I'd like to check that and supply the information for the record.

Colonel GOULD. Based on your preliminary discussions with Bureau of Public Roads, what will the Bureau contribute to this new interchange so far as effort and funds are concerned?

Mr. ULMER. I do not have that information here and I hesitate to give you an off-the-cuff answer. I'd like to supply the answer for the record.

This interchange at Goddard has been under discussion for a year and a half.

Colonel GOULD. Would you supply it for the record, please?

(The information referred to is as follows:)

ROAD INTERCHANGE, GODDARD SPACE FLIGHT CENTER

NASA will fund full cost of the proposed interchange from the Washington-Baltimore Parkway to the Goddard Space Flight Center. This is in accordance with the report of the Bureau of Public Roads dated March 30, 1961, attached, which was based upon a study of Washington-Baltimore interchange problems made by the Bureau. (This report also covers a study of traffic conditions on Glendale Road east of the parkway, and improvements to this road are now underway by NASA together with the State, the county, the U.S. National Park Service and the Bureau of Public Roads.)

As indicated in the report, the separate interchange for NASA traffic, plan 2, is estimated to cost $522,000. This figure covers only the construction of the interchange. The complete road interchange project, included in the utility installations project for Goddard Space Flight Center in the proposed budget, is estimated to cost $750,000. The $750,000 estimate includes the interchange itself ($522,000); the extension of the road across a portion of the Agriculture Research Center and within the confines of Goddard to connect with the existing Goddard internal road system; and all necessary drainage structures.

MARCH 30, 1961.

From: Bureau of Public Roads, Mr. August Schofer, regional engineer, Hagerstown, Md.

To: Bureau of Public Roads, E. F. Gleason, division engineer, Baltimore, Md.

Subject: Maryland, defense access roads, Goddard Space Flight Center, Glendale Road, Prince Georges County.

In compliance with a memorandum from Mr. Paul F. Royster, Assistant Commissioner for Operations, dated October 5, 1960, endorsed by the regional engineer, the following report on access roads needs for the subject installation, a facility of the National Aeronautics and Space Administration, is submitted.

On November 10, 1960, we met Mr. Philip Miller of NASA, and later the same day discussed these matters with Mr. John Marburger, director of public works of Prince Georges County, and talked briefly with the chairman of the county commissioners.

We submitted a report to the regional engineer dated November 15, 1960, making certain recommendations for the improvement of Glendale Road. The regional engineer requested further study of the existing interchange between Glendale Road and the Baltimore-Washington Parkway. This study required more factual information on NASA generated traffic than we had been able to obtain verbally and in correspondence from NASA. On February 8, 1961, NASA furnished us the listing of some 1,157 employee addresses which was stated to be approximately 40 percent of their anticipated full employment. We assigned these employees to corridors by judgment and transmitted the list to our regional

office. We understand the District of Columbia will use this list and supplement it with other information to provide more precise traffic assignment in the vicinity of the Glendale Road interchange. Traffic shown in this report is the latest State roads commission assignments for design hour developed without consideration of NASA and NASA traffic developed by this office from the list of addresses furnished.

1. LOCATION

The Goddard Space Flight Center is located on the north side of Glendale Road. The main entrance is approximately 1.6 miles east of the Baltimore-Washington Parkway.

2. EXISTING FACILITIES

The existing interchange at Glendale Road and the Baltimore-Washington Parkway is under contract for reconstruction, placing all movements in the two north quadrants; included in this contract is the dualization of Greenbelt Road from Kenilworth Avenue (SR-205) to the west side of the bridge carrying Glendale Road over the Baltimore-Washington Parkway. This bridge, owned and maintained by the Department of Interior, provides a 30-foot-surface width.

Glendale Road from east of this bridge to Telegraph Road, 2.75 miles, is a 20-foot macadam pavement with narrow 2- to 4-foot shoulders in fair to poor condition. Sight distance is poor due to a combination of short horizontal and vertical curves. Safe speed is approximately 40 miles per hour.

Telegraph Road is 16- by 18-foot surface treatment with 4-foot shoulders.

The Baltimore-Washington Parkway provides two 24-foot pavements separated by a 40-foot median at the Glendale Road bridge with 10-foot shoulders to face of abutment. A center pier is in the median.

The Capital Beltway *proposed* is located approximately 2,000 feet south of the Glendale Road bridge. A full cloverleaf interchange with the Baltimore-Washington Parkway is proposed. The outer connections to the north provide barely enough acceleration and deceleration length before entering the Glendale Road bridge.

3. TRAFFIC

DHV (1975) not including NASA traffic and NASA a.m. and p.m. peaks (at 70 percent of stated NASA full employment) are shown separately on the attached map. These two volumes will be cumulative to some degree. It appears NASA peak at the Glendale Road interchange may occur later in the morning and earlier in the evening than the DHV. NASA peaks will occur at 7:30 to 8 a.m. and at 4:30 to 5 p.m.

It will be noted from the traffic map that certain movements will experience considerable difficulty:

(1) Weaving from the northeast outer connection of the Capital Beltway with movements to the northeast inner loop of the Glendale Road interchange.

(2) Merging from the southwest inner loop of the Glendale interchange on the Baltimore-Washington Parkway.

(3) Left turns on Glendale Road and Southway.

(4) Volumes across the two-lane Glendale Road bridge.

It is also to be noted that NASA volumes will be concentrated in a half-hour period, resulting in maximum lane density and exceeding possible lane capacity. In this connection staggering working hours to the degree commensurate with working efficiency will provide considerable improvement in traffic conditions on the related facilities.

4. PROPOSED IMPROVEMENTS

NASA approached Prince Georges County some months ago and requested improvement of Glendale Road. They formally offered a contribution of $200,000 and 60 feet of right-of-way along their property. The county commissioners had already recognized the desirability of improving Glendale Road, and engineering was underway. Plans are being prepared for dual 24-foot pavements with 10-foot shoulders separated by a 16-foot median on a 120-foot right-of-way from the east side of the Baltimore-Washington Parkway to Telegraph Road for a distance of 2.55 miles at a rough preliminary estimate of $750,000. It was the feeling of the director of public works that initial construction would grade and drain four lanes and pave two lanes. The ultimate section would await the development of the land south of Glendale Road at which time the

developer would be asked to pay for certain roadside items of drainage and curb that were required by his development.

The chairman of the county commissioners on November 10, 1960, strongly felt that the NASA contribution was inadequate. He said initially the contribution should be 100 percent but after some discussion implied that $350,000 would be acceptable.

There is no consideration by either State or county to widen the Glendale Road bridge to a dual facility. We consider this a necessary improvement and will include it in our recommendations. At the present time it appears the owners of this bridge, the U.S. Department of the Interior, has prime responsibility to provide the improvement.

Considerable study of the interchange problems has been made by the urban highway division of the Washington office and by the Maryland division office. Two schemes are worthy of consideration:

Plan 1

A collector-distributor system through the proposed Capital Beltway interchange and existing Glendale Road interchange. Estimated cost, $650,000.

Plan 2

A separate interchange north of Glendale Road providing direct connection to and from the south on the Baltimore-Washington Parkway to the NASA site. Estimated cost, $522,000.

These plans do not include the cost of the reconstruction of Glendale which is the immediate improvement requested by NASA.

5. RECOMMENDATIONS

We recommend the immediate improvement of Glendale Road for two lanes of an ultimate dual highway from the east side of the interchange with the Baltimore-Washington Parkway to the USDA Road for a distance of 2.1 miles. We recommend further that dualization through the Glendale Road interchange and the construction of a dual bridge across the Baltimore-Washington Parkway when the county dualizes Glendale Road east of the Baltimore-Washington Parkway. We recommend plan No. 2, a separate interchange for NASA traffic north of Glendale Road be considered when anticipated traffic at the Glendale Road interchange approaches possible capacity.

6. COSTS

(*a*) Immediate first stage: Glendale Road, 2.1 miles; 24-foot high-type pavement with 10-foot shoulders; grade for a dual highway with a 16-foot median, total estimated cost, $400,000.

(*b*) Second stage: County portion, Glendale Road, 2.1 miles; complete dualization; estimated cost, $200,000: Federal portion through interchange and Glendale Road Bridge; estimated cost, $300,000.

(*c*) Ultimate costs: Separate interchange for NASA to and from provide movements from south north of Glendale Road; estimated cost, $522,000.

Total cost, $1,422,000.

7. FINANCING

(*a*) 1st stage, access roads project:	
NASA contribution	$200,000
Federal-aid secondary funds	100,000
County share	100,000
Total	400,000
(*b*) 2d stage:	
Federal-aid secondary funds	100,000
County share	100,000
U.S. National Park Service	300,000
Total	500,000
(*c*) Ultimate: Separate interchange for NASA	522,000

Colonel GOULD. I note the addition to the power plant building is $25 a square foot, as is also the cost per square foot for the Meteorological Systems Development Laboratory. Isn't this rather unusual?

Mr. ULMER. It depends on what a square foot cost includes.

The costs per square foot we show are for the basic building, its internal normal utility systems, but not including the equipment that will go into that building. In one case we are building a structure to house a boiler or air-conditioning equipment. It might cost the same as one in which we will put desks, chairs, and laboratory equipment. It's a matter of examining the building design. A lot depends on the ceiling height of the structure. Comparisons using only square-foot costs can be misleading.

Mr. KARTH. Going to the Jet Propulsion Laboratory you will find there is a million-dollar cost for the addition of space flight operations facility. I wonder if you could explain the reason why this addition is necessary and when that space flight operation facility that we are expanding was completed.

Mr. CORTRIGHT. I am glad you asked that question because this is a very important facility and a very meaningful one in many ways.

When we land our spacecraft on the Moon or place them in orbit, the experimentation has just begun and we have to mother them throughout their lives. We have to take their temperatures, see if a left arm is broken, tell them what to do to complete their missions.

In the case of Surveyor it's even more complex on the part of the earthbound equipment. In order to simplify the Surveyor it only does what it's told when it lands on the Moon. It is, in fact, operated from Earth much in the same manner as a derrick is operated by an operator sitting right in it.

The scientists can choose what sample is taken, when it's taken, and how it's analyzed. On the basis of contingencies met on the lunar surface, the planned operation of the spacecraft can be modified.

Now, we are going to be flying Rangers and Surveyors and Mariners and even Pioneers for different purposes in this program during the same time period.

What we've tried to design here is a control center which can cope with the various systems during concurrent operation.

We need enough space to provide control rooms and consoles for the operators and scientists who command the spacecraft. We also have a limited number of others available in this facility for the scientist to stay there and help diagnose the experiments with the scientific equipment.

So, the addition is designed to supplement the capacity of the original building to fit the current program. The original building was designed a little bit too small.

Mr. KARTH. Is it completed?

Mr. CORTRIGHT. It is not complete.

Mr. KARTH. I see. How about the area of development—engineering?

Is this a new bidding request?

Mr. CORTRIGHT. Yes.

Mr. KARTH. What is the purpose of the building?

Mr. CORTRIGHT. To provide project labs, machine shops, and a high bay development area.

Essentially it will take the necessary elements of engineering mechanics, which is one of the operating divisions of JPL, and pull these together in a single facility.

This has a twofold purpose. One, to bring the division together and also to provide standard rather than substandard housing.

As you are aware, at JPL we have a rat's nest of old facilities which should be eliminated. The square footage allowed per employe is too small. We are trying to make a laboratory out of it and get rid of some of the inadequate facilities such as the 189 trailers which we now have out there.

Does that answer your question?

Mr. KARTH. Yes, sir.

Colonel GOULD. In the fiscal year 1963 program Congress authorized an engineering mechanics building in the amount of $3,045,000. According to the NASA construction status report three other buildings were substituted for the mechanics building; namely, a space science lab, an addition to the physical science lab, and an applied science lab.

If I'm not mistaken, the justification in the 1963 program indicated this building was to accommodate the Engineering Mechanics Division of JPL. Is this correct?

Mr. ULMER. I would have to check my records on that. There was a change authorized in the 1963 program.

A careful review was made and it was determined that it would be more efficient to provide the authorized space by the additions of the three buildings you mentioned in lieu of constructing a single building.

I am afraid we are getting in some difficulty from the titles of these facilities.

It might be better if we used building numbers. We sometimes unnecessarily confuse you and ourselves in the terminology we use here.

We feel the change made in 1963 was not a scope change, as such. It was just a different manner of providing the building space the Congress had approved.

Mr. KARTH. The only thing I am trying to bring out is that I think it was qualified for as the engineering division you direct. It's the same thing except you changed your mind.

Mr. CORTRIGHT. I think I recall that action. As I recall, the laboratory made a reevaluation of what groups were hurting the most and determined that space could be better distributed and that the mechanics area could get along another year.

Colonel GOULD. Again, Mr. Chairman, this may be another instance where the project has been authorized previously.

Mr. ULMER. Colonel, may I comment on your statement? We are operating on the assumption that the authority for the three smaller buildings we approved uses up the authorization for the single large structure. We considered this a different method of accomplishing the same purpose and we thus feel we have used up that authorization.

Mr. KARTH. Well, was the money spent for the purpose in which it was intended?

Mr. ULMER. Yes, indeed, for providing working space for the JPL staff.

Mr. CORTRIGHT. I am not sure as many people went into that building as we thought would. This is a continuing problem in the laboratory.

Mr. KARTH. Anyway, they are going into it?

Mr. ULMER. Had it been used for anything else, it would have come up for a formal programing action.

Mr. KARTH. It was used for housing?

Mr. ULMER. Yes.

Mr. KARTH. Now the 1964 budget request includes $3,900,000 for a development engineering building at JPL.

The building includes a structures dynamic testing laboratory and its equipment.

The budget also includes, under other programs, requests for—in round figures—one and a half million for a structures dynamics laboratory at Ames; one and a quarter million for replacement facilities fatigue research at Langley.

The general requirements for the testing proposal are the same and in the case of some of this proposed equipment would seem to make the facilities interchangeable.

Would you care to comment on that?

Mr. CORTRIGHT. Only in this respect.

It is normal and proper that laboratories working in different parts of the country have facilities that do similar jobs.

At a cursory glance it would seem to be the same facility just as company A will have a large machine shop and company B will have a large machine shop; or the Lewis Research Center will have a wind tunnel and Langley will have a wind tunnel.

They use them for different projects, but they are a similar type of operation.

Mr. KARTH. You just can't use these facilities for the kind of project you need to test.

Apparently, you have to tailormake these tests to the facility.

Mr. CORTRIGHT. Some are tailormade by virtue of their program. More normally they are tailormade by virtue of their location.

All of them are scheduled heavily and we can supply loadings on our equipment which will indicate what we are using them for and how many shifts they are on.

Mr. KARTH. What about the materiels services building?

Mr. CORTRIGHT. The materiels services building provides for a consolidation of the service and support functions including such things as inventory control, central stores warehousing, shipping, receiving, inspection, property accounting, and the offices of the people who perform these functions.

These people are now occupying trailers and off-laboratory leased space and are scattered around so they do not constitute an efficient operation.

We have to do this.

We have displaced these people at different times in the past to pull together teams which could not be broken up, but it's been to our disadvantage to do so.

Mr. KARTH. How do we start these centers?

Let's take the Jet Propulsion Laboratory. I suppose we have just scads of surplus Government property in California, or elsewhere.

Mr. CORTRIGHT. Yes.

Mr. KARTH. How do these things start? We are buying very expensive property and building very expensive buildings and all of this might be available, or a substantial part of it might be available

someplace else where it's been declared "surplus" by another Government agency.

How do we get in these situations?

We are tied to Jet Propulsion Laboratory now, and I guess we are just going to have to keep on building their buildings. Is that the kind of situation: you can't do without it, and you can't do with it?

Mr. CORTRIGHT. Jet Propulsion Laboratory is a good answer to your question.

Jet Propulsion Laboratory was originally built up by the Army as a somewhat temporary installation for some of the problems encountered in the last war.

Mr. KARTH. We own the land, but we don't own the buildings?

Mr. CORTRIGHT. We own the land, the buildings, the equipment, and we also lease trailers to house people.

Mr. KARTH. When we started, there was a considerably large Government-owned installation in terms of buildings?

Mr. CORTRIGHT. About 2,400 people, as I remember, sir.

The Laboratory is now up to about 3,900. We have had to house them.

The land was Government owned.

Mr. ULMER. In establishing new centers, Mr. Karth, the procedure you described is followed.

There is a very careful review of all existing facilities, and, if at all possible, if the facility is required to be built, it is built on Government-owned land.

I thnk the Goddard Center is a good example of this.

The Langley Center and the Ames Center are other examples.

Wherever possible we try to meet the need with the use of existing facilities or existing Government-owned land.

Mr. KARTH. How about Houston?

Mr. ULMER. Houston was a different situation.

Mr. KARTH. Pretty good project; isn't it?

Mr. ULMER. Yes, it is a pretty good project.

Another example is the Lunar Excursion Model Test Facility you see in this budget. This facility will be built on existing Government-owned land at White Sands, N. Mex.

Mr. KARTH. I am happy to know this. I do know we have tremendous amounts of surplus property and buildings all over this country, really.

I guess there is quite a predominance of it on the two coasts, for example.

Mr. ULMER. As another example, there was an announcement of the proposed use of a large hangar at the Moffett Field Naval Air Station for the RIFT program. The hangar has outgrown its usefulness to the program for which it was built but may be very well useful in our program.

Mr. KARTH. The Michoud Plant, was that a Government-owned facility?

Mr. ULMER. Yes, that is another good example. It was idle after the Korean war. It was used for tank construction.

Mr. KARTH. This pretty much fits into NASA's requirements so far as space is concerned?

Mr. ULMER. It was a fortunate break for us, Mr. Chairman. It is a large plant, air conditioned and with a high bay—exactly what we

need for the construction of the large boosters. Also, the time factor in having the plant available promptly was very important.

Colonel GOULD. Also saved $120 million, Mr. Chairman.

Mr. KARTH. Well, the one last item, then, on the construction program, is the Launch Operation Center, $1,600,000. I wonder, Mr. Cortright, if you care to explain that?

Mr. CORTRIGHT. Mr. Chairman, I have had the pleasure of your company at Cape Canaveral, and you have been with me in the hangar where we now assemble and check out such spacecraft as the Mariner.

We have set about to develop a facility at AMR which is capable of final checkout and servicing, if you will, of our larger spacecraft which are starting to come out of the manufacturers plant.

This includes Surveyor, OAO, and OGO. This is a facility designed to serve just that purpose.

It will house the technicians, the engineers, and the spacecraft.

It will have air conditioning, a properly controlled environment; so that these delicate spacecraft cannot deteriorate in the corrosive atmosphere of the cape.

It's essentially a building of the type you've seen, only larger, with better accommodations for the increased flow of large spacecraft.

Mr. KARTH. There will be no testing of these spacecraft there? Merely be housed there and prepared for flight?

Mr. CORTRIGHT. You will recall we had one room about two or three times the size of this room, completely filled with electronic equipment for the Mariner. These electronic tests are conducted on the spacecraft.

The equipment themselves, to conduct those tests, are brought down to the cape for the spacecraft checkout. If that's what you are referring to as the testing, we do that.

Mr. KARTH. Yes, sir; and this is brought from Goddard?

Mr. CORTRIGHT. Goddard or Jet Propulsion Laboratory, depending what the spacecraft is.

Colonel GOULD. In a release dated February 1, 1963, concerning the Agena space vehicles, NASA announced that the Project Operations Branch at Cape Canaveral would be expanded.

Is this going to require additional facilities over and above those you have included in the 1964 program?

Mr. CORTRIGHT. We don't think so, but that's still under review.

We think that by crowding we can make use of the facilities we have asked for, but that remains to be seen.

Colonel GOULD. If this facility will not meet the requirement, will it be possible to await the fiscal year 1965 program or do you intend to reprogram?

Mr. CORTRIGHT. I can't answer that question.

We will do what we have to do to get the job done within our legal authority.

Mr. KARTH. Anything you'd like to add, Dr. Newell, to what has been said?

Dr. NEWELL. I think Mr. Cortright and Mr. Ulmer have done a fine job.

Mr. KARTH. I think they have, too—real good job.

Well, I have no further questions.

Colonel Gould?

Colonel GOULD. I have no further questions.

Mr. KARTH. Dr. Newell, Tuesday when we meet again, we will meet with the OART people, and if there are any questions in the minds of the members of the subcommittee that they should like to have you and Mr. Cortright back again, we'll contact you.

If not, I guess this will conclude our hearings for the Office of Space Sciences.

Dr. NEWELL. Did you want this submitted for the record?

Mr. KARTH. Yes; I wonder if you would submit that to the young lady for the record. That is a statement of Dr. Newell we had spoken about earlier, so please submit it for the record.

Dr. NEWELL. This is a statement on scientific and technical data and information usage dissemination.

Mr. KARTH. Excuse me, Dr. Newell.

Mr. HAMMILL. Isn't that for insertion in an earlier record?

Dr. NEWELL. The chairman had asked I be prepared to speak on the subject, so I assembled some notes here on it.

It could be inserted earlier, where the chairman requested it, or inserted here.

I don't feel it would be disconnected if it were inserted here.

Mr. HAMMILL. I think it would be appropriate to insert it at that point in the record when it was first requested.

Dr. NEWELL. All right, we'll give it to you then.

These are samples of the output of this program that was described in this paper.

I thought the committee might be interested in thumbing through some of the handbooks, reports, and so on.

Mr. KARTH. Thank you very much, Doctor. The committee is adjourned.

(Whereupon, at 12:05 p.m., the subcommittee adjourned.)

1964 NASA AUTHORIZATION

WEDNESDAY, MARCH 27, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE ASTRONAUTICS,
SUBCOMMITTEE ON SPACE SCIENCES
AND ADVANCED RESEARCH AND TECHNOLOGY,
Washington, D.C.

The subcommittee met, pursuant to adjournment, at 10 a.m., in room 214–B, Longworth Building, Hon. Joseph E. Karth (chairman of the subcommittee) presiding.

Mr. KARTH. The meeting will be in order.

Dr. Bisplinghoff, I want to welcome you to the committee.

Very happy to have you with us.

Dr. BISPLINGHOFF. Thank you, sir.

Mr. KARTH. I might say that as you proceed through your prepared testimony it may be that the committee members will have questions in mind. So that they don't forget them, they may interrupt you at any point. We operate on a very informal basis.

Dr. BISPLINGHOFF. Fine.

Mr. KARTH. We hope you have no objection to this procedure.

Dr. BISPLINGHOFF. Not at all. We are glad to conduct ourselves in any way you see fit.

Mr. KARTH. Doctor, I see you have a prepared statement. If you care to begin, we will be very happy to receive your testimony.

STATEMENT OF DR. RAYMOND L. BISPLINGHOFF, DIRECTOR, OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY, NASA, ACCOMPANIED BY BOYD C. MYERS II, DIRECTOR, PROGRAM REVIEW AND RESOURCES MANAGEMENT, AND JOHN L. SLOOP, DIRECTOR, PROPULSION AND POWER GENERATION, AND DR. EUGENE B. KONECCI, DIRECTOR, BIOTECHNOLOGY AND HUMAN RESEARCH, AND HAROLD B. FINGER, DIRECTOR, NUCLEAR SYSTEMS, AND MANAGER, SPACE NUCLEAR PROPULSION OFFICE, AEC–NASA

Dr. BISPLINGHOFF. Mr. Chairman and members of the subcommittee, our statement today is in connection with the Advanced Research and Technology Program Office which has the responsibility for advanced research and technological programs that may have general or future applications to the Nation's aeronautical and space objectives. The essential purpose of these programs is to lay the foundation and to determine the building blocks which will be needed for preeminence in aeronautics and space in the future.

Before I get into the substance of the program, I would like to outline briefly for you our concept of advanced research and technology

of aeronautics and space. I think that the history of technology over the past 100 years has shown that true progress in any branch of technology such as space technology requires and even demands a sharp cutting edge of advanced research. The kind of things we read about in the papers like the manned spaceflight effort, scientific probes, communications, and meteorological satellites and airliners we ride on today, all rest upon a foundation of research which was done in previous decades; and the research we do today in our laboratories, universities, and in industry derives vigor and freshness from the motivations of these projects and things that we are doing to benefit mankind.

At the same time, there is really a feeding in both directions, the research derives freshness from the things that are going on in the way of projects, and the projects later derive benefits from the research.

I would say that our philosophy of advanced research and technology in the NASA is an extension of the philosophy of the NACA; and this activity really divides into two steps.

First is a simple extension of the activities of the NACA in which applied research together with a substantial activity in basic research is emphasized.

Mr. KARTH. Doctor, at this point, would you tell us what you mean then by "advanced research"?

Dr. BISPLINGHOFF. The term "advanced research and technology" is not really the best term in the world. I think the adjective "advanced" really modifies "technology" more than it does "research."

The research that we think of is basic research and applied research, and, when we speak of advanced technology, we think of the development of advanced subsystems that may have applications in 5 or 10 years from now.

Mr. KARTH. What we are talking about, really, is research and advanced technology?

Dr. BISPLINGHOFF. That's right. That would be a better way of saying what we have in mind.

For some reason or other, in the formation of this Office the word "advanced" got out in front of "research and technology."

On this research side, our principal effort takes place within the field centers and within universities, and here there is a strong coupling between the two; and the objective of this part of our work could be summarized in several steps.

One, contributions to the understanding of fundamental phenomena underlying aeronautical and space vehicle technology.

By this, we mean contributions to a better understanding of such things as fluid mechanics, materials, and things of this kind which play a very important role in the design of aeronautical and space vehicles.

Secondly, reduction of complex theory to design procedures.

In many cases, the design procedures that are used by our industries are based on rather complex theories and one of the important services that we render is the reduction of these rather complex theories to design charts and methods that can be applied readily by the designer.

Thirdly, systematic testing to obtain design data for aeronautical and space vehicles of the future.

Our facilities within the NASA; such as wind tunnels, materials testing, and so forth, are used extensively to obtain design data which may be useful in design vehicles.

Over the past years, for example, we have done a great deal of work on configurations of aircraft for supersonic flight such as supersonic transport and supersonic fighters. This is the sort of thing we mean for obtaining design data for the future.

During the past few years we have come to the realization that these aims, which are the kind of aims the NACA embraced, were not in themselves sufficient to prepare properly for the future and in the formation of this office a second step of activity was added closely linked with the first; and this step could be described as pioneering of carefully selected advance subsystems to permit rapid development and engineering of future systems in the shortest possible time and at minimum cost.

Mr. KARTH. Doctor, how old is this second concept that you mentioned?

Dr. BISPLINGHOFF. This concept was introduced into the Office of Advanced Research and Technology when it was formed, a little more than a year ago. It is a concept which has been around for some time, but which was not embraced by the old NACA operation to any great extent.

Mr. KARTH. You mean hardware development?

Dr. BISPLINGHOFF. This means hardware—this means the development of advanced subsystems which we think will have application in perhaps 5 or 10 years.

Mr. KARTH. By "advanced subsystems," you are talking about the actual development of hardware?

Dr. BISPLINGHOFF. This is true.

In many cases, the actual hardware we develop will not be directly applicable to these future systems, but the technology which is derived from the development of this advanced subsystem can be used in this future effort.

Mr. KARTH. You actually develop a margin; is that what you are talking about?

Dr. BISPLINGHOFF. That is right. We have a number of examples of this.

Our SNAP–8 device for converting nuclear energy to electrical energy is an example of this.

I would say the X–15 airplane is an example of this.

Many others will come out from time to time during our testimony.

The X–15 has developed a technology of very high speed flight, the control of aircraft at hypersonic speed, the development of the use of materials for such high speed flight, the development of the technology of predicting the kinds of heat inputs that one has in hypersonic flight.

Mr. KARTH. Do you ever develop prototypes, Doctor, of things that later on go into production?

Dr. BISPLINGHOFF. It may be that some of our advanced subsystems will, in fact, become parts of systems themselves.

Mr. KARTH. Can you think of any that have, up to this time?

Dr. BISPLINGHOFF. The Office of Advanced Research and Technology is so new it is hard to point to anything we have done our-

selves along this line. SNAP–8 nuclear electric system, we hope, will actually become a part of a future flight system. The Nerva engine, we hope, will actually become part of the future flight system.

Those are two examples, of advanced subsystems we hope will eventually be a part of future systems.

Mr. KARTH. We do this inhouse; is that correct?

Dr. BISPLINGHOFF. No, sir; these kinds of subsystems are technically managed by our own centers, but they are largely done by industry.

Mr. KARTH. I see.

Dr. BISPLINGHOFF. I wanted to point out next that the operation of this kind of activity places the principal burden of responsibility within the field centers but here they are closely coupled with American industry and, as in the case of research, we are coupled with the universities. For the advanced technology part of our effort, there is a very close coupling with industry, and all these advanced developments are done by some industrial contractor working with our centers.

Mr. FULTON of Pennsylvania. Mr. Chairman.

Mr. KARTH. Mr. Fulton?

Mr. FULTON of Pennsylvania. NASA has a program of advanced research programs, fellowships at a postdoctorate level. Is that under your office?

Dr. BISPLINGHOFF. No, sir, Mr. Fulton; that's under Dr. Newell's office, the Office of Space Science.

Mr. FULTON of Pennsylvania. How do you correlate that with your own advanced technology programs with the universities?

Dr. BISPLINGHOFF. All our university contracts are handled administratively by Dr. Newell's office.

Mr. FULTON of Pennsylvania. So that you set the programs up—that's the point I want to make, Mr. Chairman—actually, it is Dr. Newell's office that handles both the programs at a postdoctorate level where it would be advance research and technology, and likewise Dr. Newell's office handles the contacts with the universities and colleges on the predoctorate level on technical fellowships leading to a doctoral degree that's given by NASA?

Dr. BISPLINGHOFF. That's right.

Mr. FULTON of Pennsylvania. So that yours is a cooperative authority with Dr. Newell's office. You don't choose them or you don't place them.

Dr. BISPLINGHOFF. Our association with the universities is more in the granting of contracts to do research.

He also has such an association, but he has the additional responsibility of handling the fellowship program and the grants program.

Mr. FULTON of Pennsylvania. Might I just comment, grammatically, that possibly the name of your office is correct; because the word "advanced" could modify both of the nouns. For example, if you were given a white house and barn you would be very surprised to find the house was white and the barn was black, so maybe it's both "advanced research" and "advanced technology."

Mr. KARTH. I don't understand your grammar, but I'll accept it.

Mr. FULTON of Pennsylvania. I wanted to reassure you on the title of your office. That's all I had in mind.

Dr. BISPLINGHOFF. Now in describing our program to you it will be convenient to divide it into two parts: the first relating to space and the second to aeronautics. Such a division is simply one of convenience and is not intended to imply the two parts are entirely separate and there are no common features between them. There are, indeed, mutual contributions of one to the other and numerous places may be pointed to where fallout from one impinges upon the other.

In order to relate our program in your mind with other parts of the Nation's activities in aeronautics and space, I shall describe it within a framework of its principal functional aspects with reference to the scientific disciplines which underlie it. The basic research component of our program which contributes to these scientific disciplines will be recognizable as a prominent part of the discussion which follows; and I won't attempt to bring out in my part of the discussion a distinction between basic research, applied research, and advanced technology; but these will all be woven together in order to make a pattern which will, I think, bring out the program in its clearest form.

Now, I'd like to talk first about our space research and advanced technology activities. The principal functional aspects of space activities are relatively few in number as illustrated schematically by figure 85.

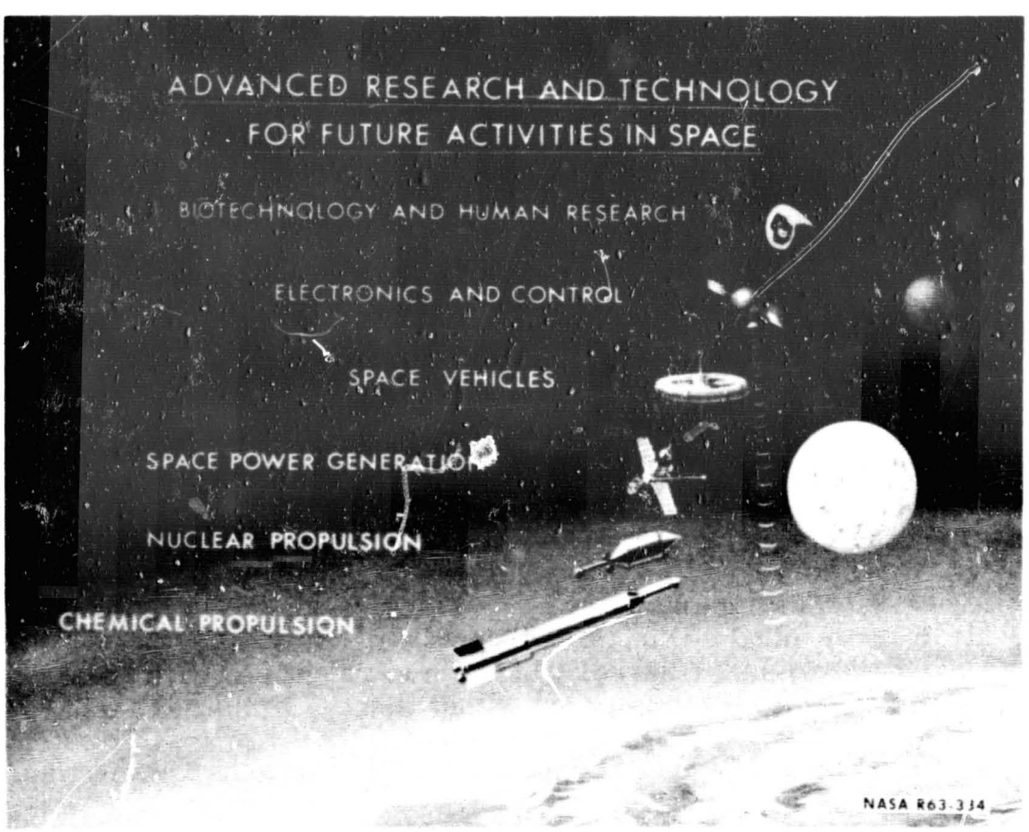


FIGURE 85

Beginning at the bottom of this figure and leading outward these activities are:

Chemical propulsion.
Nuclear propulsion.
Space power generation.
Space vehicles.
Electronics and control.
Biotechnology and human research.

I'd like to add that all of the gentlemen who are responsible for these various activities are with me here this morning in the room.

Our program of advanced research and technology is steered by continuing estimation of the requirements for achievement in each aspect. The nature of probable space missions of the future sets these requirements. Fortunately, during the next 10 to 20 years nearly all space missions will be concerned with the celestial bodies of Earth, Moon, Mars, Venus, and Jupiter.

Missions involving these bodies may include such operations as flyby, orbit, atmospheric entry, landing, or possibly on-planet operations.

By employing combinations of these celestial bodies with missions as hypothetical goals, we can identify the technologies required to provide capabilities for their completion. We can also estimate the cost in terms of time delays and performance deficiencies if the required technical advances are not there when needed.

Mr. KARTH. Doctor, are you saying you can actually do this?

Dr. BISPLINGHOFF. We can't do it in detail.

Mr. KARTH. That is, you can estimate the cost in time delays and and also estimate the cost of the performance deficiencies fairly accurately?

Is that what you are saying?

Dr. BISPLINGHOFF. No, we can't do this accurately. We can make these estimations, mainly on what we see when we try to develop our systems today. We very often find that the subsystems that we need are not there, and we have to go back and do the research to develop them. We can observe how much trouble we get into in some of our current systems because we have not done our homework or research previously. This gives us an idea of what kind of troubles we would get into in the future if we did not do some of this advance research.

Mr. KARTH. How about the Ranger program?

Would you say we hadn't done our homework on that, and that's one of the reasons we are having a little trouble with it?

Dr. BISPLINGHOFF. In the case of the Ranger program, I doubt whether this was a major factor.

Mr. KARTH. What do you think the problem was?

Dr. BISPLINGHOFF. I have not been closely identified with the Ranger program, but it's my impression that this is a problem of reliability in space.

Mr. KARTH. This is usually brought about by a lack of testing; isn't it, Doctor?

Dr. BISPLINGHOFF. This is right, yes.

Mr. KARTH. This involves homework?

Dr. BISPLINGHOFF. Well, to a certain extent this is true, but I think that the testing program that one incorporates in a current system

development is always going to be an important factor whether we do a lot of research ahead of time or not.

Mr. KARTH. Does your office have anything to do with any of the advanced research that was done on Ranger?

Dr. BISPLINGHOFF. No, sir; we came into being well after that would have been done.

Mr. KARTH. I see.

Dr. BISPLINGHOFF. Now, I'd like to turn first to chemical propulsion. Chemical propulsion is, and will be for some time to come, the means by which man initially breaks the shackles of the earth's gravitational field and reaches into space. The present advanced research and technology program of chemical propulsion for space vehicles embraces liquid and solid rocket propulsion.

The program is one of research leading to better understanding of chemical propulsion and of technology programs to increase our ability to meet the future propulsion requirements in space.

As a result of work undertaken in the past year, it is believed that the significant advancements in new concepts leading to very large rocket engines are possible. Last year we mentioned to you the possibility of new nozzle configurations to make shorter engines. We have also conducted research into the use of higher combustion chamber pressures. The potential effect of bringing these two concepts together can be illustrated by figure 86.

On your left is the F–1 engine with 1½ million pounds of thrust. This is an example of the current state of the art and is the largest engine in development in the free world.

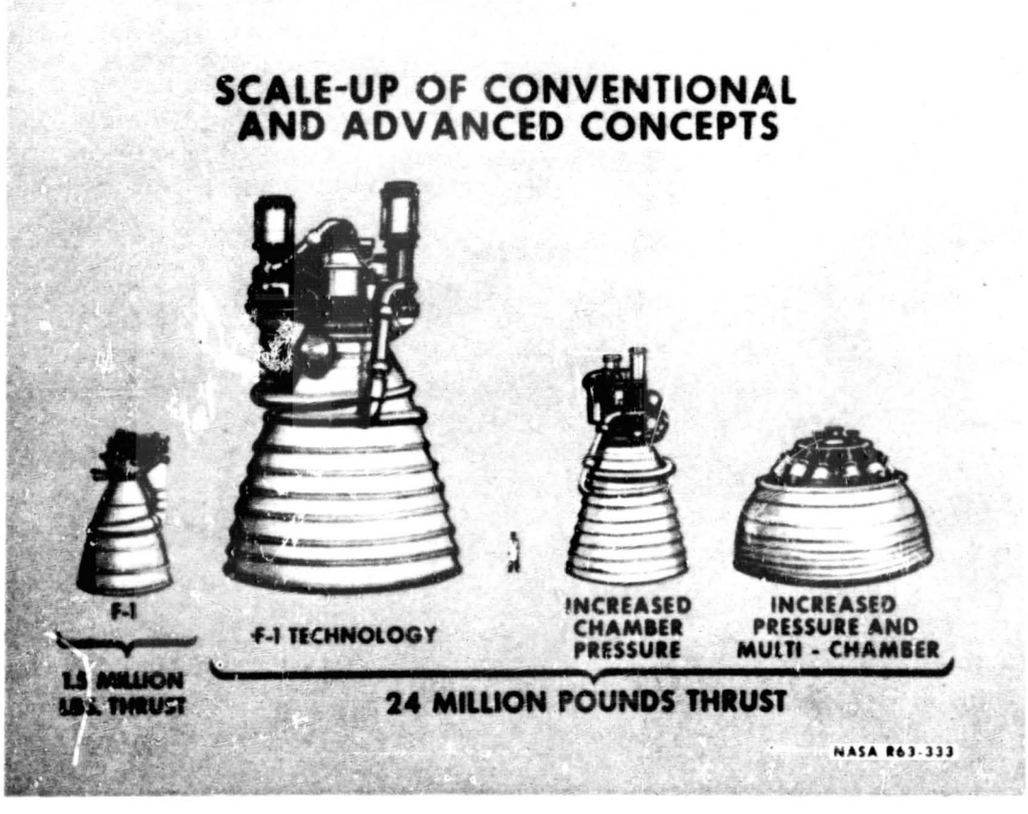


FIGURE 86

Mr. KARTH. Doctor, why do we say it that way? Is it because we don't know what the Russians are doing and therefore we can't honestly make this statement because we do not know; so therefore we say "free world"?

Dr. BISPLINGHOFF. I don't think we know with any great precision exactly what they are doing in this area. I don't think we can honestly say that they do not have a larger engine in development at the present time.

Five of these engines will be used in the first stage of the Saturn V. Engine technology has progressed such that the next larger engine size could have a thrust on the order of 20 to 30 million pounds.

The second engine shown which is compared with a man's height indicates the size of engine which would result if the F-1 technology were employed to develop 24 million pounds of thrust.

It should be noted that such an engine would be roughly equivalent in size to a four-story building.

By increasing the chamber pressure through new advances in research, the same thrust could be delivered by the third engine shown.

An even more interesting engine concept is shown on the far right where high chamber pressure in one of the new nozzle design concepts are combined to develop an equivalent level of thrust.

Figure 87 illustrates a model employing one of the advanced nozzle concepts that we have been working on which has a cluster of individual combustion chambers. It has a single large pump in the center

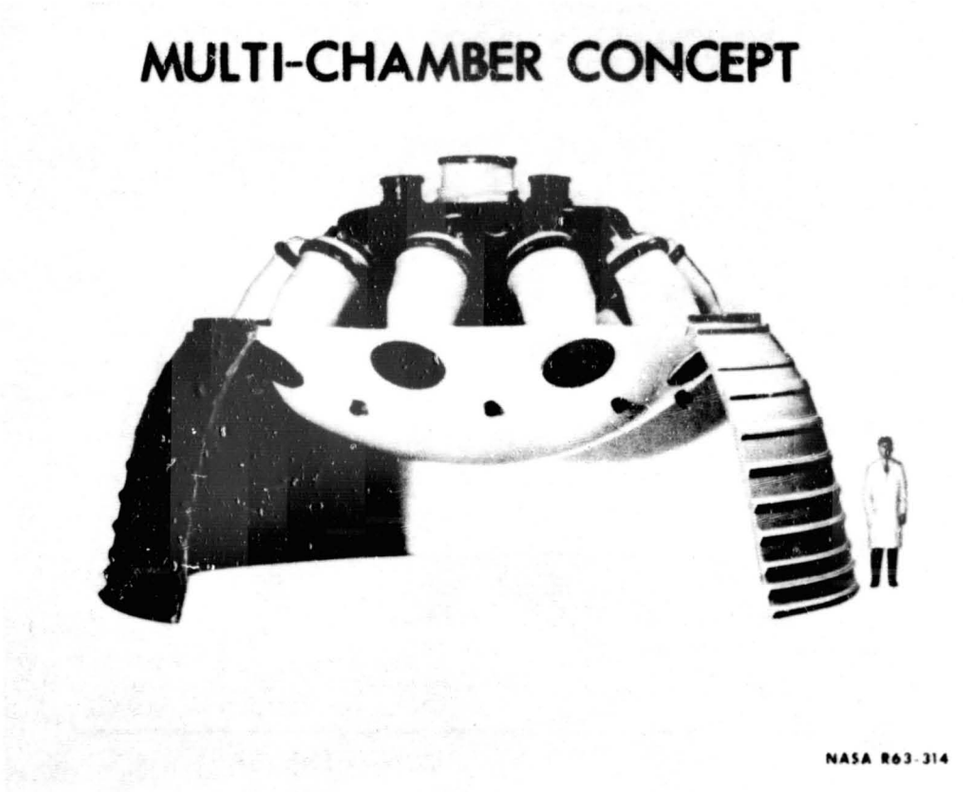


FIGURE 87

supplying fuel and oxygen into the individual combustion chambers along the periphery which, in turn, discharge into a common nozzle.

Now, we realize that we must go to higher chamber pressures, but this has introduced a number of problems which must be explored through further research.

One of these is fluid pumping—to boost the propellent pressure to the several thousand pounds per square inch required to pump it into the chamber.

With regard to the matter of propellant pumping it must be mentioned that a critical problem which continues to face us is cavitation where the liquid flashes into vapor. When cavitation occurs in a hydrogen pump, for example, the vapor generated has about one-fiftieth the density of the liquid. This influences greatly the characteristics of the flow in the pump passages and reduces the performance of the pump. This cavitation usually occurs in the first stage of the pump assembly called an inducer.

Last year pictures were shown of an experimental inducer with cavitation phenomena in liquid hydrogen. Since that time we have done a good deal of research on this and, I think, we have gotten a good deal of new insight into this phenomena which has allowed us to establish improved design criteria for inducer performance. Much more work, however, is required on the problem of cavitation, and a continuing effort in the coming fiscal year is proposed.

Another problem encountered in solid rockets and in very large liquid rockets using advanced nozzles and in solid rockets concepts is one of obtaining the necessary side thrust to produce thrust vector control. As you notice in most of our large engines, we actually swivel the engine in order to get this side thrust.

Another means of accomplishing thrust vector control is the lateral injection of a fluid into the nozzle to deflect the main flow slightly and thus cause a side thrust. New information has been obtained in the past year on the effectiveness of various types of injected fluid in their most efficient point of injection to produce this thrust control.

We feel that this means of employing thrust control will be the means that will be adopted in the future. For the very, very, large engines it's unlikely you could swivel them in the manner that we now swivel our present engines.

The performance of rocket propellants, which is generally measured by their specific impulse or thrust produced per pound of fuel and oxidizer consumed per second, remained relatively unchanged in rocket development for a number of years. In 1958 the first rocket engine development using hydrogen and oxygen was started and a significant jump was made in the performance of chemical rockets. As you know, the plan of NASA to land men on the Moon and return them to Earth depends strongly on the success of Saturn vehicles which use hydrogen and oxygen in all stages except the first. This is another example where research provided a basis for higher performance. Since we anticipate even more difficult missions in space, we are conducting research to increase performance beyond that possible with hydrogen-oxygen.

With hydrogen-oxygen and present engine technology, specific impulse of over 420 pounds thrust per pound per second of flow are attainable.

Mr. KARTH. Doctor, may I interrupt you there, just to get clear in my mind what your jurisdiction is.

For example, the Office of Space Science is doing a great deal of work on Centaur, which is the liquid hydrogen and liquid oxygen.

Dr. BISPLINGHOFF. Yes, sir.

Mr. KARTH. I assume your office is also doing research on liquid hydrogen and oxygen.

Dr. BISPLINGHOFF. No; the liquid hydrogen-oxygen is something we regard as having passed beyond our boundaries. We are thinking about propellants beyond this.

Mr. KARTH. I see. So you are doing no research in the liquid hydrogen field?

Dr. BISPLINGHOFF. We are using liquid hydrogen in other combinations, but the liquid hydrogen-oxygen combinations is one we feel has gone beyond the research and advanced technology stage.

Mr. FULTON of Pennsylvania. Mr. Chairman.

Mr. KARTH. Mr. Fulton?

Mr. FULTON of Pennsylvania. Some of us on the committee are very interested in the consumption of high energy propellants. In a NASA report of 1963, February 1963, there has been the comment of the advances made on combinations of borane and fluorine which have given a very much higher evidence of technical performance and specific impulse.

I, for one, believe that when we get booster systems that are as tall as the U.S. Capitol we are then getting "elephant" engines and "rabbit-head" payload, so that we do need more efficient fuels.

The other problem is that we are always starting from the mission and then saying what we need on a payload and next saying what kind of an engine it will take to put it up and then, of course, cutting the payload back by about 50 percent in many cases.

That is exactly the opposite practice, from my experience in this field, as you had done in the National Advisory Committee for Aeronautics that had been, I guess, in existence since about 1915. There we had placed the emphasis in the United States upon engine and fuel development so that the engine and fuel development were the lead horses in research.

My own feeling is it's a mistake of NASA to have this reverse policy where the mission becomes paramount and then rather than having a broad spectrum or shelf of fuels and engines to accomplish missions, these developments seem to come later.

Might I finish, Mr. Chairman on this?

The one place where NASA had an increase of its budget by Congress was in the high-energy fuels where we wanted, on this committee, Science and Astronautics Committee, as well as the House and the Senate and the Senate Space Committee, more research on a broader base so that we could get more payload and have to carry less fuel and smaller engines.

I had put an amendment in for half a million dollars for this purpose, fiscal year 1963, which was unanimously adopted by the Subcommittee on Manned Spaceflight by the Science and Astronautics Committee of the House and by the House 342 to 0 on the overall bill passage.

In the Senate, Senator Kerr, chairman of the Space Committee of the Senate, had added another half a million dollars for this purpose,

so that the total increase for NASA's budget for high energy fuel, through the emphasis of Congress, was $1 million above the amount requested.

That money, unfortunately, disappeared. Some agency, other than your own particular office, evidently on a reprograming got most of it.

So, with the chairman's permission I'd like to know what happened to that research money and why was it transferred out, because in your office—and the reason I am here today as a guest of the subcommittee—I want to see if the reprograming by NASA and the transfers from basic research and advance technology are getting the ice cream and cake now but are sacrificing future efficiency for present so-called emergencies.

I'd like the chairman's permission to have you put it in at this point in the record.

Mr. KARTH. I would be very interested in hearing the answer, Mr. Fulton. I would hope that Dr. Bisplinghoff would take the time right now to answer the question.

Dr. BISPLINGHOFF. May I go back to the first part of Mr. Fulton's remarks. We in NASA have what I believe is a fairly broad based program of fundamental research with the object of turning up, wherever possible, higher energy fuels.

However, because of our limitations of budget we cannot pursue these questions clear through the development of engine systems.

We must be very selective here. We can only a select a few engine systems to develop at a given time because of their very high cost.

In the NASA advanced engine development, the two types of advanced fuels which have looked promising to us are the oxygen difluoride and diborane fuel combination and hydrogen fluorine fuel combination.

Mr. FULTON of Pennsylvania. That was your technical report of February 1963 that came up with the fact that you got a 5 to 10 percent better technical efficiency in prospect out of that.

Dr. BISPLINGHOFF. I can give you the details later if you wish, of our advance technology effort in the employment of new fuels being spent along these two avenues.

Mr. KARTH. How about the additional million dollars that was authorized and appropriated by Congress?

Dr. BISPLINGHOFF. Yes. Now this million dollars has been put into research and advanced technology of borane-related fuels, and I have a breakdown of exactly how this is being spent during fiscal year 1963 that I can put into the record, if you so desire.

Mr. FULTON of Pennsylvania. I wish you would. With the chairman's permisson—my concern has been that when we get scientific teams together we are not as careful as the Soviets because they keep them going and give them other jobs to do; and when I see down in Muskogee, Okla., a plant that has been doing research on high energy fuels, tremendously competent, and supplying the Government at a much less expense than they had contracted for on these diborane compounds—and I guess they do even take borane, too; don't they?

Dr. BISPLINGHOFF. Yes.

Mr. FULTON of Pennsylvania. Which are basic to be used with other fuels in combination on hypergolic fuels, we are now, through the lack of cooperation in NASA, having the prospect of the Muskogee plant

being put in partly cold standby and almost in a mothball condition, knowing that we are going to need these fuels later because of the high energy chemical propellants that they represent.

In the meantime what happens is this, that if that plant is closed down for a year, it is estimated it will cost three and a half million dollars to start it up again while to continue it the Air Force was willing to pay $600,000 of the $1,400,000 currently needed per year to keep it operating on a hot standby.

So that NASA would only have had to put up $800,000. It costs the Air Force $600,000 to take it down into the partial hot standby they are now talking about and which is just being negotiated out at Wright Field in Dayton.

In my opinion, we are making a mistake by not keeping scientific teams in being and, secondly, we are making a mistake when we get on our own technical report for February 1963 a glowing report from your research people. Then I am sorry to hear you say, "Budgetary limitations keep us on a very limited basis and restrict us to just a few engine developments." That, to me, is a long-time-view mistake because I think that you should come and say to us what you feel is best for a good advance research and advanced technology program and make your recommendations to us, and then we can, in Congress, see how far we'd like to go.

May I finish on this? I hate to dispute you, but several hundred thousand dollars of the million dollars that we speak about was put, as you know, into advanced nozzle research which would be just as good on a liquid or a solid engine of large size or an engine that is operating at high heat or under highly compressed conditions—high compression engine—so that it wasn't specifically, you see, for the high energy fuel development which Congress had in mind.

That would be, to me, general hardware development for the next generation engines of almost any type you want to mention in respect to fuel.

Wouldn't you agree with me?

Dr. BISPLINGHOFF. I would like to speak to what Mr. Fulton has just said. We are very much interested in the diborane-oxygen-difluoride combination, and we feel that it shows promise. Nevertheless, there are a number of very difficult problems that must be overcome before we could in good conscience recommend that an engine development program be undertaken.

One of these is the high temperature at which the engine nozzle must operate. This is some 8,000° F. The combustion temperatures of this combination are very high, and unfortunately this fuel combination has poor heat transfer properties and does not allow us to use it for regenerative cooling of the nozzles. We have at the present time no material nor nozzle design which allows us to employ this combination. One of the things that we must do in order to get to the place where we can use it is to develop either new nozzle materials or new composite arrangements of materials in nozzle design.

Mr. KARTH. And is that what that million dollars was spent for, Doctor?

Dr. BISPLINGHOFF. A very small part of the million dollars was spent on this.

Mr. KARTH. What was the rest of it spent on?

Dr. BISPLINGHOFF. I can read the rest off here. Would you like me to?

Mr. KARTH. Yes, sir, I certainly would. I didn't know you had that much trouble spending a million dollars, Doctor. You channeled it off in five different programs there?

Dr. BISPLINGHOFF. $320,000 is being spent on jet propulsion laboratory research on evaluating polyethylene and hydrazine diborane in small rocket motors.

Mr. FULTON of Pennsylvania. Polyethylene and hydrazine?

Dr. BISPLINGHOFF. Hydrazine diborane.

Mr. KARTH. But it's high-energy fuel?

Dr. BISPLINGHOFF. Yes.

Mr. KARTH. $320,000 was spent properly. At least, it was spent in line with the intent of Congress. What else?

Dr. BISPLINGHOFF. $50,000 JPL contract with Callery Chemical for ingredient studies of monaborane hydrazinate. These are high-energy fuels.

Mr. KARTH. They are high-energy fuels?

Dr. BISPLINGHOFF. Yes.

Mr. FULTON of Pennsylvania. That is a good expense.

Dr. BISPLINGHOFF. We have a contract with Reaction Motors for engine tests with oxygen difluoride for $375,000.

We have a contract for the supply of 2,000 pounds of oxygen difluoride to be used in the oxygen difluoride diborane experiments for $102,000.

Mr. FULTON of Pennsylvania. In order to get the budgetary fiscal basis correct, aren't those contracts for payment in 1964 funds rather than 1963 funds?

Sure—you let the contracts now, but you see the funds will be picked up in a future fiscal year.

Mr. KARTH. That is why I'm asking the question.

Dr. BISPLINGHOFF. I am not sure of your question.

Mr. MYERS. These are fiscal year 1963 funds we are talking about now. These are the funds expended in fiscal year 1963 associated with the high-energy propellant program.

Mr. KARTH. Doctor, you are up to $847,000. It appears to me that is all that was spent on research and high-energy fuels.

Dr. BISPLINGHOFF. We have an amount of $34,000 for diborane.

We have $40,000 in a contract with General Electric Co. on the development of ablatives for high-temperature nozzles. The ablative scheme seems to be one of the ways we can lick this high-temperature nozzle problem.

Now we are at the present time in the process of letting, and I can't tell you exactly whether these contracts have been let, a $25,000 contract on decontamination tests of oxygen difluoride; $50,000 contract on studies of handling of diborane, and a $15,000 contract on toxicity studies of oxygen difluoride.

Mr. MYERS. Those last three were in the processing of committing at the moment.

Mr. KARTH. So the million dollars——

Dr. BISPLINGHOFF. It is a million and eleven thousand.

Mr. KARTH. That total, if not more, has been spent on research in high-energy fuels?

Dr. BISPLINGHOFF. Related to borane fuels, yes.

Mr. FULTON of Pennsylvania. I will check it——

Mr. KARTH. Is your office going to spend more during fiscal 1963 in research on high-energy fuels than they originally budgeted for, or less?

Dr. BISPLINGHOFF. In fiscal 1963?

Mr. KARTH. Yes.

Dr. BISPLINGHOFF. Can you tell what our total is?

Mr. MYERS. No; in this area we had a little over a million dollars available for the borane fuels part of the high energy fuels program and that's just about what we will be able to commit in 1963.

Mr. KARTH. Is that what you requested or is this the additional million dollars Mr. Fulton alluded to before?

Dr. BISPLINGHOFF. We requested a much smaller amount than that for borane fuels.

Mr. FULTON of Pennylvania. How much of this was in your regular budget for your high-energy fuels?

When you budgeted for your high energy research and development, you did not do it either by fuel designation or allocation by fuels, nor did you do it by line item. So, on your original budgetary allocation, how much did you have in here—on your regular 1963 budget—for this kind of research? You must have had something?

Mr. KARTH. Well, this is my question, Mr. Fulton. I am trying to ascertain whether or not they spent more or less in this area than they originally requested.

Mr. FULTON of Pennsylvania. That is a good point.

Mr. MYERS. In our original 1963 budget request we had approximately $464,000 representing the work of JPL in borane fuels—$450,000.

Mr. KARTH. Instead of that, you got $1,450,000. How much did you spend in this area?

How much do you expect to spend in fiscal 1963? I assume you have all your funds completed.

Dr. BISPLINGHOFF. On high energy fuels, that is borane plus other high energy fuels?

Mr. KARTH. How much?

Mr. MYERS. I don't have that figure available, but I can get it for you.

(The information referred to is as follows:)

Fiscal year 1963 OART funds for high-energy propellants are being spent as follows:

Liquid propellants	$1,709,000
Solid propellants	711,000
Storage and environmental factors	398,000
Total	2,818,000

Mr. KARTH. I might ask the gentleman from Pennsylvania, because I didn't serve on that committee last year, was this $1 million specifically based on the borane fuels or all high-energy fuels?

Mr. FULTON of Pennsylvania. Yes; aiming toward the borane fluorine combination. As you move up in the atomic and molecular field it is moving up from liquid oxygen, hydrogene and oxygen, and hydrogen. If you go on up, you even get up in beryllium before you come to the nuclear.

Mr. KARTH. I understand, but am just trying to ascertain for the benefit of the committee whether or not the intent of the full committee and the Congress last year had been adhered to by this agency. I would hope that you could supply this for the record so later on we can take a look at it.

Dr. BISPLINGHOFF. Yes, sir; we will give you the breakdown on all our high energy propellant work in 1963.

Mr. FULTON of Pennsylvania. Could we have Mr. Hammill of our committee staff put in the specific provisions of the committee report?

Mr. KARTH. No objections. Proceed, Doctor.

(The information referred to is as follows:)

Excerpt from House Report No. 1674, dated May 15, 1962 (p. 144), entitled "Authorizing Appropriations to the National Aeronautics and Space Administration":

"The committee added $500,000 to the item for 'Propulsion systems,' increasing this item from $3 million to $3,500,000. The reason for this increase was to place emphasis on the great importance of developing high-energy fuels, such as boranes with fluorine compounds."

Excerpt from conference report (H. Rept. No. 2038) dated July 26, 1962 (p. 7), entitled "NASA Authorization for Fiscal Year 1963":

"The House bill provided the sum of $500,000 for further research in the field of boron compounds of high-energy fuels through the Mississippi Test Facility. The Senate amendment increased this to $1 million and transferred this item to the Lewis Research Center, Cleveland, Ohio. The managers on the part of the House agreed to the Senate increase and to the transfer to the Lewis Research Center, inasmuch as that laboratory is engaged in basic propulsion research and could better supervise the contract management of research in boron compounds and other high-energy fuels."

Dr. BISPLINGHOFF. I mentioned before, diborane and oxygen-difluoride has approximately the same theoretical performance as oxygen and hydrogen, yet its density is three times as great.

It has the additional advantage that the fuel and oxidants have—a common liquid temperature around −250° F., which makes the combination much easier to store in space than hydrogen and oxygen. Although this combination shows great promise, there is very little experimental data to show that the theoretical performance can actually be realized in practice. We are sponsoring work on obtaining high combustion efficiencies with this combination and plan to extend our work in the future to determine if the theoretical high performance can be obtained with large area ratio nozzles operating under simulated altitude conditions. Another problem, as I mentioned earlier, is that of cooling the thrust chamber for the flame temperature approaches 8000° F., and neither propellant is suitable as a regenerative coolant.

Combustion instability in thrust chambers has been the source of many delays and difficulties in the development of large liquid rocket engines. Elimination of combustion instability during hardware development by cut-and-try procedures is very costly.

Mr. KARTH. Doctor, is it your office that's doing the research on the so-called combustion instability of the F–1 engine at the present time or is this done by the Office of Manned Spaceflight?

Dr. BISPLINGHOFF. No, this is primarily done by Manned Spaceflight. Our office is doing research of a fundamental nature to attempt to understand what the mechanism of combustion instability is, and how we can design, at the beginning, to avoid having combustion instability.

We are acting as consultants in helping, any way that we can, to overcome this problem which now exists in the F–1 engine; but we are not, primarily, responsible for curing the F–1 engine difficulties.

Mr. KARTH. Proceed.

Dr. BISPLINGHOFF. Research has long been underway to understand better——

Mr. KARTH. Doctor, that preceding sentence, "Elimination of combustion instability during hardware development by cut-and-try procedures is very costly."

Dr. BISPLINGHOFF. Yes, sir.

Mr. KARTH. How are we attempting to eliminate the combustion instability that now appears in the F–1 engine—are we doing it by this method?

Dr. BISPLINGHOFF. This is a cut-and-try procedure. Until we can understand the fundamental mechanism of this instability and incorporate this understanding in designs, we are going to have to solve the problem by cut-and-try procedures; but, unfortunately, we do not understand basically what's going on, and we are plagued with this difficulty in engines which already exist.

Mr. KARTH. Well, is there a possibility we will never get the F–1 to work?

Dr. BISPLINGHOFF. I'm sure we will get the F–1 to work. We have usually been able to overcome this difficulty by these so-called cut-and-try procedures; but they are time consuming and costly. Our object from the research viewpoint is to try to understand, in a fundamental way, what's going on so that the designer can design combustion instability out, right from the beginning.

Mr. KARTH. Which one of the centers is responsible for this kind of research?

Dr. BISPLINGHOFF. Lewis. Lewis Center in Cleveland.

Mr. KARTH. Lewis Center in Cleveland?

Dr. BISPLINGHOFF. Yes, sir.

Mr. KARTH. Have they been making good progress on this, Doctor?

Dr. BISPLINGHOFF. We think we have been making good progress.

Mr. KARTH. Has it been adequately funded?

What seems to be the problem?

Dr. BISPLINGHOFF. It is the difficult problem of thermo-dynamics chemistry and heat transfer, that is it is difficult to understand.

It's one of these research areas which requires not so much money but basic ideas and people who are knowledgeable in this field.

Mr. KARTH. Doctor, now the Office of Advanced Research and Technology requested x number of dollars for fiscal year 1963.

Dr. BISPLINGHOFF. Yes, sir.

Mr. KARTH. Did you get more or less than you requested, and if you got less, what happened to it?

Dr. BISPLINGHOFF. How did that balance out?

Mr. MYERS. We got more than we requested.

Mr. KARTH. You got more?

Mr. FULTON of Pennsylvania. Mr. Chairman.

How much was reprogramed out of your office so that you ended up with less?

Mr. KARTH. Well, this is my question, of course.

I assume it's understood.

Mr. MYERS. None was reprogramed out of our office. We had a net increase over what was requested.

Mr. KARTH. Well now, I'm not sure that I understand this.

The Office of Space Sciences felt that they enjoyed good fortune during fiscal year 1963. I think they said some 48 million of additional dollars had been reprogramed into the OSS.

You say that you got more, too. Manned Spaceflight, I think, got more.

Who got less? Where did it come from?

For the record, how much more did you get?

Mr. MYERS. Yes. For the record, we requested 222.210.

Mr. KARTH. Yes, sir.

Mr. MYERS. And we obtained in our final figure 235.250.

Mr. KARTH. About $33 million more than you requested?

Mr. MYERS. No, sir; that's 13.24, I think.

Mr. KARTH. I misunderstood your figure.

Mr. MYERS. 222.2 to 235.45.

Mr. FULTON of Pennsylvania. Mr. Chairman, where did all this reprograming then come from?

I think the chairman's question should be answered.

Mr. MYERS. I think Dr. Seamans covered that in his reprograming presentation.

I can't tell you in exactly all of the different pots, so to speak, in which the general manager then reallocates out of his total funds; but I can tell you in detail, if you like where we got increases and where we reprogramed within our own office.

Mr. KARTH. Well, I don't think that's important at this point. I just had the feeling that the Office of Advanced Research and Technology had received less than they had requested.

We can take a look at the overall question later on.

Mr. FULTON of Pennsylvania. Before we leave that point——

Mr. KARTH. Yes.

Mr. FULTON of Pennsylvania. Why does Dr. Bisplinghoff then say you are doing your best on engine development that you can on a limited budget—with budget limitations—and that seems to be the reason that you are not making as much progress as you would like in the high energy fuels field as well as engine development and technical fields?

Mr. KARTH. I guess he means that the budget is not unlimited.

Mr. FULTON of Pennsylvania. Yes; he then complains—not complains, but he talks of a limitation of programs, because of a limited budget, but when we hear it now there seems to be no budgetary problems whatsoever and they got more than they requested.

Mr. KARTH. The doctor's testimony was that they could not follow on with the development of engines in all of the high energy fuels because this became a very costly process.

Is that your testimony?

Dr. BISPLINGHOFF. This is correct.

We can always use more money in this research activity.

Mr. KARTH. The development of the engine is another problem, as I understand it.

Dr. BISPLINGHOFF. This is right.

This becomes very expensive when you start an actual engine program.

Mr. FULTON of Pennsylvania. Have you had any budgetary limitations in the F–1 field?

Dr. BISPLINGHOFF. To the best of my knowledge, no.

Mr. FULTON of Pennsylvania. The way it's stretching out, I am afraid the President and his brother are going to look like the Smith Bros. on the cough drop box by the time we get the engine.

We supply the money and the committee keeps hearing it's gonna be—it's gonna be. I think the American taxpayer is entitled to some results.

Mr. KARTH. Let me ask this.

Is the F–1 behind schedule?

Dr. BISPLINGHOFF. I cannot comment in detail on the F–1 schedule.

I suspect it may be somewhat behind schedule because of this combustion instability difficulty.

Mr. MORRIS. Mr. Chairman. Does NASA have a schedule for the F–1?

Dr. BISPLINGHOFF. I would not be able to tell you in any detail what that is since it's part of the Manned Spaceflight Office.

Mr. MORRIS. In your connection with it then it is only in the study of combustion instability.

Dr. BISPLINGHOFF. Yes; our interest is one of understanding the mechanism of combustion instability so that we can prevent its reoccurrence in future engines and we, of course, do everything that we can to help the F–1 project people to cure the difficulty which they have; but our most important research objective is to understand it for the improvement of future engines.

Mr. MORRIS. Does your office have an input of funds into the F–1 engine program in any manner?

Dr. BISPLINGHOFF. No.

Mr. MORRIS. Do you receive any funds from the manned spaceflight project?

Dr. BISPLINGHOFF. No.

Mr. MORRIS. Thank you.

Dr. BISPLINGHOFF. Some of our research people meet with the F–1 project people to try to assist them in overcoming the difficulty but there is no other connection besides that.

Mr. STAEBLER. Mr. Chairman.

Mr. KARTH. Mr. Staebler?

Mr. STAEBLER. Isn't this a rather good example of the point that has been made by previous representatives of NASA that the balance between fundamental research and applied research is very important?

Isn't this an illustration of the fact that our application has caught up with us. We didn't have enough fundamental knowledge ahead of our application and that when we think of the stockpile of fundamental information, it always looks as though it's pretty big and therefore it is unnecessary to keep stockpiling ahead: but here we find ourselves faced with costly delay and additional expenditures because we didn't have a big enough stockpile.

Isn't that the lesson to be drawn from this particular problem?

Mr. KARTH. Every indication is this is a lesson we should learn, yes.

Dr. BISPLINGHOFF. I think this is a very true statement.

Mr. KARTH. I think on the other hand it's also true though, Doctor, that we do not have the time nor will we be able to afford exhaustive

research on every single problem that might develop in our total space program.

This becomes an impossibility from several standpoints—manpower, for example.

Dr. BISPLINGHOFF. Yes.

Mr. KARTH. Finances and every other standpoint you can think of. Isn't this true?

Dr. BISPLINGHOFF. Yes; we are very keenly aware of this.

We try to conduct our business in a way so we have a broad base of fundamental and applied research which is rather inexpensive in comparison with the larger projects, and then to try to be extremely selective in those things, we carry into the advance subsystems stage.

Mr. KARTH. Don't we have to pick and choose, Doctor?

Dr. BISPLINGHOFF. Yes, sir; we must pick very carefully.

Mr. KARTH. Probably pick those areas where private industry, for example, has very little reason, if any, to do any research work in the area?

Dr. BISPLINGHOFF. Yes.

Mr. KARTH. For example, private industry, is not going to build any one and a half million pound thrust engines for consumer items.

They are nonsalable. As a result of that, I think we have got to do the research in the area.

There are other areas, however, where private industry has great capacity, and tremendous capability to do a tremendous consumer business. In these areas, I think maybe the Government would be wise not to involve itself too much with so-called in-house research. You agree with that, Doctor?

Dr. BISPLINGHOFF. Our job is one of catalyzing them to do it on their own in view of an interest in the space program.

Mr. KARTH. You agree with my last statement?

Dr. BISPLINGHOFF. Yes, sir. I do.

Coming back to combustion instability again, research has long been underway to understand better this phenomenon and to devise techniques for its control. New studies have indicated a relationship between the vaporization rates of the least volatile propellant in the combustion chamber and the onset of combustion oscillations. Through analytical and experimental research we are making some progress in defining the effect of various engine design parameters on combustion oscillation susceptibility.

In the area of large solid rocket motors we are working closely with the Air Force in the joint NASA-DOD solid motor technology program. In addition, NASA is also engaged in further research and technology on solid rockets for space applications. Work is underway on evaluation of two promising solid propellants containing boron and a third is being studied for possible motor applications.

Figure 88 illustrates, schematically, present and advanced concepts of solid motors as well as the principal research goals which we have set in our program.

Mr. KARTH. Doctor, how many research dollars has NASA spent on solids, as opposed to research dollars spent on liquids?

Dr. BISPLINGHOFF. During fiscal year 1963?

Mr. KARTH. Let's go back and start from the beginning.

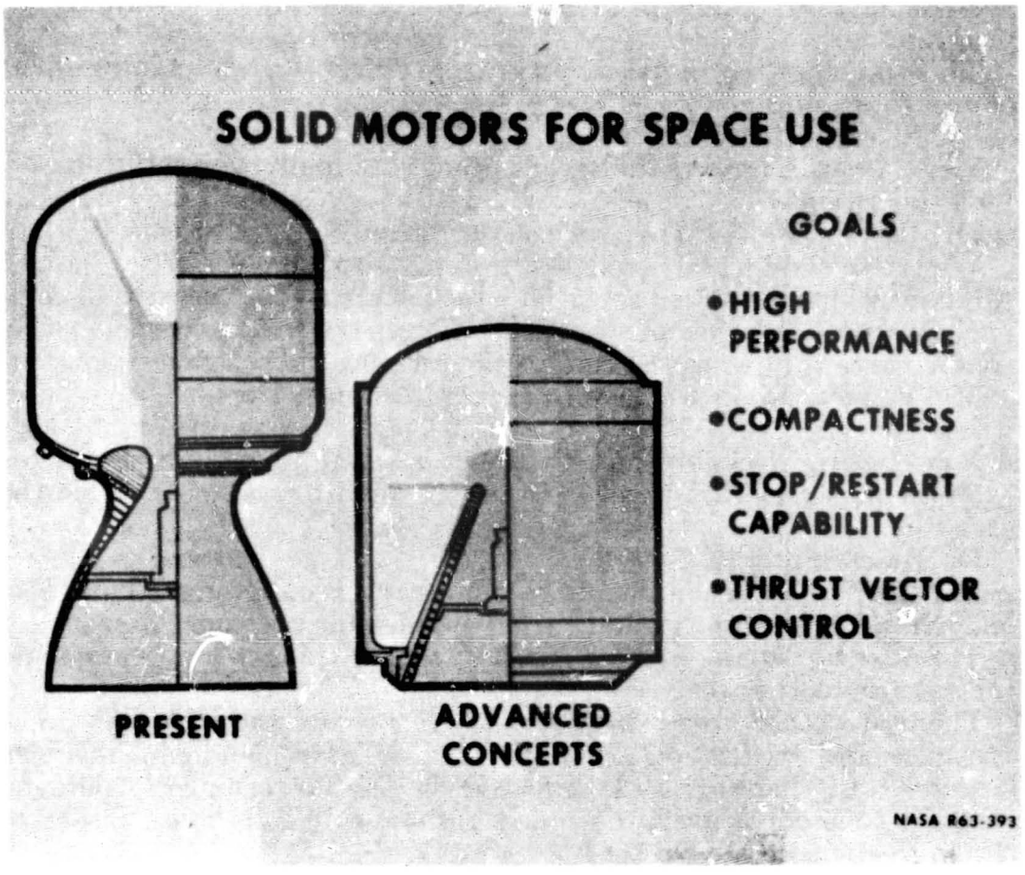


FIGURE 88

How much total research money has been spent on solids, and how much total research money has been spent on liquids?

Dr. BISPLINGHOFF. I don't know. We can give you this money clear back to the beginning.

We can find it for you.

Mr. KARTH. Would you try to supply it for, at least, the last 3 years or so?

Dr. BISPLINGHOFF. We can give it to you through 1962 and 1963 right now.

Mr. KARTH. Thank you, I'd like to have that and then if you will supply the total for the record, please.

Mr. MYERS. All right, for the fiscal year 1962 in solid propulsion—solid propellants, we spent about $340 million. Not "about." That was an exact figure.

Mr. KARTH. 340—what?

Dr. BISPLINGHOFF. 340,000.

Mr. MYERS. 340,000. Excuse me.

In solid rocket components, in solid rockets systems, $185,000.

And then in our advanced engine technologies in solid rocket components and systems it's 192,000—whatever they add up to, in the solid area.

Dr. BISPLINGHOFF. That is in 1962.

Mr. MYERS. That is in fiscal year 1962.

Mr. KARTH. Yes, sir.

Mr. MYERS. In fiscal year 1963 we will have, by the end of this year, obligated a million 109—$1,109,000—excuse me; and $711,000 in high energy propellants and solids.

In the advanced engine technology, $207,000 in solids and in the advanced spacecraft engines, we will have spent $570,000, whatever they add up to.

Mr. KARTH. In solids?

Mr. MYERS. In solids; yes, sir.

Mr. KARTH. What about liquids in these 2 years?

Mr. MYERS. I can repeat those same figures in liquids, although there is other work in liquids that should be counted in. I don't know whether I can add them up quickly enough for you.

These are in various pieces of programs. I would rather summarize this for you and supply it for the record.

Mr. KARTH. What do you mean you can repeat those same figures? You mean we spent identical sums on solids and liquids in 1963?

Mr. MYERS. I mean the same categories of things; such as propellants, we have liquid propellants and solid.

In advanced concepts, we have liquid and solid advanced concepts.

Mr. KARTH. Thank you, if you went through the same sequence that you went through with solids, I'd appreciate it.

Mr. MYERS. All right.

Mr. Sloop, who is Director of this, has a summary of it? He says he can speak for it.

Mr. SLOOP. It is roughly this for the research and development. It is 4 million, solid; and 8 million in liquids for 1963.

Mr. KARTH. How about 1962?

Mr. SLOOP. I don't have that with me, but I can get that.

Mr. KARTH. Dr. Bisplinghoff apparently has it there, don't you?

Dr. BISPLINGHOFF. Yes; we can read off numbers similar to the solid numbers for 1962 if you would like us to read those for the solids—the liquids, please. You read the solids.

Mr. MYERS. For 1962 I read the solids.

Dr. BISPLINGHOFF. Read the liquids in 1962.

Mr. MYERS. The liquids 1962 are 1.8 and 1.803—$1,803,000 in aerothermo chemistry, $341,000 in materials, $1,263,000 liquid propellants, $73,000 on the liquid rockets components in the engine technology, $1,062,000 in liquid rocket systems, $75,000 in liquid rocket components in spacecraft engines and $1,526,000 in liquid rockets systems in spacecraft engines.

Mr. KARTH. I am apparently not getting the figures I am interested in.

I don't know just what figures these are. Apparently, they are very basic research figures.

This year we are spending $100 million on Centaur. That is a liquid hydrogen liquid oxygen engine. I want the total research and development dollars that have been spent in both of these areas now for the last 3 years.

Dr. BISPLINGHOFF. Yes.

Mr. KARTH. I would like to be able to make a comparison. I am sure the committee would be interested in knowing what our efforts have

been in both liquids and in solids. This has been of some concern in the past and I assume will be of at least passing interest.

Mr. Sloop?

Mr. SLOOP. One reason this demarcation is not clear at this moment is there are many—in our technical disciplines we often cross the boundaries between solid and liquid.

It is an artificial boundary. For example, liquid people think in terms of dry propellants which is, too, liquids and solids. Beryllium, you might say, is an additive and the solid people talk in terms of hybrid rocket combustion which is a liquid and a solid.

They are both concerned with thrust vector control, Dr. Bisplinghoff mentioned, and many of our disciplines are crossing the boundaries between solids and liquids.

Mr. KARTH. Both of those are very small parts of the total I am attempting to get.

Mr. SLOOP. For example, in aerothermo chemistry we are concerned with particles in the exhaust. We are concerned with this in both solids and liquids and therefore we have felt in our basic disciplines it was an artificial division to say this is solid and this is liquid because the same physical phenomena occurs in both.

So, in these basic areas we have simply worked on the problem and not worried about whether it was in a pocket called "solid" or the pocket called "liquid."

Mr. KARTH. Mr. Morris.

Mr. MORRIS. May I ask a question.

Is the F–1 a liquid fueled engine or a solid?

Dr. BISPLINGHOFF. F–1 is a liquid fuel engine.

Mr. MORRIS. Is it in the stage of research and development?

Dr. BISPLINGHOFF. No, sir.

Mr. MORRIS. It is in an operational——

Dr. BISPLINGHOFF. It is in the stage of development of an operational engine.

I think our dilemma is, that Mr. Karth would like to have the total NASA budget in liquid solid R. & D. dollars and we have been reading off here only that part of the budget which is concerned with research and advanced technology. We would be glad to get this total figure for you and put it in the record if you wish.

Mr. KARTH. The figures you have been giving me are those funds that your office has expended in this area?

Dr. BISPLINGHOFF. Yes, sir; what we classify as advanced research and technology.

Mr. KARTH. I would like to have the NASA funds spent in these two areas.

Dr. BISPLINGHOFF. Yes, sir; we will be glad to supply these for you.

(The information referred to is as follows:)

The following table shows total NASA R. & D. direct funds for liquid and solid rockets by fiscal years. In the case of liquid fueled engine development the engines are indicated.

[In thousands of dollars]

	1962	1963	1964
Supporting research and technology:			
Liquid	8,260	16,693	32,447
Solid	3,450	5,726	13,850
Subtotal, SRT	11,710	22,419	46,297
Liquid engine development:			
RL-10	35,343	35,374	39,670
H-1	5,662	5,260	5,200
F-1	48,320	50,800	54,100
M-1	16,705	35,000	45,000
J-2	33,635	44,542	48,200
Subtotal	139,665	170,976	192,170
Grand total	151,375	193,395	238,467

Dr. BISPLINGHOFF. Turning now to nuclear rocket propulsion; for some time we have realized that there is a need for increased rocket performance for high energy interplanetary missions. It is clear that nuclear propulsion will be required in our spacecraft. We feel nuclear propulsion is probably the only answer that we can turn to for this purpose. Our nuclear rocket program has the objective of establishing the capability to employ nuclear rocket engines and vehicles in advance launch vehicles so that they make possible the accomplishment of high payload deep space missions. Currently, we take as our major target the accomplishment of flight testing a nuclear powered stage. The overall AEC–NASA program consists of the KIWI research reactor, the NERVA engine, the RIFT stage and our research and technology efforts aimed at more advanced systems. The program will, however, certainly not terminate with the flight testing of the NERVA engine in the RIFT stage. The NERVA propelled RIFT stage could be developed into an operational version as the third stage of the Saturn V and many useful space missions could be accomplished with such a vehicle.

Mr. KARTH. Doctor, I wonder if I could interrupt you here just for a moment.

Dr. BISPLINGHOFF. Yes, sir.

Mr. KARTH. I would like to find out whether or not your schedule would permit you to appear this afternoon at 2 o'clock.

Dr. BISPLINGHOFF. Yes; I could do this.

I have been asked to go to the DOD on a matter at 2:30, but I can see if I can get out of this meeting and come here.

Mr. KARTH. Well, if you have a commitment that you must keep, of course, this is something else, because this is very short notice indeed; but I wasn't sure at the beginning of the week that the House would not be in session today.

Dr. BISPLINGHOFF. Yes.

Mr. KARTH. Nor was I counting on not being able to have a meeting that we had originally scheduled earlier in the week, due to the unavailability of the committee room.

Dr. BISPLINGHOFF. Yes.

Mr. KARTH. So, to make up for lost time, I thought we might meet this afternoon.

Dr. BISPLINGHOFF. I see no reason I can't get out of this to come here this afternoon.

Mr. KARTH. If this is no hardship, we would like to meet. I'm going to leave it up to you, Doctor.

Dr. BISPLINGHOFF. Let's let it go at this moment that I will be here.

Mr. KARTH. All right; thank you very much.

Dr. BISPLINGHOFF. What time would that be, sir?

Mr. KARTH. Two o'clock.

Dr. BISPLINGHOFF. Two o'clock.

Figure 89 illustrates a sketch of an operational nuclear Saturn V. It consists of the F–1 powered S–IC first stage, the J–2 powered

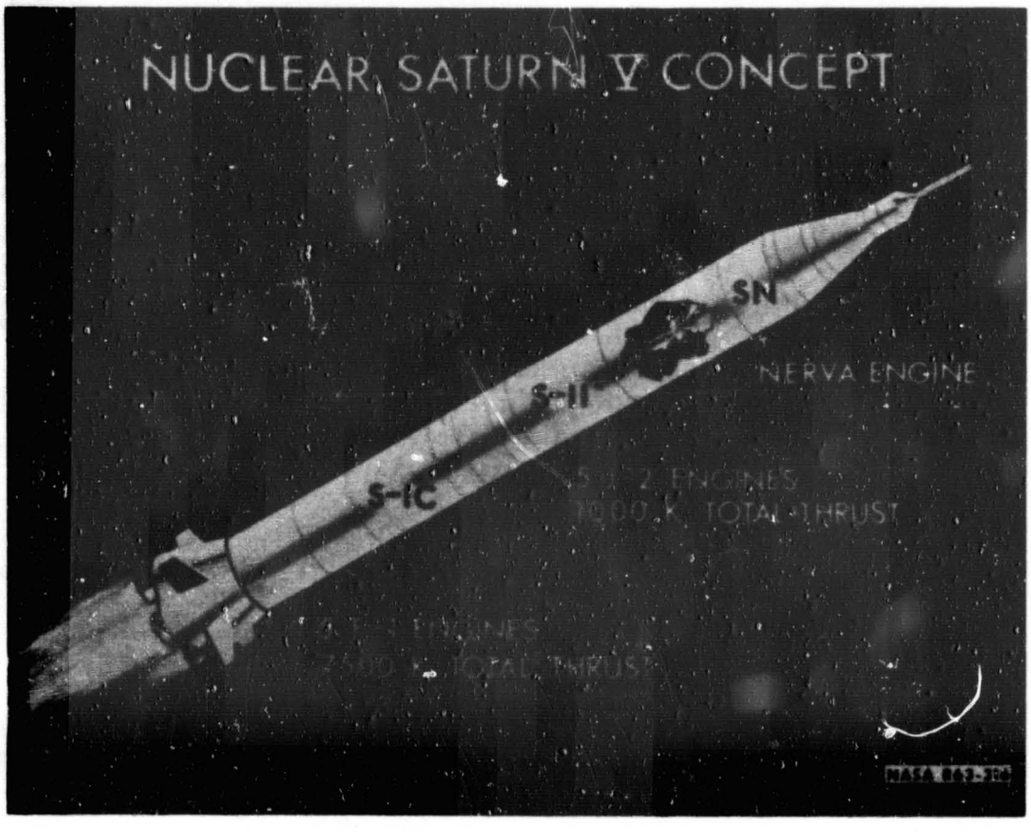


FIGURE 89

S–II second stage, and the NERVA-powered S–N third stage. The S–N designation refers to an operational version of the RIFT stage. Above the S–N stage, we have illustrated a typical payload configuration topped by an escape rocket system for manned flights.

Figure 90 shows an advanced manned interplanetary mission that could employ an operational version of RIFT as a third stage of the Saturn V. It is interesting to note that the demands on the nuclear propulsion system in this mission are not severe since the nuclear stage is utilized only near the earth in propelling the spacecraft to the energy necessary to "coast" to Venus and back to Earth. A restart capability would not be required. In this mission, chemical rockets

FIGURE 90

would be used for midcourse maneuvers and for retrofiring upon return to earth to slow the spacecraft to a reentry speed that is comparable to that which will be required in the Apollo mission.

The next figure (fig. 91) shows two unmanned interplanetary missions that are also possible with the nuclear Saturn V. The left side of the figure shows the capabilities for exploration of Mars in preparation for visits by men. The nuclear Saturn V could propel a spacecraft to Mars on a 100-day trip. Upon reaching the planet, chemical rockets would fire in such fashion as to permit the spacecraft to orbit Mars. The 25,000 pounds in the Martian orbit would permit examination of the environment on our neighbor planet even to the extent of landing large equipment packages on the surface. The trip time for the Jupiter flyby mission, portrayed on the right-hand side of the figure is 18 months using a nuclear Saturn V. It appears that enough payload could be provided to permit guidance, midcourse correction, scientific experiments, communications, and power supply.

These charts have illustrated missions that could be considered as functional goals of the nuclear rocket program. The major steps of this program, which have been given the names of Kiwi, NERVA, and RIFT, are illustrated schematically by figure 92.

We have prepared this chart to indicate the relationship between the major activity of the nuclear rocket program. As shown, the Kiwi reactor technology feeds into the NERVA engine project. A NERVA engine will propel the RIFT stage to be flight tested on the Saturn V as shown on the right side of the chart. The objective of

FIGURE 91

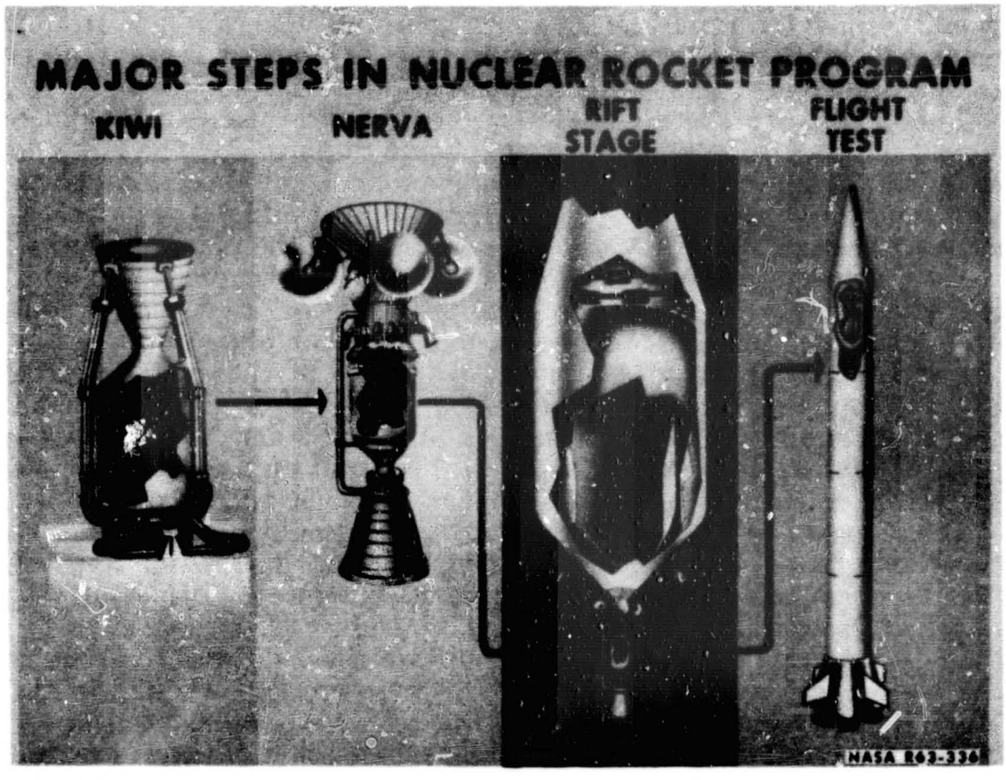


FIGURE 92

the Kiwi project, which is being conducted by the Los Alamos Scientific Laboratory, is to provide the basic reactor design for the NERVA engine. The Kiwi project has moved from the Kiwi A series of tests, which demonstrated the materials technology for rocket reactors, into the Kiwi B series which will provide the basic design information for the reactor of the NERVA engine. Thus far, three reactors have been tested in the Kiwi B series, the last being Kiwi B–4A tested at the Nuclear Rocket Development Station in November 1962.

In the Kiwi B series of reactors the Los Alamos Scientific Laboratory established several designs which represented different approaches to the solution of problems associated with the use of a brittle material in the environment of a nuclear rocket. The first of these the Kiwi B–A reactor was tested with gas coolant flow in December of 1961. In September of 1962 a similar reactor (Kiwi B–1B) was tested with liquid hydrogen inlet flow as required in a flight rocket engine. The results of this test indicated that the reactor could be started stably with liquid hydrogen. However, in the Kiwi B–1B experiment damage occurred in the reactor core similar to that which had occurred in certain of the Kiwi A tests. The fact that this damage has not been explained through extensive laboratory tests and analysis has made us discard the Kiwi B–1, for the present, as a candidate for the NERVA engine.

It is important to point out that prior to this date the decision had been made to proceed with the Kiwi B–4-type reactor design as a basis for the first NERVA reactor design. The Kiwi B–4 design is different in many respects from Kiwi B–1. The decision in favor of Kiwi B–4 was based on the best available analytical and laboratory experimental data and on the fact that the Kiwi B–1 type of design had failed in the Kiwi A tests and the failure was not explained. It was also based on the belief that the Kiwi B–4 provided greater margin of performance for operation of the reactor. The first Kiwi B–4 type of reactor, the Kiwi B–4A, was tested by Los Alamos last November. Almost as soon as the test of the Kiwi B–4A reactor was started flashes of light were noted in the exhaust jet. These flashes indicated that material from the core was being carried away in the jet. Nevertheless, the test was continued until the frequency of these flashes became so rapid that it was apparent that more could be learned by shutting down and examining the reactor than by trying to attain a design power condition. Upon examination it was found that the thermal insulation component around the reactor had broken and had been ejected from the reactor, and that fuel elements had suffered extensive damage. The data indicate that vibrations took place in the reactor and that these vibrations were probably generated within the reactor.

Actually, we got up to about 50 percent power before the shutting down.

Work is now actively underway by Los Alamos and Westinghouse to modify the mechanical design so as to minimize the possibility of such mechanical vibrations. There is very strong feeling among all participants in the program that this vibration is the explanation for the damage during test operation. We have determined, however, that before further full-scale hot tests are run, component assembly and full-scale mechanical testing and cold flow testing will

be conducted. The purpose of these tests will be to evaluate the failure mode hypothesis that has been made of the Kiwi B–4A reactor damage. Such testing will also be conducted to check the suitability of redesign of that reactor to overcome the mechanical difficulties experienced.

The Kiwi project is largely funded by the AEC and conducted by the AEC's Los Alamos Scientific Laboratory, although NASA supports it by providing nozzles, liquid hydrogen feed systems, and liquid hydrogen.

The NERVA project is in the process of expanding as the Kiwi project phases out. A request for proposals was issued by the joint AEC-NASA Space Nuclear Propulsion Office on February 2, 1961, for phase I of the NERVA development project, and the selection of Aerojet-General as prime contractor and Westinghouse Electric Corp. as principal subcontractor was announced on June 7, 1961. The phase I effort was completed on January 10, 1962. A follow-on contract was signed by AEC and NASA effective January 11, 1962. This contract will cover the entire development effort through September 30, 1966, funded on an annual basis. The contract covers the program of prototype hardware design and development and its execution is paced by achievements in the Kiwi reactor program. The Westinghouse Astronuclear Laboratory is designing the first NERVA experimental reactor, and some of its components are now under fabrication or procurement. Collaboration between Los Alamos Scientific Laboratory and the NERVA contractor is under way on certain design and fabrication efforts related to Kiwi and NERVA work.

The work to be performed in fiscal year 1964 will involve procurement and integration of certain engine components aimed at evaluating critical design and operating data, supported by appropriate design, analysis, test, and simulation activities. No major procurement of nonnuclear components will be undertaken until successful reactor operation is achieved. Several NERVA reactor tests will be conducted at the Nuclear Rocket Development Station. Another important area of work in NERVA will be studies of radiation effects on components and subsystems.

The RIFT project moved out of a 2-year study into the initial development phase in late June 1962. The 2-year study program, while at a relatively low level, had formed a basis for initial development effort and had indicated those areas which need immediate attention. The prime contractor in the RIFT project is the Lockheed Missiles & Space Co. of Sunnyvale, Calif.

Mr. KARTH. How was the contractor selected in this case, Doctor?

Dr. BISPLINGHOFF. This was a competitive bidding process and Lockheed was judged to be the best of these bidders.

Mr. KARTH. Competitive bid contract?

Dr. BISPLINGHOFF. Yes, sir.

Mr. KARTH. Thank you.

Dr. BISPLINGHOFF. The RIFT stage development project will be paced by the development of the NERVA engine. There will be no commitment of major hardware until the results of the reactor program indicate a high level of confidence. The initial effort under the RIFT contract consequently is confined to preliminary design in

all subsystem areas and the solution to those technical and manufacturing problems requiring long study and lead time.

System development activities were initiated last year and will be continued at a minimum level throughout calendar year 1963 and 1964. These activities are concerned principally with insulation, materials, and laboratory investigations. Conceptual design, initiated last year, will be continued at a nominal level throughout calendar year 1964 and will be paced by the outputs of the structural, materials, and radiation test programs.

The advanced research and technology portion of the nuclear rocket program supports the current projects, established a base of technical information for design of nuclear engines and vehicles, and provides the necessary technology for future engines and vehicles.

To support these objectives, we conduct research in the following areas:

Rocket reactor research.
Engine systems technology.
Safety.
Vehicle technology.

Rocket reactor research is largely funded by the AEC although the NASA budget for this work includes funding for reactor test support components (nozzles and pumps) and liquid hydrogen for reactor tests. NASA in-house reactor-oriented work is conducted at the Lewis Research Center and the Jet Propulsion Laboratory. Lewis is studying various reactor concepts and performing research on reactor material properties. Both Lewis and JPL are conducting studies and research on cavity or gaseous core reactor concepts.

Mr. KARTH. What kind of duplication is this, Doctor? What they are doing at Los Alamos?

Dr. BISPLINGHOFF. The Los Alamos reactor work is channeled along the lines of a solid—of a graphite fuel element material.

The KIWI reactor is—is a reactor which employs a graphite fuel element.

At the Lewis Laboratory we are doing very preliminary work on fuel elements made of tungsten to provide us what might be called an alternative approach to the whole problem.

On the other hand, there is a totally different kind of reactor concept where the fissionable material is supported by a gaseous phase and both Lewis and JPL are conducting studies here.

Now, I might say the amount of money involved in the gaseous core reactor research is very, very small, and this is something that could come to fruition in perhaps 20 to 30 years.

It's in the very early research stages. It shows promise of having, however, a very, very high performance and we are anxious to continue this very fundamental level of effort of research on the gaseous core reactor.

Mr. KARTH. Mr. Morris has a question.

Dr. BISPLINGHOFF. Yes.

Mr. MORRIS. Doctor, when did you start funding this research?

Dr. BISPLINGHOFF. On the gaseous?

Mr. MORRIS. Is this funded through your offices?

Dr. BISPLINGHOFF. Yes, sir. Yes.

Mr. MORRIS. When did you start funding it?

Dr. BISPLINGHOFF. On the gaseous cone reactor——

Mr. MORRIS. When did Lewis get into the nuclear reactor and research business?

Dr. BISPLINGHOFF. Let me hasten to add, the gaseous core reactor that we are doing and JPL——

Mr. MORRIS. I know it is basic to the nuclear reactor research. This is the way you get in this business, you know.

You start out with a little basic research in a place and then the first thing you know you are really in business. You have got facilities and you've got everything else and you say we are started now and now we got to build this up.

What you are leading up to, it looks to me, is the starting of a nuclear research laboratory.

I may be mistaken. This is what it looks to me like.

Dr. BISPLINGHOFF. The gaseous core reactor research is purely fluid mechanics—fluid flow studies.

The biggest problem here is one of getting a stable gaseous system which contains fissionable material and still allows one to squirt this liquid hydrogen by it so as to pick up the heat.

Our work now, and for some time to come, will be fundamental work in fluid mechanics.

At such time as this might become a system where we'll actually want to put fissionable material in, I expect the AEC would get involved at that time.

Mr. MOSHER. Mr. Morris, may I interrupt?

I have the impression Lewis has been in nuclear research elements of this type for a long time. Isn't that right?

This isn't new to Lewis, is it?

Dr. BISPLINGHOFF. On the solid core reactor work, Lewis has been studying the possibility of a tungsten fuel element for sometime. There has been no live reactor work done at Lewis. This has been largely the study of a tungsten reactor material and a conceptial design as to how this can be incorporated to a reactor.

Mr. MOSHER. Mr. Chairman, again, as long ago as 1960, it seems to me I was shown work that Lewis was doing in nuclear propulsion.

Dr. BISPLINGHOFF. Yes. There is nothing involving a critical reactor in the Lewis——

Mr. MOSHER. The question Mr. Morris raised, I think, was whether or not the participation of Lewis in nuclear propulsion research was new. Isn't that the question you asked?

Mr. MORRIS. That is exactly right.

Dr. BISPLINGHOFF. No; it's not new.

This materials and fluid mechanics work has been going on some time.

Mr. MORRIS. Let's get down to a little more definite what we mean by "new."

When did you start in the nuclear research business in Lewis Research Lab?

Dr. BISPLINGHOFF. I am going to have to leave that to Mr. Finger.

Mr. FINGER. Congressman Morris, the Lewis Research Center had a reactors research division, I would guess from some time in the early 1950's, I guess—1953 or earlier.

They, in fact, did work in response to requests from the Navy to assist in the submarine program—certain heat transfer, corrosion problems, control rod work.

The Plum Brook reactor construction started about 5 or 6 years ago and its initiation was for the nuclear powered airplane program involving both nonnuclear components and reactor work.

Mr. MORRIS. You know that is gone now?

Mr. FINGER. The reactor is there and is a very useful tool to apply to the nuclear rockets as well.

We are proposing to use it for nuclear rockets. This has a long history. Actually, the work is research effort and I am sure no one in NASA would agree to the Lewis Center developing a reactor. That is a job of the AEC.

I should also point out the Lewis propulsion work in this area is reviewed by the Joint AEC–NASA Office operating with its NASA "hat" essentially, so it is a coordinated program actually.

Mr. MORRIS. That is your office?

He says he reviews it. I will go along with him.

Mr. KARTH. Mr. Mosher?

Mr. MOSHER. Could I go back for a minute, since we mentioned Lewis?

The first full paragraph on page 20 where you say this work will be paced by the outputs of the structural materials and radiation test programs; is Lewis involved in those test programs?

Dr. BISPLINGHOFF. This is the RIFT—Lewis is involved in an indirect way since we have a very strong materials research organization.

Mr. MOSHER. Is any of the test work at Plum Brook involved here?

Dr. BISPLINGHOFF. I would think it would be involved in an indirect way.

Lewis is not directly involved with RIFT as this is technically directed by the Marshal Center at Huntsville.

Mr. MOSHER. Would the reactor available at Plum Brook be useful?

Dr. BISPLINGHOFF. Be useful in radiation testing, I should think.

Mr. MOSHER. There would be no reason to duplicate?

Mr. DOWNING. Doctor, maybe you explained this before. If you have, I'm sorry.

For my own edification, tell me what is the great advantage of having nuclear propulsion in rockets?

I have always thought of nuclear propulsion being useful because it could last for long periods of time without being refueled, but in rocketry the idea is to get it up to some certain altitude and then coast. You don't use your particular system, do you?

What is the tremendous advantage of nuclear propulsion?

Dr. BISPLINGHOFF. Yes; this figure of merit we used before, specific impulse, is at the root of the answer to your question.

As we mentioned before, chemical engines give us specific impulses of the order of 400 seconds. This is pounds of thrust per pound of fuel per second.

If we look at a nuclear rocket engine, one with a solid fuel element core, we find that we can just about double this specific impulse because of the high temperatures that can be created in the core of the reactor and the possibility we can pass liquid hydrogen through these cores.

If we do this with a gaseous reactor, we feel we can raise the specific impulse to perhaps 2,000 so that you can see just on the basis of the figure of merit we have an advantage with the nuclear system.

Mr. DOWNING. In other words, you could get 800 seconds of specific impulse?

Dr. BISPLINGHOFF. As opposed to 400.

Mr. DOWNING. 400 seconds with the chemical fuels?

Dr. BISPLINGHOFF. With the gaseous core reactor if it ever materializes this may go to 2,000 which is quite a step above what we can do with the chemicals.

But you touched on one of the other advantages.

We would like to be able to restart these vehicles in space and if we can, then the only limitation on how far we can go would be in how much hydrogen, liquid hydrogen, we could carry which is the fuel that is ejected from the rocket.

Mr. DOWNING. And you don't think any other propellants will have these potentials?

Dr. BISPLINGHOFF. No, sir; we can't see any of the chemical propellant combinations we now know of that can give us this potential.

Mr. DOWNING. The chairman has suggested electrical.

Dr. BISPLINGHOFF. Now, the electrical propulsion is extremely important to us for deep space missions but as you know, the thrust is very low and we must choose the mission applications of electric propulsion to those applications where we can have a very, very low thrust of the order of maybe a pound or something like this; but this pound of thrust pushing for hours or days or weeks can, of course, get us to a very high velocity.

Mr. DOWNING. What is the budgetary request for the nuclear program?

Dr. BISPLINGHOFF. We can give this to you in detail.

Mr. DOWNING. The overall figure is what I mean.

Dr. BISPLINGHOFF. For 1963 or for 1964?

Mr. DOWNING. Fiscal 1963 and 1964.

Dr. BISPLINGHOFF. Fiscal 1963 and 1964.

Mr. MYERS. Total R.D. & O., fiscal 1963 was 89.248 million.

Fiscal 1964 is 118,919,000.

Mr. MORRIS. This is NASA's request?

Dr. BISPLINGHOFF. Yes, sir.

Mr. MYERS. This is for the nuclear rocket program.

Mr. MORRIS. Funded by NASA?

Dr. BISPLINGHOFF. The NASA part of the program.

Mr. MORRIS. You gentlemen should understand there is more money in that program—funded by AEC.

Mr. DOWNING. How much is funded by AEC?

Mr. FINGER. In 1963, AEC requested $74½ million, I believe, and this year it's $99 million—right around in there.

I'll have to check that. Total of almost $200 million for fiscal year 1964 in the request that's before the committee now.

That doesn't include construction, incidentally.

There is an additional amount for construction in both agencies.

Mr. DOWNING. Can we get that figure?

Mr. FINGER. The total figure for 1964 for both agencies, including construction is $221.5 million.

Mr. DOWNING. Thank you very much. Thank you, Mr. Chairman.

Mr. MOSHER. Mr. Downing mentioned electrical propulsion. Are these the same? I am not quite sure.

Dr. BISPLINGHOFF. The ion propulsion is one of the several types of electrical propulsion.

Mr. MOSHER. Don't you need the reactor to create the heat you need?

Dr. BISPLINGHOFF. This is correct; yes.

Fundamentally, the electrical propulsion devices could operate with any electric power source.

However, for long missions it's quite clear we need——

Mr. MOSHER. You need a nuclear electrical system?

Dr. BISPLINGHOFF. Yes, sir.

Mr. MOSHER. Is any of that there part of this other nuclear electrical research?

Dr. BISPLINGHOFF. This is a separate item in our budget.

This is under nuclear electric power conversion.

Mr. MOSHER. It's not duplication in any way, or part of it?

Mr. KARTH. Mr. Hammill has a question.

Mr. HAMMILL. On page 18, you state that the Westinghouse Laboratory is designing the first experimental reactor and that some of its components are now under fabrication or procurement.

I understood that the results of the KIWI tests that you have conducted in Nevada were such that the design of the core is not really considered satisfactory at this point.

Dr. BISPLINGHOFF. That is right; yes.

Mr. HAMMILL. I wonder how the contractor can proceed, based upon a design that is not considered to be satisfactory.

Dr. BISPLINGHOFF. What we are doing here, Mr. Hammill, is having the Westinghouse Co., which is a very experienced engineering firm, work closely with Los Alamos to—in an attempt to produce a design—reactor design, using their engineering ability which improves on the Los Alamos design and which we hope will overcome the shortcomings that the KIWI B–4A test showed us; so the Westinghouse effort is really a complementary reactor effort to the Los Alamos effort and Westinghouse's engineering abilities will complement Los Alamos scientific abilities, we feel, in this.

Mr. HAMMILL. Well, the real question is whether or not they are going to pursue the core design that has been used up to now, or are they perhaps going to look into a totally new design?

Dr. BISPLINGHOFF. They are looking into several alternative designs and we are not quite sure, at this moment, which of these will be chosen for the next test, but we are looking into designs which will definitely overcome this cracking difficulty we had in the last reactor.

Mr. KARTH. I think Dr. Finger wanted to address himself to that question.

Mr. FINGER. I'd just like to add to what Dr. Bisplinghoff has said; the Westinghouse design uses the basic features of the last reactor test.

However, it is a redesign effort to try to make it a good suitably engineered system.

In addition to that, they are looking at alternate design ideas to try to make sure we have something coming along that will be able to serve us if the design work that is now in process doesn't work out as well as we would hope.

Mr. HAMMILL. What is the time scale for this kind of development?

I understand, from reports in the trade press, that the whole program now has been set back some 18 months.

Dr. BISPLINGHOFF. Harry, would you answer that, please?

Mr. FINGER. The component work that we have been planning is already partially in process. There is a great deal of design work be-

ing done now and analysis work both at Westinghouse and Los Alamos.

We expect, through this kind of component work, we will end up with a reliable reactor and we'll have to do power tests on a full reactor because we can't completely simulate a full reactor arrangement in components.

We expect the power tests will be run late this year at the earliest. If the components show problems or if the simulated subassemblies show problems, then the power test date would slip into next year. That's about the timing of it.

I don't know how to refer to these reported 18-month delays or anything like that, because it really depends on when you are counting from.

Mr. MORRIS. Mr. Chairman, while Mr. Finger is on his feet, I'd like to ask: Do you have a firm test date now for the next reactor power test?

Mr. FINGER. No, sir, we don't at this point. We have dates and plans for cold flow tests and components but the power test date really depends on the technical outcome of those preliminary tests and it is still being planned.

Mr. MORRIS. Thank you.

Mr. KARTH. Proceed, Doctor.

Dr. BISPLINGHOFF. Thank you.

In order to summarize the nuclear rocket program, I have prepared figure 93 that shows the major milestones for calendar year 1964.

FIGURE 93

It is anticipated the KIWI project will be completed in calendar year 1964 and that we will continue reactor development through tests of reactors for engines. Flight safety reactor tests are planned for operation at the Nuclear Rocket Development Station to determine the fission product sources that could be produced in abnormal power excursions.

In the RIFT project, we hope to verify the type of insulation, the techniques of installation, bonding and vapor barrier material on scale model tanks in a cryogenic and radiation environment. We expect delivery of the hydrogen feed system to the Nuclear Rocket Development Station for installation in Test Cell C which will be used for advanced reactor tests. The complete Dynamics and Controls Research Facilities at the Plum Brook Research Station will be available for test operation late in fiscal 1964.

ELECTRIC ROCKET PROPULSION

The chemical and nuclear rocket propulsion systems considered above are characterized by high thrust. A complementary propulsion system is provided by electric rocket engines which have low thrust with specific impulses several times as high as those of chemical and even nuclear rockets (from 1,000 to 10,000 Isp or more). These higher specific impulses are the underlying reason for the potential performance advantages for deep space missions of electric rocket engines. However, low thrust to weight ratios will require that the propulsion system operate for long periods in order to achieve the desired vehicle velocities. For a Mars mission, this operating time is of the order of 400–1,000 days, hence the requirement for long life. Since repairs en route are impossible for an unmanned probe and difficult for manned vehicle, this long life must be achieved if at all possible without allowance for maintenance.

The efforts during the past years on electric propulsion have been directed largely toward the scientific and engineering development of the engine or thrusting device. The fundamental feasibility of the electric engine or thrusting system has become an accepted fact. Attention has been given to the vehicles which can be propelled and missions that may be performed. In addition, during 1963 and 1964, more attention will be given to studies of power conditioning components.

Electric thrust engines may be segregated into three principal groups:

(a) Electrothermal engine—an engine which develops thrust by heating a gaseous propellant to a high temperature and expanding it through a nozzle.

(b) Electrostatic or ion engine—an engine which develops thrust by accelerating charged particles by means of an electrostatic field.

(c) Electromagnetic engine—an engine which develops thrust by accelerating a plasma by means of a stationary or varying magnetic field.

During the past year small cesium contact ion engines have reached a stage of development where their utility for space propulsion can be

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stated with confidence and in certain cases these engines are now available for space tests.

Figure 94 illustrates a sketch of a linear strip cesium ion engine module. This unit module will produce a thrust of approximately 0.01 pound with an overall size of 4 by 5 inches outside dimensions and should form the basic module for larger engines.

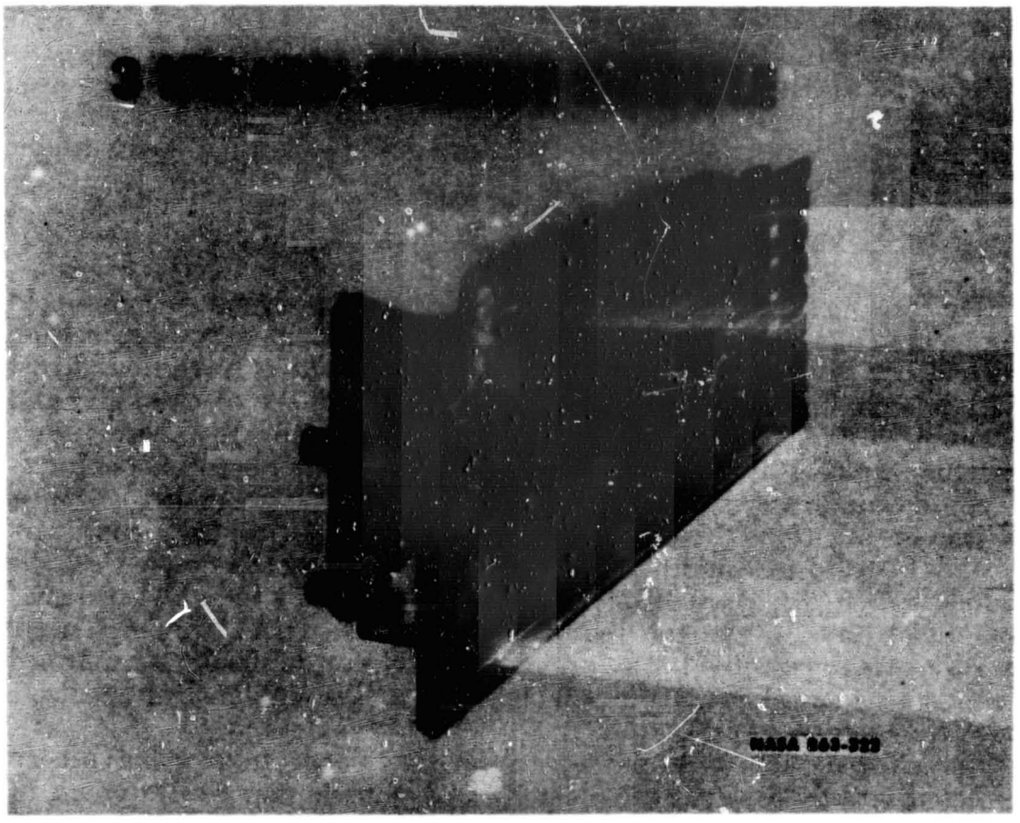

FIGURE 94

Figure 95 illustrates conceptually how the module of the previous slide might be clustered to form engines of higher thrust level. In this modular concept, it is believed that ion engines of essentially any desired thrust could be made by clustering, allowing flexibility in engine size, together with ease of replacement.

For example, it may be possible to cluster nine unit modules in a package 12 by 15 inches as shown by the middle sketch on this figure.

This cluster would produce a thrust of about 0.1 pound, a specific impulse of approximately 6,000 pounds per pound-second, and could be powered for test purposes by the SNAP–8 nuclear electric power generating system which I will discuss later.

You may recall from last year's discussions that the SERT project is composed of a series of electric rocket engine tests that cannot be performed meaningfully in ground facilities alone. By comparing flight test results with data obtained in ground facilities, we can determine the limitations and accuracy of our ground tests.

Mr. KARTH. Doctor, maybe we could stop right there and then continue at 2 o'clock this afternoon.

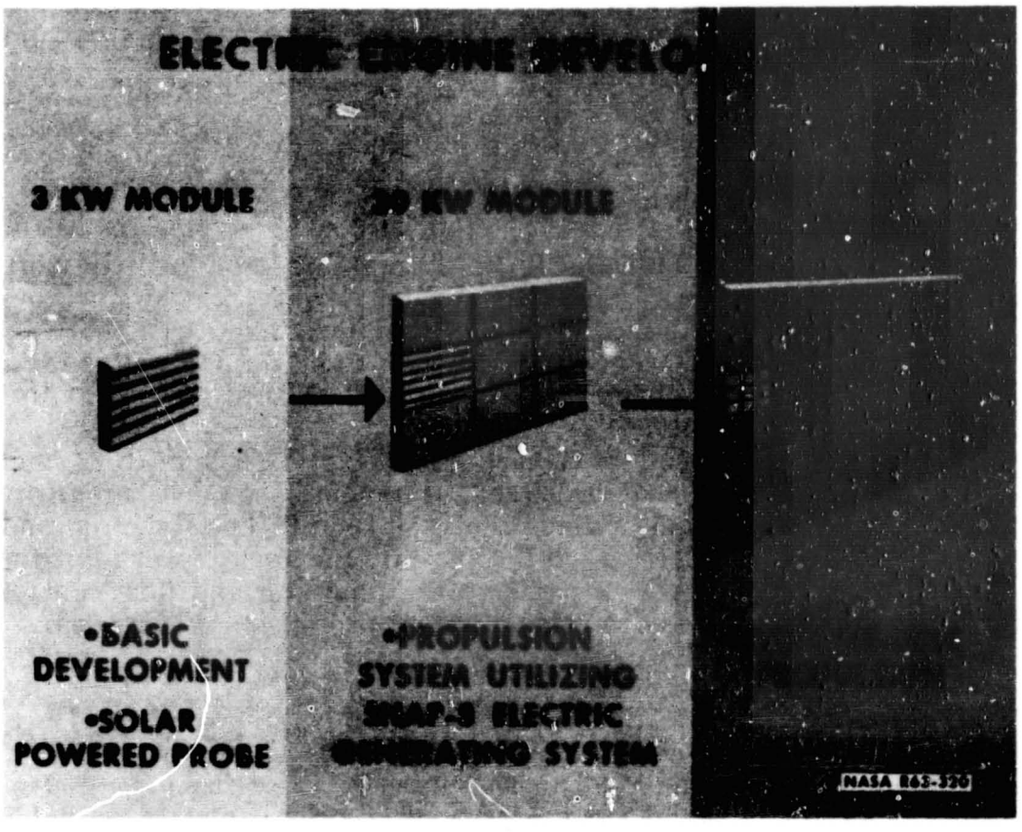

FIGURE 95

Dr. BISPLINGHOFF. Yes, sir.

Mr. KARTH. I wonder if, before we recess, I could ask you where the Plum Brook Research Station is located?

Dr. BISPLINGHOFF. It is located in Cleveland, Ohio, near the Lewis Research Center.

Mr. MOSHER. It is located in my district near Sandusky, Ohio.

Dr. BISPLINGHOFF. Sandusky: yes, sir.

Mr. KARTH. I assume the dynamics and controls research facility a part of Plum Brook Research Station?

Dr. BISPLINGHOFF. Yes, sir.

Mr. KARTH. And what is the extent of research that you do there?

Dr. BISPLINGHOFF. In the dynamics and control facility?

Mr. KARTH. Yes.

Dr. BISPLINGHOFF. This is to study the control problems which one has in a nuclear rocket system. The problem of controlling the reactor and the vehicle thrust and the dynamics of the vehicle and things of this kind are the purpose of this facility.

Mr. KARTH. The Plum Brook Research Station then is a nuclear experimental station?

Dr, BISPLINGHOFF. Yes, sir. Yes.

Mr. KARTH. Thank you very much.

Mr. SLOOP. Also fluid.

Mr. MORRIS. Doctor, are you going to let the record stand on that definition?

You going to let the record stand on that definition of it?

Mr. MORRIS. I mean, I'm not arguing with you; but it's not my understanding that is the definition of the lab now. I certainly could be mistaken.

Mr. MOSHER. Historically it's been a fluid propulsion test station.

Dr. BISPLINGHOFF. This is right. It really has a broader purpose than just the nuclear.

Mr. SLOOP. Dr. Bisplinghoff, may I add something?

Dr. BISPLINGHOFF. Yes, would you like to?

Mr. SLOOP. I came from the Lewis Lab and I know a little more about the background of that. The Plum Brook Station includes many things. It includes the reactors for materials research.

It includes some of the chemical propellant and fluid dynamic work that we could not do in the restricted area in Cleveland—liquid hydrogen pumping, for example.

Some work on fluorine is done at the Plum Brook Station, and pumping of hydrogen, heat transfer that use both the nuclear reactors and chemical propulsion systems that are there. The dynamic and controls research facility is used for not only the nuclear work but for these fluid systems in which we have the pumping and flow control and other things common to both chemical propulsion and nuclear.

Mr. MOSHER. Mr. Chairman.

Mr. KARTH. Mr. Mosher?

Mr. MOSHER. I think it's fair to say the advantages of the Plum Brook location and the reason it was originally chosen is, it is very convenient to Lewis and yet is a vast acreage away from the metropolitan area of Cleveland. It was a vast acreage completely available without cost to NASA because it was an Army installation which had been given up and required just a transfer of the land without any cost.

Mr. KARTH. Thank you very much.

Mr. DOWNING. Mr. Chairman, is it definite we will reconvene at 2?

Mr. KARTH. We will reconvene at 2 o'clock.

Dr. BISPLINGHOFF. I am sure I can get out of this commitment. I will promise to be here.

Mr. KARTH. Thank you very much, Doctor.

We will recess until then.

(Whereupon, at 12:02, the subcommittee was recessed until 2 p.m. the same day.)

AFTERNOON SESSION

Mr. KARTH. Doctor, if you would care to proceed where you left off this morning we would appreciate it.

Dr. BISPLINGHOFF. Thank you, sir. We had gotten to the bottom of page 24, the section entitled "Space Power Energy Sources."

Electrical power for space vehicles is required for guidance, control communications, instrumentation, life support, mechanical devices, and electrical propulsion. Similar requirements for electrical power generators will also exist for bases on the moon or planets. The three principal sources of energy for space power are chemical, solar, and nuclear. Their selection depends upon the required power level and the total electrical energy which must be delivered. The major power source for unmanned spacecraft to date has been batteries and solar cells. As space missions become more complex, higher power levels will be required.

Figure 96 shows an assessment of the regimes of applicability of the three sources of space power energy. It may be seen that chemical energy is of interest for all power levels with relatively short time durations. For longer durations, solar systems prevail for low, and nuclear systems for high, power levels. Although they are not indicated on this figure, nuclear isotope systems also offer advantages in the range shown for solar power.

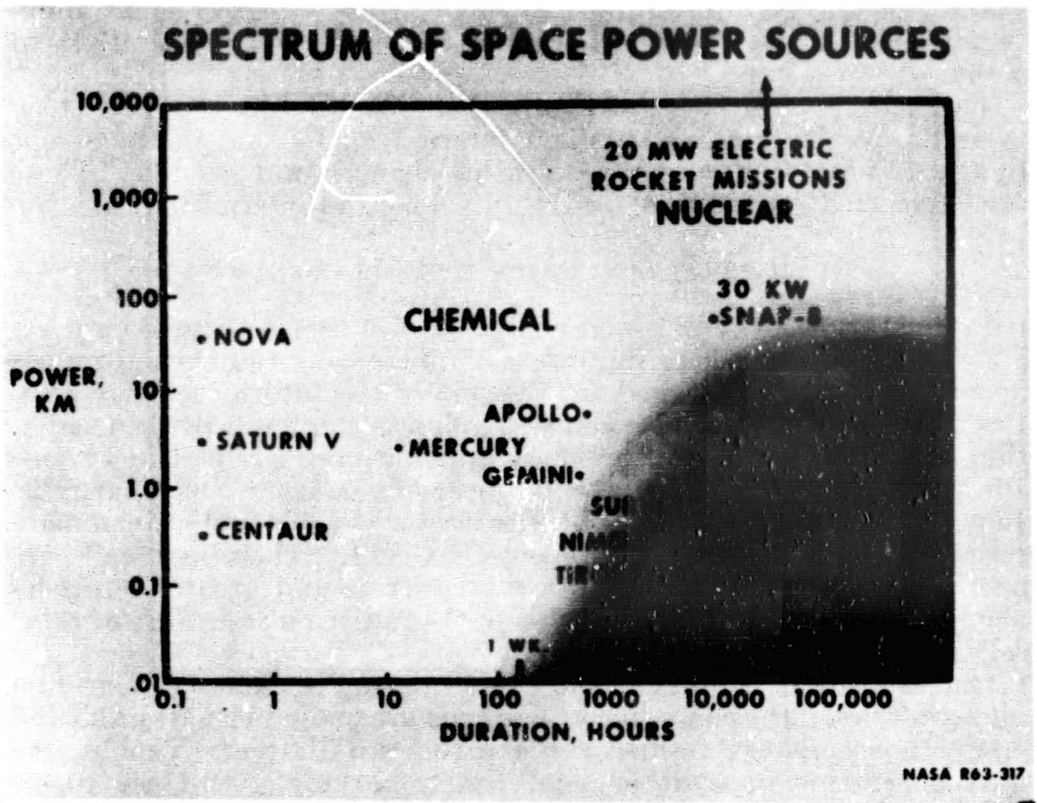

FIGURE 96

CHEMICAL SPACE POWER SYSTEMS

What I will do now is discuss each of these three sources of space power in turn. I will discuss first chemical, solar, and then finally nuclear power systems.

Chemical space power systems range from a few watts to kilowatts and durations from a few hours to 2 weeks or, for intermittent use, months. Last year we reported progress in improving batteries for spacecraft use. The improvements mentioned were in the area of quality control. This year our work has led to improved battery seals such as the ceramic seal. Our research also produced an improved silver-cadmium battery which has a higher energy level per pound than the present nickel-cadmium batteries. This new battery is nonmagnetic, an asset in scientific measurements. These batteries were employed successfully on the Explorer XII satellite for the first time. There is still much progress to be made in increasing operating temperature limits and improving battery reliability in the space environment.

Fuel cells are electrochemical devices like batteries except that the reactants are supplied to the cell from external tanks. They are highly efficient and have excellent potential in space applications. Last year the technology we developed for hydrogen oxygen fuel cells was used as the basis of a development contract for the power supply of Apollo. A hydrogen-oxygen fuel cell of another type that is capable of operating at a different temperature is planned for Gemini. In this type, an ion exchange membrane, first developed for desalting sea water, was successfully applied to fuel cell use. Fuel cells are quite versatile and we have, for example, studies underway to operate them on human waste.

There are several types of chemical engines for space power. One is similar to the familiar auxiliary internal combustion engine except that it uses hydrogen and oxygen rather than air and gasoline. These are envisioned for relatively short durations and intermittent use.

SPACE POWER GENERATION FROM SOLAR ENERGY

Power generation from solar energy is most useful at low to moderate power levels and long durations. Unmanned satellites and probes flown thus far and planned for the immediate future use solar cells. Last year the value of solar cell research was emphasized when radiation from a nuclear explosion in the upper atmosphere had an adverse effect on the power of several satellites using conventional solar cells. Research on solar cells pointed the way to make solar cells much more resistant to radiation than conventional cells. These new cells are now being installed for many new spacecraft and greater improvements are possible even beyond this in the radiation resistance of solar cells.

One exciting possibility in solar cell research is the use of thin-film photovoltaics. Present silicon solar cells are made in small units and many thousands are needed for a given installation. Nimbus, the next generation of weather satellites, for example, will use 10,494 cells approximately 1-inch square. These cells are about twenty-thousandths of an inch thick. Thin-film solar cells can be made in much larger sizes, yet are only three-thousandths of an inch, or one-seventh as thick. These thin-film solar cells are made of cadmium sulfide or gallium arsenide. There is some evidence that they may be more resistant to radiation damage than silicon cells. An additional advantage is the possibility of using these thin-film cells on flexible surfaces, so that a large area could be furled or folded into a tight package aboard a spacecraft. At present the efficiency of thin-film cells is much lower than conventional solar cells and research is underway to increase their efficiency. If successful, this will greatly extend applications of solar cells for space use and perhaps for certain arid or remote regions on earth.

A thermionic power system, illustrated by figure 97, consists of a large mirror or solar collector, a thermionic diode, and associated mechanical and electrical equipment. The mirror concentrates solar energy on the diode, and the heat generated boils electrons off the emitter or cathode and drives them to the relatively cool collector (anode) whence they pass through an external circuit to provide electrical energy. These devices do not have the radiation problems of solar cells and appear attractive for probes to Venus and Mars. In

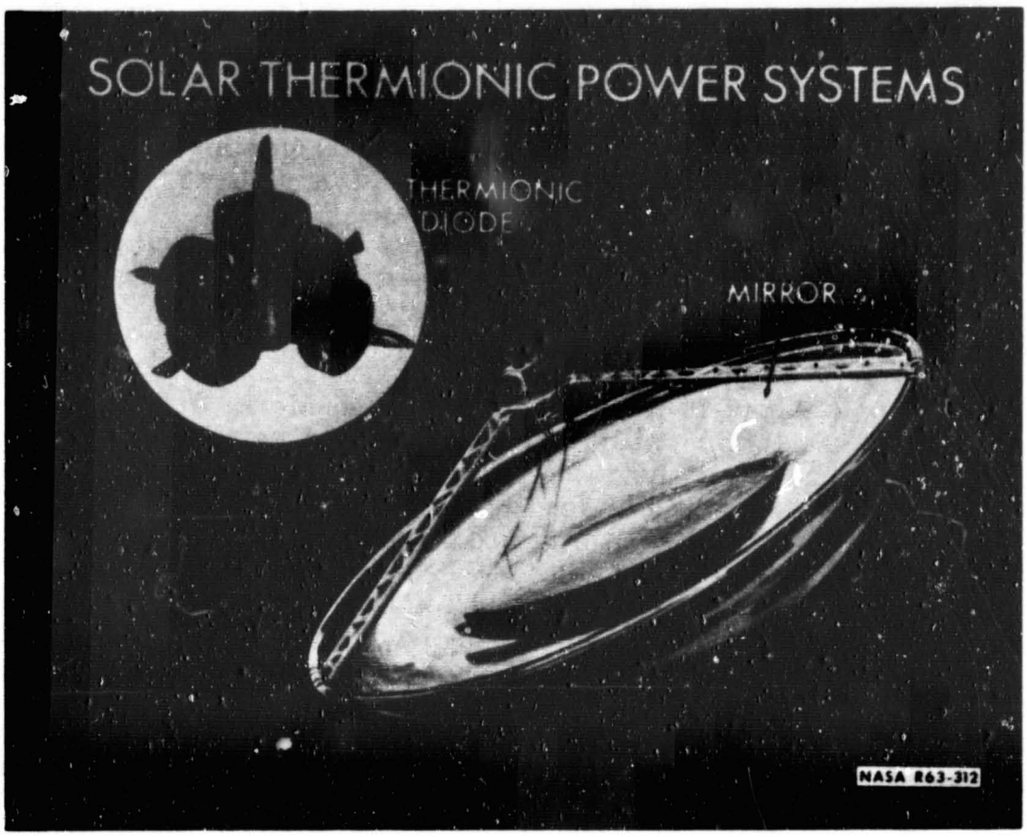

FIGURE 97

addition they may be operated by any source of heat energy. A thermionic diode is quite compact and has no moving parts. An experimental solar-thermionic power unit, using these diodes, is under investigation at the Jet Propulsion Laboratory. The design goal is a capability of generating over 250 watts near the Earth's surface and about half that near Mars, because of its greater distance from the Sun. Other goals include a diode efficiency of 21 percent and an operating life of 1 year. Several experimental diodes are being studied for this unit. One of these diodes was operated successfully for over a thousand hours. Recently, a successful test of a complete mirror and diode system was made by Electro Optical Corp. in California with a power output of 40 watts.

Mr. KARTH. Doctor, is it necessary that we follow down the very expensive road of research and development, four or five different areas of power sources? Can't we concentrate on, let's say, two or three areas, and feel quite confident that these three different methods will meet all of our needs for the next 20 years or more? Why do we need the thermionic, for example, if we can perfect the fuel cell?

Dr. BISPLINGHOFF. Well, I think the thermionic system is something that is going to have an important purpose in space. If we can convert heat to electricity without going through a turbo generator system we will have a great advantage over the kinds of energy conversion devices that we have on the ground. We feel that this direct energy conversion such as represented by this diode may give us an advantage in the future well beyond anything we can do now.

Mr. KARTH. How big is the dish? How practical is this thing? What kind of a time frame are we talking about? Are we talking about developing it in 15 years, 10 years?

Dr. BISPLINGHOFF. I might remark the diode concept, the concept of going directly from heat to electrical energy is a concept which is independent of the idea of the dish. This could be used with a nuclear system or any other means of producing heat.

The dish itself for this particular system is, I think, well in hand. We have the technology available to do this. However, if one makes much larger dishes there is a question as to how well it can be done.

Mr. KARTH. How big does the dish have to be, for example, to produce 500 watts of electrical power?

Mr. SLOOP. About 10 feet. It is 130 watts at Mars. It depends on where you are talking about. Ten feet would be four times that power which is about the value asked for. Ten feet in diameter—with Saturn we can put a 31-foot dish, rigid dish into orbit with Saturn. And if you use the Saturn third stage you are limited to 21 feet. However, there is research going on——

Mr. KARTH. You mean 21 feet is the total payload?

Mr. SLOOP. The payload diameter of the Saturn 5 is around 21 feet, yes, sir. We are working on foldable mirrors of 32 feet in diameter that will fold into a space small enough to get aboard Centaur which is considerably less, which has a maximum diameter of 10 feet. There are other mirrors that can be made from expandable plastic, that is, the same technique as the Echo balloon.

Mr. KARTH. Mr. Sloop, what is the weight-saving ratio between a fuel cell and this thermionic cell? What gains do we make? Sure, this thing converts heat directly into electrical energy. That is fine. We eliminate one of the steps along the way. Does it have any practical advantage other than that?

Mr. SLOOP. A fuel cell, as one of Dr. Bisplinghoff's slides shows, is in the area of a relatively short duration. It is very good for applications of several weeks. If you are going to operate, have a continuous demand for power for over a year's period, for example, you would find the fuel cell much heavier from the technology that we know than is the thermionic system. It consumes a reactant. It uses hydrogen and oxygen and the reactant is water. You have to continuously supply these to the fuel cells. Over a long period of time this weight is appreciable. For 2 or 3 weeks or a month, in this order, like the Apollo application, the fuel cell makes the best sense. It is compact. It gives you a lot of power per unit volume. And it fits very well with missions where you are carrying the main reactants along for other purposes, for example the hydrogen-oxygen for propulsion or the oxygen for breathing and things of that sort. The answer is that each of these power systems has a particular niche or area of application which is best suited for it. There is no panacea of one that will fit all applications best. This I am afraid is the answer to that.

Mr. KARTH. Thank you very much. I think it is a good answer.

Dr. BISPLINGHOFF. Last year we mentioned work on a solar dynamic system called Sunflower. This system, illustrated by the photograph in the upper left corner of figure 98, consists of a solar collector, a mercury boiler, a thermal energy storage system, a turboalternator—a turbine and generator—a condenser, and associated equipment. The

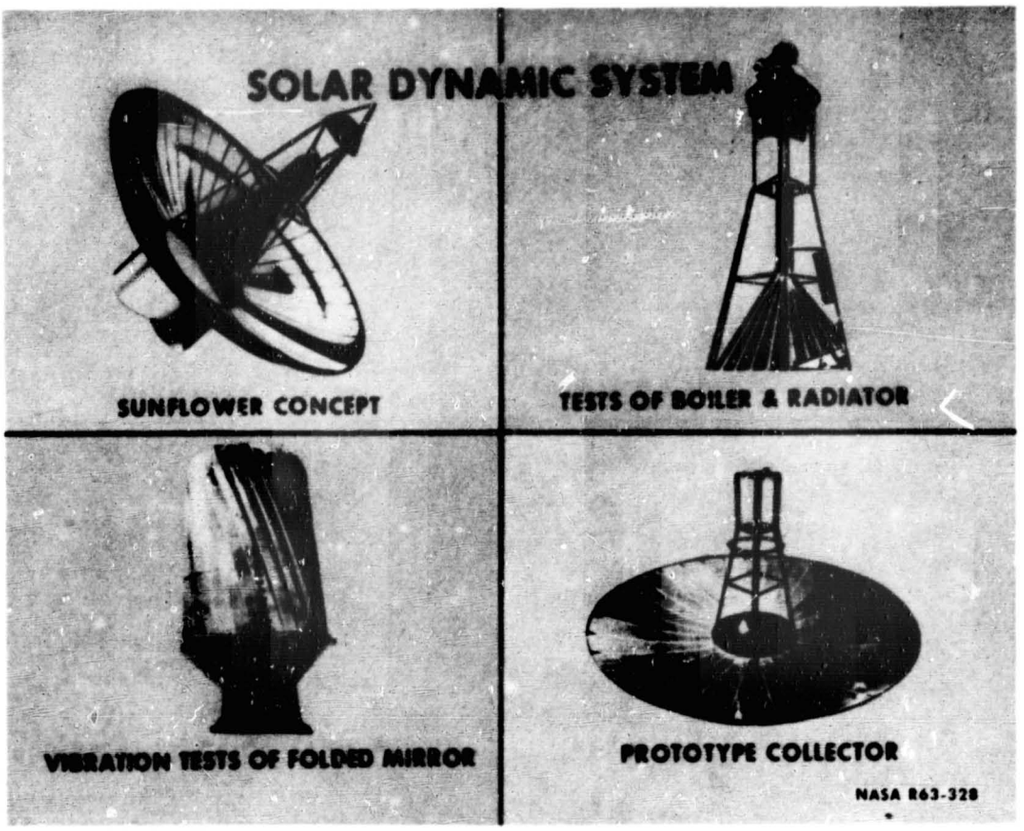

FIGURE 98

other photographs of the above figure show hardware built and tested during the year. On the upper right is a photograph of the mercury boiler and condenser that have been undergoing tests. The lithium-hydride thermal energy storage system, designed to provide heat when the unit is in the Earth's shadow, also worked satisfactorily in component testing. The bottom photograph shows the mirror in folded and unfolded conditions. Fabrication techniques have been developed for the folding mirror which is currently undergoing various optical and mechanical tests, including vibration tests. The turboalternator recently underwent a successful test of over 2,000 hours but failed thereafter because of the buildup of mercury corrosion products in the turbine. This is the best test of liquid metal turboalternators in the past 2 years, and we believe the life can be extended to the design goal of 10,000 hours. At present the components of Sunflower are being assembled into a complete system.

NUCLEAR SPACE POWER GENERATION

The early and practical utilization of nuclear electric systems in space represents a major goal in NASA's space propulsion and power generation program. In the range from tens of kilowatts to many megawatts, nuclear reactor energy represents a particularly attractive and perhaps the only possible power source. Applications representative of such power levels include orbiting manned space platforms, manned interplanetary spacecraft, communications satellites, and unmanned planetary probes.

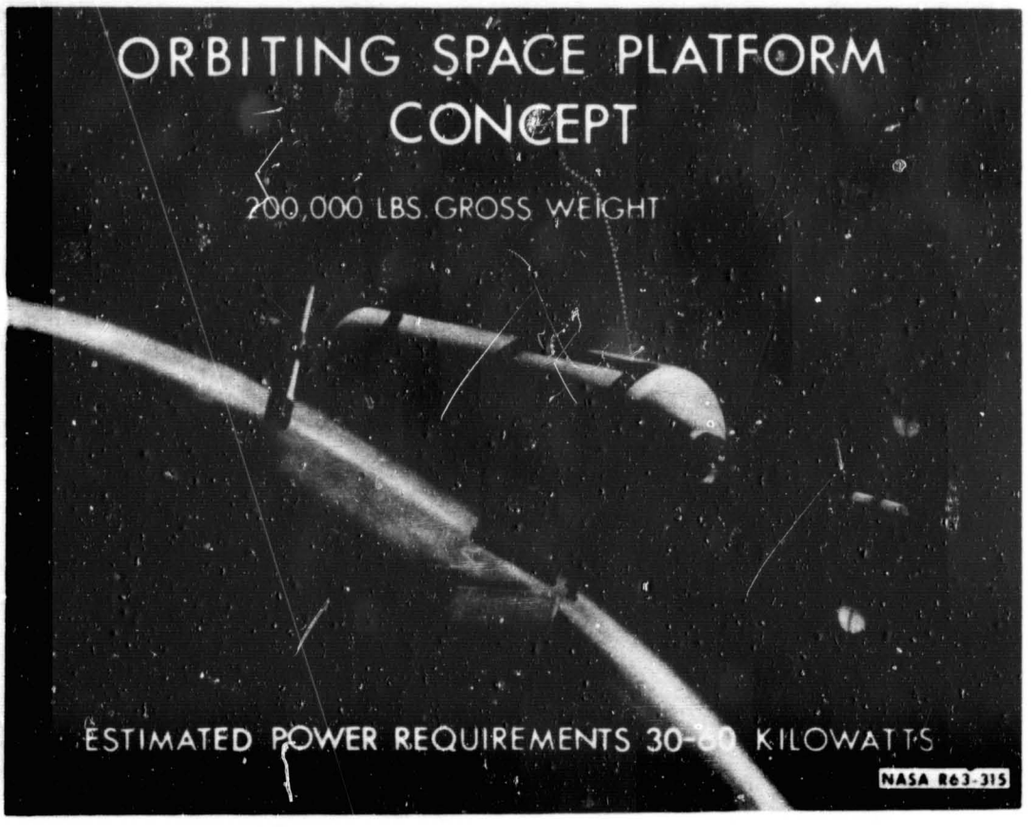

FIGURE 99

An orbiting space platform concept is illustrated by the sketch of figure 99. It consists of a tank suitably equipped with life-support systems and having a nuclear power generation system installed on a tower at some distance from the tank proper to reduce shielding requirements. The estimated electrical power requirement of 30 to 60 kilowatts for on-board power to operate the platform is within the capability of the SNAP–8 electrical generating system, including shielding of some 15,000 to 30,000 pounds. Further, it is in reasonable harmony with the allowable 200,000-pound gross weight based on a Saturn V launch vehicle.

Another application, in the more distant future, is the manned interplanetary spacecraft depicted by the sketch of figure 100. Such a vehicle might weigh a million pounds, require orbital assembly, and utilize a large electric rocket propulsion system requiring 20 to 30 megawatts of electrical power. The nuclear reactor is placed at the greatest practicable distance from the crew quarters in order to reduce shielding requirements. The usefulness of electrically propelled spacecraft such as this is critically dependent upon the weight of the nuclear electric power generation system which produces the power for the electric rocket engines. A power generation system weight of less than 10 pounds per kilowatt would result in a spacecraft weight competitive with a nuclear rocket for a manned Mars mission.

Current systems such as SNAP–8 weigh in excess of 100 pounds per kilowatt. Nuclear power systems used for electrical propulsion with power levels between the 30-kilowatt SNAP–8 and the 20–30-megawatt

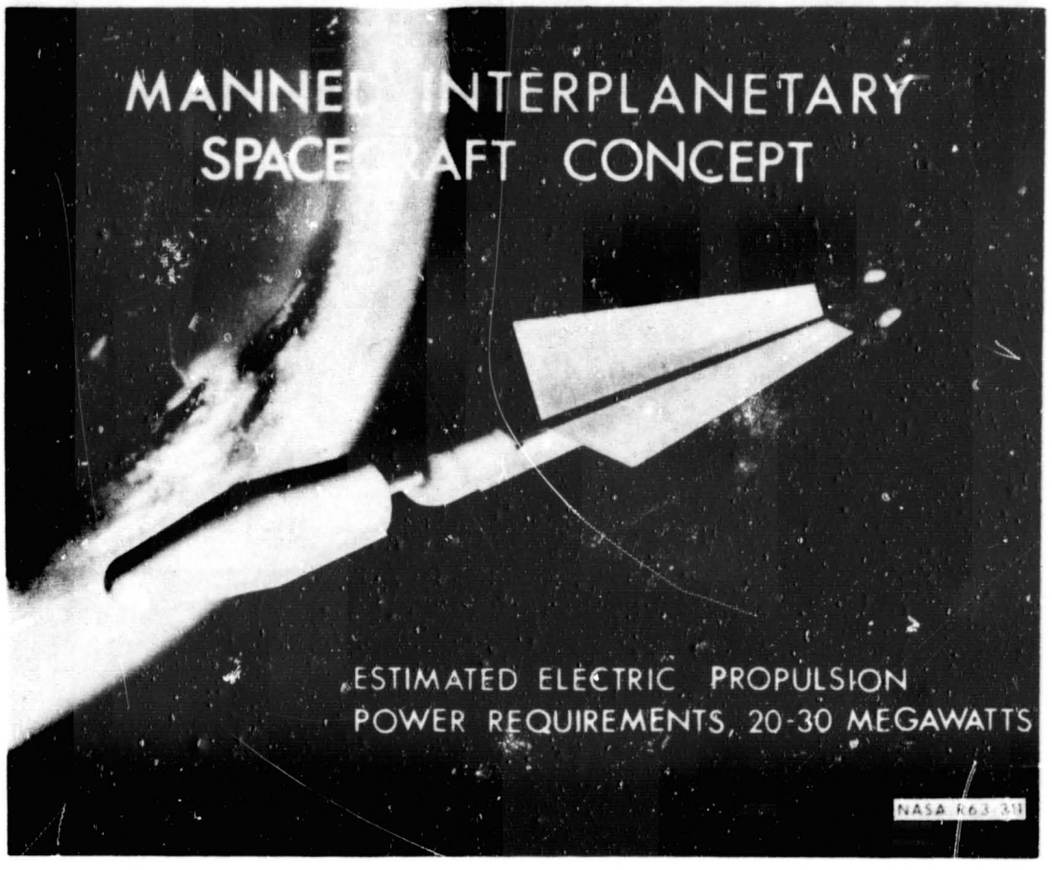

FIGURE 100

systems show good performance potentials for unmanned planetary probe missions.

You will recall that the SNAP–8 development project is a 30–60-kilowatt fission reactor powered electrical generator suitable for space flight application. As shown by figure 101, it is composed of two major components—the nuclear subsystem and the power conversion subsystem. Significant changes have been made in the design during the past year. The nuclear subsystem is composed of a nuclear reactor, shielding, pumps, and a working fluid necessary to transfer the heat generated in the reactor to the boiler. The working fluid, a mixture of sodium and potassium, Na-K, is heated in the reactor and pumped through refractory metal-lined tubing to the boiler where its heat energy is transferred to the boiler.

The heat energy transferred to the boiler causes liquid mercury in the second loop to boil. The resulting mercury vapor passes through a turbine which extracts energy to drive the generator. The mercury vapor is then condensed in the condenser and the resulting liquid pumped back to the boiler for recycling. The heat energy released by the mercury in the condenser is removed by a fluid which is pumped to the radiator. Here the excess heat energy is radiated to space and the cooled fluid is returned to the condenser. In simpler terms, heat energy produced in the reactor is transferred to the turbine section, where approximately 8 percent is extracted in the form of electricity and the unused heat energy is rejected to space by the radiator.

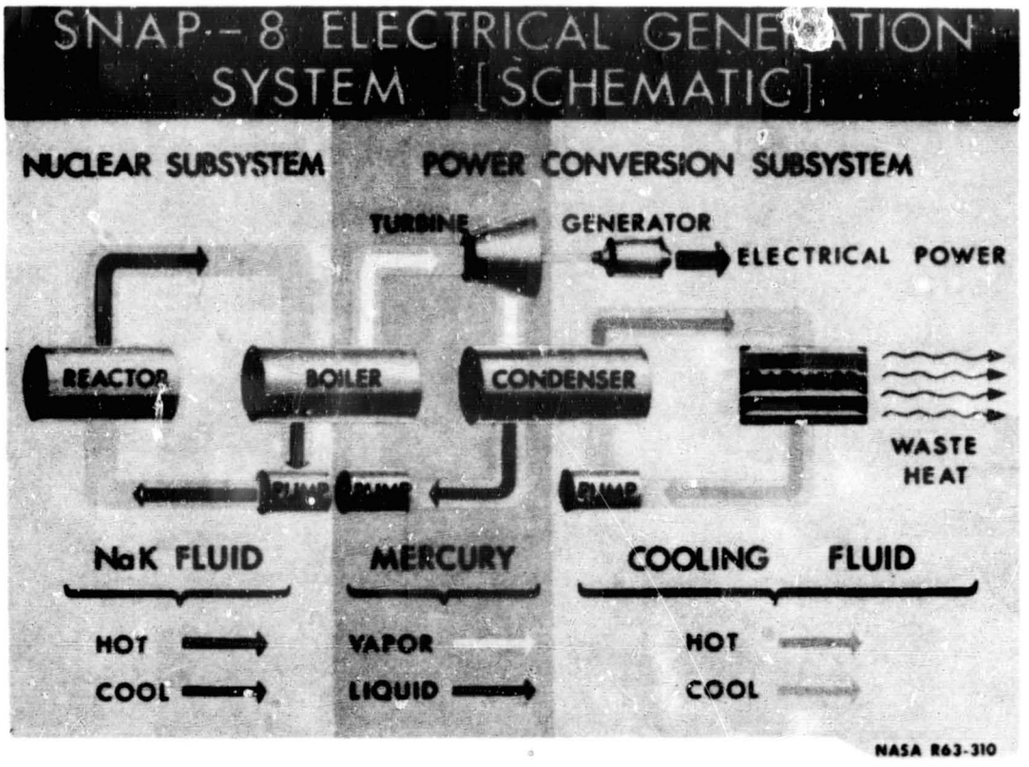

FIGURE 101

Cycle temperatures range from 1,300° F. in the reactor to 180° F. in the generator. These temperatures, coupled with the 10,000-hour, maintenance-free lifetime requirement, pose difficult problems in materials selection and bearing and seal design.

A SNAP–8 flight project is planned with the objective of evaluating the problems of starting and operating a SNAP–8 electric generating system in the space environment and of demonstrating feasibility. A Saturn CIB launch vehicle will be employed to boost the system into orbit. No major hardware commitments are planned in this project, however, until SNAP–8 progress warrants such action. Preliminary studies of testcraft design and operational safety problems of testcraft design and operational safety problems are being initiated in fiscal year 1963.

Mr. KARTH. Is this under private contract, Doctor?

Dr. BISPLINGHOFF. Yes, sir.

Mr. DOWNING. What time period are we talking about now, when the nuclear propulsion will be completed?

Dr. BISPLINGHOFF. This nuclear electric system such as SNAP–8 would have as one of its principal applications the supplying of power to an electric thruster. And these are deep space missions which are certainly well into the 1970's.

Mr. DOWNING. Thank you.

Dr. BISPLINGHOFF. As we pointed out here, our progress depends on how quickly we can get the weight down in this thing. The current technology will provide a system that weighs something in excess of 100 pounds per kilowatt. We feel, in order to use this effectively, it has to be nearly 10 pounds per kilowatt. This will require a fairly large effort in development.

Mr. KARTH. How much are we spending in each one of these areas, Doctor?

Dr. BISPLINGHOFF. We can give you those figures.

Mr. MYERS. On SNAP–8 in fiscal year 1963 we are spending $15 million, SNAP–8 development itself.

Mr. KARTH. What about these other power source developments; how much are we spending on those?

Mr. MYERS. In the others that were mentioned by Dr. Bisplinghoff, and various technologies we are working in we are talking, roughly, $10 million in 1963.

Dr. BISPLINGHOFF. That is the total?

Mr. MYERS. Yes.

Mr. KARTH. How much are your requesting, in total, in 1964?

Mr. MYERS. You are still speaking of the nuclear electric system?

Mr. KARTH. I was speaking generally of all these power systems. Going through the fuel cell, thermionic, and the electric.

Mr. MYERS. It would be about 1½ million in the nuclear electric systems, and I will have to look up the nonnuclear system—16½ million.

Mr. SLOOP. Fiscal 1964 R. & D.

Mr. KARTH. Is this in-house R. & D.?

Mr. SLOOP. Research and development, that includes private contracts and all the equipment that we purchase, except direct in-house personnel.

Mr. KARTH. I assume the military do a good deal of research in all these power source areas, fuel cells, thermionic, chemical. Is there any coordinated effort between NASA and what they are doing and the military?

Mr. SLOOP. Very much so. There is a group called the Power Information Center with a contract with the University of Pennsylvania, which has as its express purpose this coordinating function, which the various Government departments—Army, Air Force, NASA, and Navy—supply the information about their projects, meet together occasionally with special panels, there is one on fuel cells, and discuss their mutual programs. This way we get a very close coordination. Of course, we also have the normal exchange of individuals visiting each other and individuals visiting between centers and in professional meetings. There is a very close coordination.

Mr. KARTH. Do you find that two or three agencies might be going down the same road at the same time?

Mr. SLOOP. I don't believe so. The agencies are generally looking at these power sources for different applications. For example, the Army is looking at the fuel cell as a means for specialized applications; in some cases of putting it on a man's back, for example. The Navy is looking at it for underwater applications.

Mr. KARTH. The Navy is looking at them, and I suppose the Army is looking at them from the standpoint of supplying power to a satellite, aren't they?

Mr. SLOOP. Yes.

Mr. KARTH. Aren't they doing pretty much the same thing you are doing in certain areas?

Mr. SLOOP. Not the same thing——

Mr. KARTH. The same type of thing.

Mr. SLOOP. We are doing the primary work for space application and the others are looking to NASA to spearhead in space. When it comes to ground and underwater applications, they have their own programs.

Mr. KARTH. We are not differing here in terms of sematics, are we? All the members here are Members of Congress, too, you know.

Mr. SLOOP. Yes.

Mr. KARTH. I suppose technically we could say we do different things, but I doubt if that would make a reasonably good argument to those who knew what we do.

Mr. SLOOP. The use of space power, or power systems for space applications, and I am speaking of chemical and solar, now, rest primarily with NASA.

Mr. KARTH. Wouldn't it be advantageous, and wouldn't it be much more efficient if somehow we could pool our resources, that is, NASA make such a contribution as they deem necessary to a common fund, the military make a contribution to a common fund, and any other agency of Government interested, and then have one management team give the direction and run the research program? Doesn't this make any sense to anybody?

Did anybody ever think about this?

Mr. SLOOP. This is approached by this interchange of information and program level data.

Mr. KARTH. Except you have separate and distinctly different managers and researchers in all the different agencies of Government.

Mr. SLOOP. Yes.

Mr. KARTH. From that standpoint in itself you have duplication, haven't you?

Mr. SLOOP. Well, for example, let us take batteries. We use batteries in space applications where the environment of space imposes completely different requirements on a battery than, say, a battery for a radio here for an Earth application. We had to spend a great deal of money to seal the batteries because under the environment of space they generate an internal pressure, and they have to be sealed against the vacuum of space, and against the radiation effects.

We have the problem of the batteries and magnetic materials affecting the special instruments we use in space. If applied to a submarine or to the Army—the research we want to do in these areas, the other services wouldn't be interested.

Mr. KARTH. Except the Navy might well be interested in it as a result of Transit. You are assuming that the Navy doesn't have any space program whatsoever by which they have to supply power. I think this is an erroneous assumption. The same is true with the Air Force. I assume if the Air Force has a requirement, and the Navy has a requirement, and if NASA has a requirement, you develop a battery that will supply power in space. I assume that basically the problem is pretty much the same. You may have a little different objective. One may be thinking only about orbiting vehicles. Another one may be thinking about vehicles that are designed to go into deeper space. But, basically, I guess you have pretty much the same problem, one a little more acute, probably, than the other.

Mr. SLOOP. Yes.

Mr. KARTH. That is what I am thinking about. I know a battery in a submarine, for example, would be substantially different than one in a satellite.

Mr. SLOOP. I mentioned we in NASA are doing the primary research and technology on these power systems for space applications. I also mentioned that this coordination functions is where the other services are aware of what we are doing, and when each of us, for example, contemplates work that is of interest to the other, we communicate with them and let them know. In some cases they serve on our advisory teams that help us select these things.

This coordination, I believe, is going on to much more an extent than you perhaps have indicated.

Mr. KARTH. Doctor, who is in charge of this for your office?

Mr. SLOOP. Mr. Walter Scott is the member of the Power Information Group for NASA.

Mr. KARTH. What is your position?

Mr. SLOOP. I am Director of Propulsion and Power Generation.

Mr. KARTH. Then tell me what the Navy, the Army, the Air Force, are doing in the field. I would like to know and in substantial detail, really. As long as we know of this great coordination I think it should be a part of the record. This is how we are going to justify some of these budget requests.

We will take all the time you want. Go ahead and put it on the record.

Mr. SLOOP. In space power?

Mr. KARTH. You tell me what the Navy is doing in developing this kind of a capability. This coordination gives us this information, obviously.

Mr. SLOOP. I am afraid that I, personally, cannot answer that in detail. As I mentioned, I have people who are following this in detail.

Mr. KARTH. I wonder if you would have them furnish that for the record?

(The information referred to is as follows:)

Coordination of NASA programs on power generation with that of other Government agencies goes on through many channels at all working levels. Some of these are:

(1) The Interagency Advanced Power Group and its working groups.
(2) The Aeronautics and Astronautics Coordinating Board and its panels.
(3) Ad hoc groups formed to deal with specific technical questions.
(4) Visits and meetings between individuals working in this technical field.
(5) Government and professional society meetings and seminars.
(6) Reports.

The Interagency Advanced Power Group (IAPG) was established in November 1958. Its purpose is to "effect an exchange of information at the technical level on research and development programs, of the agencies involved, in its field of interest, defined herein, with the objective of increasing the effectiveness of the total interagency power program." The following Government agencies participate in this group:

U.S. Army.
U.S. Navy.
U.S. Air Force.
Advanced Research Projects Agency.
U.S. Atomic Energy Commission.
National Aeronautics and Space Administration.

The group carries out its work through a steering group and five working groups (electrical, electrochemical, mechanical, nuclear, and solar). There are 23 different NASA personnel serving on these groups from Headquarters, Mar-

shall Space Flight Center, Lewis Research Center, Goddard Space Flight Center, Manned Spacecraft Center, Jet Propulsion Laboratory, and the Langley Research Center. These groups meet periodically to exchange information of mutual interest and to talk about their programs. They are assisted by a power information center operated under contract by the University of Pennsylvania. According to the last annual report (Aug. 1, 1961–July 2, 1962), the power information center collected a total of 737 project briefs and these were sent to 617 separate addresses with a total printing of 958,901 sheets. The power information center listed 17 meetings of the steering group and working groups and special meetings during this period.

A project brief classifies the work according to one of five technical fields: tells the starting date of the program; title; name and address of contractor and principal investigator; the directing agency; and address, name, and telephone number of project engineer; the contract number; the agency identification number; the period the contract runs; its estimated completion date; funding; a description of the project and its status. These sheets then provide a means for exchange of information about programs sponsored by the agencies mentioned.

The Aeronautics and Astronautics Coordinating Board was established in September 1960 by the National Aeronautics and Space Administration and the Department of Defense to coordinate aeronautical and space activities of the NASA and the Department of Defense at all management and technical levels. It is charged with facilitating:

(1) The planning of activities by the National Aeronautics and Space Administration and the Department of Defense to avoid undesirable duplication and to achieve efficient utilization of available resources;

(2) The coordination of activities in areas of common interest to the National Aeronautics and Space Administration and the Department of Defense;

(3) The identification of problems requiring solution by either the National Aeronautics and Space Administration or the Department of Defense; and

(4) The exchange of information between the National Aeronautics and Space Administration and the Department of Defense.

There are six subsidiary panels of the AACB to aid in carrying out this coordinating function.

In summary, there are many channels available and used for a close correlation and communication of related work among Government agencies.

Dr. BISPLINGHOFF. We can do this. As Mr. Sloop mentioned, Walter Scott, who works directly under him, is responsible for the space power area. Mr. Scott isn't here. We can furnish this for the record, and will, if you so desire.

Mr. SLOOP. I would like to submit for the record the Power Information Center's objective, their charter, their types of records that they distribute both to NASA and to the other departments, Department of Defense agencies.

I would also like to bring into the record the fact that we have the aeronautics and astronautics coordinating board, which is a group set up to coordinate work betwen NASA and the Department of Defense. It is through these interchanges of information at the working level and at various levels that this coordination goes on.

Dr. WEAVER. On this coordination of the research, is it done directly with military service involved, or is it done with the Department of Defense?

Mr. SLOOP. On the Power Information Center, for example, there are representatives from the Department of Army, the Navy, and Air Force. Therefore, it is done down in the services. For example, the Army Signal Corps has representatives on this. As a matter of fact, they administer the contract out of Fort Monmouth. They have various committees and subcommittees. For example, there is a panel on fuel cells, and Mr. Cohn of my office is on this panel, along with people in the Department of Defense. They meet regularly.

Dr. WEAVER. The responsibility lies with the Department of Defense, or with the particular service involved?

Mr. SLOOP. This coordination function and exchange of information is done down at the working level, which is done with the various agencies of the Department of Defense. It includes members of IDA and ARPA.

Dr. BISPLINGHOFF. We can mention also the NASA Research Advisory Committee. NASA has a series of research advisory committees in practically all of the areas in which we are doing advanced research and technology. Each of these advisory committees, in addition to industry and university members, has members on them from the Armed Forces at the working level. These committees meet about twice yearly to review the NASA research program.

Mr. SLOOP. Last March, for example, there was a symposium held with NASA as the host of this Power Information Center attended by about 300 people; people from industry and various Government agencies.

Next week there will be another meeting of this kind here in Washington among a small group of people. There was another meeting on radiation damage held at the Goddard Space Flight Center about 2 months ago in which members of industry and various Government centers met at Goddard and discussed this problem mutually. You will find that people working in the details—the field know each other, and meet together quite often. It is on this interchange of information that we depend upon in getting the most effective program in our area and programs which are not duplicated in other areas.

Mr. KARTH. Knowing research for what it is, I would assume that although there is probably an appreciable amount of interchange, or exchange, that there is less exchange than would be desired. The Department of Defense, it seems to me, has quite a number of people assigned to various NASA offices where they are in really quite a good position to have firsthand knowledge about what is going on, and then report back to their respective services.

I think this is really fine. I think probably this gives us an opportunity to exchange information so as to avoid unnecessary duplication.

How many people does NASA have in various agencies of the Government doing the same thing that the military is doing with NASA? How many people do we have assigned to the Department of Defense? How many do we have in the Navy? How many do we have with Army, with the Air Force? Do we have any?

Dr. BISPLINGHOFF. There is no such arrangement the other way that we have with the military services.

Mr. KARTH. Why isn't there? How can we exchange information except at the yearly or semiannual symposiums or whatever they might be? Or unless the individuals make a special effort to get together, and then they might feel they have proprietary information they don't want to give to the other. I think this is only a matter of professional jealousy if I may use the designation. Why don't we have people working over there and getting the benefit of that information? Can't we establish a system of reciprocity?

Dr. BISPLINGHOFF. This could be done, certainly.

Mr. KARTH. Doctor, has this been explored? Have we made a request of the Department of Defense that they allow us to have x number of personnel working with them on these projects in behalf of NASA, paid by NASA, just to make sure that we are up on the technology they are developing so that we don't have to duplicate this work? Have we made this request?

Dr. BISPLINGHOFF. To the best of my knowledge, we have not made a request that our NASA people be allowed to work in the DOD laboratories. I know of no such request as this.

Mr. KARTH. Do you know of any reason why we might not have made this request?

Dr. BISPLINGHOFF. I suppose we have been so busy building our own organization that we haven't thought of this concept.

Mr. MYERS. I think we should mention, Mr. Karth, in addition to these committees and the informal, you might say, exchange of information, that is should be brought out that we publish some 2,000 or more research reports each year, that these are published by some 4,000 research scientists within NASA. The DOD also has in house laboratories, although a great part of their program is carried on out of house, and these are scientists and engineers, and are professionals, also. They know each other. They recognize each other's work. They read each other's results, in many cases before they are published. They exchange this information quite frequently. It is just like one doctor in a hometown and another doctor; they exchange information on what they are learning.

I think we have quite good exchange of information at the working level, at the bench, so to speak, and no professional man wants to repeat what another professional man has done unless the results are in question, or unless there is another approach which professionally makes it sound to do so.

I think there is a great deal of coordination down below even the levels Mr. Sloop spoke of that is quite good. We have found this to be very satisfactory over the years. We do have these exchanges and in these other committees at higher levels for more lengthy projection programs in the future, 5 or 10 years ahead. We discuss it with them, and so forth. For the detailed coordination, this is quite good, I think.

Mr. KARTH. I think what you say makes sense, if this is the way it is actually practiced. I can agree with you that a good professional man would not knowingly want to duplicate what some other professional man is doing. I think that is the key word. We can't spend $14 or $15 billion in research in this country every year, and retrieve and disseminate all of this information so that most of the people who are doing the research are aware of what everyone else is doing in that field. We cannot do it with the kind of money we allow for this kind of job.

How much money is in the NASA budget for just retrieving all the research information that NASA has and disseminating it to the other agencies of Government, and industries with which you do business? How much is in the budget for this?

Mr. MYERS. Mr. Day testified on this the other day. I don't recall the figures. It is in another office. I know it was brought out in testimony. I don't know if it was in this subcommittee, or not.

Dr. BISPLINGHOFF. We can find this figure and put it in the record.
Mr. KARTH. It would be of great interest.
(The information referred to is as follows:)

NASA and OART are very much aware of the problem of information retrieval and dissemination. For this reason, NASA plans to spend $6,325,000 this fiscal year, fiscal year 1963, on such information activities as documentation, technical publications, and technical information services, e.g., reproduction and library services. Next year, fiscal year 1964, because of the expanding nature of the problem, we are requesting $9,330,000 for these activities.

Dr. BISPLINGHOFF. I think the greatest danger is that the different agencies don't duplicate identical systems. Some of the more fundamental research I think as Mr. Myers pointed out is self-cleansing in its nature, because scientists and engineers just won't knowingly do the same thing if they can help it.

Mr. KARTH. Doctor, I don't have the information with me, now, but I will make sure it gets in the record later on. It seems to me I read a Senate report that was made last year or the year before, or maybe even the year before that. That Senate report was very lengthy document, maybe 200 pages or more, and the Senate had apparently gone into this problem in great depth, and considerable detail. Anyway, they came up with a conclusion that fantastic sums of money that are being wasted in research, just because too many people are following down the same parallel road, not knowing what the other one is doing. In many cases, they followed down the road that someone else had followed down years before, and come to a dead end, found it couldn't possibly work. They estimated a wasteful expenditure in the neighborhood of, I think, $300 million a year. Maybe I should get a copy for you and let you read it. I don't mean it facetiously. It might be very valuable as a matter of information for you.

Dr. BISPLINGHOFF. A scientist or engineer has a very real problem on his hands in keeping abreast of his exploding field. There is so much new in every one of the fields of specialization that we have that there just aren't enough hours in the day to do the work and read what is available. I think this is one of the biggest problems we face. We have frequent technical society meetings. We have, within the NASA, a large number of NASA conferences and seminars. We have our own reports. There are the reports of the technical societies. A great deal is already being done, but I share your concern. I think that this is one of the biggest problems that the individual scientist or engineer has.

Mr. KARTH. Doctor, good researchers tell me that they don't really get much out of information just by virtue of the fact that they read it in a book. Unless they actually do it, unless they perform the experimentation and feel this thing as a result of their own doing, they really don't get much out of this.

Someone from NASA gave us that argument before this subcommittee just a week or so ago. I don't remember the subject matter upon which the argument was given. You have stimulated my curiosity and I am going to look it up.

Dr. BISPLINGHOFF. I think a good reseacher in a given field will read the material in his field carefully. He will take account of that before he starts in on any research. If he is convinced by reading the literature that a given thing has been done, he will avoid this

and use it as background material to perhaps go in some other direction. I think a good researcher uses his technical literature in a very important way. What he does is quite dependent on what he sees in this literature.

Mr. KARTH. Someone told me they don't even have time to read it. If they read all the literature they wouldn't have time to do the work. I don't know which one you should believe. I want to take your word for it. Some of these other people make persuasive arguments.

Dr. BISPLINGHOFF. I cannot imagine anyone doing effective research in this day without reading the literature.

Mr. KARTH. I can't. That is why I feel, sometimes, this isn't being done, and not follow down so many parallel roads is my concern. I am not sure I am right.

Dr. KONECCI. Dr. Bisplinghoff is not aware of our coordination yet because it has not yet finished its study stage. In DOD and the Office of the Secretary we have Air Force, Navy, and Army participation in our life sciences area. We have actually been studying the very question and things that you have just brought up, of putting NASA people in DOD laboratories and, in fact, this has been done to some extent. Not in our own personal research right at the moment, but certainly the Johnsville Laboratory centrifuges have been utilized. Right now three of my men are at Johnsville centrifuges doing a piece of research they feel is important, but only for a few days.

Mr. KARTH. I am talking on a permanent basis.

Dr. KONECCI. I am, too. This is something we are working out specifically with the Air Force right now because of the capability of the School of Aerospace Medicine. We are talking about putting people in the Ames Laboratory and vice versa. We feel the same as you do. A facility exists; they should not only use the facility but find out what the other agency is doing. These are still in the preliminary stages.

We had a meeting recently with the whole DOD group in my office giving them a 5-year sort of advance program plan to have them aware of what we intend to do, and we have asked them to do the reverse.

Mr. KARTH. Apparently the military finds this to be advantageous, and I am sure it is. I would encourage Dr. Bisplinghoff to give his opinions for the record whether or not this is a good idea, and whether or not NASA should very aggressively seek to do this. If you can help in any way, I think it is your responsibility to do so. Dr. Newell has given his opinion for the record, I believe. I would like to have yours.

Dr. BISPLINGHOFF. I think this is an excellent idea. As I mentioned previously, I know of no steps that we have taken to put permanent NASA people in DOD laboratories. This is something that we will look into and see if it can be done in the future.

Mr. KARTH. Your personal opinion is that this would be a very helpful thing?

Dr. BISPLINGHOFF. Yes; I think it would work good both ways.

Mr. KARTH. Dr. Weaver.

Dr. WEAVER. On this question of research and all, I would agree with the good doctor here, you have to have all the background material and then go ahead. You couldn't research every previous project before you went ahead on your own. It would be impossible.

You have to add your own experiences to do that before you can go forward. It is a problem of interchange of material.

I do like the idea you are talking about, of going back from NASA to the Defense Department and their subdivisions and back and forth. I think that is excellent for intercommunication.

Dr. BISPLINGHOFF. You mentioned a management scheme earlier, Congressman Karth, that we have employed in the so-called SNAP-50 agreement, the preliminary research leading to the development of a higher power nuclear electric system in the order of a megawatt power which involves a three-way team consisting of AEC, Air Force, and NASA working in concert.

This, I think, is an example of how the strengths of these three agencies can be brought together in one effort to aim toward the development of a higher power nuclear system in the SNAP program.

Mr. KARTH. Doctor, just for the record, the Senate report I had in mind that I alluded to just a few moments ago goes only to one phase of research. It was an area where the Federal Government spends about $2 billion a year, at least this was true in 1960.

They found in their investigation that approximately 200 million of the 2 billion was wasted, and it wasn't a matter of not having enough research work; it was a matter of having a good deal of research work but too many people not really knowing how much research is really being done in what areas of that particular research.

Dr. BISPLINGHOFF. May I ask what field that is?

Mr. KARTH. Here is the report. It is the "Committee on Government Operations, U.S. Senate, Subcommittee on Reorganization and Internal Organizations, Coordination of Information on Current Federal Research and Development Projects in the Field of Electronics."

We are talking about building another laboratory to have some more information that we don't know what to do with. It is dated September 20, 1961, sir.

Mr. MYERS. That was research and development?

Mr. HAMMILL. I will show it to him.

Mr. KARTH. It was $2 billion. I don't know what that buys.

Proceed.

Dr. BISPLINGHOFF. A subsidiary program of research in nuclear-electric power generating systems is aimed at supporting the SNAP-8 development and acquiring the technology on which to base future systems.

Research is underway in such areas as energy conversion components and systems, liquid metal containment and zero gravity effects on liquid metal boiling and condensing phenomena.

The 8 or 10 minutes of zero gravity exposure needed to establish equilibrium conditions for the latter research can be obtained only in freely falling vehicles at high altitudes. In the MECA project small two-stage, solid rocket launch vehicles will loft a 950-pound experiment on a ballistic trajectory to an altitude of 230 miles. The first experiments are in direct support of SNAP-8 and will utilize mercury fluid and SNAP-8 boiler and condenser component configurations.

Space vehicles: The space vehicle comprises the total entity which is propelled into space and which carries, protects and provides a suitable surrounding for the support of lunar life or instrumentation pay-

loads. As man probes deeper into space, enters the atmosphere of other planets, and returns to Earth, a twofold problem arises of defining the total environments of this space excursion and of providing the technology to design vehicles capable of withstanding the environments. These environments are totally unlike any others confronted in the history of mankind. The demands made upon materials of vehicle construction are illustrative of these environments.

A decade ago, before we had capabilities of launching spacecraft, materials demands could be satisfied with relatively few classes of materials. Aircraft, together with their powerplants and accessories, did not experience operational requirements or conditions drastically different from other machines such as those for rail, automotive, or marine use. Essentially, aircraft technology was but a refinement of other technologies and could grow as extensions of them.

With the arrival of such developments as space travel, hypersonic speeds in the atmosphere, and novel power plants, entirely new materials requirements arose. In many instances, the old established technologies offered little help. Approaches using new classes of materials had to be found.

Figure 102 shows the sharp increase in the classes of materials that have entered the scene during the past decade as candidates in the design of spacecraft systems.

The impact of these new needs is even more drastic than the mere numbers of material-classes would indicate. This is so because utilization of most of the new classes of materials requires an understanding

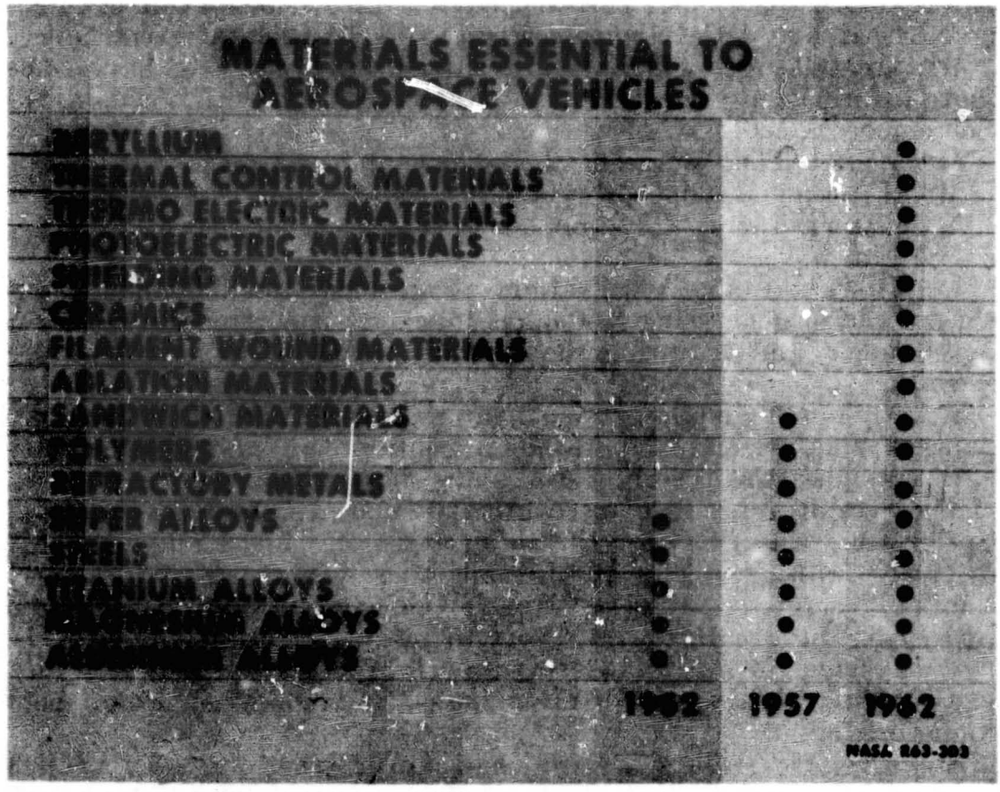

FIGURE 102

of a great many more physical properties than had been required in the older material applications.

Materials research is particularly adapted to ground testing, and a new space environment research facility for this purpose is proposed this year for the Ames Research Center.

Current spacecraft designs contain extra factors of safety and reliability which result in redundancy and additional weight because the knowledge of material behavior in the space environment is incomplete. The proposed facility will simulate the spatial environment and will include equipment to provide for high-vacuum, electromagnetic and particle radiation, heat and micrometeroid impact.

Among the hazards of space flight is damage caused by impact of meteoroids. In this connection, the problem is one of providing protection of the spacecraft and its contents against catastrophic damage. A knowledge of the meteoroid content of space must be obtained as well as the effect of meteoroids on spacecraft structures.

In order to provide this knowledge, space probes or satellites must be employed to measure not only the meteoroid content of space, but also to determine penetration damage statistics.

Mr. KARTH. What are you doing in this area?

Dr, BISPLINGHOFF. The Office of Advanced Research and Technology has the responsibility for the putting up of satellites to measure the meteoroid content in the near earth environment.

Mr. KARTH. Isn't the Office of Space Sciences doing some of this too?

Dr. BISPLINGHOFF. No, the Office of Space Sciences has, in many of their satellites and space probes, a microphone arrangement to get rough qualitative information on the meteoroid content, but the designer of space vehicles needs a much more precise indication of what the number of meteoroids are in the near earth environment. We have designed a satellite which we launched on December 16, Explorer 16, which actually counts the number of meteoroids which are encountered and gives us an idea of how large they are.

By this means, we hope to be able to determine what the design conditions must be for the walls of the space vehicles which will operate in the near earth environment.

Mr. KARTH. I don't want to cause a jurisdictional fight, but it almost sounds as if that belongs to Space Sciences.

Dr. BISPLINGHOFF. You are right, but the information we seek is beyond what their normal interests are. It was the decision——

Mr. KARTH. Don't you say that to Dr. Homer Newell.

Dr. BISPLINGHOFF. Yes, we do. There is no jurisdictional dispute here. This I think is well understood throughout the whole agency.

Flight experiments are underway and planned as a part of an extensive program to ascertain the severity of the meteoroid hazard. In addition to the satellites placed in orbit by SCOUT rockets, known as Explorer XIII and Explorer XVI, there is currently planned a satellite experiment designed to record larger meteoric particles that occur less frequently. The design configuration for this spacecraft is shown by figure 103.

Mounted on both sides are meteoroid sensors. A sketch of the sensor is also shown on the figure, and it is, in essence, a parallel plate capacitor. A meteoroid which penetrates the aluminum sheet will ionize the

FIGURE 103

aluminum in the immediate vicinity of the penetration, and the resulting ionization trail will short out the condenser.

During the time interval in which the material is ionized, battery current is allowed to flow, producing a signal. After a short time interval, the ionization decays, the charge recovers, and the capacitor is recharged once again ready to detect another penetration.

The Earth itself is a gigantic and permanent meteor collector. Our flight experiments will help to calibrate, in terms useful to the space engineer, the voluminous data obtained by ground-based observation of meteors. We are also assisting in the support of certain ground-based photographic and radar meteor observations that will provide data useful for space vehicle design and space operations.

I was going to mention that this larger satellite that we just showed you will ride on the Saturn I vehicle, Saturn No. SA–8, whereas they had originally planned to carry water ballast. In the early tests of this vehicle we conceived the idea of eliminating the water ballast to put this payload up with the Saturn vehicle. We have heretofore been restricted to what might be called the poor-man rocket, the Scout rocket, which doesn't allow us to get a vehicle near this size in orbit. By riding piggy-back on the Saturn SA–8, we are allowed to get a much larger vehicle into orbit.

Mr. KARTH. Who launches your satellites?

Dr. BISPLINGHOFF. The Explorer XVI is launched from Wallops Island. The SCOUT rocket is provided by the Chance-Vought-Ling-Temco Co., and their people actually do the vehicle work.

Mr. KARTH. Does the Office of Advanced Research and Technology have their own launch team?

Dr. BISPLINGHOFF. Not at all.

Mr. KARTH. No one is connected with any kind of a launch program?

Dr. BISPLINGHOFF. We make use of the vehicle purchasing and managing entity in the Office of Space Sciences in all of the SCOUT work, and in the work using SA–8 and SA–9 we make use of that same entity in the Office of Manned Space Flight.

Those two offices are constantly launching vehicles.

We are interested only occasionally, and we ask these other two offices to do this work for us.

Mr. HAMMILL. Following up the chairman's earlier question and your very last remark; since it appears, superficially at least, that this program for measuring numbers of meteoroids would normally fall within the jurisdiction of the Office of the Space Sciences, is there any reason why your office couldn't ask the Office of Space Sciences to do this for you?

In other words, do you feel free to lay requirements on that office?

Dr. BISPLINGHOFF. Yes, we could certainly do this. It may be that our requirements would find a fairly low priority in their total program. Our interests are not from the standpoint of just getting scientific information in space. We are interested in finding what the environment is as a basis for vehicle design. So there is really a different motive, a different motivation here.

I think there is a proper division of responsibility here myself.

Although there has been much speculation concerning life behavior under zero-g. conditions, there are other difficult problems which face the physical scientist in establishing the behavior of liquid and vapor systems. These include positioning of fluids in propellant tanks and liquid-vapor equilibrium configurations in the condensers and radiators of auxiliary power systems. The behavior of the liquid-vapor interface under zero gravity conditions affects such functions as engine restarting, tank venting, propellant transfer during rendezvous, and orientation of auxiliary power system.

Liquid in a tank under normal one-g conditions rests on the bottom in the manner familiar to all of us in everyday life. This is due to the overwhelming predominance of gravity over surface tension forces. However, under zero-g. conditions, the liquid mass may assume an odd equilibrium configuration, due now to the predominance of the surface tension forces, quite unlike that under normal conditions.

As a result of theoretical research followed by experimental verification in a drop tower, a basic understanding of this phenomenon has been achieved and methods have been found to facilitate positioning of the liquid in a desired manner.

Figure 104 illustrates the behavior of a wetting fluid such as water, alcohol, or a hydrocarbon, under zero- and one-g. conditions.

On the left is a flask containing the liquid in the Earth's gravitational field. The liquid is, of course, pulled downward and the gaseous vapor lies above it. In this case, it is easy to pump the liquid in the ordinary way and to vent gas either into or out of the region of the container vacated by the liquid.

Under zero-g. conditions, as shown by the middle diagram, surface tension causes spreading of the fluid completely around the

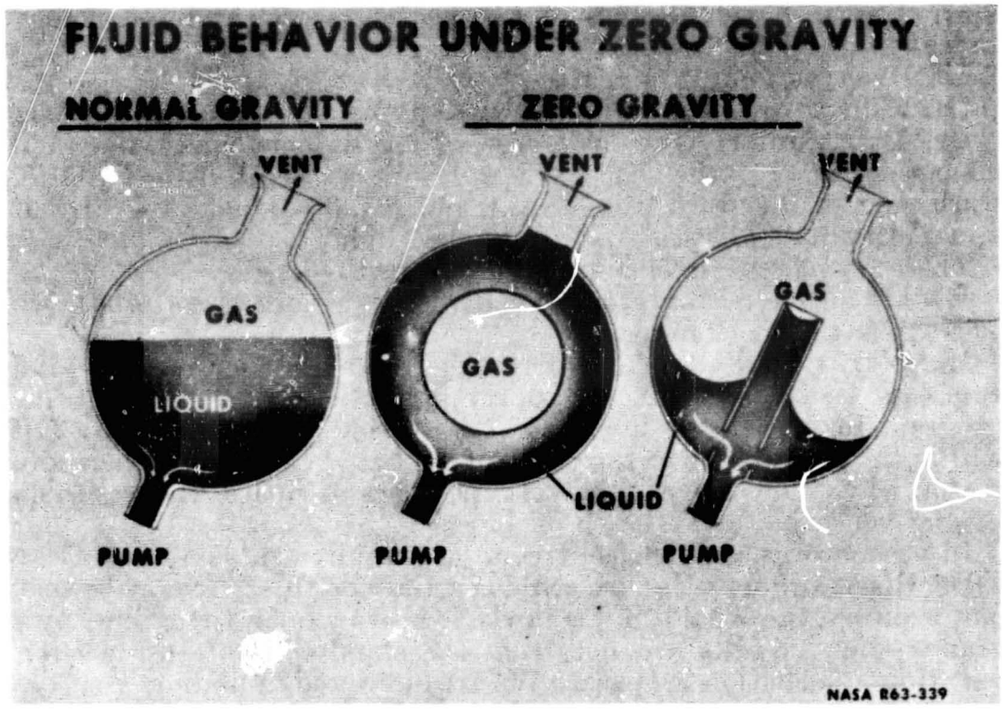

FIGURE 104

wall of the container and the gas is now a bubble in the center. Since the gas bubble is not vented to the outside, the pump will not work satisfactorily. If a standpipe with suitable openings in the bottom is placed in the container, as shown by the diagram at the right, surface tension will act in such a way as again to place the liquid and gas at opposite sides of the container. In this case, the pump will work.

You would put the pump right under the place where the standpipe is.

As a result of pioneering work at the Lewis Laboratory it has become clear that much useful research on zero-g. fluid behavior can be done on the ground in drop-tower experiments. One of the facilities proposed in this budget is a zero-g. drop-tower at the Lewis Laboratory to extend this work.

I think this is one of the most interesting developments we have made in ground-based facilities to simulate something that happens in a space environment.

The observation that one can get with this hydrostatic equilibrium in a few seconds of time lets us drop these things free in a tower that doesn't have to be too high and we can get a great amount of valuable information without having to go into expensive rocket flights.

We are constantly trying to find means to do everything we possibly can on the ground in the evaluation of the space environment and in the development of devices to go into space.

Of course, the zero-g. thing is one of the most knotty problems we have. I believe this drop tower is going to give us a good deal of information for short-time effects.

Among the most challenging areas of space research have been those concerned with the aerodynamic flow and heating problems during

reentry into the Earth's atmosphere. These problems directly influence the shape of the space vehicle, the type and weight of the critical heat-shield component, and the vehicle payload.

Figure 105 illustrates the sharp rise in heating intensity which can be expected as we progress beyond lunar return speeds.

Our understanding of the nature of the flow and heat transfer to vehicles entering at satellite speeds (around 17,000 miles per hour) is well in hand—I think we understand quite well how to design for these conditions—and I am happy to report that we have made progress in our research during the past year in increasing our knowledge of these phenomena up to the lunar reentry speed range (around 24,000 miles per hour) and a little beyond.

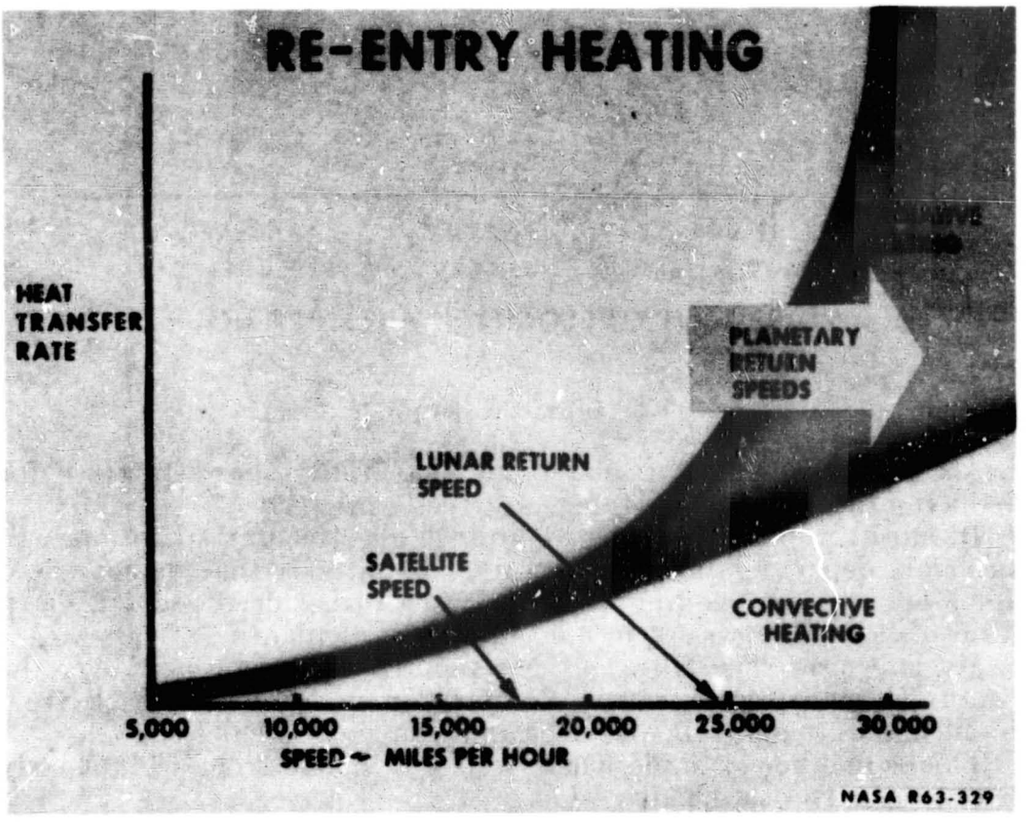

FIGURE 105

We are now pushing research in reentry physics into the speed range associated with reentry from interplanetary missions (around 31,000 miles per hour and higher).

As shown by the previous figure, the problem becomes aggravated in this high-speed range. I would like to illustrate a possible solution.

Figure 106 shows the total heat transferred to a blunt-nosed body and to a relatively slender-nosed one.

At speeds up to lunar reentry, wherein convective heating is the major contributor, the blunt nose, such as used on the Mercury and Apollo vehicles, has a lower total heat transfer than does the slender-nosed body. At speeds beyond lunar reentry, wherein radiative heating becomes the predominant factor, the relatively slender-nosed body

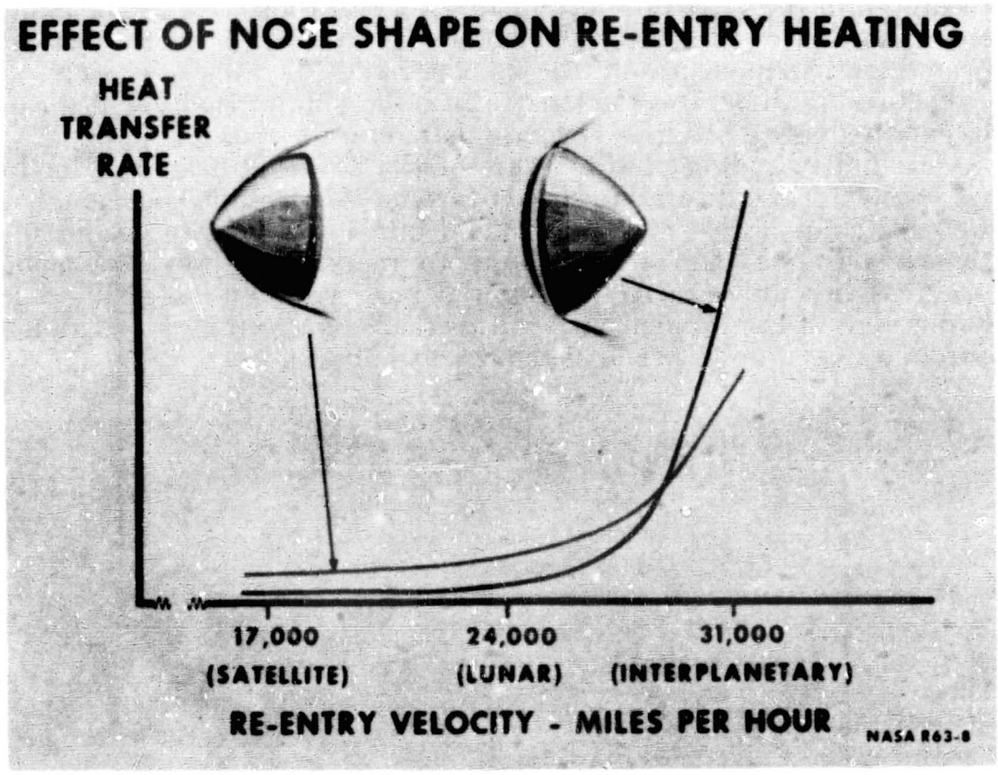

FIGURE 106

has a lower total heat transfer and potentially shows promise for reducing the heat-shield problems at these speeds.

In effect, we are saying as we go to higher reentry speeds we will probably depart again from the rather blunt body that we have used for Mercury and Apollo and go back to a rather needle-nosed, sharp kind of body that we see in our supersonic airplanes.

My colleague, Dr. Kurzweg, has pointed out to me how over the centuries, man has gone from rocks to arrows and gone back from blunt bodies to sharp bodies over and over in his vehicles.

This is another example where we see a change from a blunt body back to a sharp-nosed body.

Much basic research work is required to check out this concept and to deal with the many new problems that are entailed in using such shapes at hypersonic speeds.

The above research is an example of how new knowledge can be obtained in ground facilities. A new concept in a ground facility is the Hot Gas Radiation Research Facility proposed in this budget for the Langley Research Center. Experimental facilities must carry the major burden of defining the radiative heat-transfer distribution about reentry vehicles both to verify theoretical results and to avoid, as much as possible, expensive free-flight testing. The proposed facility will provide test capability for large models with on-board instrumentation at speeds up to interplanetary reentry.

A few selected flight-reentry experiments must be conducted to validate laboratory data and provide greater confidence in applying it to full-scale reentry heating. An important reentry-flight research ex-

periment to be flown in fiscal year 1964 is Project Fire in which a highly instrumented 200-pound test vehicle will reenter the Earth's atmosphere at 25,000 miles per hour. The objective is to obtain critical data on radiative and convective heating in the true flight environment. A sketch of the essential components of the Project Fire vehicle is shown by figure 107.

During the final stages of Atlas launch, the spacecraft, comprised of velocity-impulse and reentry vehicles, is ejected and proceeds along a ballistic trajectory toward an impact area south of Ascension Island.

Just before reentry, the velocity impulse vehicle rocket motor is

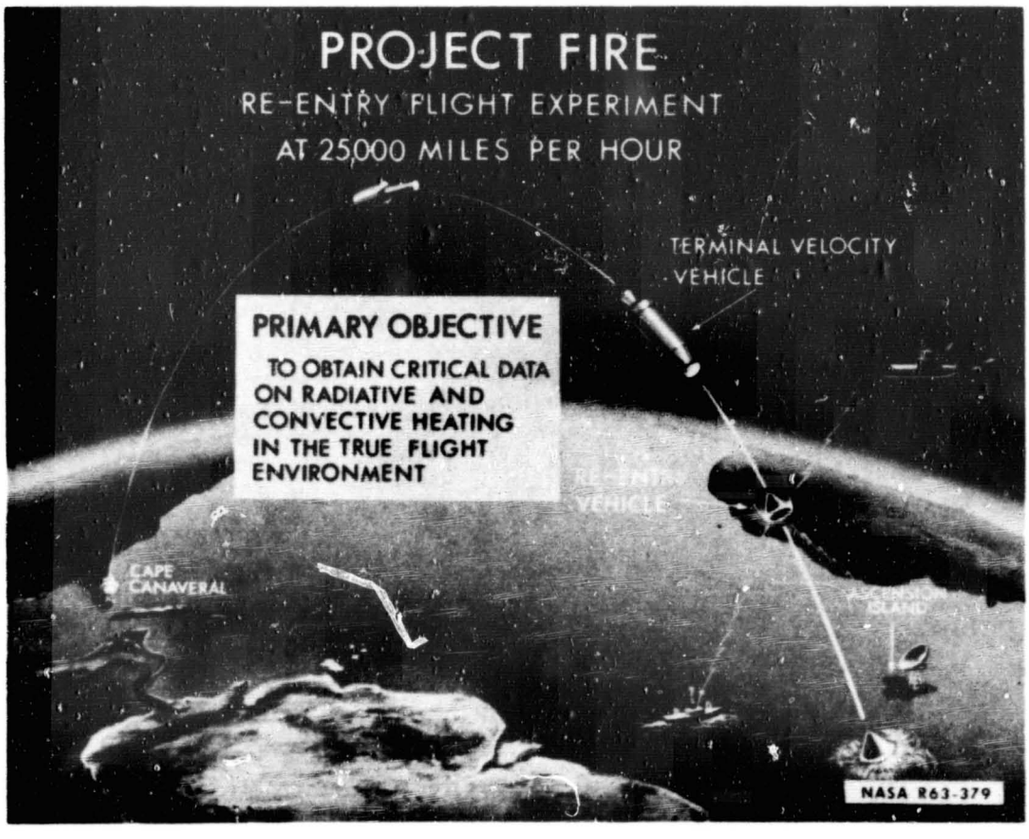

FIGURE 107

ignited to boost the reentry test vehicle from 14,000 miles per hour to 25,000 miles per hour. At burnout the 2-foot-diameter reentry vehicle separates and reenters the atmosphere blunt face forward. The reentry test vehicle contains thermocouples for measuring temperatures and heating rates, radiometers for measuring the total radiant intensity and spectral content of the hot gas surrounding the vehicle, and various instrumentation for determining surface pressures, vehicle forces, motion, and radio-signal transmission during the communication blackout. The data are telemetered to receiving equipment at Ascension Island and aboard range ships and aircraft.

Along with research on reentry into the Earth's atmosphere, similar research is also progressing on entry into the atmospheres of other planets, particularly the nitrogen-carbon-dioxide atmospheres thought to exist on Mars and Venus. To obtain an understanding of the radia-

tive heating in such environments, preliminary measurements have been made of the thermal radiation emitted from the hot-gas cap of blunt bodies flying in nitrogen-carbon-dioxide mixtures.

The measurements were made on ¼-inch plastic models fired from a light-gas gun launcher. The results are shown as a band on the chart of figure 108 in which the radiative heat output of the mixture is presented as a multiple of the heat output in air. The brackets shown on the chart indicate that the atmospheric constituents are fairly well defined for Mars but are unclearly defined for Venus.

In both cases, the limits are quite well established and agreed upon by the scientific community. It can be seen that, at a given speed,

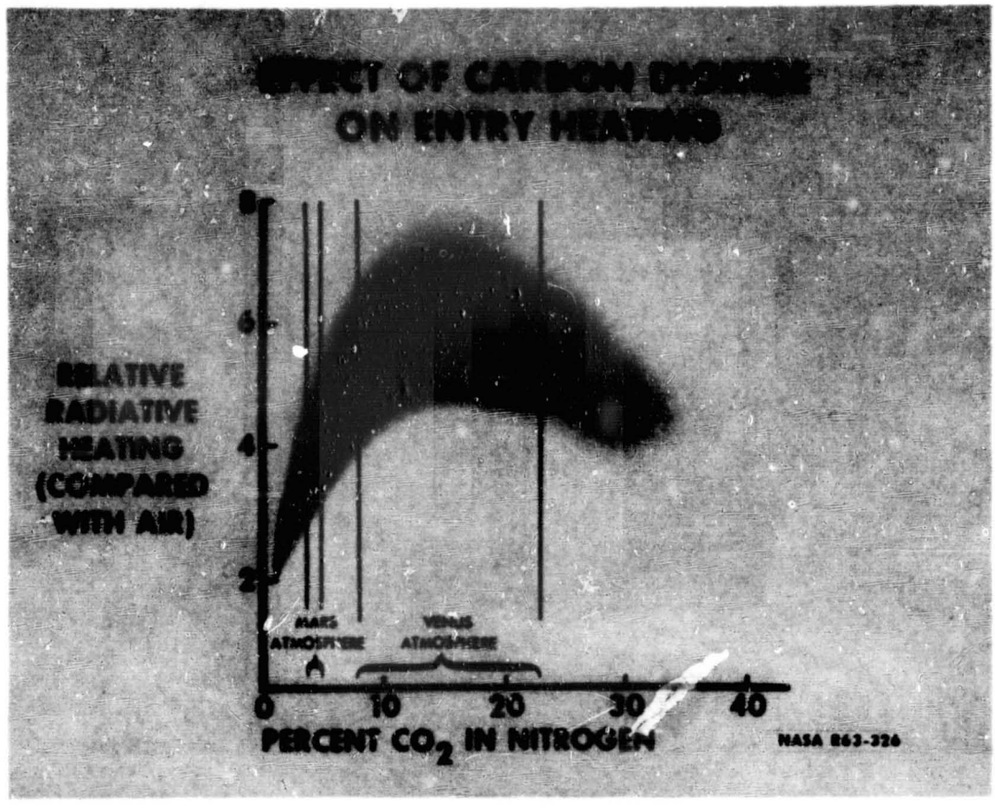

FIGURE 108

the radiative heat transfer problem is considerably more severe during entry into the expected Martian or Venusian atmospheres than in the Earth's atmosphere. Additional studies will investigate new body shapes to determine optimum configurations for successful entry into the atmospheres of the near-Earth planets.

The development of materials to withstand the severe heating conditions of atmospheric entry continues to be one of our most important research objectives. The chart of figure 109 shows the change in efficiency of ablating materials since 1960 and indicates that improvements have been accomplished at the expense of structural strength. The thermally efficient materials are, in fact, so devoid of strength that the structural backbone must be independently supplied.

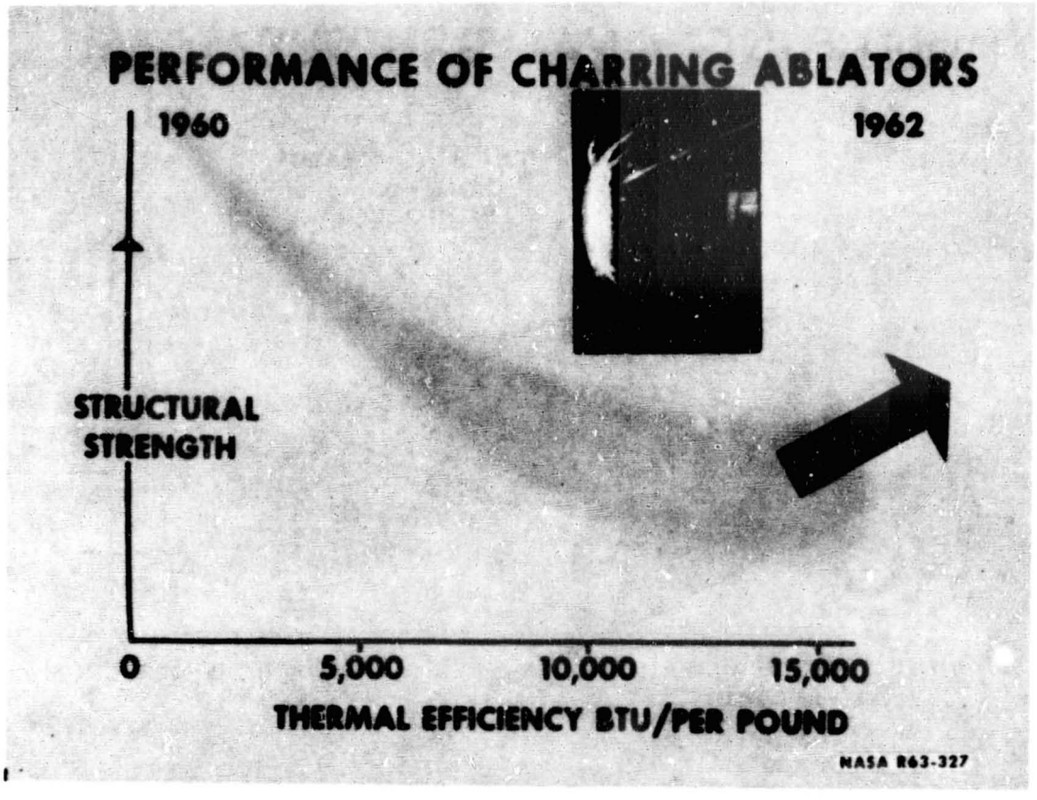

FIGURE 109

The chart indicates that our research objectives for ablating materials are improvement in structural strength while continuing to improve thermal efficiency. The photograph on the chart indicates that these objectives will be sought through research performed in ground facilities.

The diagram of figure 110 is offered to indicate our direction of thinking concerning space vehicle structures. It shows a structurally weak charring albator reinforced with honeycomb to provide efficient reentry thermal control while acting also as a meteoroid bumper. A second layer of honeycomb is filled with hollow rubber spheres which provide a barrier against heat conduction while furnishing at the same time a self-sealing system against meteoroid penetration. As the structural wall is penetrated by a meteoroid, the efflux of pressurized air from the spacecraft forces a sphere into the outer structural wall to preserve pressure integrity.

This is just one sample of what one can do to provide for the kind of environments we are talking about. Unfortunately, the weight of such a structure is much beyond what we would like to have, but it, nevertheless, illustrates the kind of thinking that we are undergoing now.

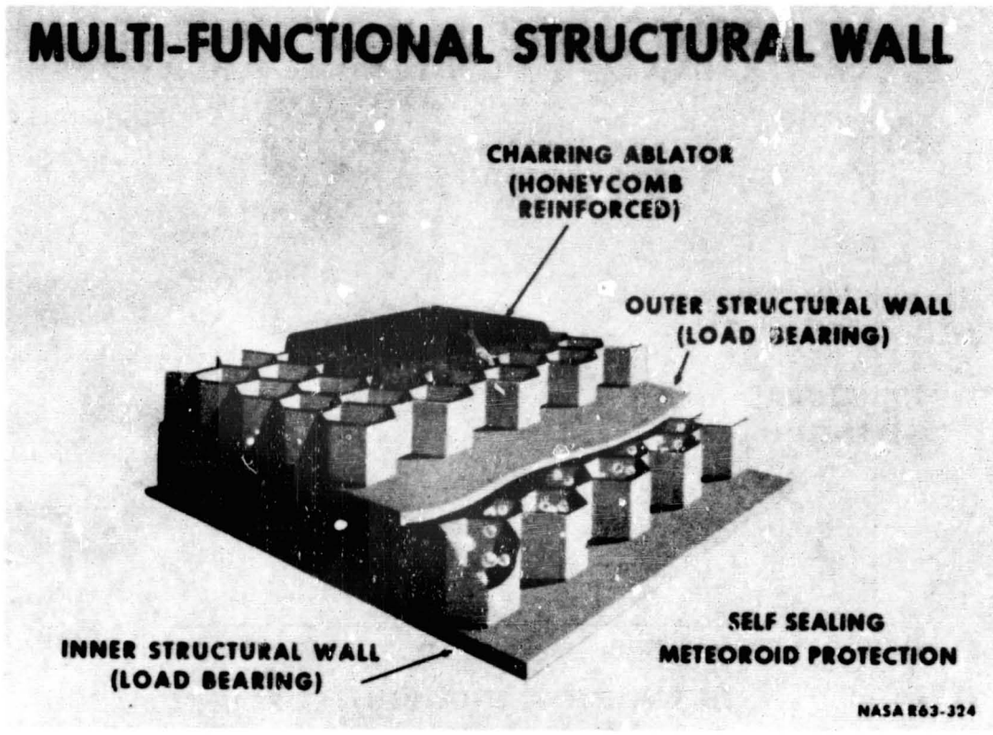

FIGURE 110

ELECTRONICS AND CONTROL

The most powerfully propelled and efficient space vehicle would be useless if it could not be controlled, guided, and communicated with in space. Electronics systems in spacecraft and launch vehicles play roles analagous to the senses and nervous systems in human beings. Navigation and control systems are man's sight and sense of balance and communication systems permit man to extend his senses of sight and sound over distances much beyond their natural range. Instrumentation, computation and data processing devices serve as the spacecraft's "brain and nervous system." This is an area of advanced research and technology in which the NASA is building its capability. It is an area which was not regarded of prime importance in the mission of the NACA, but which in the NASA has now assumed equal importance with the technologies of propulsion and space vehicles.

An indication of this importance may be realized from the estimate that approximately 70 percent of spacecraft costs go into electronics. The NASA field organization has a strong propulsion research capability at the Lewis Research Center and the Marshall Space Flight Center. The other principal aeronautical and space technologies are strongly represented at the Langley, Ames, and Flight Research Centers. Since there is no comparable concentration of electronics research experience and capability within NASA, this budget proposes an Electronics Research Center to be established in the Greater Boston, Mass., area. The principal functions of this Center will embrace research and component development in the related fields of communications, data processing, guidance, instrumentation, control, and energy conversion. Its unique feature will be a concentration of

effort on the advancement of the arts and sciences of these fields to meet the requirements of aeronautics and space flight.

The NASA planetary missions of the future, both manned and unmanned, require navigation instruments capable of operating accurately and reliably for mission durations measured in terms of years. The prolonged periods of free-fall operation, low-thrust type corrections, and efficient energy management are criteria demanding increased accuracy and stability on the part of the navigation and guidance sensors; for example, an initial error of 0.5° in thrust angle at the beginning of the coasting period in a Mars orbital mission can produce a position error on the order of 200,000 nautical miles in the vicinity of Mars. Figure 111 depicts two promising inertial sensor

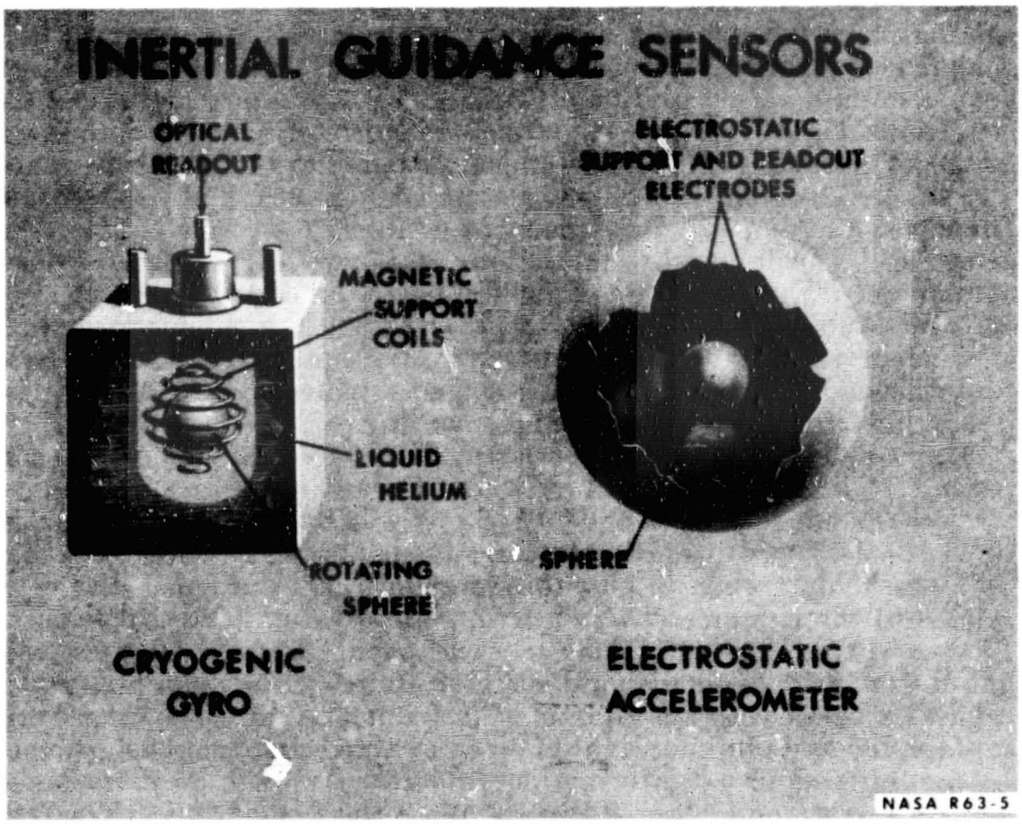

FIGURE 111

concepts currently being pursued in both Government and industry laboratories under NASA sponsorship. These techniques are also being developed by the Department of Defense along lines related to military systems applications. The cryogenic gyro utilizes the principle of superconductivity wherein electrical resistance disappears at temperatures near absolute zero to provide a magnetic field requiring no electrical energy input, after initial establishment, to support a rotating gyroscopic mass. Although a promising technique, such problems as that of obtaining suitable cryogenic materials require continued research before these devices can be considered practical.

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In addition to industry efforts, research on cryogenic techniques is being conducted at the Jet Propulsion Laboratory. The electrostatically suspended gyro (and accelerometer) differs from the cryogenic type in that it uses electrical rather than magnetic forces to suspend the inertial element. It does not require cryogenic temperatures but does need a high vacuum internal environment for its operation. This sensor is promising but is more sensitive to high acceleration environments and requires further effort to develop and demonstrate the ability to operate during the launch environment without performance deterioration. We are also working on devices such as pressurized gas bearing gyros to fill the time gap between the currently available shorter lifetime gyros and the cryogenic and electrostatic devices.

An important adjunct to today's aerospace research is the art of simulation. It is utilized in scientific exploration and design of both manned and unmanned spacecraft and launch vehicles. The closed loop simulation of satellite attitude control systems facilitates the determination of component and subsystem requirements, defines the range of parametric tradeoffs and approximates the performance of the selected system. New systems and techniques, novel design approaches, and improved components related to attitude control systems can be examined by simulation techniques in the postulated environment. The Ames Research Center is conducting this type of research and its ultimate payoff will provide unmanned satellites with accurate and stable attitude control systems capable of long-term and efficient performance in space systems related to instrumentation, communications, navigation, and meteorological missions.

Flight and space simulators are versatile and effective tools for collecting and examining data related to man's performance indices while he is subjected to a wide variety of selected and controlled conditions. Various control display arrangements can be operated under many task constraints in an effort to determine pilot capability as it relates to the equipment which he has to aid him. Recent work at Langley Research Center may be mentioned. The Langley investigators found that a man could successfully control a simulated space rendezvous task with a minimum of instrumentation. The target was represented as a blinking light upon a projected star field background. Using only this visual information, pilots were able to estimate range and range-rate and successfully complete the rendezvous. Research of this type is continuing at the Langley Research Center and one aspect of their future work will examine the broad spectrum of manned-automatic control systems in lunar letdown operations.

Instruments are being developed to enable a close surveillance of the physical well-being of personnel in the spacecraft. These devices are small and light enough that their presence will not limit an astronaut in his movements. They are outwardly extremely simple. Prototypes which will sense and transmit heart action and respiration rate and volume have been tested. These devices are completely self-contained and include sensors, batteries, and radio transmitters with a range of about 30 feet. When completed, such devices, utilizing molecular electronic techniques, will be about ½ inch by ½ inch by ⅛ inch in size. The first use will be at the Ames Research Center where they will be applied to the chest of a man riding on a centrifuge. With the centrifuge in motion, it will be possible to receive by radio and display

at a stationary monitoring console, a cardiogram of the man as well as records of his respiration rate and volume. Later, the devices may be used on crew members of a spacecraft.

Our work with simulators and bioinstrumentation is coordinated closely with similar work in our biotechnology and human research program and the bioscience program of the Office of Space Sciences.

An embryonic area of electronics research and advanced technology development is called microelectronics. The technology of microelectronics, wherein a single piece of material is designed to perform the functions of a number of individual electronic parts or elements is an outgrowth of the transistor technology. As illustrated in figure 112 a single block of material about the size of a dime can now

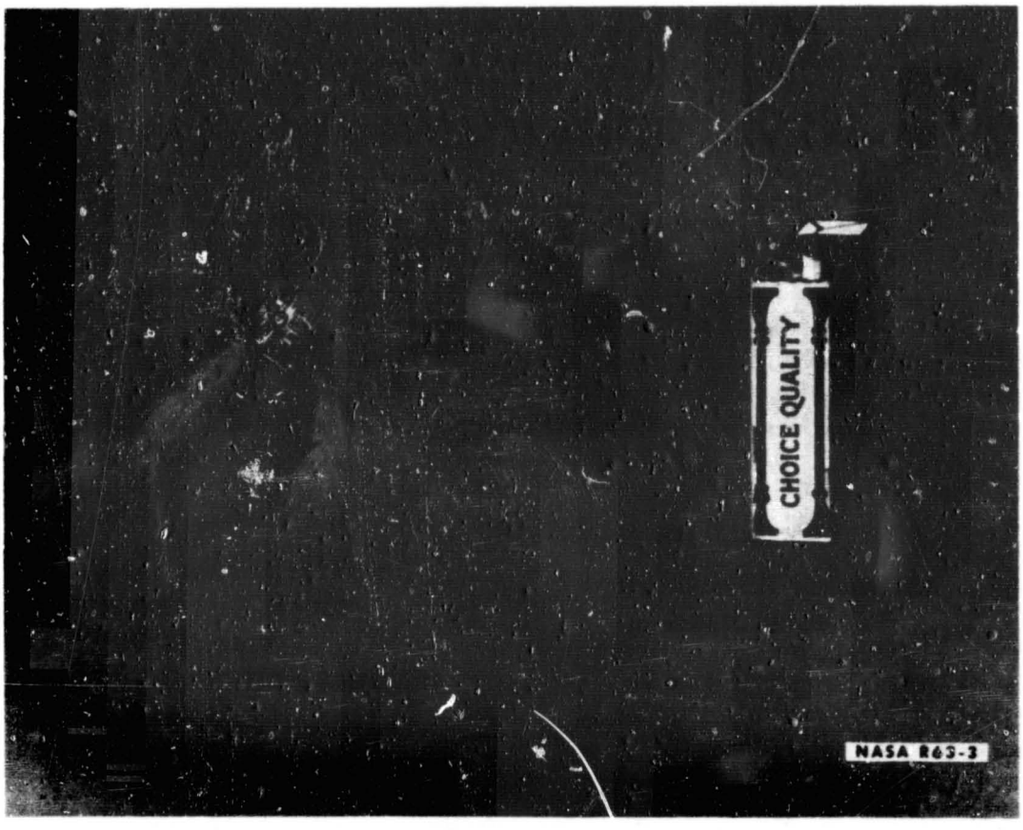

FIGURE 112

be fabricated to perform the functions of a conventional transistor electronic blackbox of components equivalent in size to a pack of cigarettes. Microelectronic techniques and devices are of importance to space programs primarily because of the new order of reliability expected with their use. Size and weight decreases are of similar importance.

Mr. KARTH. I wonder if you would define for the record what you are doing with simulators and bioinstrumentation; if you could differentiate the work you are doing in these areas?

Dr. BISPLINGHOFF. Yes. The bioinstrumentation work is largely along the lines of developing these little transducers that can be put at various places on the body to pick up such things as blood pres-

sure, heart rate, and so on. In addition to these little transducers we are developing small, short-range transmitters which can transmit this information to a larger transmitter on the spacecraft which in turn can transmit it to the ground. I think we would say that the biotechnology instrumentation research is largely along the lines of these little transducers that might be placed at various places on the body.

Mr. KARTH. How does that compare with the bioscience program of the OSS?

Dr. BISPLINGHOFF. The bioscience program in OSS has no such objectives in it. We are concerned in this office with the behavior of man and how he can be integrated into a space vehicle system. Their concern is mainly with the biological, more fundamental biological aspects of the space environment. And, of course, things like extraterrestrial life and so on.

Our main concern is one of determining what must be done to a spacecraft to support life on board the spacecraft, and what capabilities does the man in fact have of performing a useful role inside the spacecraft?

Mr. KARTH. Thank you.

Dr. BISPLINGHOFF. On the simulation side, here we are concerned with actually taking models of spacecraft and placing them in this simulation device and determine how accurately they can be controlled and guided.

We try to provide complete simulation on the ground so that, for example, the occupants of the spacecraft can sight stars, other heavenly objects, and use this as a means of actually guiding, controlling the spacecraft. At the Ames Research Center we are building a simulator. We have in fact a small simulator now and we are building a larger simulator so that the environment insofar as degrees of freedom of the spacecraft and the sighting of the stars and things of this kind can be provided, and that their control and navigation systems can be researched and checked out.

Mr. KARTH. Thank you, Doctor.

Dr. BISPLINGHOFF. Inherent in the evolution of microelectronics is the wealth of knowledge gained in transistor technology which has resulted in great strides in the understanding and use of solid-state physics in electronic systems. Also, the fabrication of a microelectronic integrated circuit is accomplished by vacuum deposition processes involving fewer steps than the manufacture of a conventional electronics system. These processes can be and must be precisely controlled and the results should be reproducible to a greater degree than heretofore possible. Also, the integrated circuits may be designed so that the number of electrical connections are minimized. One of the limiting factors in modern-day technology involving the reliability of electronic systems is the number of connections which must be made, either by soldering, welding, or other techniques. It is widely agreed that the reduction of interconnections, either within integrated elements or between integrated circuits, is of very great importance in achieving reliability. A further important reason for reliability in microelectronics is the potential radiation resistance of devices which utilize thin-film techniques. Figure 113 illustrates how radiation might easily pass through a thin-film microelectronic device without affecting the crystal or physical structure of the material. On the

other hand, the impingement of this radiation on the more bulky structure of a conventional semiconductor device can dislocate or disrupt the crystal lattice and result in a malfunctioning of the electronic circuit in which the device appears.

We are simply saying here if one has a very thin film the probability of a proton striking one of the atoms in the crystal lattice is much less if it is thin than if it is somewhat thicker.

Analysis and past experience have illustrated that when redundancy is employed in electronics systems, improved reliability is obtained. While it would be impractical to employ duplicate circuitry in systems employing conventional electronics, the whole idea becomes vastly

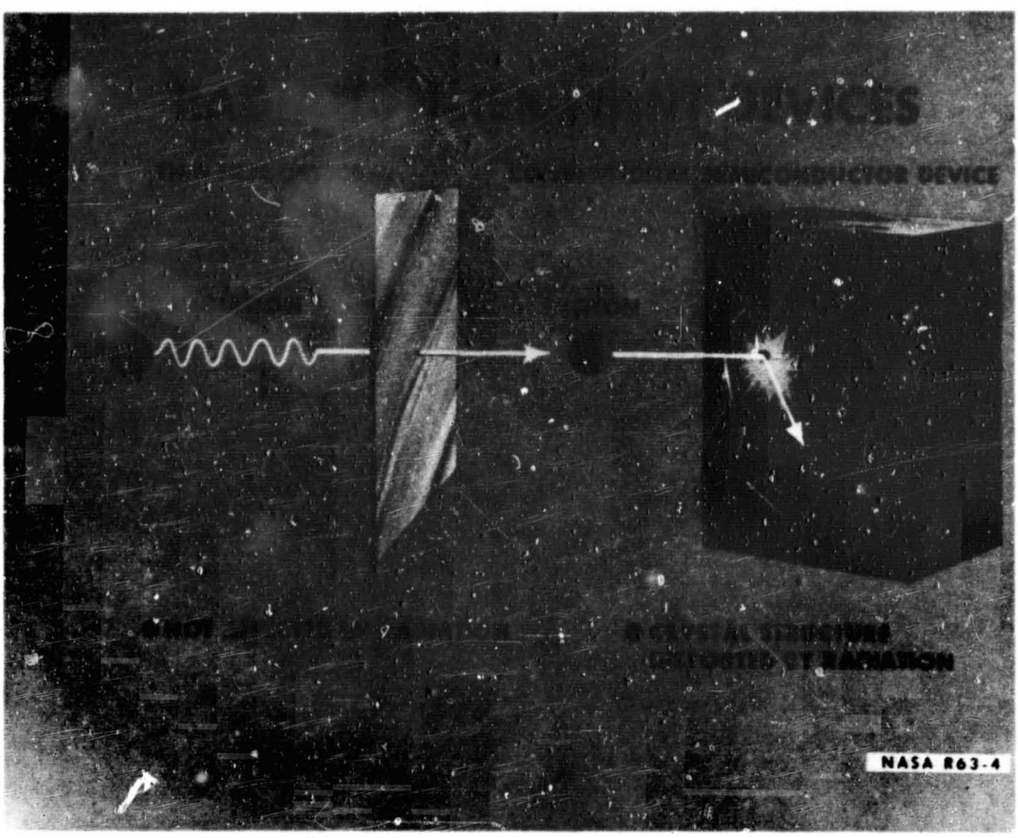

FIGURE 113

more practical with the processes and techniques of microelectronics.

One of the most interesting new areas of research in space communications and tracking is provided by the laser. Let me take a few moments to explain what a laser is, how it operates and what it may be used for.

All electromagnetic radiation, whether from a radio transmitter, radar, or light bulb, can be viewed as being made up of elemental "packages" of energy called photons. These photons individually contain a very small amount of energy. A 100-watt household light bulb will emit over a quintillion (a billion billion) photons per second. Characteristically, all of the photons from this light bulb are not identical. A laser is a light source that creates this billion billion photons such that they are almost identical in terms of frequency,

content, phase and amplitude characteristics. A ruby laser produces these identical photons in the manner indicated in figure 114.

A light source illuminates a rod of ruby crystal. The chromium atoms in the ruby crystal absorb and store photons from the light source much in the same way as a car battery stores the potential to deliver current. When a sufficient number of atoms have absorbed noncoherent photons, they begin to release others with limited coherency. After release, the photons are successively reflected from the mirrored end surfaces of the rod. These photons being reflected back and forth entice other atoms to release identical photons. The

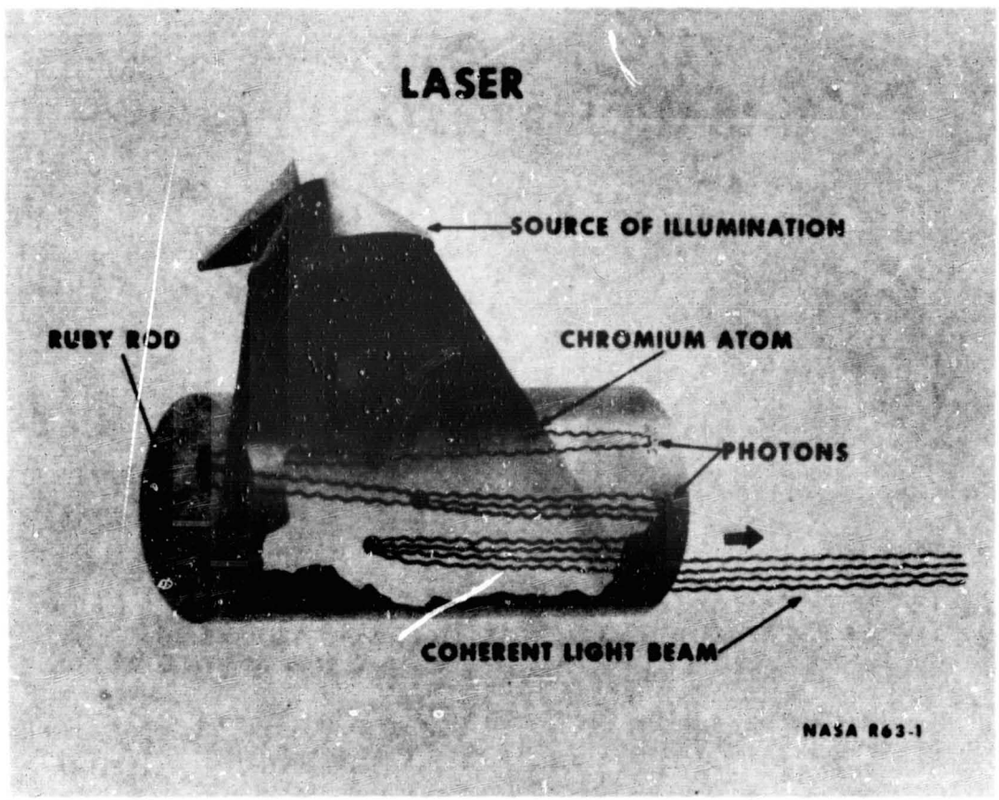

FIGURE 114

process continues building up billions upon billions of photons which are all identical.

Since the internal reflection of the mirrored ends is not ideal, some photons escape to form a "coherent beam" of light.

Mr. KARTH. Is the ruby rod the only thing from which you can produce laser light?

Dr. BISPLINGHOFF. No, there are other materials. The ruby laser is the one that has come under the most attention.

Dr. KELLEY. One of the newest ones is gallium arsenide. It will be more efficient than the ruby laser that we have right now. The ruby laser is a relatively inefficient device as we have it right now in the laboratory.

Dr. BISPLINGHOFF. This beam has the property that all of the photons remain closely packed together as the beam propagates over

interplanetary distances. These billions upon billions of energy packages upon escaping from the laser will pass through an area smaller than the cross section of a pencil eraser every second providing an extremely high energy density.

The same is not true for radio waves since they are more diffuse. There are at present two principal NASA applications for such high energy density optical beams, namely spacecraft communications and tracking as shown in figure 115. Since radiating energy is the means whereby information or data is transferred, it is essential that the maximum possible amount of power radiated from a spacecraft be

FIGURE 115

received. Thus to optimize mission capability, NASA scientists are evolving efficient lasers as optical transmitters.

Areas of applied research and development work are being pursued which encompass not only the efficient conversion of electrical energy to single frequency coherent optical radiation, but also to investigate modulation (means of applying intelligence) as well as its detection or information recovery.

The effect of the aerospace environment on coherent optical radiation presents another complete set of research problems, the initial characteristics of which will be obtained by utilizing the S–66, polar ionosphere beacon satellite.

These problems, reflected in figure 116, involve such factors as how the laser beam is degraded as it traverses space and the Earth's atmosphere and how relativity influences not only the signal on the laser beam, but the direction in which it is moving.

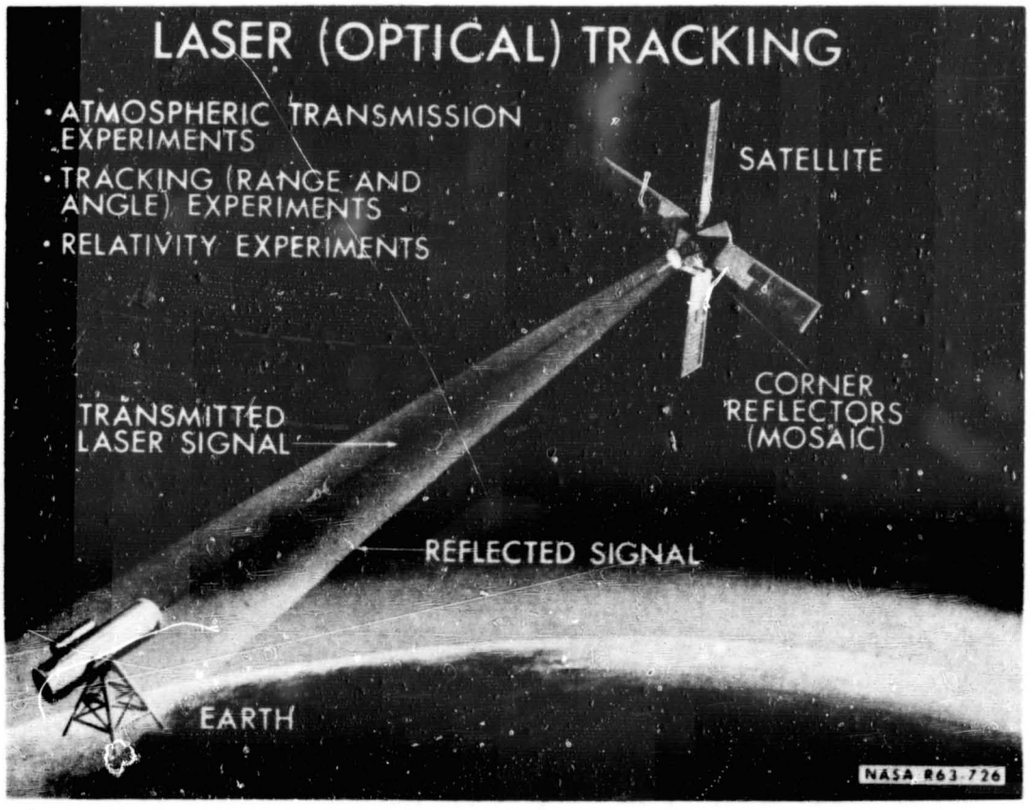

FIGURE 116

Mr. KARTH. Doctor, I think that we might well recess at this point until 10 o'clock tomorrow morning.

I know most of you as well as most of us must get back to the office to do what we couldn't do while we were here.

Dr. BISPLINGHOFF. We will be back at 10 o'clock.

Mr. KARTH. We will see you at 10 o'clock. Thank you very much for coming. The meeting is adjourned.

(Whereupon, at 4 p.m., the subcommittee was adjourned, to reconvene at 10 a.m., Thursday, March 28, 1963.)

1964 NASA AUTHORIZATION

THURSDAY, MARCH 28, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SPACE SCIENCES
AND ADVANCED RESEARCH AND TECHNOLOGY,
Washington, D.C.

The subcommittee met, pursuant to adjournment, at 10 a.m., in room 214–B, Longworth Building, Hon. Joseph E. Karth (chairman of the subcommittee) presiding.

Mr. KARTH. The committee will come to order.

Doctor, if you would like to begin today where you left off yesterday afternoon when we adjourned at 4 o'clock, we would be very happy to make an effort to get through your testimony today.

STATEMENT OF DR. RAYMOND L. BISPLINGHOFF, DIRECTOR, OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY, NASA; ACCOMPANIED BY BOYD C. MYERS II, DIRECTOR, PROGRAM REVIEW AND RESOURCES MANAGEMENT, AND DR. EUGENE KONECCI, DIRECTOR, BIOTECHNOLOGY AND HUMAN RESEARCH

Dr. BISPLINGHOFF. Good morning, Mr. Chairman and gentlemen.

We were at the bottom of page 54 when we stopped last evening. The next topic I would like to go into is "Biotechnology and Human Research."

As you are aware, NASA's total program in the life sciences ranges from fundamental research in the biosciences under the Office of Space Sciences, to human participation in space flight under the Office of Manned Space Flight.

During the past year a directorate of biotechnology and human research was established in the Office of Advanced Research and Technology. Its objectives are complementary to those of bioscience and actual manned flight and can be summarized by the three categories of man, man-machine, and man-system as illustrated schematically (fig. 117). In somewhat more detail, these objectives are:

(1) To obtain a better understanding of man's capabilities and limitations in advanced aerospace systems through research on body systems, psychophysiology, and biological, medical selection factors.

(2) To obtain design requirements for equipment and subsystems which will guarantee an adequate crew environment through development of life-support systems, protective systems and man-machine control systems and displays.

(3) To integrate human requirements into the design of advanced systems by means of systems analysis and human factor research.

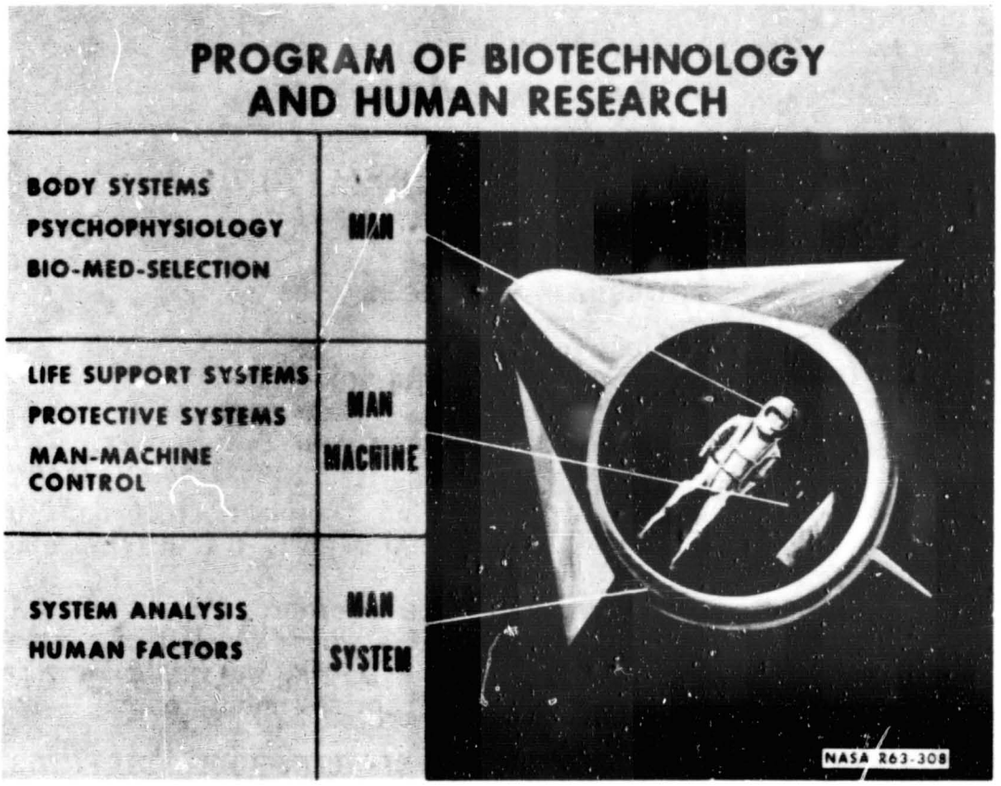

FIGURE 117

The Life Sciences Laboratory Facility proposed for fiscal year 1964 to be constructed at the Ames Research Center will be a primary instrument in carrying out these objectives. The Ames Research Center is presently working on a large part of the biotechnology and human research program and plans call for an increased effort to meet our objectives. This Center has already made significant contributions to the better understanding of man in their psychophysiological, and simulation experiments.

An advanced psychophysiological monitoring system has been studied and will be put on contract shortly under the supervision of the Flight Research Center at Edwards Air Force Base. It will be employed in obtaining dynamic psychophysiologic data on human pilots in chambers and experimental vehicles such as the X–15 aircraft. The successful demonstration of this concept could lead to a store of human dynamic data which would be standardized from one laboratory to another to perform correlation studies.

The Department of Defense capabilities in the life sciences are being utilized in reaching our objectives by the allocation of approximately $1.4 million in fiscal year 1963 for services on specific research projects. In addition, $750,000 has been allocated to the AEC for radiobiological studies.

A human factors study has been initiated on space maintainability with the Marshall Space Flight Center in cooperation with the Armed Services. The Man-Machine Information Center is being supported in its important work along with the Navy, Army, and the Federal Aviation Agency.

The program requirements illustrated schematically by figure 118 must be pursued through advanced research and development prior to the design of any manned system.

Mr. KARTH. How much money are you asking for for fiscal year 1964 and the Life Sciences Laboratory at Ames?

Mr. MYERS. This is $4.88 million, Mr. Chairman.

Mr. MORRIS. Is this a new facility?

Mr. MYERS. Yes.

Mr. MORRIS. Have you explored all existing facilities?

Mr. MYERS. Yes, sir.

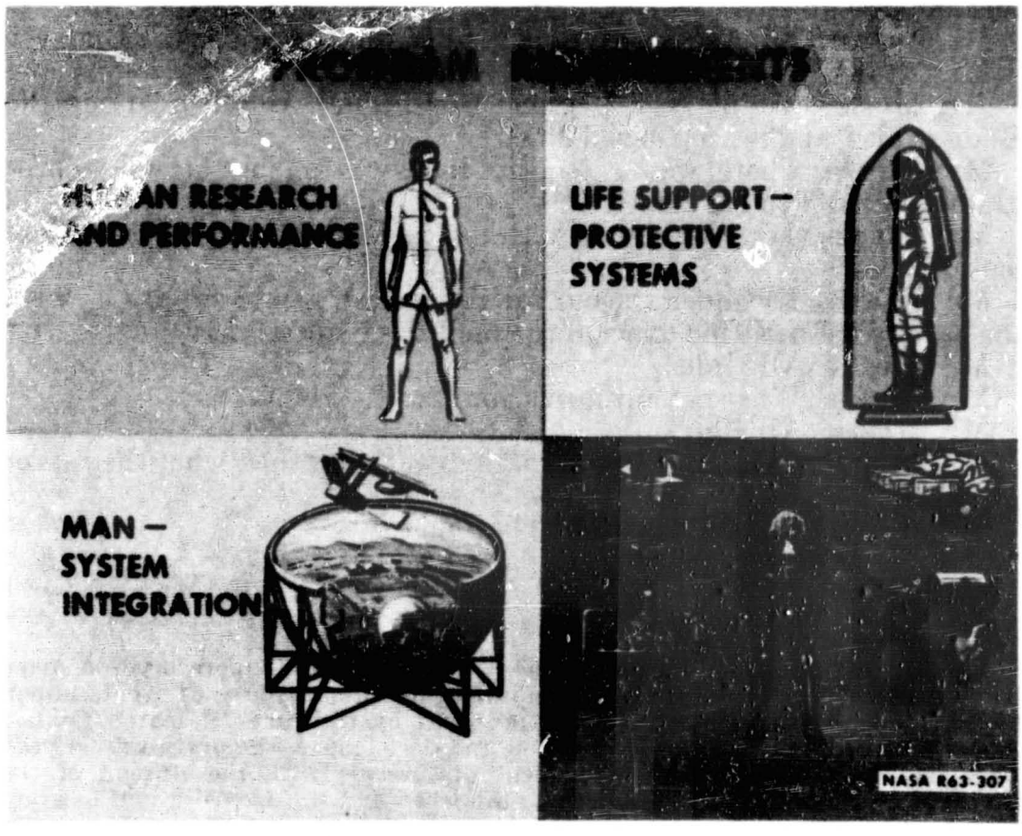

FIGURE 118

Mr. MORRIS. Where? What studies did you make in connection with that?

Mr. MYERS. We have been working closely with the Air Force and Navy and Army, NIH, and have taken advantage of the programs they are able to carry out for us. This facility represents a laboratory that is not in being, and which is needed to carry out the program, which other services cannot handle for us. So we have a very close tie-in with the other services, working in this area.

Mr. KARTH. This is the first appropriation request for this facility, is that right, Doctor?

Dr. BISPLINGHOFF. Yes.

Mr. MORRIS. This is your first request for authorization for that, is that correct?

Dr. BISPLINGHOFF. Yes. There is a program already in existence at Ames, using existing buildings, and so on. There are people at work at Ames. Small equipment has been purchased already. But this is our first request for an actual facility.

Mr. MORRIS. Did this appear in the line items in your last budget?

Dr. BISPLINGHOFF. No, this is new.

Mr. KARTH. Didn't the Office of Space Sciences a year ago make some sort of request?

Mr. MORRIS. Didn't we turn it down?

Dr. BISPLINGHOFF. I am not sure.

Mr. MYERS. There was a facility proposed, but it was taken out of the budget before it reached Congress.

Mr. KARTH. You mean before it went to the Bureau of the Budget?

Mr. MYERS. Yes.

Mr. MORRIS. Didn't you get one up through the Bureau of the Budget, also, and it was turned down?

Mr. MYERS. There was a facility that was in, but it was reprogramed out. You are correct.

Mr. MORRIS. Mr. Chairman, I think we ought to take a real close look at this.

Mr. KARTH. I wonder if you, for the record, would supply us with the backup information on what the facilities request was?

Mr. MYERS. All right.

Mr. KARTH. What the authorization was?

Mr. MYERS. All right.

Mr. KARTH. What the appropriation was, and then what the reprograming of funds was.

Mr. MYERS. All right. We will be glad to.

Dr. BISPLINGHOFF. We will be glad to do that.

Mr. KARTH. Thank you.

(The information referred to is as follows:)

The budgetary history of the proposed Life Sciences Laboratory for Ames Research Center in fiscal year 1963 followed the normal course of events in our budgetary process. The facility was proposed by the Ames Research Center. After NASA headquarters consideration and decisions on the overall fiscal year 1963 facilities program and subsequent discussions with the Bureau of the Budget, the need for the facility was established and its size, cost, and location within the Center were agreed upon. This facility became the Bioscience Laboratory mentioned on page 922.

Dr. BISPLINGHOFF. In the area of human research and performance, a number of research pathways must be followed if we are to understand fully man's true capabilities in the space environment. Fundamental studies of the human heart and circulation are needed in order to develop and use indirect techniques for monitoring man's performance in space. Studies planned for fiscal year 1964 include the evaluation of man's performance under individual and combined environmental factors, such as acceleration, atmosphere, radiation, and magnetic and electrostatic fields.

Pharmaceutics research, relative to therapeutics and prophylaxis, previously limited to radiation protection, will be expanded to include remedies for counteracting motion sickness and other environmental stress factors.

In the field of life support protective systems, feasibility studies on 3- to 6-month physical-chemical systems under the technical super-

vision of the Langley Research Center should be completed early in calendar year 1964. Studies of a 6-month to 1-year systems are expected to be undertaken shortly thereafter. Specific investigations will also be conducted to provide information on the type of life support instrumentation that should be utilized for very long duration flights.

Mr. KARTH. Doctor, if I may interrupt again, apparently a great deal of this is dependent on the Life Sciences Laboratory facility. Could you give the committee an idea of what overall total cost of this facility is going to be, and when you expect to make your last request, what year, that is?

Dr. BISPLINGHOFF. That is the Ames facility you are speaking of?

Mr. KARTH. That is right, the Life Sciences Laboratory facility at Ames, what you expect the overall cost of that facility to be, and when you expect the total program to have been completed.

Dr. BISPLINGHOFF. I will ask Dr. Konecci, who is in charge of this work, to answer the question.

Dr. KONECCI. The $4.88 million is actually a combination of four individual laboratories comprising the life sciences facility. This is really the last appropriation. It is to get the physical building. The people are presently doing work with equipment scattered through the wind tunnels and various other places all over Ames Research Center. We are trying to bring them together in one facility. This is, in fact, the one, the only, appropriation for that facility. Of course, they will be using other facilities that already exist.

Mr. KARTH. But this $5 million request includes construction of facilities?

Dr. KONECCI. Yes, sir.

Mr. KARTH. And is a total cost for the program?

Dr. KONECCI. Yes. Of course, there may be individual things that an individual might need as part of a specialized research problem but that is not part of this. Basically, the building, and all that is required to operate that building, are included in this request.

I know the appropriation you are discussing for last year was for $900,000, and that was put through, and it is now a biosciences building that is now being constructed. But that is a small building, to house just one part of a laboratory.

Mr. KARTH. Where is the building located?

Dr. KONECCI. At Ames, sir.

Mr. KARTH. Is it contemplated you will add to that building, or build a new building?

Dr. KONECCI. In the Ames plan, they have located a site within the center of the other facilities, so the life sciences people are located in the center around the hangars, and so on.

Mr. KARTH. What does the $900,000 building do?

Dr. KONECCI. That is part of the biosciences effort in basic biology.

Mr. KARTH. It is all part of this problem, is it not?

Dr. KONECCI. Yes, sir, in a way. Actually, this involves exo-biology, the biotechnology laboratory and the biomedical research facility. So these are all three together.

The housing requirements for the presently established personnel and research programs that are there, in fact, require this kind of a building to bring these people together, since they are physically at

Ames. The equipment they are working on in their research program is there.

I believe we could make available for the record a drawing (fig. 119) of where they are placed, all over the Ames facility.

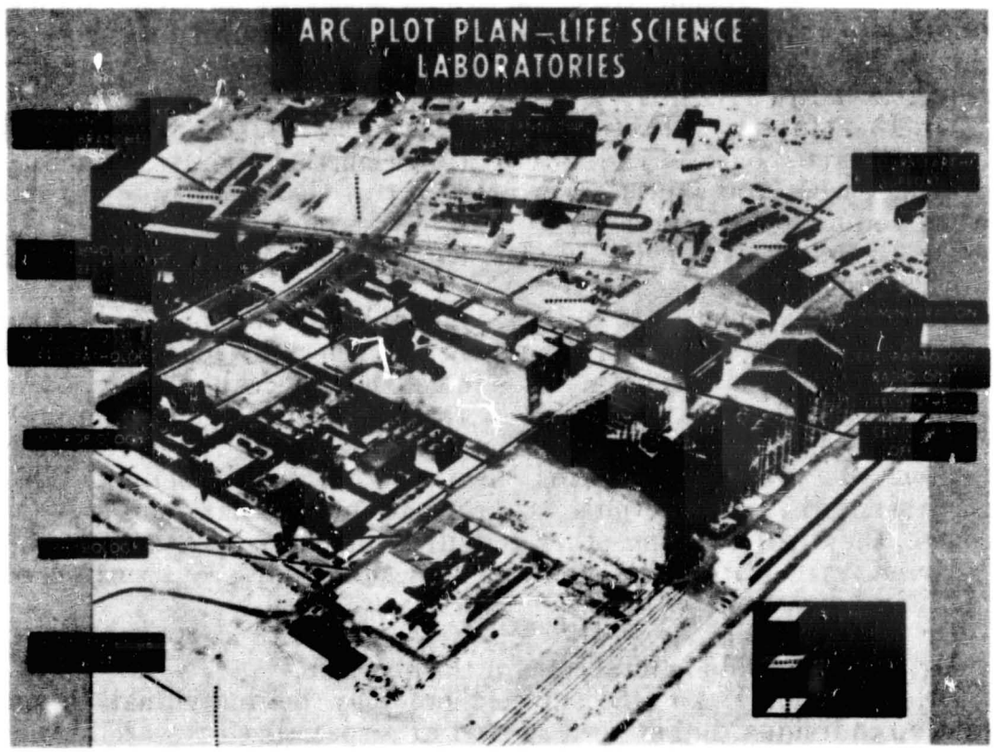

FIGURE 119

(The information referred to is as follows:)

The fiscal year 1963 budget submission contained a Bioscience Laboratory, cost $924,000, under the Office of Space Sciences. Funds were appropriated by Congress; $54,000 was allocated for engineering studies and $870,000 for construction.

The fiscal year 1964 budget submission contains a Life Sciences Laboratory, cost $4,880,000. The timing of this request is in consonance with the buildup of the life sciences program. A nucleus of qualified personnel are now on board to pursue life science programs authorized within the NASA mission. Pending construction of this facility, the life sciences staff is being housed in temporary laboratories equipped as necessary to conduct approved programs. This equipment will be moved from these temporary locations to the proposed facility. Accordingly, the cost estimate does not request funding for portable equipment.

Attached is an aerial view of Ames Research Center annotated to show location of life science activities and the location of the proposed Life Sciences Laboratory.

Mr. KARTH. Any information you could offer would be of benefit to the committee. Because, frankly, we are going to take a very close look at this request for added facilities.

Dr. KONECCI. Yes, sir. I think I can give you an example of their present problem. There is one individual trying to do cellular work, working in a room they made for him in a wind tunnel building, and

when they run up the wind tunnel, it practically destroys the experiment, because of the vibration. They have requested outside rental to house some of the laboratory equipment, with people. That has been refused, pending this facility request.

Mr. KARTH. What was that last statement?

Dr. KONECCI. They have requested from GSA to get additional laboratory space, at least to house the people they have, with their equipment, and let them do their research off the Ames base, in order to have adequate space.

Mr. KARTH. On a rental basis?

Dr. KONECCI. Yes. That was turned down pending this——

Mr. KARTH. When would you expect this to be completed, if Congress granted your request?

Mr. MYERS. I think it was an 18-month construction time. I would have to check that.

Mr. KARTH. So you are in the middle of 1965, then?

Dr. KONECCI. Yes, sir.

Mr. KARTH. I assume this is to give life sciences support to the manned lunar landing program.

Dr. KONECCI. The Ames people are working, in fact, on the projects associated with manned space flight; they work not only for OSS and OART, but also supporting the project of the manned space flight; yes, sir.

Mr. KARTH. It would be a little late for the lunar landing, wouldn't it?

Dr. KONECCI. But not for the manned laboratory in space, manned orbital laboratory, or the lunar base and other programs that follow.

Mr. KARTH. I am not familiar with any of these programs.

Dr. KONECCI. They are not programs, sir. These are present concepts of work.

Mr. MORRIS. What do you mean? Are these approved programs that you are talking about?

Dr. KONECCI. No, sir. No, sir.

Mr. MORRIS. Why are you wanting to spend money on somebody's dream? Before you build facilities, isn't it customary to get a project?

Dr. KONECCI. No, sir. The facility is for the present research that is being committed to the laboratory, sir.

Mr. MORRIS. Then, when you go into these other programs you will need a new facility?

Dr. KONECCI. No, sir. This can also answer the questions of those——

Mr. MORRIS. Then is it a combination facility?

Dr. KONECCI. Yes, sir.

Dr. BISPLINGHOFF. I think in this facility, fundamental research will be done having as its ultimate objective the kind of programs Dr. Konecci mentioned; there is no intention that such programs will be worked on in an active way in these facilities. I think that is what Dr. Konecci is saying.

Mr. KARTH. The supposition is if we have a follow-on manned program this facility would then be utilized for whatever need would be required of it in further manned space programs. Is that it?

Dr. BISPLINGHOFF. It would be partially used for that. But I would think it would also continue to be utilized for research, which is really a large part of its function.

Mr. KARTH. Research for manned space programs, now, or just plain raw medical research? What are we talking about?

Dr. BISPLINGHOFF. The ultimate objective would be manned space flight programs; yes.

Mr. KARTH. Manned space flight programs?

Dr. BISPLINGHOFF. Yes.

Mr. KARTH. So today it would be in support of the manned lunar landing program, and if there be any follow-on manned space programs then, of course, the facilities would be utilized to do whatever work was necessary to support those programs; is this correct?

Dr. BISPLINGHOFF. Yes, sir.

Mr. MOSHER. Mr. Chairman.

Mr. KARTH. Mr. Mosher.

Mr. MOSHER. Would it be fair to say if the Apollo program makes any sense at all, and assuming it is successful, then there certainly will be follow-on programs? Couldn't we all assume that?

Mr. KARTH. I think that is a very reasonable assumption. I was not quite clear as to the purpose of its facility. I think the purpose has been pretty well established now.

Thank you, Doctor.

Dr. BISPLINGHOFF. We were at the bottom of page 57, next to the last paragraph.

Under man-system integration, the program will encompass systems studies of the total man-machine complex. These studies will be aimed at a number of objectives ranging from improved safety in aircraft to the evaluation by means of simulators of man's capabilities to perform tasks in space.

Advanced concepts include the various areas of biotechnology and human research which could lead to improvement of existing techniques or reveal new approaches. For example, in fiscal year 1964, preliminary studies on small extravehicular systems will provide some of the human factors related to the transportation of man on the lunar or planetary surfaces.

A broad flight program has been laid out to commence in fiscal year 1964, so oriented as to attack the major biotechnology problem areas in both aeronautical and space application. This program will eventually encompass balloon flights, ballistic rocket flights, experimental aircraft flights, and orbital flights based on maximum use of existing hardware.

ADVANCED RESEARCH AND TECHNOLOGY RELATED TO AERONAUTICS

I have mentioned previously the matter of mutual benefits between the aeronautics and space sides of our program.

Mr. KARTH. What kind of duplication with military services does that reference in the previous paragraph involve us in? Haven't the services been doing a great deal of this for a considerable period of time, these ballistic rocket flights, and so forth? And don't their programs call for a substantial amount of that to continue?

Dr. BISPLINGHOFF. Yes. On the balloon flights, for example: The participation we will have in moon flights will be in conjunction with

the Navy, a joint Navy-NASA effort, making use of Navy balloons, Naval retrieval systems, and would involve mainly putting our experiments into their systems.

Mr. KARTH. What we might term a "jointly funded venture?"

Dr. BISPLINGHOFF. Yes, sir.

Mr. KARTH. Experimental aircraft flights, how about them?

Dr. BISPLINGHOFF. Here they are largely connected with the X–15 program, a joint NASA-Air Force venture, of course, and certain work we plan to do on vertical or very short takeoff and landing aircraft, which are supplied to us by the military services.

So I believe in all cases here you would find a very close relationship between us and the military services.

Mr. MORRIS. Mr. Chairman.

What about ballistic rocket flights? Is this going to be involved on guidance and reentry of vehicles?

Dr. BISPLINGHOFF. Yes. This is an area we have not formulated in detail yet. But I can say anything we would do here would be as indicated on the last—in the last phrase, "maximum use of existing hardware." We have no intention of cranking up any special program of our own in this connection.

Dr. Konecci, maybe you can give an example of this.

Dr. KONECCI. Yes, sir. We were told there are possibilities of putting on piggyback experiments, for instance, on Gemini and Apollo, where we might want to perform a very simple experiment on the human.

On the ballistic flights presumably there are available a few pounds of payload on military vehicles. We would try to put one on and not pay for the vehicle.

Mr. MORRIS. Unless they are misinforming me, there is certainly not going to be a pound on Gemini for any hitchhikers.

Dr. KONECCI. They are establishing a committee for review, and if the experiments are pertinent to the Gemini program, so that that is the prime objective, or to Apollo—and this is one of the reasons we are trying to back them up with advanced equipments or experiments—they will try to put them on. Sometimes these things only weigh a few ounces.

Dr. BISPLINGHOFF. A pound might do it for us.

Mr. MORRIS. And a pound might break Gemini's back, unless they get the extension they are in process of studying.

Mr. KARTH. I understand some of these experiments would be life support type of experiments, what must we do to keep a man alive, for example?

Dr. KONECCI. That is very true.

Mr. KARTH. And I suppose that is important essentially for Apollo.

Dr. KONECCI. Yes. We have a contract proposal out for a 6 months life support system. Unless you want a closed session, I couldn't give the details of who is being considered. Boeing has a contract with our organization for a 30- to 60-day five-man life support system on the ground, but it is an advanced sodium superoxide system that will be demonstrated in June of this year.

There are principles of it, for example, gas phases, whether oxygen will evolve during weightlessness, that would involve very small light experiments.

Mr. KARTH. What do you anticipate the cost of this broad flight program to be?

Dr. KONECCI. We are talking about—oh, probably around $5 million to start with, sir. Some of these will continue for a few years. We are part of the OSS request for the biosatellite program, if this comes about. In other words, it is a joint effort to try to utilize, again, one vehicle for experimentation. We will provide them with the life support system.

Mr. KARTH. You anticipate this program to cost approximately $5 million a year for the next few years, is that what you are saying?

Dr. KONECCI. I would think so, sir, yes; again, unless added requirements are set down.

Mr. MORRIS. Have you considered using any of these Jupiter or Thor missiles that they are dismantling, or intend to dismantle if they have not started already?

Dr. KONECCI. Yes, sir.

Mr. MORRIS. Which might be a saving in connection with some of these programs?

Dr. KONECCI. Yes, sir. The Ames Research Center has done a complete series of studies and recommendations were made to Dr. Seamans from the Scout vehicle, through the Thor, Thor-Deltas, Agenas, and the various ones. That is why they have the present study out on contract to determine what would be the best all-around vehicle.

They have studied utilization of Mercury capsules, how could you modify them and save all the technology as well as the capsule. I am not prepared at the moment to give all of the details. That could be made available to you.

Mr. MORRIS. What did they say? Did they think it might be feasible?

Dr. KONECCI. The problem comes down to, you could use them now, but we would have the same problem we have had in other programs, of not enough growth factor to take care of future requirements; and Dr. Seamans wanted to have it studied, so if you do perform a program for several years, you are not limited by just present technology.

Mr. MORRIS. Thank you.

Mr. KARTH. Doctor, you may proceed.

Dr. BISPLINGHOFF. Thank you.

The early foundation laid by aeronautics for space technology can be easily identified. In fact, the impact of aeronautics on other areas of transportation such as rail, automotive, and marine can also be shown. It is not nearly so easly to demonstrate the fallout from the rapidly developing space technology, and the truly significant influences can probably only be identified in retrospect. However, guidance and control, materials, structures, fuels, and biotechnology will unquestionably influence the efficiency and safety of aeronautical vehicles of the future.

The NASA aeronautical programs are being continued in the established framework of theoretical and experimental research activity of the NASA Research Centers and are primarily in-house effort. The detailed objectives of the program change to suit national needs as far as such needs are apparent or can be envisioned.

On figure 120 I have attempted to illustrate the scope of the current NASA aeronautical research program. At the top left of the chart an artist's conception of a hypersonic airbreathing vehicle is shown

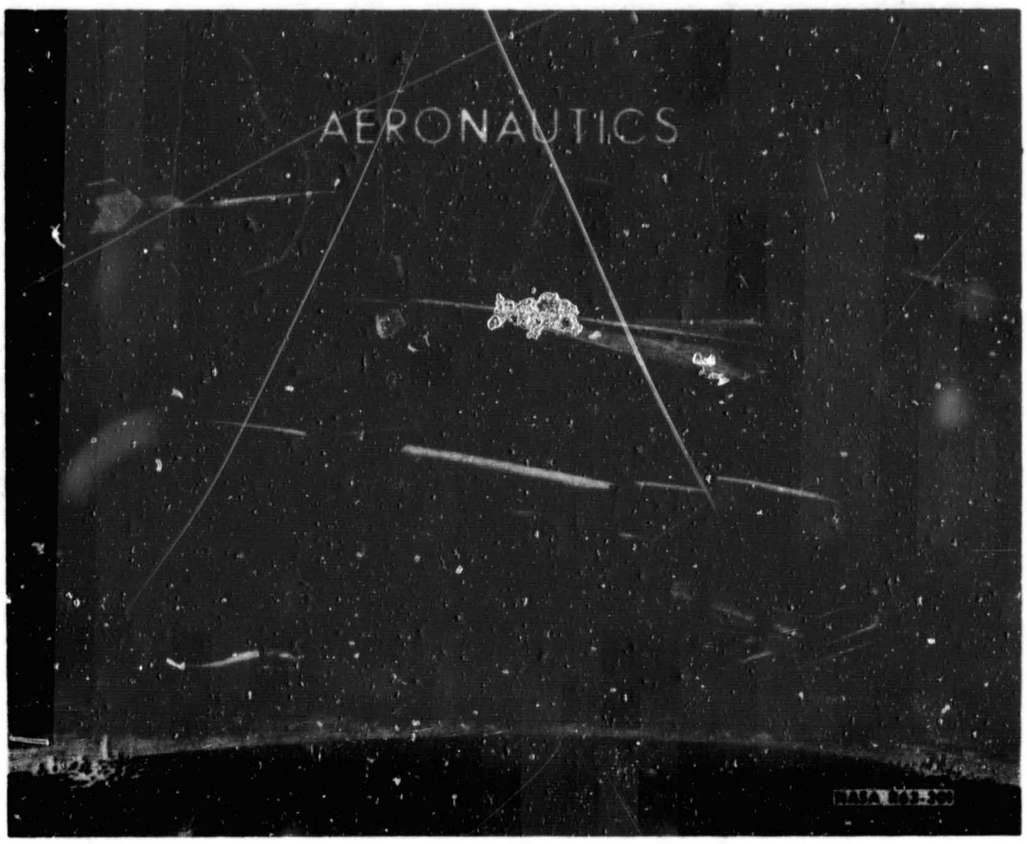

FIGURE 120

to symbolize the comprehensive program of hypersonic research that is just getting underway in cooperation with the Air Force.

At the top right of the chart is illustrated the X–15 which is well known to you and which will continue as an active program in fiscal year 1964. In the center of the chart two concepts of the supersonic transport are shown. The supersonic transport program as you know is a joint FAA/NASA/DOD effort. NASA research support of this program will be expanded in fiscal year 1964.

Mr. KARTH. By how much, Doctor?

Mr. MYERS. We will have to explain this a little, Mr. Chairman, because there is an overall expansion in the program. We break out our program in general research, which applies to the supersonic transport, and then we have certain items definitely done just for the supersonic transport, that we identify as such, and the R. & D. funds in that actually decrease, but the overall increases for the year, I will have to work the figure out and get it in terms of supersonic transport for you, because the in-house program is actually increasing, and part of the contract program is actually decreasing.

Mr. KARTH. What area of research on the supersonic aircraft are you intending to expand? I suppose there are several areas, but what areas do you expect to increase or decrease?

Dr. BISPLINGHOFF. The one area that we are very active in now is a contract which we have just let with the Boeing and Lockheed companies to make feasibility studies of four types of supersonic transportation configurations that have been developed by the Langley

and Ames Research Centers. By "feasibility studies," we mean studies to evaluate these designs and see what their structural weights might be, what kind of performances they might have if they have certain structural weights, and in general, whether these designs would be feasible for construction.

Mr. KARTH. Yes; but your request for loads and structures has decreased 33 percent from last year.

Dr. BISPLINGHOFF. This is funded in this year and will be a one-shot proposition, and that will be the end of that, so there is a decrease in effort in this particular area.

Mr. KARTH. Right. Where do you expect to have the increases?

Dr. BISPLINGHOFF. There will be an increase in effort in aerodynamics between 1963 and 1964. Here we are concerned with pursuing further our work on the effects of variable sweep, for example. One of the biggest concerns we have in the supersonic transport is the sonic boom, this is another area where we want to increase our effort.

Mr. KARTH. Has the DOD effort also increased in that particular area this year? I am trying to ascertain whether or not we are just taking turns in increasing certain areas of support. What is DOD doing in this area in fiscal 1964? Are they also increasing their request?

Dr. BISPLINGHOFF. To the best of my knowledge, they are not.

Mr. KARTH. Are they decreasing it; do you know, Doctor?

Dr. BISPLINGHOFF. The FAA, NASA, and DOD, have a joint group which sits together to determine the total research program for the supersonic transport.

Mr. KARTH. But the FAA, having most of the responsibility in this area, if not all of it, just a few years ago, is not even asking for funds for fiscal year 1964 in this program?

Dr. BISPLINGHOFF. Yes, sir. I am aware of that.

Mr. KARTH. But NASA is?

Dr. BISPLINGHOFF. Yes, sir; NASA is. This joint group has together determined what the total research program should be on the supersonic transport in the past couple of years.

Mr. KARTH. Why do we feel it is easier for NASA to get the money than it is for FAA to get the money? Is there some kind of theory that is adopted here by the joint FAA–DOD–NASA group?

Dr. BISPLINGHOFF. NASA has always carried on a modest program in this area.

Mr. KARTH. But it has been kind of a supporting program to the FAA.

Dr. BISPLINGHOFF. Yes.

Mr. KARTH. This year you are proposing we carry the program. And FAA, I don't know what they might provide, maybe a little technical assistance, but they are not even asking for funds.

Dr. BISPLINGHOFF. It is my feeling the reason they have not asked for funds is that when the decision is made by Mr. Halaby as to whether he wishes to ask the President for money to develop an actual supersonic transport, then the request will be made at that time.

Mr. KARTH. But this is not a new program. You mean Mr. Halaby is just thinking about whether or not it is important enough to ask for funds?

Dr. BISPLINGHOFF. This is going from a research stage, which we have been in, to an actual request for money to develop the actual flight article.

Mr. KARTH. So FAA is not really sure yet as to whether or not they should request funds for this program?

Dr. BISPLINGHOFF. Yes, sir.

Mr. KARTH. But NASA is sure they should.

Dr. BISPLINGHOFF. Yes, sir. We feel we should continue our much more modest program of research on the supersonic transport.

Mr. KARTH. What did FAA ask for fiscal year 1963 in this program, do you know?

Mr. MYERS. I think around $20 million.

Mr. KARTH. What is our request?

Mr. MYERS. Our request for research on the supersonic transport specifically is $3.79 million.

Mr. MORRIS. Mr. Chairman.

Mr. KARTH. Mr. Morris.

Mr. MORRIS. Do you have any idea about what percentage of the budget of your office is budgeted for areonautical research?

Mr. MYERS. Yes, sir; we can give you that figure. It is slightly less than 10 percent.

Mr. MORRIS. Slightly less than 10 percent.

Mr. MYERS. Out of $508 million, we are talking of $45 million for aeronautics.

Mr. KARTH. How much money is DOD requesting in their fiscal year 1964 budget for supersonic transport research?

Dr. BISPLINGHOFF. To the best of my knowledge, there is no specific request anywhere in the DOD budget for supersonic transport.

Mr. KARTH. What are they going to supply? You said this is a joint effort. What will DOD supply?

Dr. BISPLINGHOFF. DOD has supplied the contractual mechanism for letting out the contracts on these research programs, and also their technical staff has been involved.

Mr. KARTH. Let me see if I understand you properly. NASA is requesting the funds and DOD is proposing to tell them how to spend it. Is that what you are saying?

Dr. BISPLINGHOFF. No, sir. Let me go back a minute and let me explain: In the spending of the FAA funds, in 1963, which amounted to some $20 million, a joint NASA–DOD–FAA committee determined how the funds should be spent, and the funds were funneled out through the DOD contracting organization at Wright Field.

In addition to this $20 million, there was some $4.287 million spent independently by NASA last year, which was coordinated with what was done by this other group, but funneled through the NASA's contracting agency, and technically monitored entirely by NASA people.

Now, if the DOD—or, if the FAA drops this money out of its budget, the only money for research will be what we are doing ourselves in 1964.

Mr. KARTH. This is the interesting question that keeps cropping up in my mind, Doctor: Why does the FAA, which is really administratively responsible for this area of research and technological advancement, why do they feel apparently that this is unimportant

enough not to request funds for the purpose, and NASA, on the other hand, that I guess is really administratively responsible for more things other than that, feel it is important enough to request funds.

Dr. BISPLINGHOFF. We feel we are responsible for research in this area.

Mr. KARTH. You are saying NASA, in line with the true intent of the Organic Act of 1958, is assuming research responsibility in this area?

Dr. BISPLINGHOFF. Yes, sir. We intend to continue the level of research we think is appropriate to this area.

Mr. KARTH. Thank you, Doctor. I guess it was the question we were on, I couldn't understand it.

Dr. BISPLINGHOFF. It is a complicated business.

Mr. MOSHER. To what extent does FAA have research facilities in this area?

Dr. BISPLINGHOFF. They have no research facilities in this area.

Mr. MORRIS. So any research they want done they refer to you?

Dr. BISPLINGHOFF. Much of the research that was done with the $20 million budgeted through FAA was done by outsiders, universities, and so on.

Mr. MOSHER. When FAA is contemplating such research contracts with outsiders, do they first consult with you folks?

Dr. BISPLINGHOFF. Yes. As I said, the decision was made by a joint FAA–NASA–DOD steering committee.

Mr. CHENOWETH. Would the gentleman yield?

Mr. MOSHER. Yes.

Mr. CHENOWETH. Has the Joint Committee decided now to do nothing further?

Dr. BISPLINGHOFF. The Joint Committee is still in existence and as far as I know, continues to meet.

Mr. CHENOWETH. What is the function of the Joint Committee?

Dr. BISPLINGHOFF. It was formed to advice Mr. Halaby on all aspects of the supersonic transport, including the distribution of these research funds. It will continue to advise Mr. Halaby on these matters.

Mr. CHENOWETH. But I don't understand why there is this lack of interest on the part of FAA and DOD, yet you insist on going ahead. This would be developed for other uses, certainly; it wouldn't be primarily and essentially a NASA function, as I see it.

Dr. BISPLINGHOFF. I don't think the lack of request in the budget by FAA reflects lack of interest on their part. I think there is a delay on Mr. Halaby's part until he gets results of studies being made by the Stanford Research Institute and Rand, indicating to him the economic feasibility of such advice.

If in his opinion, these studies show favorable results, it is my feeling he will ask the President or Congress for a sum of money to start developing this airplane.

Mr. CHENOWETH. Should we postpone further work until he reaches a conclusion?

Dr. BISPLINGHOFF. No, sir. I think the NASA research should be continued. We believe the supersonic transport will eventually come into being.

Mr. CHENOWETH. It is something FAA and DOD would have more interest in, as I see it.

Dr. BISPLINGHOFF. We feel we are responsible for the basic research in this area. DOD has little interest in that.

Mr. MOSHER. The ultimate recommendation to Congress will be really from the White House?

Dr. BISPLINGHOFF. Yes, sir. Yes, sir.

The lower portion of the chart illustrates VTOL or STOL aircraft as they could be used for intercity transports to augment longer range aircraft as part of an integral transportation system. There is, of course, great military interest in such aircraft for logistics support.

Mr. MORRIS. Doctor, I saw a television program the other day, demonstrating a British aircraft that apparently they have already developed this technique of takeoff and landing on very short runways, and hover techniques.

Dr. BISPLINGHOFF. Yes, the British have been very active in this field. The technique has been developed by a number of people and a number of machines exist that allow us to take off vertically or take off and land in short distances, both by means of jets and by means of rotors.

The big question is, though: Can you do it economically in a transportation system? Much of our effort lately has been directed to narrowing down the many ideas that have been proposed for this technique into just a few ideas which have some economic future, that may be used for this short haul, intercity transportation.

The military, of course, are not so much interested in economics as the airlines. But we have given a lot of thought lately toward trying to get this thing to the place where it can be used in our transportation systems.

Mr. MORRIS. Thank you, Doctor.

Dr. BISPLINGHOFF. The point this chart illustrates is that our aeronautical research program encompasses the speed range from hovering to hypersonic speeds and the altitude range from the surface of the earth to the fringes of the atomsphere.

I have illustrated the scope of our aeronautics program by sketches of vehicles and I will talk more of these later but I would like first to turn to the aeronautics building blocks. As indicated on figure 121, these are aerodynamics, loads and structures, propulsion, and operating problems. It is these building blocks that provide a foundation of technology which permits the development of new vehicles or the improvement of existing vehicles.

Aerodynamics: Aerodynamics research in fiscal year 1964 will continue to provide a basis for the Nation's competitive progress in aeronautical vehicle systems. The studies in aerodynamics are directed at an understanding of the problems associated with both military and civil aircraft for flight at subsonic, supersonic, and hypersonic speeds. Particular emphasis is now being placed in the latter area. The objective is to provide the technology necessary for the development of vehicles for sustained hypersonic flight. This is considered to be the next frontier in aeronautics. The potential of such a vhicle lies in hypersonic reconnaissance or bombing capabilities from the outer fringe of the atmosphere and in hypersonic transports. There is also a great economic incentive to develop recoverable hypersonic air-breathing boosters.

Mr. KARTH. May I interrupt, to better understand what you are doing?

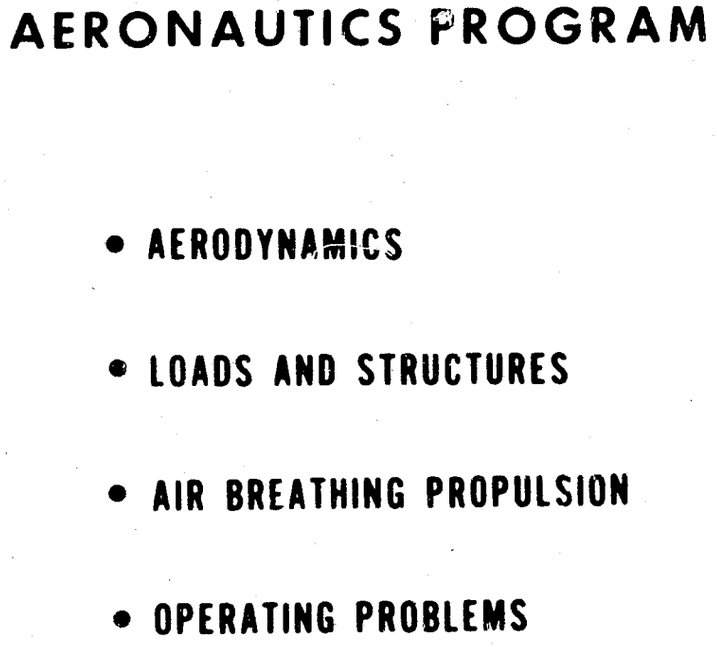

FIGURE 121

Dr. BISPLINGHOFF. Certainly.

Mr. KARTH. I notice in the distribution of R.D. & O. funds, by major project and location on these very questions, we are talking about, that is the V/STOL aircraft, supersonic transport, and the X–15 research aircraft, we have so many dollars requested for headquarters. Let's talk about the supersonic transports as a specific item. Headquarters, $1,148,000. Langley Research, roughly $2½ million. Ames Research, roughly $3¼ million. And Lewis Research Center, roughly $1 million.

Mr. KARTH. Why are we spending money on this specific item in all of these different areas? I mean, should we not concentrate our effort in one research center so that the whole technical team can be working together and toward a common objective? That way we are positive, No. 1, that there is no duplication, but, No. 2—probably even more important—so that everyone is in constant, daily, hourly communication with each other and assured of the fact they are all going down the same road?

Why aren't we doing that? There is some request in this budget to do that, because they say it is impractical to do it here, there, and all over.

Yet, here you say we are doing it that way. Could you explain the reason for that?

Dr. BISPLINGHOFF. In the various disciplines that underlie the supersonic transport these various disciplines just don't have the overall

strength in only one of our Centers. For example, in the propulsion and materials areas, our strongest laboratory is Lewis. The materials part of the supersonic transport is a very critical part of the thing. If it is to be economically feasible, it must have about a 30,000-hour life, and we simply do not have knowledge of how materials behave over these long periods of time under cyclic temperature variations, so the Lewis Laboratory has been using the materials group to evaluate various candidates for the materials of supersonic transport airplanes.

We have no other capability within the NASA to do that, and we must give it to the Lewis Lab.

On the business of airbreathing propulsion, some fairly significant advances must be made beyond the subsonic jets and the supersonic jets that the military use, in order to get a jet engine for supersonic flight. The Lewis Laboratory has taken part in this.

At the Flight Research Center we have assigned them work because any flight simulation work we can do is best done from the Flight Research Center where the capabilities for flying high-performance aircraft exist.

Mr. MORRIS. Doctor.

Dr. BISPLINGHOFF. Yes, sir.

Mr. MORRIS. What do you mean by the "capabilities for flying?"

Dr. BISPLINGHOFF. We have our pilots, who are experienced in flying high-performance airplanes. We have a center which is oriented toward the getting of flight test data, and specificially what we are going to do here is take an existing jet airplane, Jet Star, and build into it the computers that will give this Jet Star the kind of capability and control characteristics that a supersonic transport would actually have. Our pilots will fly this and get experience in the handling properties of such an airplane.

We feel that the best possible place to do this is at the Flight Research Center.

Mr. MORRIS. Where is that?

Dr. BISPLINGHOFF. Edward Air Force Base. The Langley and Ames Laboratories have in a sense, some overlapping capabilities, especially in the field of aerodynamics, due to the fact they both grew up as part of the NACA laboratory arrangement.

In the field of aerodynamics, we asked the Langley Laboratory to work on the concepts of variable sweep in this supersonic transport development, and we asked the Ames Laboratory to work on the aerodynamic concepts of nonvariable sweep, and so we came up with four aerodynamic designs, two of which originated from Ames, two of which originated from Langley, and these were the aerodynamic designs that were made a part of our feasibility studies that are being carried out by the industry.

Mr. KARTH. You are not doing everything then within the framework of one discipline and one research center?

Dr. BISPLINGHOFF. No, they are all complementary.

Mr. KARTH. Are any of of them duplicative?

Dr. BISPLINGHOFF. No, sir; there is no duplication within these.

Mr. KARTH. Just complementary?

Dr. BISPLINGHOFF. Yes. I would like to add the structures part of the work is done at Langley, where unique capability exists.

Mr. KARTH. How about propulsion, where is that done?

Dr. BISPLINGHOFF. At the Lewis Laboratory.

Mr. MOSHER. Do I judge these are historical developments, that these capabilities developed in different spots because of other and older projects, and therefore their geographic location is determined by the history of NASA's development and its predecessor development?

Dr. BISPLINGHOFF. Yes.

Mr. MOSHER. Ideally, if you were just now establishing these facilities, you might well concentrate them in one spot and cut down the cost of organizational buildings, that sort of thing; but given the present situation the practicalities forbid that, is that it?

Dr. BISPLINGHOFF. That is right. These laboratories developed with the kinds of strengths I have outlined, throughout the history of the NACA, and four laboratories that were mentioned were, of course, the four NACA laboratories inherited by the NASA.

Mr. KARTH. I am not sure what you have said makes sense to me, as far as the figures are concerned. It appears to me your request for propulsion in this area has gone up quite considerably, about 200-percent increase, I guess, and if Lewis does this I am a little surprised not to see the funds there. Where is the money going?

Dr. BISPLINGHOFF. At the present time the Lewis Laboratory air-breathing propulsion work has gone way down because of its efforts in other directions.

Mr. KARTH. But they are experts.

Dr. BISPLINGHOFF. Yes, they are the experts.

Mr. KARTH. If they are the experts, and this is one of the reasons we are spreading this supersonic transport money around the whole complex of research laboratories of NASA, why don't I find it at Lewis Research Center, in your proposal?

Dr. BISPLINGHOFF. We are attempting to get the Lewis Laboratory back into the air-breathing propulsion area more than it is.

Mr. KARTH. Where are you going to spend the funds for 1964 that you are requesting?

Dr. BISPLINGHOFF. I believe a fair amount of that will go out on contract.

Could you tell us about that?

Mr. MYERS. I think what you are getting at is what are we doing under the classification of air-breathing, propulsion work. You will see funds at Ames and Langley, and that is for inlet and exit work, related to propulsion, to get the efficient inlets and exits that you must have, which are geared into the aerodynamics program, but specifically related to the air-breathing propulsion.

Mr. KARTH. Oh, I have no quarrel with it. I thought it was being done at one center or another because the center had the capability. My question is: Why do we spread this money around? And the doctor gave me an answer, but the figures do not bear out the answer the doctor gave me.

Mr. MYERS. Mr. Karth, which figure were you questioning?

Mr. KARTH. I understood the doctor to say Lewis Research Center was doing research on propulsion. The reason they were doing the propulsion work is because they had the capability. I don't argue that point. But then my question is: Why aren't they getting the money?

For Lewis Research I see a request here only for disposition of funds, $998,000.

Mr. MYERS. For Lewis.

Mr. KARTH. That is right. That certainly doesn't include all the money you are asking for in the field of propulsion for the supersonic transport; not by a long shot.

Mr. MYERS. Well, Lewis is doing the studies on the supersonic propulsion engines, that is their effort.

Mr. KARTH. Where is the rest of the money going for propulsion in the supersonic transport field?

Mr. MYERS. I can run down this for you, if you would like. In the subsonic and transonic propulsion systems, which are part of this, the work is going to Langley and Ames for inlet and exit studies. This includes also some contract for low pressure and low temperature combustion studies.

Mr. KARTH. Mr. Mosher?

Mr. MOSHER. The answer is that the capability exists there, not at Lewis; is that the point?

Mr. KARTH. No, the answer was previously given that Lewis had the capability for doing propulsion research. That is fine. But my question is: Why aren't they getting the funds for it? All of a sudden now we have a capability somewhere else, too.

Dr. BISPLINGHOFF. Mr. Myers pointed out that we have included under "Propulsion" inlet and exit studies of the engine. This is primarily an aerodynamics problem.

Mr. KARTH. I am confused enough. All I want to know is why, as long as Lewis is the center that has the expertise in propulsion, why aren't they getting the money you are asking for that in the fiscal year 1964 budget.

Mr. MYERS. They are getting the money, and they are going to use it for the cycling studies in conjunction with the air-breathing propulsion systems plus lubricants and bearings associated with the supersonic transport at high temperatures, and that is another capability they have, to work on these problems; it is all part of the air-breathing engine research program.

Mr. KARTH. You are asking for air-breathing propulsion for fiscal year 1964, $5,550,000. Lewis Research Center, for the supersonic transport—and the figures I have talked to you about are supersonic transport—$998,000 plus $1.7 million for supporting research and technology, substantially less than you are requesting. Then on "Propulsion" for the X–15 you are asking for $140,000; propulsion for the V/STOL, you are asking for $175,000. This gives a grand total of over $3 million, but Lewis is only getting $2¾ million.

The rest of this money is being budgeted for private-industry contract purposes; is that what the answer is?

Dr. BISPLINGHOFF. No. As we mentioned, these inlet and exit studies have been included under "Propulsion," and we feel they are better done at Langley and Ames.

Mr. KARTH. But we have also an aerodynamics breakdown. Shouldn't they have been more properly in there?

Dr. BISPLINGHOFF. That is a good point. Perhaps they should have gone into aerodynamics.

Mr. MORRIS. Is it possible they are in both of them?

Dr. BISPLINGHOFF. I hope not.

Mr. MYERS. Whenever we do an inlet-and-exit study specifically related to one of the four feasible configurations Dr. Bisplinghoff referred to, when it gets that specific, that it would be applicable directly to the supersonic transport, we label it as such.

If it is a general inlet-and-exit study then it will come under aerodynamics.

Mr. KARTH. For the benefit of a bunch of poor Congressmen who have an opportunity to look at these figures once a year, and then only on a very limited basis, I wonder if he couldn't put most of everything under the same heading, instead of scattering it around. This is very confusing, indeed. I know I am pretty much lost with the figures you have presented.

I am not sure I can follow this thing through. If there are any doubts as to what you are doing, or where the moneys are, or whether you are spending them where they should be spent, I think maybe you are going to lose some. I am not saying to you these funds are being scattered around for the purpose of confusing us. I am sure you have a very good reason, but we are not the bookkeepers as are the professional bookkeepers that you have employed.

Captain Ditch?

Captain DITCH. If I understand, it was three models from Langley and one for Ames, for your studies?

Dr. BISPLINGHOFF. Yes; three from Langley, one from Ames.

Captain DITCH. Weren't two from Langley variable sweep?

Dr. BISPLINGHOFF. Yes; two variable sweep, one fixed configuration.

Mr. MORRIS. What is the one from Ames?

Dr. BISPLINGHOFF. It is not a variable-sweep configuration, it is fixed wing.

Mr. MORRIS. Two variable sweeps?

Dr. BISPLINGHOFF. Yes. One of the fixed came from Ames, and the other from Langley. So there were three from Langley and one from Ames.

Mr. KARTH. So you have a little bit in each one of these two Centers?

Dr. BISPLINGHOFF. In the field of aerodynamics, that is true; yes, sir.

Mr. KARTH. Thank you.

Dr. BISPLINGHOFF. Loads and structures.

As aircraft speeds increase from the supersonic to the hypersonic range the structural designer is faced with an even more formidable problem of aerodynamic heating. He can no longer use the conventional aluminum alloys, but must employ heat-resistant metals which are characteristically heavier. Thus, the B–70 which at mach 3 must withstand temperatures upward of 500° F., is constructed largely of steel. The X–15, which is subject to temperatures over 1,000° F., is made out of a heat-resistant nickel alloy. For still higher hypersonic speeds, the only materials which appear to have value are the refactory metals and alloys.

One phase of our current research is aimed at developing structural designs whereby these heat-resistant metals are employed so efficiently as to offset their inherently heavier weight. In figure 122 we illustrate some results of this type of research. There is shown a section

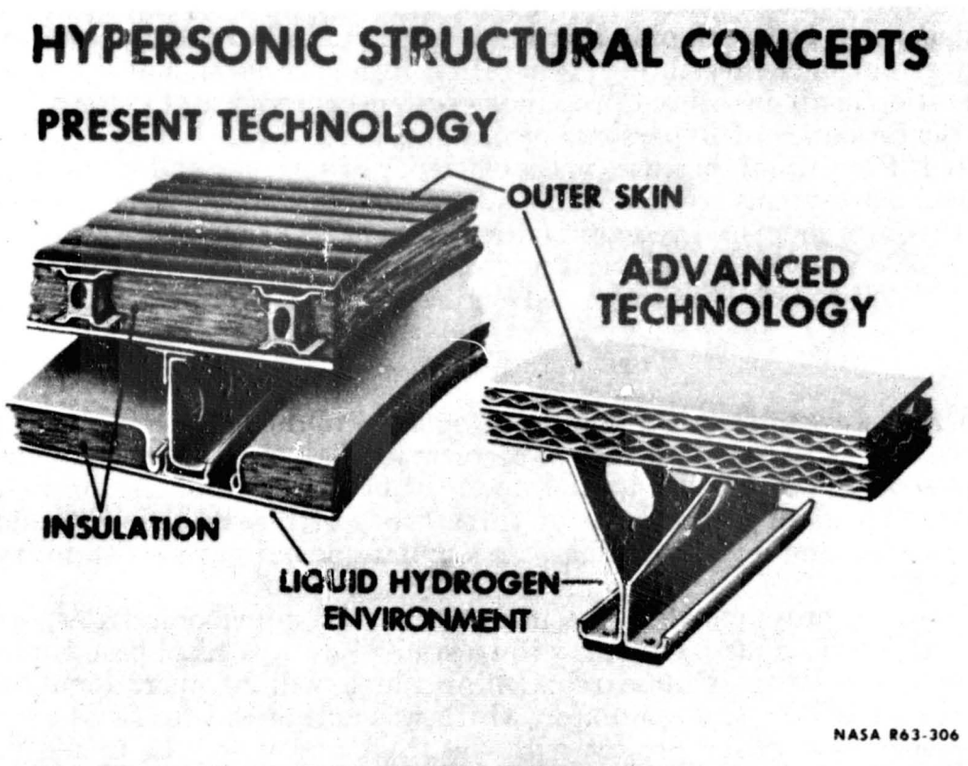

FIGURE 122

through a structure that could be the fuselage of a hypersonic aircraft containing liquid hydrogen fuel. The outer skin is heated to 3000° F., while the inner structure is at the temperature of liquid hydrogen, −450° F.

The sketch at the left represents present technology. It has a hot outer skin with underlying insulation to protect the strcutural sandwich structure in the middle. Additional insulation is used to reduce the heat carried into the liquid hydrogen.

On the right is a new concept being developed at our Langley Research Center. I have a small model of this with me that you may inspect, if you wish. Here we have a structure made up of multiple layers of dimpled or waffled sheets, which are fastened together as shown. These sheets are polished to reduce heat radiation and evacuated to reduce heat conduction. It is in a sense truly a "flying thermos bottle."

Structures built to withstand these environments, using previous technology, weigh about 6 pounds per square foot. Advanced techniques resulting from our research will permit fabrication of structures, similar to this small model, to do the same job which will weigh only 3½ pounds per square foot. This reduction in weight is extremely important if hypersonic hydrogen-fueled vehicles are to become practical and efficient.

AIR-BREATHING PROPULSION

The goal of air-breathing propulsion is to increase the performance of current and future subsonic, transonic, and supersonic aircraft, such as conventional airplanes, helicopters, VTOL and STOL aircraft, and

ground-effects machines, by improving currently available propulsion systems, and by developing new ones. At hypersonic speeds, the goal is to establish the feasibility, general performance level, and limits of operation in air-breathing propulsion system concepts so that the overall performance of hypersonic cruise and boost aircraft may be predicted Significant increases in the efficiency of subsonic and supersonic propulsion systems are achievable. Attaining these efficiency increases will require increased research effort of a generalized nature in fiscal year 1964 involving analytical and experimental studies of complete propulsion systems, the associated engine cycles, and components.

OPERATING PROBLEMS

A major area of our aeronautics program embraces a determination of the effect of aircraft flying characteristics both on the ability of the pilot to safely control flight and upon the basic design of the aircraft itself. This work makes use of three types of research equipment; fixed-based simulators, moving-base simulators, and variable-stability aircraft.

Problems anticipated in the integration of a supersonic transport with air traffic control systems will be studied using a fixed base simulator at the Langley Research Center which will be operational in fiscal year 1964. This simulator, which was authorized for fiscal year 1963, is a cooperative project with the FAA and it will be linked in its operation by leased telephone lines to the FAA's National Aviation Facilities Experimental Center air traffic control simulator at Atlantic City, N.J.

By this means at the Langley Research Center there will be a device which represents the airplane with all of its flying qualities. It will be a stationary device in the laboratory, pilots will be in it, and they will be connected by telephone lines to the traffic control system, a simulator of the air traffic control system, at the FAA's facilities, and by this means we can study how this supersonic airplane might be integrated into the air traffic control system.

Mr. KARTH. Doctor, is NASA funding the cost of this simulator?

Dr. BISPLINGHOFF. The one at Langley, yes, sir.

Mr. KARTH. Are there any FAA funds in that simulator?

Mr. MYERS. There were out of last year's funds of the FAA. They did put in $50,000 toward the simulator.

Mr. KARTH. What was the total cost?

Mr. MYERS. I believe $900,000.

Dr. BISPLINGHOFF. Experience with modern subsonic jet and piston transports has shown that under some operating conditions the capabilities of the pilot are taxed to the limit. For the supersonic transport and other advanced aircraft types including the V/STOL, the piloting problem will become even more complex. The most feasible method to explore these problems is through the use of advanced ground based and flight simulation.

The development of a versatile airborne simulator is an important step in providing advanced research information. A maximum of realism in motion cues, visual cues, and cockpit environment is thus provided. Figure 123 illustrates a sketch of the planned NASA variable stability airborne simulator. The aircraft is being procured in fiscal year 1963 and the details of the simulation system and instrumentation

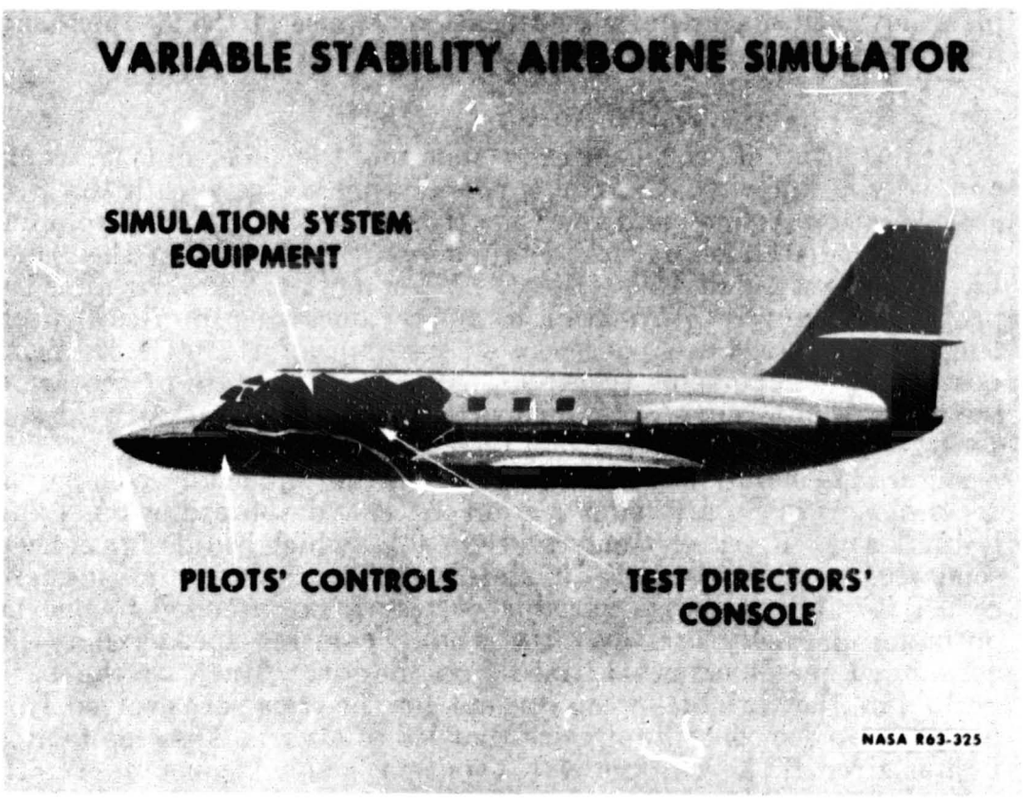

FIGURE 123

are now being designed. Wide variations of handling characteristics will be possible with this vehicle such that experience may be obtained for a variety of aircraft ranging from military fighters to the supersonic transport.

This is the aircraft I mentioned previously that is going to be taken to the Flight Research Center.

Although a large part of the research in the operating problems area is being concentrated on simulator studies, there are continuing programs in steep approach techniques, noise and sonic boom, and various aspects of flight safety and aircraft operating environments.

THE X-15 RESEARCH AIRPLANE

Since the first powered flight on September 17, 1959, the three X–15 aircraft have made almost 80 flights. In these flights a velocity of 4,104 miles per hour was attained on June 27, 1962. Three weeks later the airplane was flown to an altitude of 314,750 feet. All flights to date have been developed and flown to provide a maximum amount of research information.

Because of the success of the X–15 aircraft in its primary research role, a follow-on research program has been formulated consisting of advanced aeronautical and space-science experiments. Of the 15 experiments in the approved follow-on program, although 10 are space-oriented, there are 5 advanced experiments in the aeronautics field which will contribute both to the supersonic transport and hypersonic air-breathing vehicles. It is presently planned to conclude the remainder of the program by the end of calendar year 1965. This

plan, however, may require modification because of the X–15–2 landing accident in November 1962.

SUPERSONIC TRANSPORT

A substantial effort has already gone into the supersonic transport and, as you know, the NASA is cooperating actively with the Federal Aviation Agency and the Department of Defense in developing the required technology. A detailed program involving the Ames, Langley, Lewis, and Flight Research Centers of NASA is aimed at providing research information to answer questions in critical problems areas in 1963. A concentrated research effort on the problems posed by the supersonic transport will bring the state of the art to the stage where industry will have sufficient information to design a safe, economical U.S. supersonic transport.

Figure 124 shows four of the more promising supersonic commercial air transport or SCAT configuration concepts developed by our Langley and Ames Research Centers. SCAT 17, which is a design concept somewhat similar to the B–70, and SCAT 4 are fixed-wing designs. SCAT 15 and 16 utilize variable-sweep wings, intended to provide optimum characteristics over the whole operating speed range—not considered possible with a fixed-wing design. Much of the background on the variable-sweep concept for the transport evolved from NASA's earlier conceptual work that led to a variable-sweep tactical fighter aircraft; as you know, this concept is now incorporated in the design of the F–111, to be built by General Dynamics.

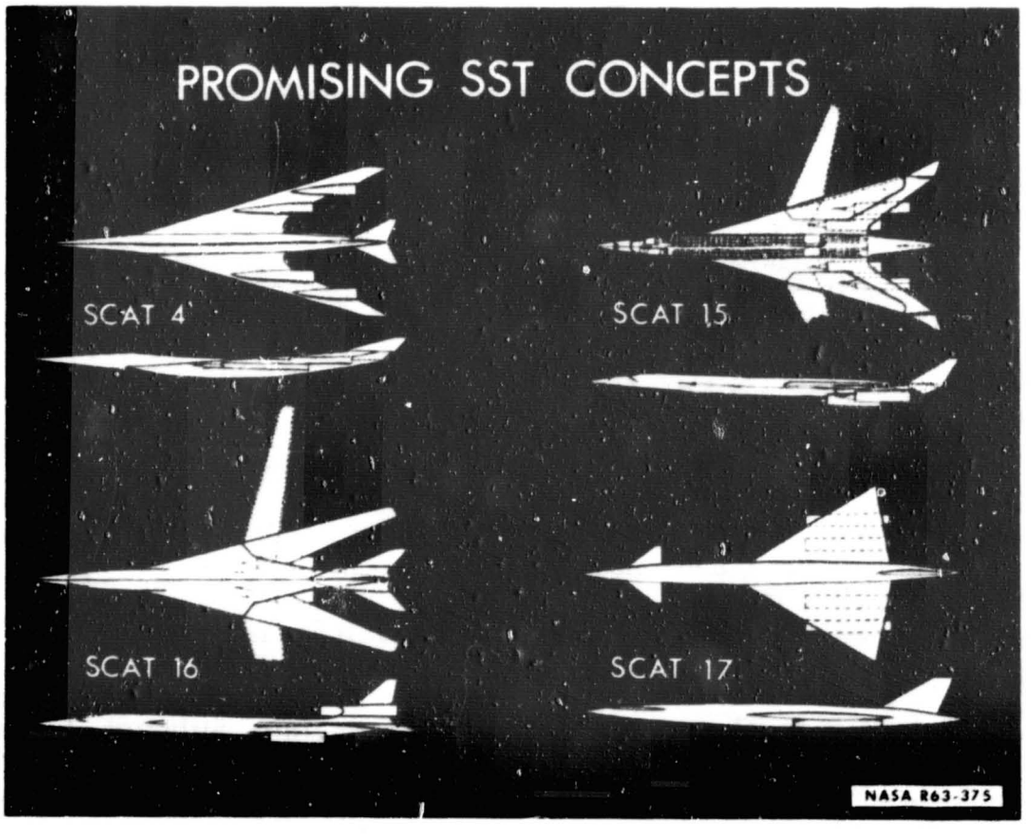

FIGURE 124

Each of the four concepts shown has unique design features, however, which would make it suitable for supersonic transport use. To aid in directing future NASA SST research, engineering studies are now being conducted by Boeing and Lockheed; it is intended that these studies will determine the practicality of each design concept as a possibility for the design of the supersonic transport and to indicate possible additional research problem areas for NASA investigation. The study contracts were awarded following a request for proposals to industry and NASA evaluation of the proposals submitted. It is expected that the results of the research investigations suggested by the industry evaluation will be of particular value in the eventual design of the U.S. supersonic transport, even if the final configuration differs substantially from any of the four shown on this chart.

V/STOL aircraft. (By this abbreviation we mean vertical short takeoff and landing aircraft.)

Through research undertaken in the past 3 or 4 years it has been shown that vertical or very short takeoff and landing flight, commonly abbreviated as V/STOL, is practical with varying degrees of acceptability. The NASA V/STOL flying test-bed program conducted at the Ames and Langley Research Centers using a number of these vehicles has provided the first insight into the flying qualities required of this class of aircraft. Much of the exploratory aerodynamic research required to delineate the most promising of the many possible V/STOL types has been completed, leading to design, fabrication, and flight test of the vehicles shown (fig. 125).

FIGURE 125

It is now necessary to provide aerodynamic stability and control information on the more promising types. Such information is required for the development of operational aircraft to exploit the unique military and civil capabilities of V/STOL aircraft in the future. Our research program in fiscal year 1964 is planned to fill that need.

The potential capabilities of the vertical takeoff and landing aircraft (helicopters and other configurations) need to be developed to the extent of operational usefulness. All-weather vertical landing capability is not operationally feasible, at present, because of the inadequate flying qualities of VTOL configurations and the lack of adequate procedures and equipment for operating in and around landing areas under all-weather conditions.

Flying qualities criteria, utilizing the expanded possibilities offered by new airframe designs and anticipated new freedoms of design obtained by utilizing electronic systems, will be defined for characteristics and regimes of flight important for an all-weather vertical takeoff and landing capability. Studies will be made of the V/STOL terminal area flying quality needs, using such vehicles as the Langley variable-stability helicopter and, later, the Ames deflected slipstream short takeoff and landing aircraft.

CONCLUSION

I have attempted, with this statement, to summarize the scope of the advanced research and technology program which is being carried out by NASA in order to discharge its mission as assigned by the Congress. Since such a statement as this cannot be exhaustive, I have attempted to choose examples which point up the important directions of each portion of the program. I would like to emphasize finally that although the cohesiveness, technical direction, and much of the research effort of the program is provided by the NASA field centers, a close coupling of the Nation's universities and industry with the centers has been established. This three-way partnership is a key to the Nation's future preeminence in aeronautics and space.

Mr. KARTH. Thank you.

Mr. MORRIS. Mr. Chairman.

Mr. KARTH. Thank you, Doctor, very much.

Mr. Morris.

Mr. MORRIS. If I may ask—this may seem to be a facetious question, and I might get a facetious answer—I notice you mentioned in here the F–111.

Dr. BISPLINGHOFF. Yes.

Mr. MORRIS. Is that what some of the people refer to as the FX?

Dr. BISPLINGHOFF. They are identical.

Mr. MORRIS. Were you on any these committees that were making selections and studies?

Dr. BISPLINGHOFF. No, sir; not all.

Mr. MORRIS. Thank you, Doctor. So you actually are not in a position to have an opinion as to the merits of the different designs?

Dr. BISPLINGHOFF. No, sir. NASA was very active in the formulation of the concept of variable-sweep, which is incorporated in these designs, but NASA had nothing whatsoever to do with the evaluation of the two designs which were in competition.

Mr. KARTH. You are sure NASA can't take credit for the design of the F-111?

Dr. BISPLINGHOFF. We take credit for the variable-sweep which is incorporated in that; yes.

Mr. KARTH. Has NASA been asked to appear before the McClellan committee?

Dr. BISPLINGHOFF. No, sir.

Mr. MORRIS. Do you think you could make any contribution over there? [Laughter.]

Mr. KARTH. Thank you very much, Doctor. I really appreciate very much the great contribution you have made to the committee and to the committee's better understanding of what the Office of Advanced Research and Technology has as its primary responsibility.

Dr. BISPLINGHOFF. Thank you.

Mr. KARTH. I understand you would like to introduce Dr. Herman Kurzweg, who is Director of Research, to give us the benefit of his particular knowledge and experience in this field, and call to our attention some of the things he has in mind; is that correct?

Dr. BISPLINGHOFF. Yes; we would like to do this, very much.

Dr. Kurzweg has planned to go to Europe and would be leaving tomorrow. We would much appreciate the opportunity for him to talk today.

Mr. KARTH. Dr. Kurzweg.

Dr. BISPLINGHOFF. Dr. Kurzweg is our Director of Research. By "research" we mean here basic research. In my testimony you notice I did not break that out as a discrete item, but rather it was interwoven all through the statement. I am particularly anxious for you to hear Dr. Kurzweg, because he can tell you what we are doing in basic research.

Dr. Kurzweg.

Mr. KARTH. Dr. Kurzweg, we are very happy to have you before the committee. Will you proceed with your statement, please?

Dr. KURZWEG. Thank you.

STATEMENT OF DR. HERMAN H. KURZWEG, DIRECTOR OF RESEARCH, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

(The prepared statement of Dr. Herman H. Kurzweg is as follows:)

Dr. KURZWEG. Mr. Chairman and members of the subcommittee, as has been shown in the previous talks, the word "research" is used for a great part of NASA's space and aeronautics activity. It covers a wide spectrum which reaches on the one side into the fields of hardware, engineering, and technology, and on the other side far into the fundamentals of all natural sciences. It is this latter side of the research spectrum which will be discussed in this presentation to show its significance as the fundamental requirement for the advancement of each of the technical and scientific phases of NASA's work.

It should be understood that this kind of research is, in general, not directly connected with any current space project, and that, on a broad basis, it provides the general understanding, new concepts, and methods of theoretical and experimental treatment of physical phenomena encountered in NASA's mission. Part of such basic research

results can be immediately applied to practical vehicles. The greater part comes to bear several years later and it is, therefore, mandatory that a rigorous and continuous basic-research program be maintained at all times in NASA's research centers, assisted by universities, nonprofit, industrial, and other governmental laboratories. Without such basic research, NASA's future technology will always be in second place.

The Office of Advanced Research and Technology has recognized the importance of basic research by designating a separate office for this purpose. The research program is divided into four major disciplinary areas—fluid physics, electrophysics, materials, and applied mathematics.

In the following sections, I have selected highlights of our work in these areas, which show the diversity and complexity of the problems we face and some of the methods we use to solve these problems. The examples are, as far as possible, illustrated by potential applications. Their significance, however, reaches, in most cases, far beyond the indicated specific uses.

FLUID PHYSICS

Fluids interact not only with aircraft and spacecraft in their flight through the atmosphere but are integral to the operation of most of the internal systems aboard such vehicles. Thus, characteristics of fluids and their motion are pertinent to almost all phases of aeronautical and space technology. This program is concerned with investigations into the fundamental aspects of fluid behavior over a wide range of states and dynamic conditions, with the term "fluid" being used to denote gases, liquids, mixtures of both, and plasmas.

In solving any fluid-mechanical problem it is essential to know the physical properties of the fluid. That is, we must know the relationship between temperature, pressure, and density and the effectiveness of the fluid to transport heat, mass, momentum, and electricity. These properties, and the manner in which they are affected by the physical environment, critically influence, for example, estimates of the performance and behavior of re-entry space vehicles and their propulsion systems.

Through research, our knowledge of fluid properties is being extended into the extreme temperature regions, very cold and very hot. Experimentally, the difficulties become continuously greater, for example, when the temperatures are so high that existing materials cannot contain them. Fortunately, our theoretical understanding of the problem has made good progress and based on assumed models of the interaction between molecular, atomic, and ionized particles, theory can be used to predict the desired thermodynamic and transport properties with substantial accuracy. The interaction (attraction and repulsion) between particles as a function of distance between particles is shown schematically in figure 126. The experimental determination of the interaction curve of the type shown, which is needed as a base for the gas-properties calculations, requires relatively few high-temperature particles, and thus the above-mentioned difficulty with the container can be circumvented. The principle of such a particle-beam experiment is illustrated on the chart. The apparatus consists of a high-temperature particle source which emits the particles at high velocity into a target gas. If there were no inter-

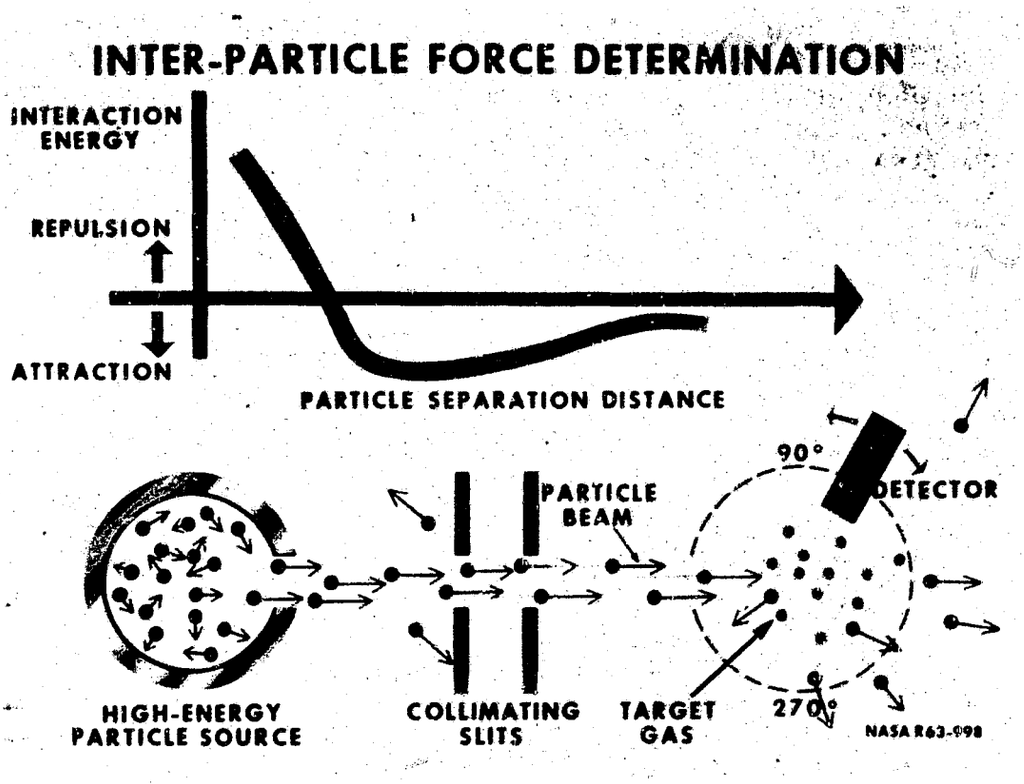

FIGURE 126

particle-force fields, the particles from the source would, aside from direct collisions, traverse undeflected through the target-gas particles. Because of interparticle forces, however, the particles in the beam will be angularly deflected by varying amounts. By measuring the angular scattering of the beam particles as a function of their initial velocity, the repulsive and attractive forces between the beam and target-gas particles can be deduced. A great deal of research of the kind just illustrated is needed in this branch of science to perfect the theoretical concepts and techniques of measuring and analyzing high-temperature gas properties.

An important and challenging part of the fluid physics research program is concerned with basic gas dynamics and heat transfer. Part of this work deals with, for example, fluid-flow and heat-transfer problems which are connected with spacecraft during reentry into the Earth's atmosphere from planetary missions. Only from such knowledge can a feasible shape of the spacecraft, and the type and weight of the critical heat-shield component be devised. Our understanding of the nature of the flow and the heat transfer to vehicles entering at satellite speeds (around 17,000 miles per hour) is pretty well in hand, and much progress has been made in our research during the past year toward increasing our knowledge of these phenomena up to the lunar reentry speed range (about 24,000 miles per hour) and a little beyond. As might be expected, the problems become aggravated in the high-speed range associated with interplanetary missions (approximately 31,000 miles per hour and higher) and I'd like to illustrate with the next few charts the nature of some of these problems and the research which is needed to solve them.

The heat load experienced by a blunt body—in this case, a spherical nose—is shown as a function of reentry flight speed on the left-hand side of figure 127. The total heat load is made up of two parts—a convective-heat input caused by direct contact of air and body, and a radiative input arising from radiation of the compressed air behind the shock surrounding the nose of the vehicle. At speeds up to lunar reentry, the prime heat-load contribution comes from convective heating, and the blunt nose, such as used on the Mercury and contemplated for the Apollo vehicle, minimizes this kind of heat transfer. At speeds beyond lunar reentry, the radiative input of these blunt shapes rises

FIGURE 127

at a phenomenal rate, thus requiring a prohibitively heavy heat shield to protect the body. A possible solution is shown on the right-hand figure, which shows heat inputs experienced by somewhat slender-nosed bodies (that is, a cone in this case), as a function of speed. Although the convective-heat load for such shapes is greater than it is for blunt-nosed bodies, the radiative heat-load is substantially less beyond about 30,000 miles per hour, resulting in a reduced total-heat load. Such moderately slender-nosed shapes theoretically show great promise for reducing heat-shield weight for interplanetary spacecraft. Much basic research work, especially with regard to the effects on other aerodynamic characteristics such as drag and stability, needs to be done to check out the concept and to deal with the many other problems that result from using such shapes at high hypersonic speeds. For example, the concept is predicated upon the assumption that a conical

vehicle would remain conical during reentry. This might be difficult to realize in practice at the high heating rates (and thus high rates of mass loss due to ablation) for the reentry velocities under consideration. In this connection, the fundamental research problem of maintaining laminar boundary layers, that is, aerodynamically "smooth" flow over the body, has been for many years and still is the subject of mathematical and experimental studies. The solution of this problem would mean that the convective heating could be kept at reasonable levels.

Along with the heat-transfer research on reentry into the Earth's atmosphere from interplanetary missions, similar research is also progressing on entry into the atmospheres of other planets, and in particular into the nitrogen-carbon dioxide atmospheres thought to exist on Mars and Venus. As indicated in figure 128, one current estimate of the CO_2 content in the Martian atmosphere is about 2.2 percent by volume. The CO_2 content of the Venusian atmosphere is subject to considerable uncertainty but is estimated to range from about 3 to 23 percent by volume. The balance of the atmosphere in each case is believed to be nitrogen with a possibility of a small amount of argon. To obtain an understanding of the radiative heating in these planetary environments, preliminary measurements have been made of the thermal radiation emitted from the hot gas cap of blunt bodies flying in such N_2–CO_2 mixtures. The measurements were made on ¼-inch diameter plastic models fired from a light-gas launcher. The results are shown as a band on the chart in which the thermal radiation of the mixture is shown compared with air. It can be seen that, at a given speed, the radiative heat-transfer problem is con-

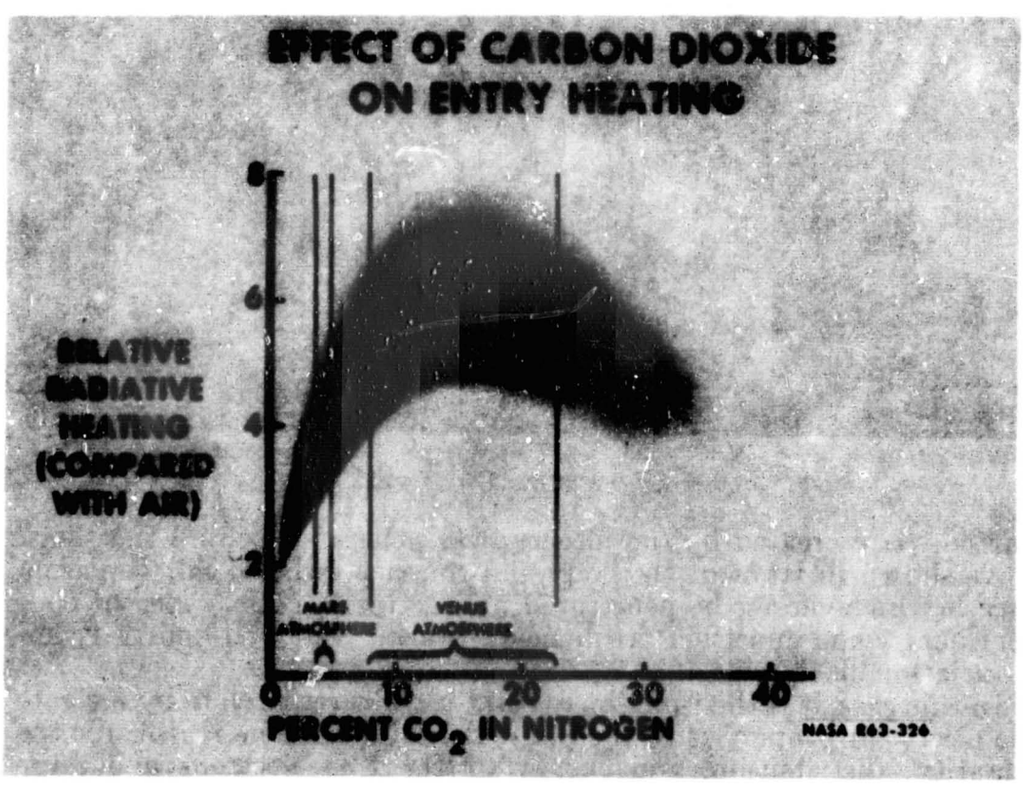

FIGURE 128

siderably more severe during entry into the atmospheres of Mars and Venus than during reentry into the Earth's atmosphere, perhaps by as much as a factor of 7. The data obtained are far from conclusive, however, and more work on the problem needs to be done.

Many basic phenomena are closely connected with each other and eliminating one problem might aggravate another. For example, the change of the shape to reduce heat transfer causes variations of the nature of the entire flow field about the body. The chemical and electrical changes of the gasses, caused by these variations, must be known in order to be able to predict the aerodynamic forces acting on the spacecraft. These forces determine its drag, stability, and control characteristics.

One aspect of the problem is shown in figure 129, which illustrates the distribution of free electrons about a reentry body. This distribution is affected by the shape and speed of the body. The charged

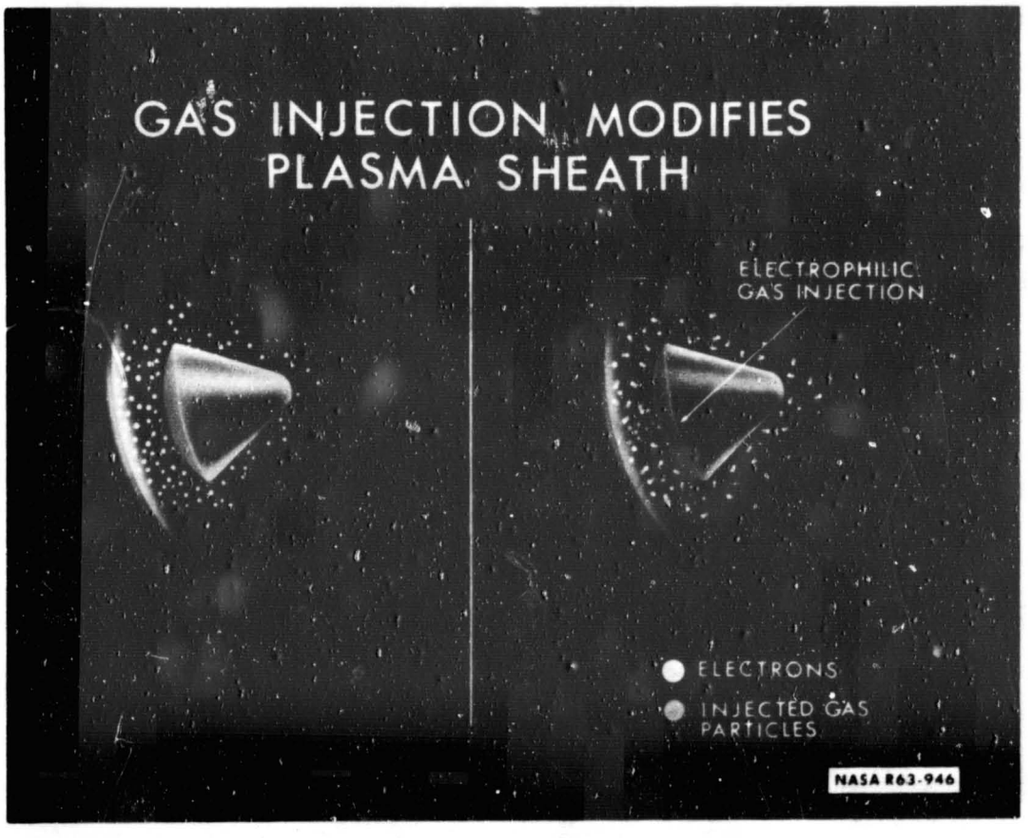

FIGURE 129

particles are created by the intense heat generated behind the shock wave shown in front of the body and constitute the so-called plasma sheath which cannot be penetrated by electromagnetic waves of conventional communication frequencies, causing the well-known "communciation blackout."

In this case, it is the function of fluid-physics research to investigate the electrical properties of the plasma sheath, find the reason for the quantity, distribution, and energy of the free electrons about the body, in order to be able to alter these characteristics if necessary.

One possibility toward the elimination of the "blackout" which is being looked into, is illustrated on the right side of the figure. The technique consists of injecting an electrophilic, that is, electron-trapping, gas into the plasma sheath with a resulting formation of negative ions and a corresponding reduction of free electrons. It is anticipated that the heavy negative ions will not interfere with radio transmission. Problems that will be studied include the determination of the most effective electrophilic mixture and the nature of the mixing processes of the injected gas and plasma under the extreme-flow conditions of reentry.

Theoretical results of fundamental research must be checked by experiment. Some basic information can be obtained by costly, large-scale flight tests; most, however, must be worked out more economically and thoroughly in ground-test facilities. Such facilities change with time according to the state of the art. For example, a new high-performance research facility, shown in figure 130, for which fiscal year 1964 construction funds are being requested, is necessary in connection with the heat-radiation problem. The important elements of the facility are: a 6-inch-diameter electrically driven shock tube, a 12-inch-diameter electrically driven expansion tube, and a large bank of capacitors to power the two tubes (only the expansion tube is shown in the figure). The proposed facility will be capable of investigating radiation from air at temperatures characteristic of velocities in excess of 40,000 miles per hour. This capability exceeds that of the existing shock tubes at NASA centers.

In addition to the investigation of radiative-heat transfer in air, other useful research programs, such as radiation studies in planetary atmospheres, studies of chemical reaction rates, and convective heat-transfer research will be carried out in this facility. Whereas this facility will move high-speed gas over a fixed model, complementary tests will continue in ballastic ranges wherein small-scale models (up to one-half inch in diameter) are fired either into still air or into an airstream produced by a shock tunnel.

Although very valuable data have been and will continue to be obtained in range facilities, the small model size employed prohibits the use of extensive on-board instrumentation needed for measuring the distribution of desired quantities along the test body. In contrast, the proposed 12-inch-diameter expansion tube will permit the testing of fixed models up to 4 inches in diameter with on-board instrumentation capable of measuring the spatial distribution of radiation-energy flux, as well as other basic quantities.

In contrast to ordinary shock tubes, the airflow will be generated by the expansion tube with very close duplication of free-stream properties prevailing at full scale in free flight. Also, asymmetric lifting-reentry configurations at any angle of attack will be investigated. Thus, the Hot Gas Radiation Research Facility is expected to lead, not only to new fundamental knowledge, but also to provide a major source of information for direct use by the designer of reentry vehicles for heat-protection systems.

In addition to external-flow problems just discussed, fluid-physics research is being conducted on problems of internal flow that will greatly influence the design of advanced propulsion systems. Radiative-heat transfer, for example, plays an important part in advanced

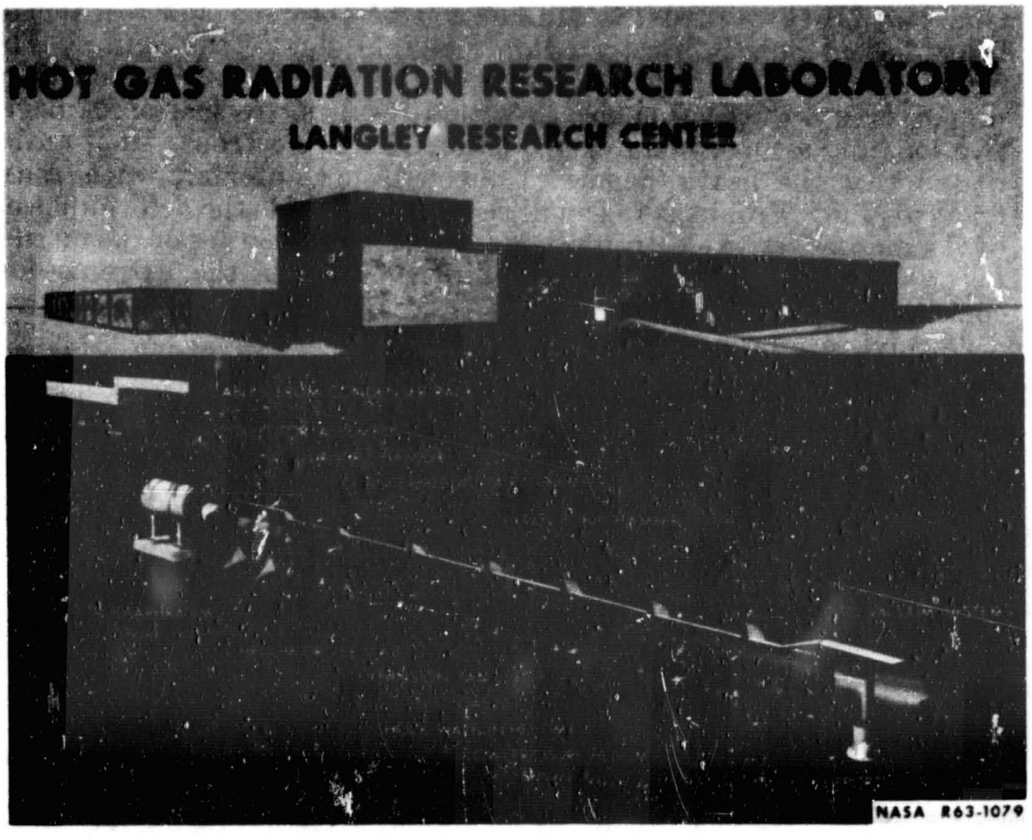

FIGURE 130

nuclear rockets. One problem concerns one of the most advanced propulsion concepts—the coaxial-flow, gaseous-nuclear rocket. Here, the technological solution will decisively depend on the basic understanding of the flow process.

The coaxial-flow gaseous reactor is illustrated in figure 131. Gaseous-nuclear fuel is injected into the reactor cavity at much lower velocity than that of the surrounding hydrogen propellant. The hydrogen is then heated to temperatures beyond material limits by thermal radiation from the fissioning fuel. However, at temperatures below 10,000° F. the hydrogen is transparent to thermal radiation, thus causing inefficient operation of the reactor and excessive heating of the reactor walls. One method of augmenting the heat-transfer process from the nuclear core to the hydrogen propellant which is being studied involves the addition of absorbing material to the gas. At the same time, the absorbing material serves the purpose of reducing the intense heat radiated by the core from reaching the internal walls.

Theoretical research performed thus far has established the heat-absorbing effectiveness of the gas-particle mixture. One result of the theoretical study is shown in this chart where the fraction of the heat generated in the core which reaches the wall is shown as a function of the opacity of the gas. The opacity is a measure of the absorptivity of the gas to the radiative heat; the greater the opacity, the more heat is absorbed by the gas. Many problems remain to be solved by research on radiative-absorbing materials, the hydrodynamics of solid-

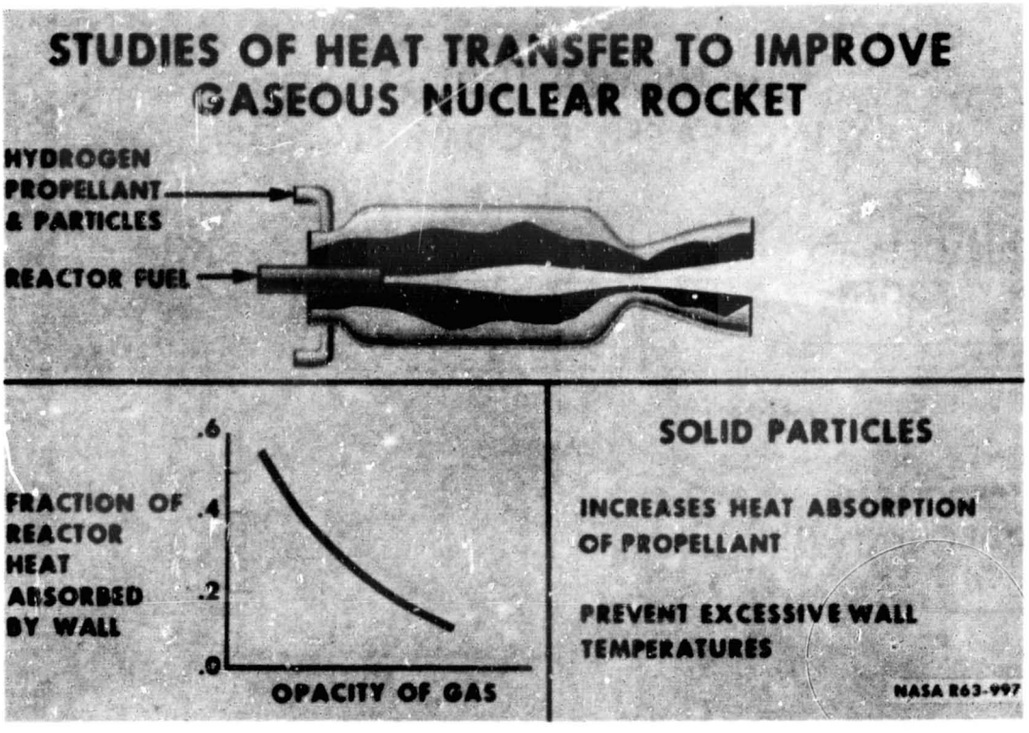

FIGURE 131

gas mixtures, and the basic, radiative, heat-transfer processes in such cases.

Another aspect of internal-flow research in fluid physics is concerned with nonequilibrium flow processes in expansion nozzles. In nuclear-hydrogen propellant rockets, chemical rockets, turbojets and ramjet engines, for example, the propellant is heated to high temperatures and one of the consequences of the high temperature is that the propellant dissociates into the basic atoms of which it is composed. A certain amount of energy is absorbed in the dissociation process.

Maximum thrust is obtained from the system, however, if the energy tied up in dissociation is released during recombination of the atoms in the form of heat as the flow expands through the exhaust nozzle. Further research is needed to provide better understanding of the basic mechanism of the recombination process, which, in turn, might lead to methods of inducing recombination, for example, by proper shaping of the contour of the nozzle. An extremely long (but comletely impractical) nozzle can be shown to give nearly complete recombination. Our current research program is, therefore, oriented toward providing the information with which to develop the most efficient configuration for a practical nozzle size.

Another technique which contributes to increased recombination involves the use of additives in the propellant. The upper diagram in figure 132 shows the usual situation for a hydrogen rocket. Here the dissociated hydrogen is discharged through the nozzle and although a few atoms recombine, most remain in the atomic state. In the lower diagram, a small amount of a recombination-inducing material is added to the propellant. As a result, a larger number of atoms recombine in the exhaust nozzle with a resulting increase in thrust.

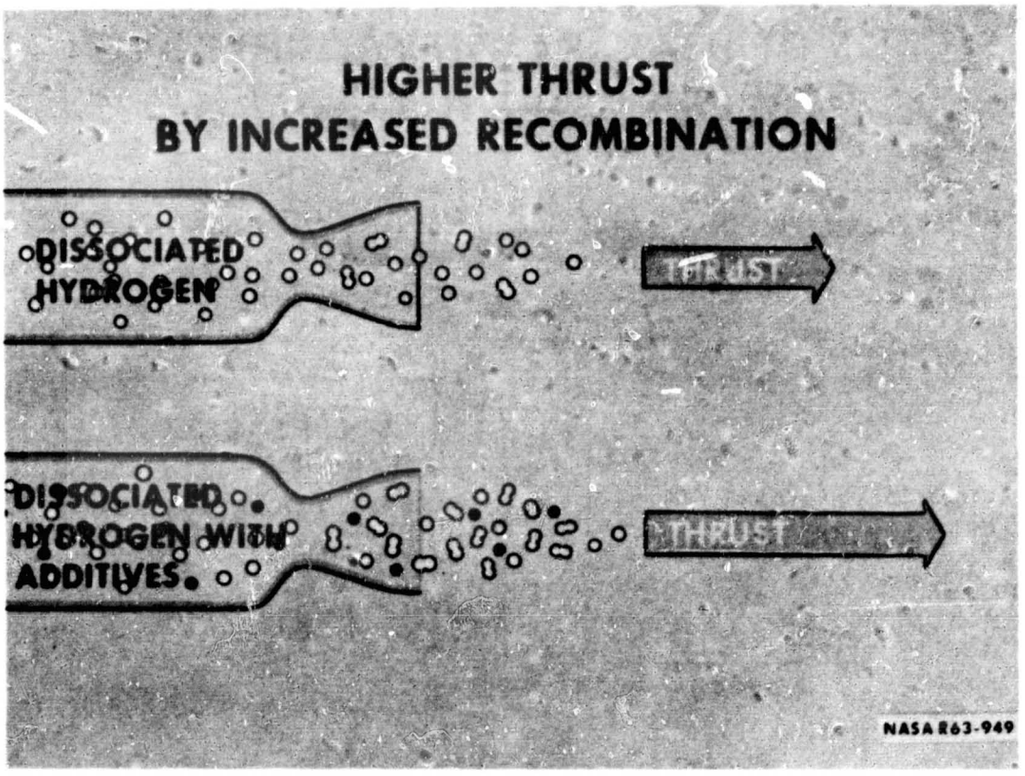

FIGURE 132

Most of the effective additives which have been investigated so far suffer a compensating loss of thrust because the additive makes the propellant heavier. Further research is needed to understand the basic process better which might lead to a light-weight additive as a good recombination promoter.

Another area of increasing importance in the fluid-physics research program is that of plasma physics. As you may remember, a plasma is a state of matter where the particles are electrically charged, that is, where free electrons and ions exist in approximately equal numbers. As a consequence, these particles can be influenced by electric and magnetic forces contrary to nonconducting gases and liquids, such as ordinary air, for example. Because of the important role plasmas play in the development of very fast vehicles, in the science of space, and in space technology, it might be desirable to spend a little time in explaining some typical plasma phenomena in the physical world.

In figure 133, we see the universe divided into the different states of matter with a temperature scale which indicates the region of their existence. It can be seen that most of the matter in the universe exists in the form of a plasma. The temperatures which are produced by friction and compression during the interaction of vehicle and gas reach far into the region of the plasma state, dependent on the relative speed. Since, for example, the interaction temperature of a vehicle moving with the velocity of sound (about 700 miles per hour) is about 100° F. and about 20,000° F. at 17,000 miles per hours (satellite speed), one can imagine the tremendous temperatures which vehicles will encounter with even higher speed such as in returning from interplanetary missions. The plasma state of matter is therefore of sub-

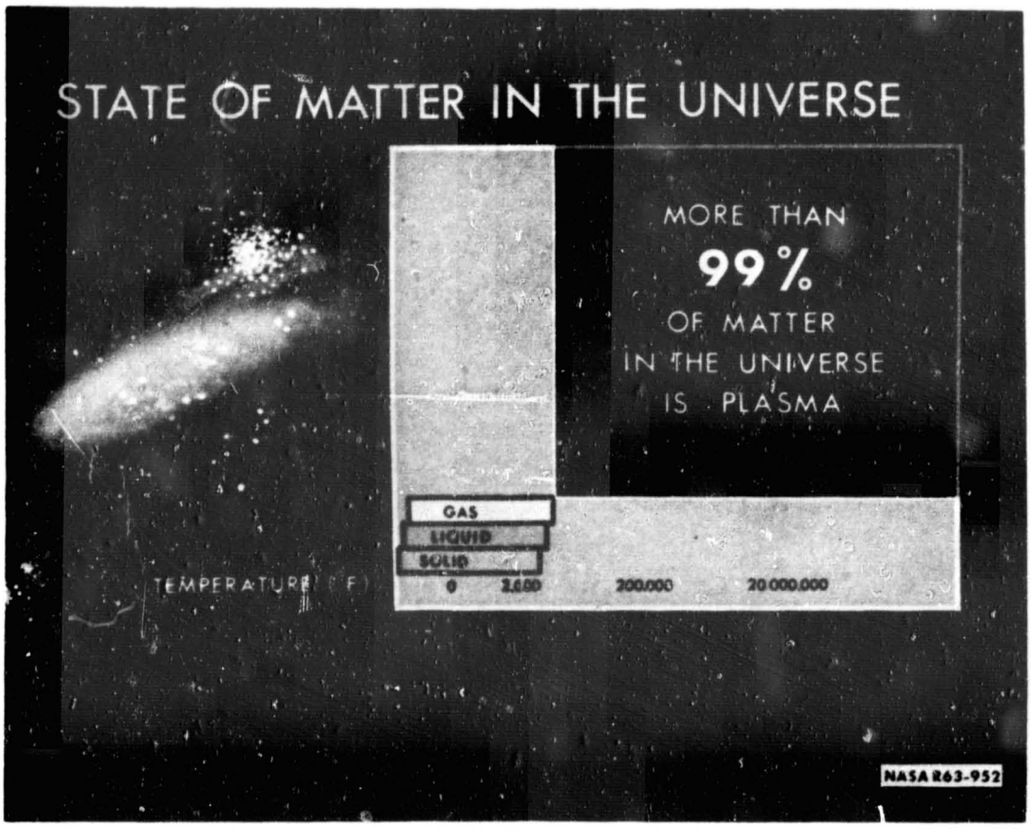

FIGURE 133

stantial interest in fluid-physics research. Results from plasma studies will have far-reaching impact on all branches of modern physics.

Theoretical studies must go hand in hand with experimental investigations. Much effort is spent, therefore, to produce phenomena in the laboratory under well-controlled conditions. Figure 134 shows an example of our current plasma research. This illustrates an actual experiment as it was conducted at our Langley Research Center. On the upper left, a so-called plasma gun produces a plasma with a powerful electrical discharge and then accelerates it in pulses to very high velocities. In this particular case, the velocity is 500,000 miles per hour. The plasma is then stopped abruptly by a magnetic barrier wherein its high-kinetic energy is converted into heat, producing a temperature in excess of 1,000,000° F. On the bottom of the chart we see a photograph of the actual experiment. The whole event takes place within a few millionths of a second and during this short time, observations and measurements have to be made.

We would like to stress at this point the technical difficulties involved in, first, producing such an energetic plasma and, second, in making good observations during the extremely short time intervals. Much research must still be performed to develop the complex instrumentation required to make accurate measurements of conditions during the test period.

Most of our plasma work is done in much more moderate temperature region. We have, for example, arc-jet facilities which provide continuous-plasma streams at 20,000° F. Such facilities are used to study

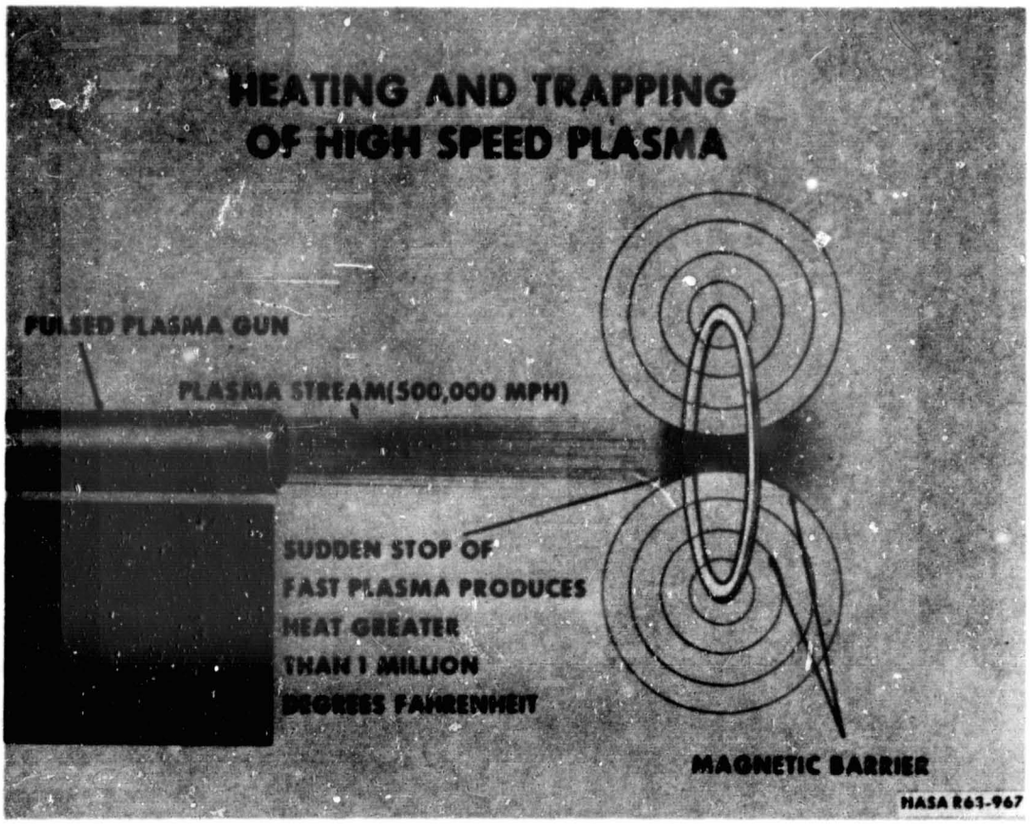

FIGURE 134

plasma behavior at temperatures occurring during atmospheric reentry of space vehicles. We are also carrying out studies of the principles of magnetohydrodynamic plasma acceleration which are necessary to understand MHD propulsion and power-generating devices. Other methods of plasma generation and plasma heating, and the development of techniques for measuring and analyzing their characteristics, are also under investigation. In addition to our in-house research, we are supporting a number of plasma projects at university laboratories. Unfortunately, these high energy experiments are elaborate and expensive, but no cheaper way can be seen to provide the necessary scientific information which we need for our present development of space technology.

ELECTROPHYSICS

The electrophysics research program is concerned with the effect of static and dynamic electric and magnetic fields upon electrons and ions imbedded in gases, liquids, and solids and also with nuclear reaction processes. The program encompasses physics research on such topics as gaseous discharges, atomic and molecular behavior, spectroscopy, electromagnetic waves, electron and ion dynamics, nuclear reactions, high energy particles, and theoretical physics.

The following examples will show some of this research activity. One very interesting and promising field is that concerning the electrophysical laws governing the interaction of a magnetic field with a flow of ionized gases which plays a very important part in modern physics and technology. Figure 135 shows a possible practical use of

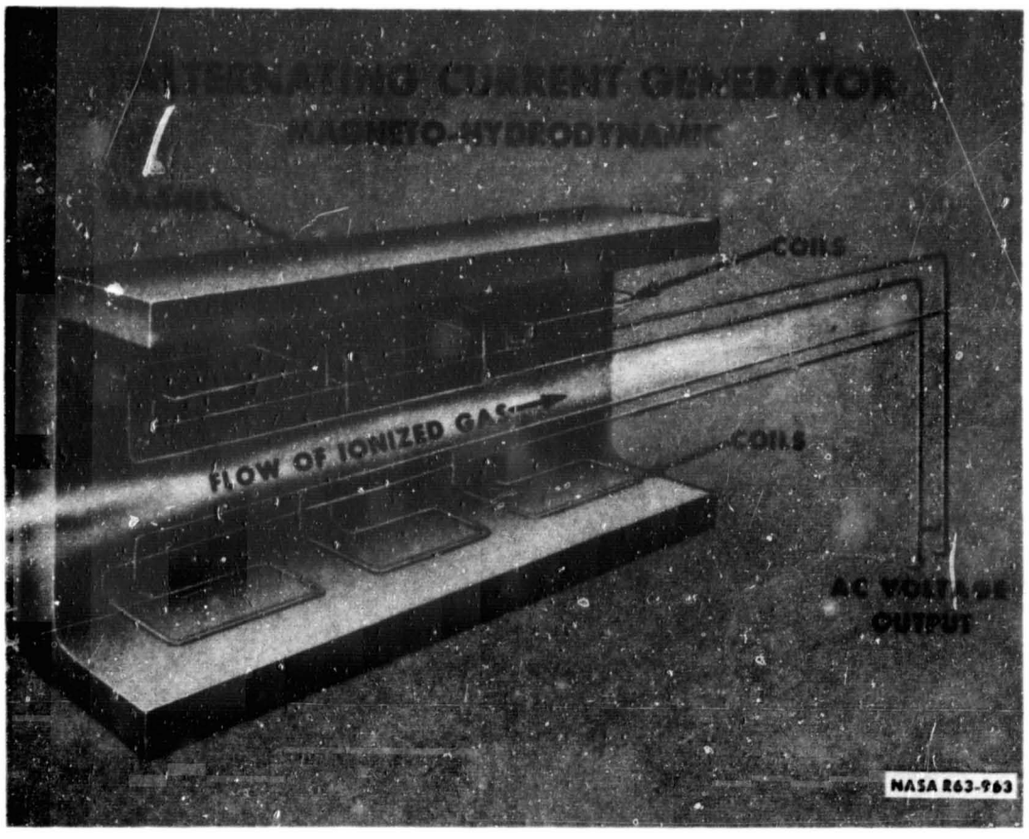

FIGURE 135

this principle, which involves the generation of power by passing an ionized gas through a magnetic field and extracting the resulting electrical power. This is a problem which is being studied by many investigators in Government, industrial, and university laboratories. To date, most experimental MHD devices have generated direct current.

Theoretical analyses of MHD principles and studies of the basic behavoir of the processes involved indicate the presence of a magnetoacoustic wave which produces cyclic variations or waves in the flow field. This may lead to the direct generation of alternating current with such a device. Current experimental investigations are attempting to verify the existence of such a theoretical concept and whether these waves can be sufficiently controlled to produce alternating current.

Another scientifically interesting phenomenon is superconductivity which occurs at temperatures close to absolute zero. Here again, many immediate uses can be seen if the phenomenon were basically better understood. Superconductivity is a state in which the electrical resistance of a conductor falls to zero. It is also a state in which magnetized materials retain their magnetism even when the magnetizing source is removed. Since there is no electrical resistance in superconductors, coils in electromagnets are very much smaller than water-cooled coils wound of copper at room temperature producing the same magnetic-field intensity. An explanation of this phenomenon by studying the electron behavior, is the goal of these investigations.

A good step forward in this direction has been made by JPL physicists who have devised a method to increase stepwise the magnetic-field density in a superconductor without requiring the application of a larger external magnetic field.

Figure 136 illustrates such a magnetic-flux pump. A block of niobium is placed in an external magnetic field parallel to the axis of the cylindrical holes. The block is cooled below its critical temperature, about 4° above absolute zero, with liquid helium, and the external magnetic field is then reduced to zero. The magnetic field remains trapped inside the two cylindrical holes of the superconductor. The superconducting piston is then inserted into one hole

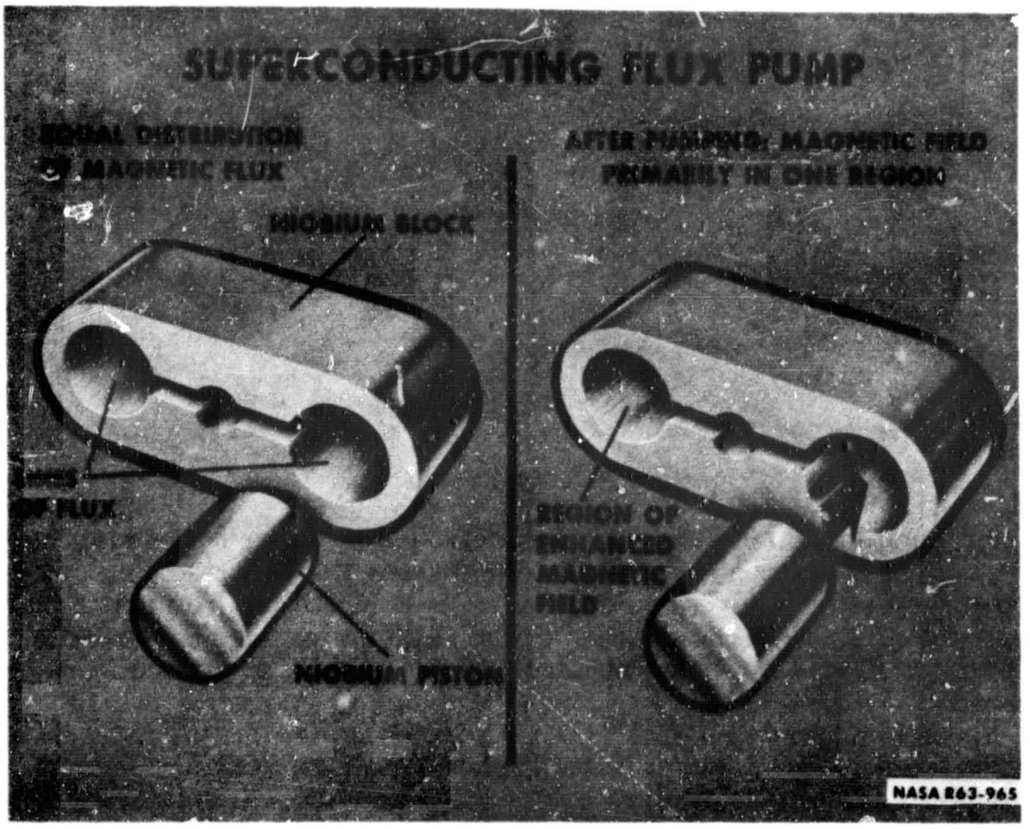

FIGURE 136

which increases the field in the other hole by a factor of almost two. By reversing the process, the flux density can also be reduced, thus making a variation of the field from zero to a high level possible. The significance of this effect for laboratory experiments and control of magnetic devices in spacecraft is obvious. Also, for example, the reduction in vehicle surface temperatures during reentry is a possible benefit of this research.

While the flux pump is still a laboratory device, this work illustrates ingenuity and imagination in exploring and devising new techniques to utilize known phenomena. Superconductors may very well be the solution for the problems, such as drag and drift rates, which have plagued gyroscope designers and users for many years. The requirements of future space exploration far exceed the capabilities

of conventional gyroscope systems. Essential improvements can be seen by using a cryogenic gyroscope with a superconducting rotor suspended in a vacuum by a constant magnetic field created by two superconducting coils.

Figure 137 illustrates the experimental arrangement of this gyroscope which will greatly reduce drag with a resultant reduction of drift rate and an increase in accuracy. The rotor is started spinning by a jet of air while the coils and rotor are so arranged that the magnetic flux keeps the rotor balanced during its spin. Current studies are directed toward a better understanding of the basic principles involved so that undesirable dragging actions of the rotor may be

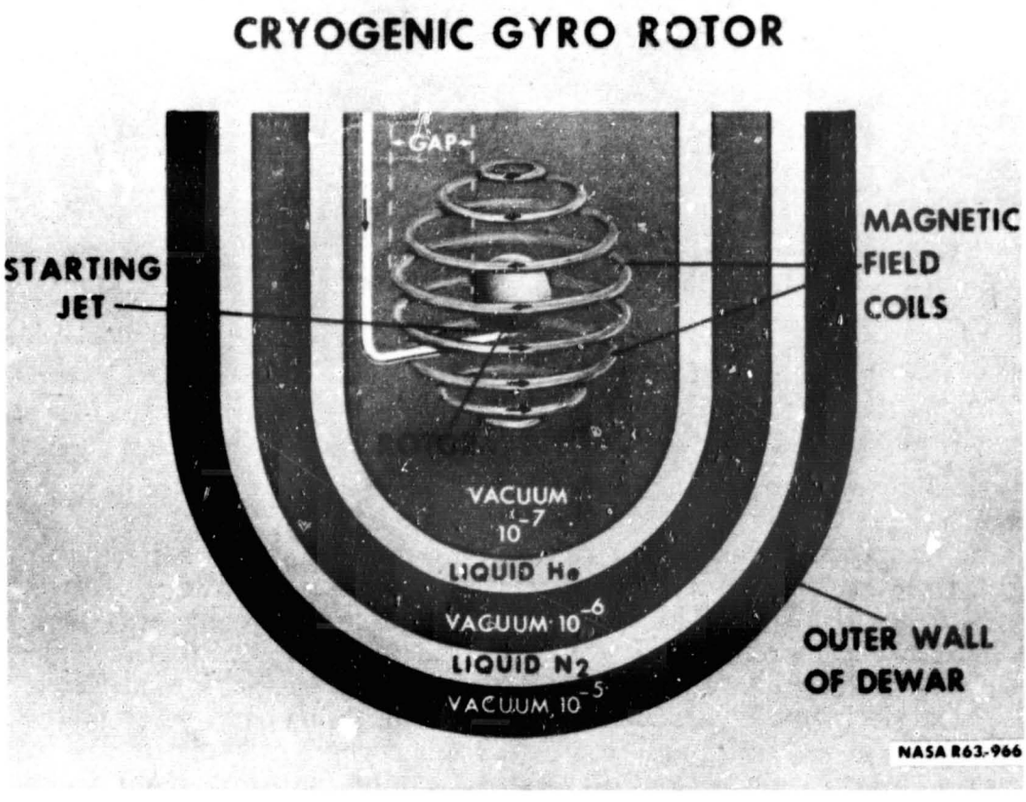

FIGURE 137

further reduced to achieve extreme accuracy and operating stability.

The basic studies of electron location and behavior within the crystalline structures of solids led some years ago to transistors which have drastically changed the radio technology. A similar outgrowth of such basic activity is showing up in lasers, electronic devices which may revolutionize our communication systems and special energy transmissions in the future. Figure 138 shows the frequency region potentially covered by the laser. It can be seen that this region reaches far beyond that of the conventional radio waves. While the figure appears to show only a doubling of the usable frequency spectrum for communication, the logarithmic scale indicates a new region which is 1 million times greater. The pace of progress in this field is dependent upon how fast we reach a thorough understanding of the

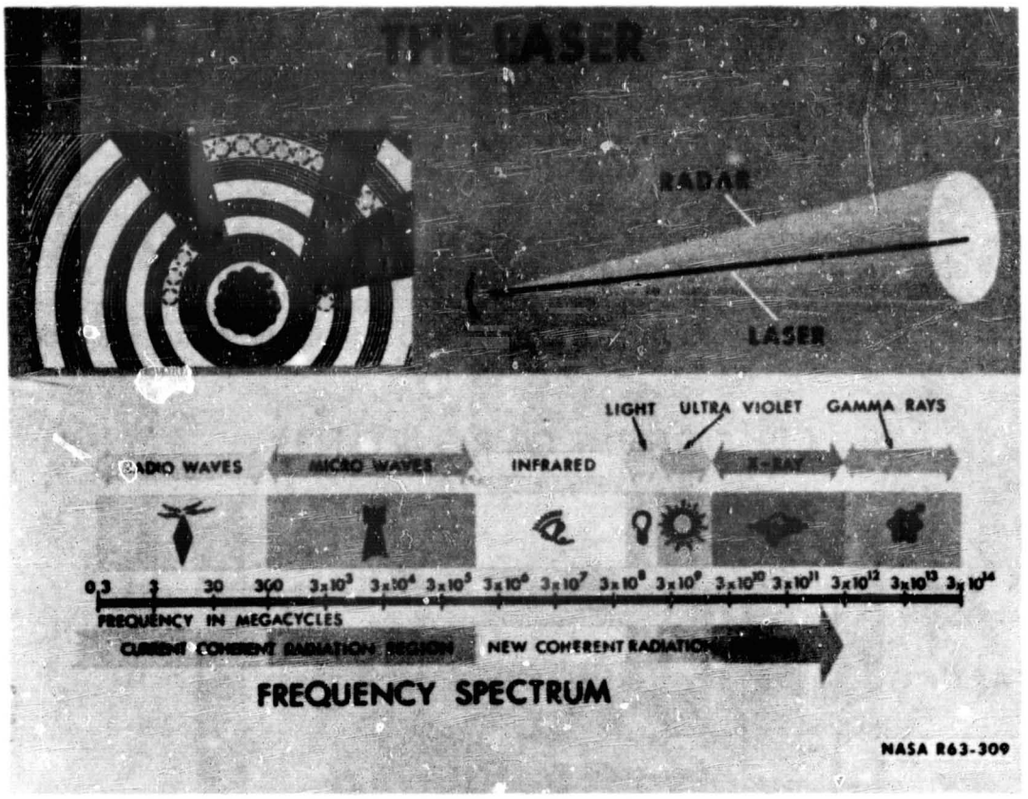

FIGURE 138

physical principles which involve complicated atomic and molecular processes.

One form of the laser consists of a ruby rod which is excited with light from an intense flash lamp and then the laser emits a narrow pencil beam of a special kind of infrared light with the physical term "coherent." Coherent means that the light waves are all of the same frequency and in phase. The sketch on the upper left shows an atom in which electrons in certain concentric shells called energy levels are excited by green light and jump to higher energy levels or shells. After a certain time period, they can be stimulated to return to their original energy levels at the same time and in phase with one another, releasing energy in the form of coherent infrared light. The narrowness of the laser beam is one of its outstanding characteristics and is graphically compared in the upper right of figure 138 with the beam from a high-resolution radar. The radar beam spreads very quickly but the laser beam, which is about 1,000 times narrower, keeps its sharp, pencil form for great distances, thus losing little of energy. This permits high resolution and fine detail for ranging or mapping of terrain.

In the NASA program, considerable emphasis is being placed on laser research at universities such as Stanford and MIT with scientists who have been chiefly responsible for the birth and development of laser concept. This research is devoted to achieving higher power, greater frequency purity and stability, and improve modulation, amplification, and detection of laser radiation.

The interaction of charged particles with electromagnetic fields led our electrophysics researchers from the laboratory investigations to

the explanation of particular phenomena of space. Figure 139 shows the nearby magnetic field of the Earth and its magnetosphere which is defined as the boundary line of the Earth's magnetic field (about 40,000 to 60,000 miles from the Earth). Satellite data, such as from Pioneer V, taken near the magnetosphere have revealed heretofore puzzling variations in the strength of the magnetic field. Scientists of the Ames Research Center studying these data have recently deduced a theory which adequately describes the interference of a solar "wind" (a stream of ionized gas from the Sun) with the magnetic field of the Earth and thus offers an explanation for the observed variations of the phenomena. The correlation was accomplished by analytically

FIGURE 139

establishing a simplified model of the physical environment, that is, a magnetic piston moving through a region containing electrons and protons. Such similarity studies, theoretically and experimentally, conducted in the laboratories under correct observation of similarity rules, promote the basis for our understanding and further exploration of the universe.

MATERIALS

Materials research is concerned with understanding the internal structure and fundamental principles governing the behavior of matter, predominantly in the solid state, when subjected to various environmental conditions such as stress and vibration, high or low temperatures, corrosive and oxidizing atmospheres, vacuum, and

electromagnetic and particle radiation. The objective is to obtain superior materials for the wide and ever growing multitude of NASA needs. The basic aspects of this effort are the concern of the solid-state physicist. By knowing the forces holding atoms in place, he can calculate a theoretical strength for any material. We know that the strength actually achieved by most metals is only a small fraction of the calculated value and we hypothesize that the difference is caused by defects in the crystalline structure. A large part of our work then reduces to a study of the types of defects in matter and how they can be controlled and eliminated.

The upperline on figure 140 indicates the theoretically attainable strength of a given material. In practice, however, only a few

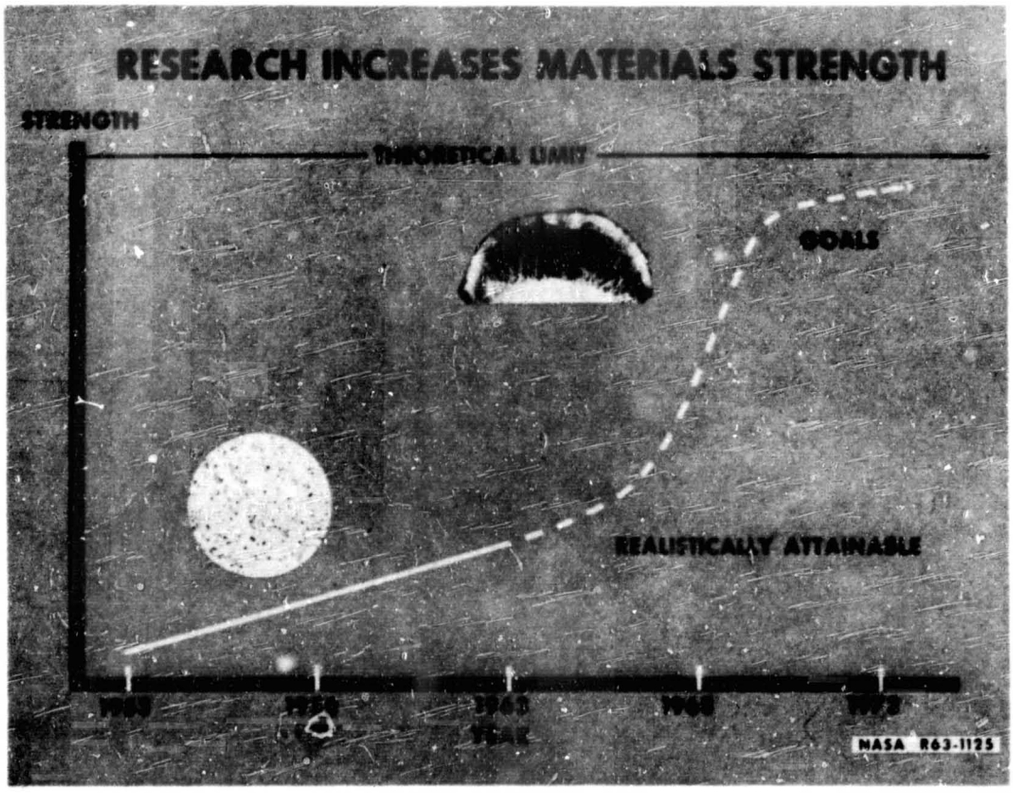

FIGURE 140

isolated perfect crystals in the very fine whisker form shown in the upper insert have come near these strengths (a million pounds per square inch or higher). The materials we use in our space vehicles have improved in strength—mostly empirically—over the years but are still far below the theoretical strength. We have found that defects in the crystal lattice (some of which are dislocations), lack of proper alinement between crystals, and other imperfections exist in our common materials. Some of these are shown as dark spots in the lower insert. By studies of such defects, we hope to learn how the theoretical strengths may be achieved or at least approached.

Since atomic configurations are too small for optical resolution by existing exploratory techniques, advanced-research tools are necessary to study defect-interaction phenomena. The field ion emission micro-

scope, a new tool which displays individual atoms on a fluorescent screen, promises to give us direct information on atom-atom interactions which we can only infer at present. Figure 141 shows the pattern of atoms as seen by such a device. NASA is participating in the exploitation of this significant advance in microscopy. One of the many investigations in this direction is concerned with the influence of particle radiation on the generation of the defects, the dislocations, et cetera. Results from these studies will immediately contribute to solutions of the radiation-damage problem in actual space vehicles.

The materials-research program is, to a large degree, directly useful to actual hardware programs. Designers need data on materials for

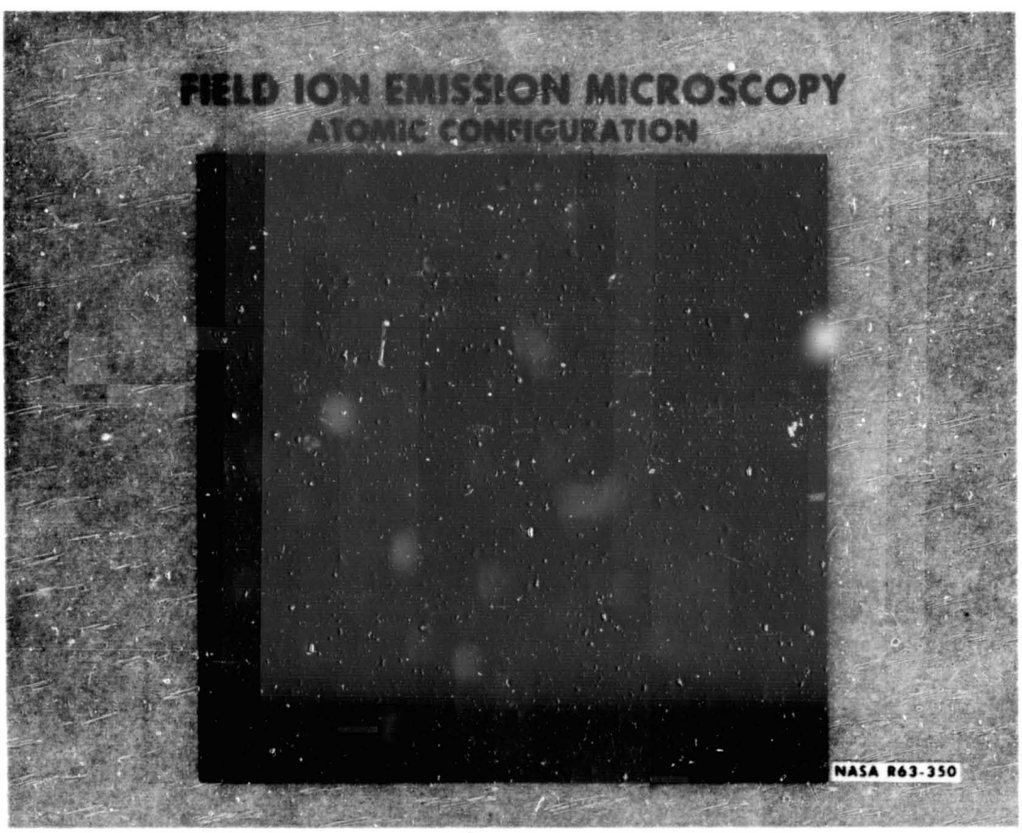

FIGURE 141

immediate use. The following examples are taken from this more applied work which is carried out on metals, ceramics, polymers, and lubricants.

In the case of metals, our major effort is in the area of alloys for very high temperatures. A few years ago, materials research was concentrated in the area of alloys for the engines of military aircraft (at temperatures up to about 1,600° F.). The operating temperatures of these components are now the "cool" end of the temperature problems facing us in space vehicle and space powerplant development.

As one specific example, I might mention the components of a nuclear rocket which could be exposed to a 3,500° to 4,000° Fahrenheit propellant gas.

Only metals and their alloys have sufficient ductility for some components subjected to thermal cycling and stressing. Strength require-

ments at these temperatures are still beyond the capability of present alloys.

Figure 142 shows the considerable accomplishments we have achieved to date with our research and where we expect to be in a few years. Further advances will need considerable effort. Precipitation hardening, the strengthening mechanism which has been so useful in developing our current jet-engine alloys, is ineffective when the alloy is to be used near its melting point. Other approaches must be explored.

The metals which look promising for this research are refractory: difficult to prepare, melt, fabricate, and evaluate. They are also ex-

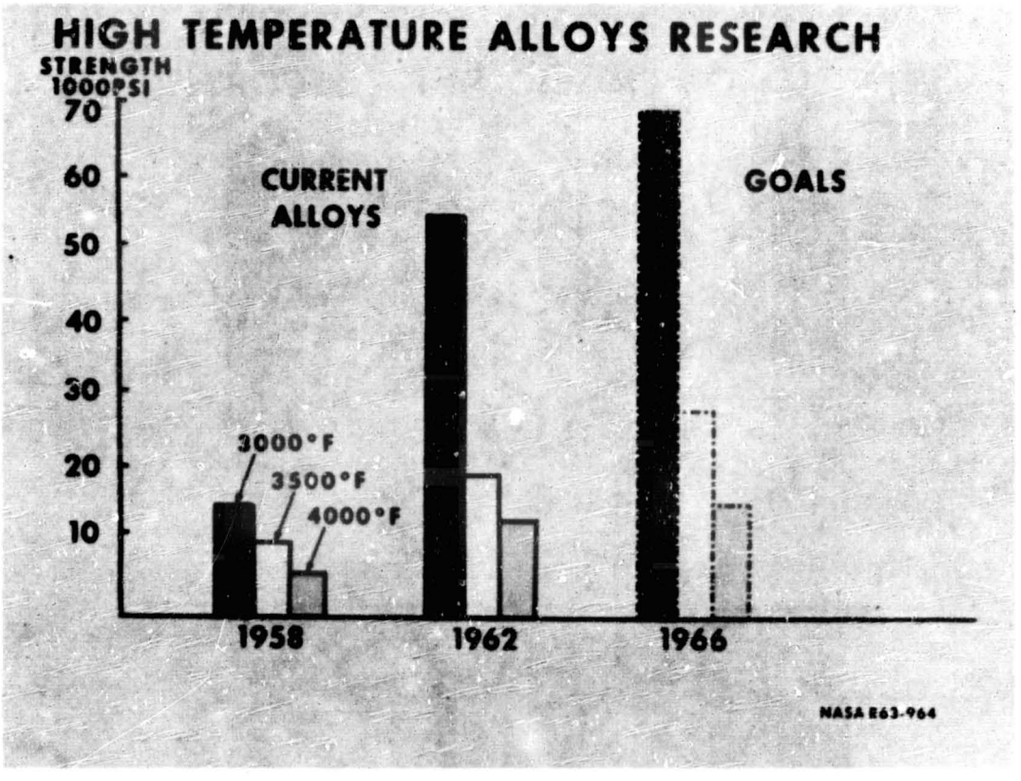

FIGURE 142

pensive. The cost of each research project is accordingly much higher than with steel or aluminum, for example. Yet these materials are urgently needed and will be used as fast as we can get them.

One new area of metallurgy is the use of metal foils as structural materials. We currently use metal foils (metals in thicknesses less than 0.005 inch) as vapor barrier materials in packaging and housing. They are primarily used for this application because they are impervious to moisture and chemically stable. They are not required to carry any load.

In the never-ending effort to make our aerospace structures both lighter and stronger, there are many ways we might be able to use alloys in foil form to advantage. Such metal foils differ greatly in properties from those of the bulk material and these properties must be explored. Also, a whole new technology of producing, forming,

and joining these materials must be developed. Figure 143 shows some of these possible applications and the associated problems.

Some space structures, such as collectors of solar radiation in space, as shown on the left, must be large, light, and rigid. If we had foil of a stiff metal such as beryllium, which has by far the best combination of the latter two characteristics, we might be able to design and fabricate the best possible solar reflector. Unfortunately, we cannot now make satisfactory beryllium-foil components. We first need basic advances in our understanding of the nature and behaviors of beryllium before we can.

The second example, in the center, shows the use of a metallic honeycomb to make strong, stiff panels that resist the vibrational and ther-

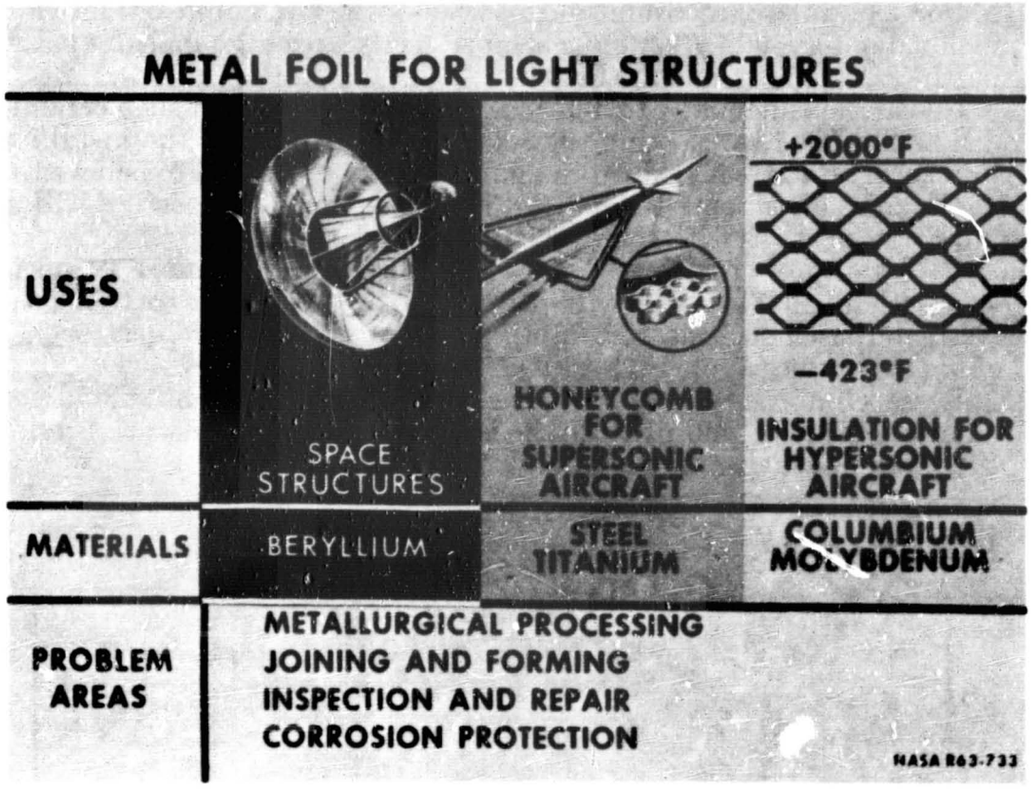

FIGURE 143

mal-fatigue stresses of such aircraft as the commercial supersonic transport that is now fast approaching the stage where preliminary designs are being considered.

Before we can use such honeycomb materials that will satisfy the severe and inflexible requirements for safety and economy of commercial transport aircraft, we need more basic knowledge and understanding of these materials. This basic knowledge is essential to the development of cheaper and more reliable foil honeycomb.

The third example shown on the right is an insulating structural material for a hypersonic vehicle that must operate in the atmosphere. Since the aerodynamic heating will raise the surface temperature to 2,000° F. or greater, and since the fuel must be liquid hydrogen at −423° F., it is clear that we need a very good and lightweight insulator.

One possible approach to this very difficult and critical problem is the placement of many layers of a refractory metal foil between the hot and cold sides of the large, tanklike structure. Unfortunately, we cannot do this today. First, we must learn more about how to control the properties of the foil alloy, and how to protect it on the one side from reactions with the atmosphere at these very high temperatures and on the other side from brittleness when it is in contact with low-temperature propellants.

Another aspect of materials research, which shows promise to solve many of the high-temperature problems of space flight, is the refinement and understanding of the old empirical science of ceramics. Generally speaking, refractory ceramics are compounds of a large metal atom and a small nonmetal atom.

For example, zirconium and oxygen form zirconium oxide which melts about about 4,700° F. Such materials have high melting points, hardness, strength, and are brittle.

Research is underway to determine if the properties of such ceramics can be modified by varying the relative proportions of the metal and nonmetal atoms. As shown in figure 144 there is reason to believe that by having fewer small nonmetallic atoms, some properties will be improved perhaps with some sacrifice of strength.

It is also conceivable in some cases that relatively more nonmetal atoms than metal atoms will provide improvement in certain other characteristics such as sinterability (firing a molded object such as china to produce a coherent solid).

Research in the effects of varying the proportions of metal and nonmetal atoms may well provide the knowledge to allow materials scientists to compose specific compounds for special tasks.

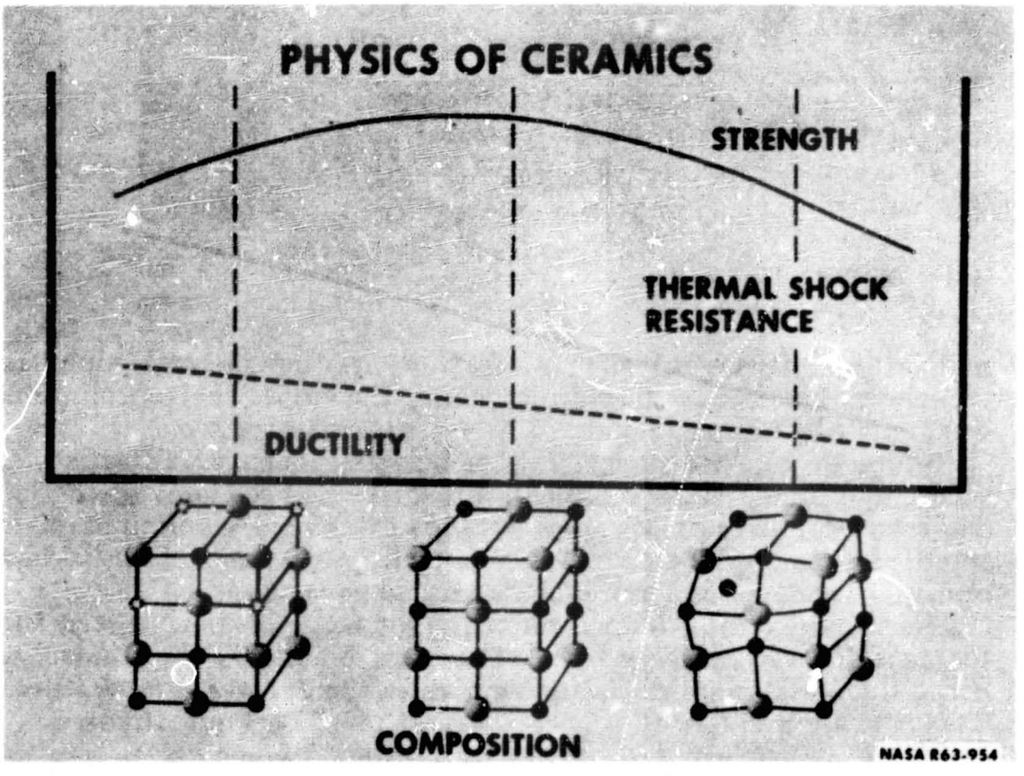

FIGURE 144

A recent trend in ceramics research is to deviate from studies of high-density materials to the exploration of ceramics for inclusion in composites and for use in the loosely packed condition. This trend has resulted in a manifold increase in the utilization of ceramics.

Figure 145 shows some of the forms of ceramics which are emerging for application to aerospace vehicles. Refractory ceramic composites, capable of withstanding the high temperatures and stress of reentry, will enable spacecraft to safely enter the earth's atmosphere. High-temperature, low-density ceramic wool will insulate the crew members.

The refractory metal leading edges of these wings will have thin ceramic coatings capable of protecting them from oxidation and, at the same time, bend as the structure flexes. The structure will also be reinforced with refractory ceramic foams. Ceramic fibers in filamentary form or in yarn, tape, or cloth will be used for pressure-resistant vessels such as these fuel tanks.

Research is currently underway on how to use these forms of ceramics for reinforcing structural metals to increase their operating temperature. Through research on new and novel ways to form ceramics we will be able to take advantage of the desirable characteristics of brittle materials while avoiding the undesirable properties.

Ceramics are also proving to be useful as highly stable coatings which may have the quality of controlling the internal temperature of spacecraft as they pass from sunlight to shadow.

The temperature for these space vehicles must be controlled within relatively narrow limits to insure comfort for astronauts and maximum operating efficiency for equipment. Coatings of metals, ceramics, and polymers are widely used for these purposes in spacecraft.

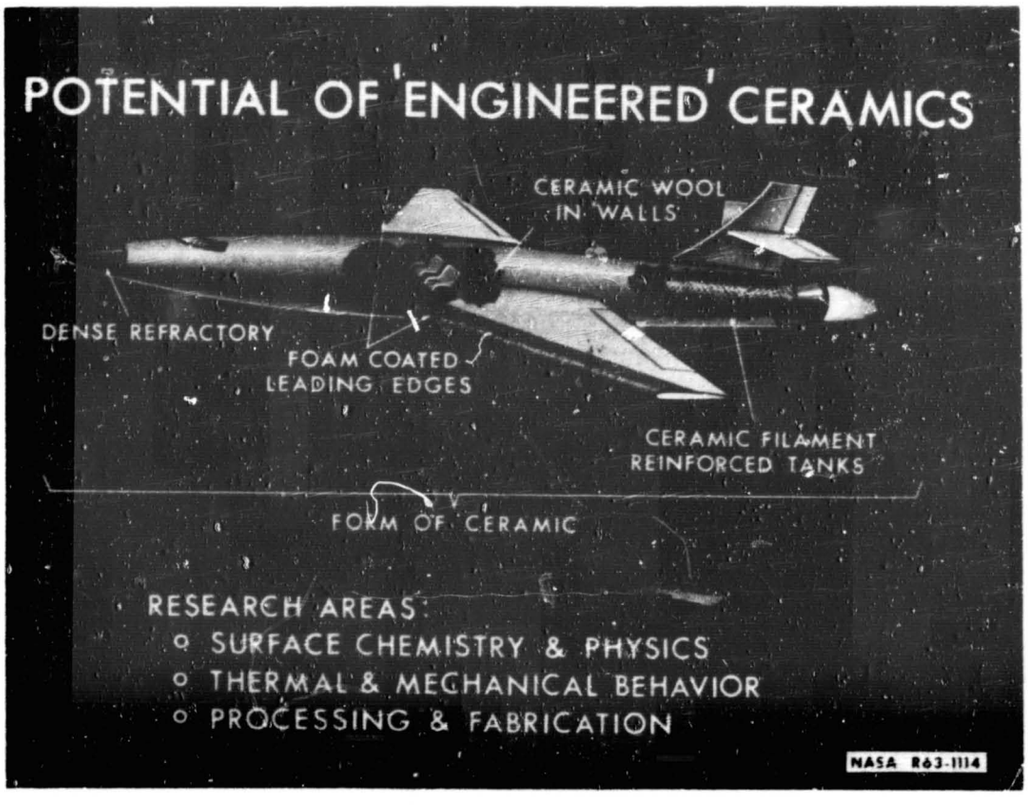

FIGURE 145

To do the proper job, the coating selection must be based on how much light or energy it absorbs, how much heat it can radiate away from the spacecraft, and at the some time it must be stable, for long periods, in the space environment. The ratio of the absorbing and radiating (or emitting) qualities of the coatings determines the internal temperature.

As figure 146 indicates, currently available coatings are generally satisfactory for today's space mission. Some future spacecraft, however, Apollo for example, will require coatings which are beyond the limits of our current capabilities. The requirements of these new coatings create extremely difficult goals.

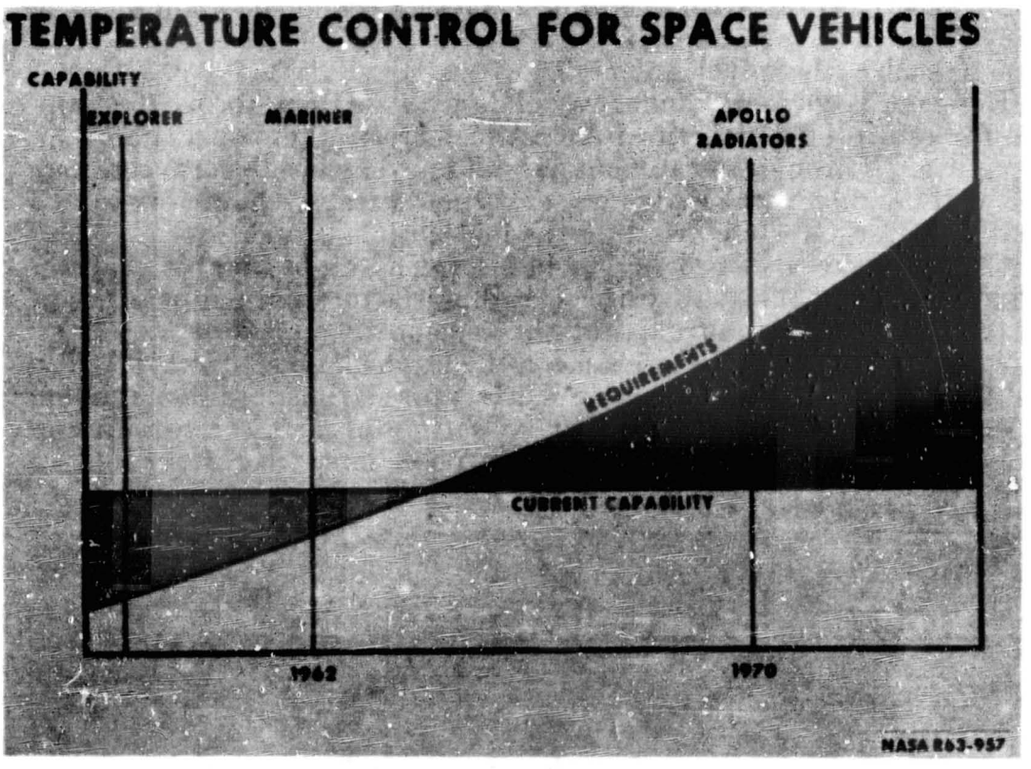

FIGURE 146

Research is presently underway to determine the behavior of new materials and coating compositions when exposed to the solar energies and the space environment. This research should lead to the development of required temperature-control coatings.

Figure 147 illustrates the operation of an automatic temperature-control coating. When the satellite with an existing coating is exposed to the sun, more energy is absorbed than is rejected and the temperature rises. With the automatic coating, the reflectance would increase and the space vehicle would remain comfortably cool.

On the other hand, when the vehicle without the automatic-control coating is shaded from the sun, it is rejecting more heat than it is receiving and its temperature falls. With an automatic-control coating, the characteristics change preventing the rejection of heat and the temperature remains relatively stable.

This research effort will have numerous beneficial applications other than to spacecraft. It can be applied to houses or other enclosures

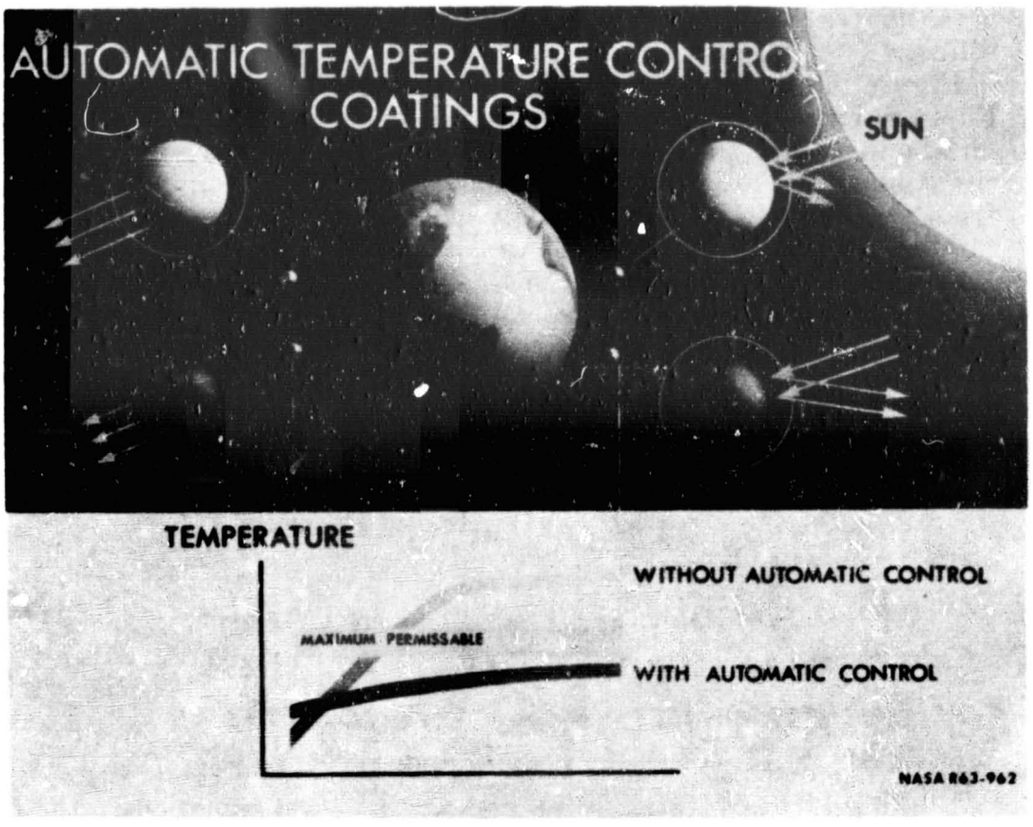

FIGURE 147

placed upon the moon or any other place in space where heat transfer primarily occurs by the process of radiation. On the earth, roof coverings for buildings, paints for exterior walls, and coatings for windows can be expected to produce substantial gains in heating and air-conditioning efficiency.

A very important area in materials research is polymers. There are many natural polymers, natural rubber, wood, wool, and animal tissues, to name a few.

Polymers which show great potential are those synthesized to produce properties superior to those of natural polymers and in many cases superior to metals and ceramics as well.

For example, natural rubber makes a good automobile tire; but, as you know, synthetic rubbers (or elastomers) can be produced with superior properties for other specific applications where oil resistance and high-temperature stability are required.

Another possible example might be in tire cord where the reinforcement has progressed from cotton to rayon to nylon resulting in much stronger synthetic materials with less bulk and less heat build-up in the tire.

Polymers are high-molecular-weight materials which we can visualize as consisting of long, chainlike molecules which, although synthesized relatively recently, have found many applications in our economy. These materials are proving necessary to our exploration of space as seals and sealants, inflatable structures, coatings, fibers, lubricants, and adhesives; to name a few of their uses. Polymers

actually represent broad classes of materials from liquids to rigid solids.

Figure 148 shows that, at normal temperatures and, in general, in an Earth environment, we have many polymers capable of performing satisfactorily for numerous requirements. In space applications the environment is much more rigorous, ranging in temperature alone from extremely hot to extremely cold. As we deviate from the familiar Earth environment, we have fewer and fewer polymers capable of meeting the requirements.

For example, polymers are available for use up to temperatures around 500° F. and current research suggests that 1,000° F. is conceivable; however, the future needs may require 2,500° F.

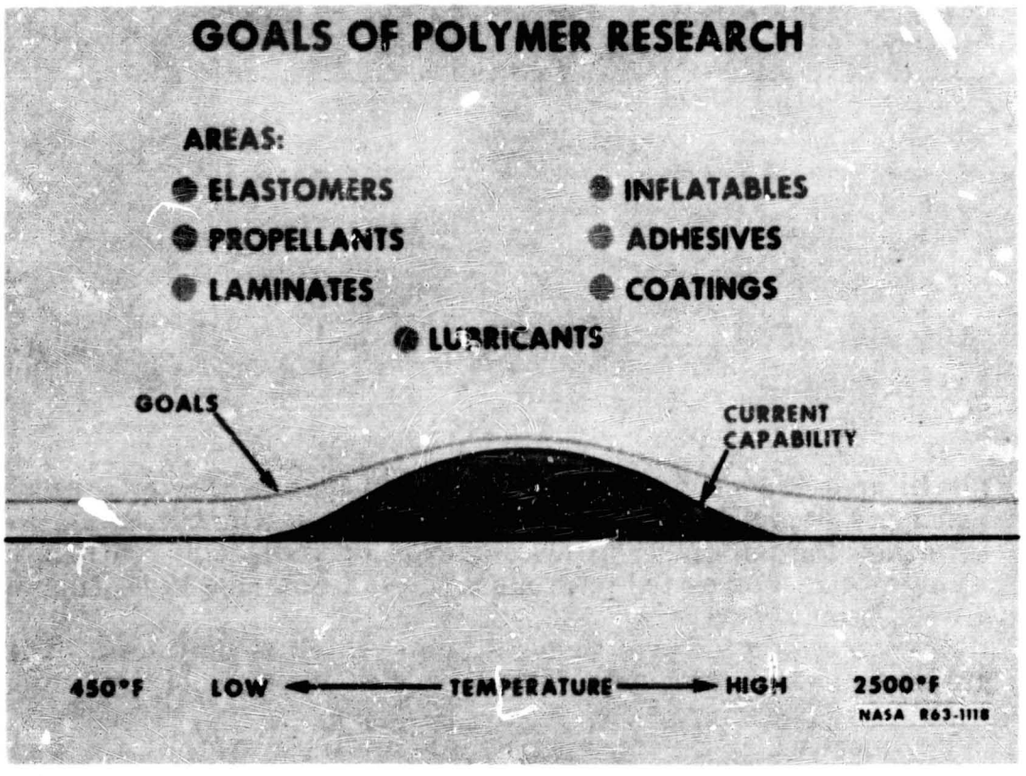

FIGURE 148

A similar situation exists on the other end of the temperature scale, that is, with respect to cryogenic temperatures. Of course, these new polymers must withstand all the factors of the new environment, including radiation, vacuum, and so forth, in addition to the thermal requirements.

In order to obtain polymers capable of withstanding space conditions it is necessary to conduct a basic research program in the area. In order to do this successfully a Space Environment Research Facility, proposed as a fiscal year 1964 facility item for the Ames Research Center, will devote large efforts in the proposed space to basic research on polymeric behavior under the space environment.

One aspect of polymer research is the control of the chemical composition of the long, chain-like molecules and the arrangement of these chains in the material, because this determines the properties of

polymers. Polymers, which are generally composed of carbon, hydrogen, nitrogen, sulfur, and other elements, have the elements attached as closed loops or rings to their chain arrangement.

Research has shown that certain rings and certain strong bonds in the polymer chains enhance resistance to radiation and high temperature.

The usual polymer structure shown at the top of figure 149 represents random order in the chains, perhaps like a bowl of spaghetti. It can be seen that these chains can flow past one another and will easily be deformed by pressure. If we orient these chains so that they crystallize as shown on the left, or perhaps crosslink the chains as shown in

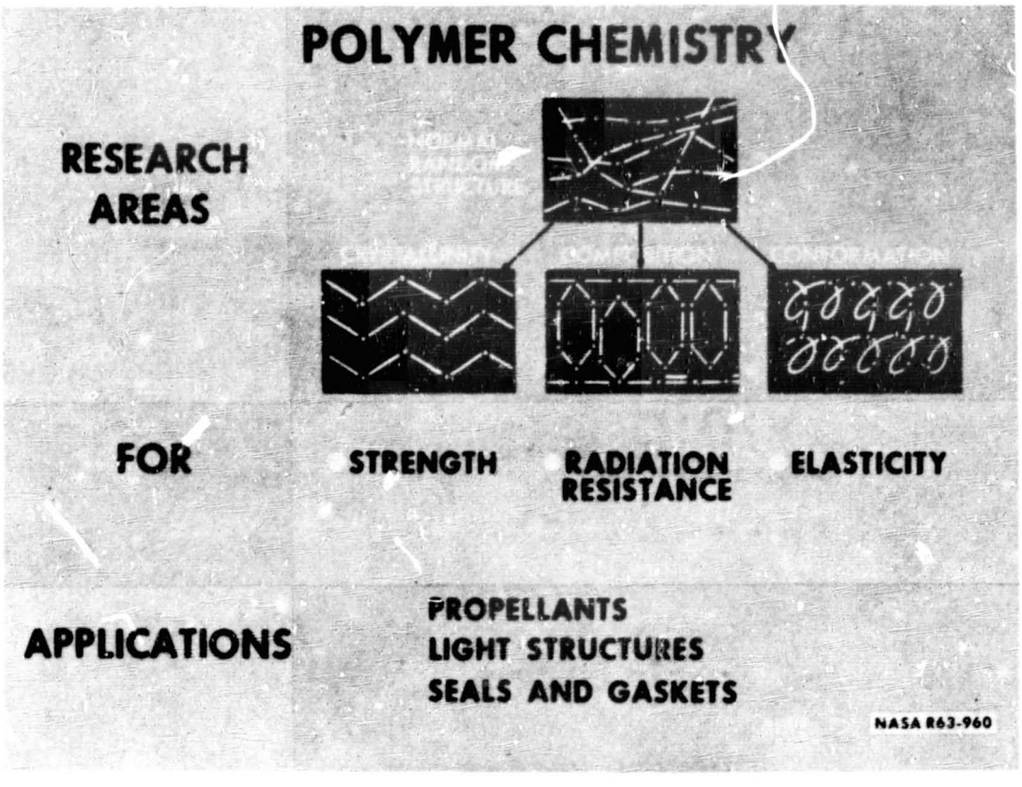

FIGURE 149

the center, the materials will resist flow and deformation. A major advantage of polymers is their elasticity. This is accomplished by a chain configuration as shown on the right, that is, coiling and crosslinking which act to make a material that springs back into shape.

The polymer scientist speaks of "tailoring" his materials to do a specific job. In other words, he synthesizes from basic elements the type of chemical and physical structures that meet a given set of requirements. In the last decade, considerable knowledge has been acquired in this respect, but the space age has advanced the requirements fantastically. Basic research in polymer chemistry is required to understand the fundamental mechanisms so that materials can be created to meet the challenge and to prevent the loss of time, money, and talent inherent in an empirical approach to provide the answers.

One significant facet of polymers is their use as bonding agents or adhesives. They have wide use in the space program for holding dif-

ferent materials together. The use of nuts, bolts, and rivets is actually impractical for many space structures and applications. For example, an inflatable structure of composite materials, such as in the Echo II communications satellite, consists of a sandwich of Mylar film between thin foils of aluminum. The aluminum must be properly bonded to the Mylar to make an integral structure. Adhesion is a primary problem in composites and meeting increasing strength requirements will, in a large part, be dependent upon the effectiveness of the bonding agent. The adhesives with which we are concerned are polymers which are generally applied as liquids to the materials to be bonded. The attachment of the polymer molecules to the surface to be bonded is of utmost importance. Figure 150 shows diagrammati-

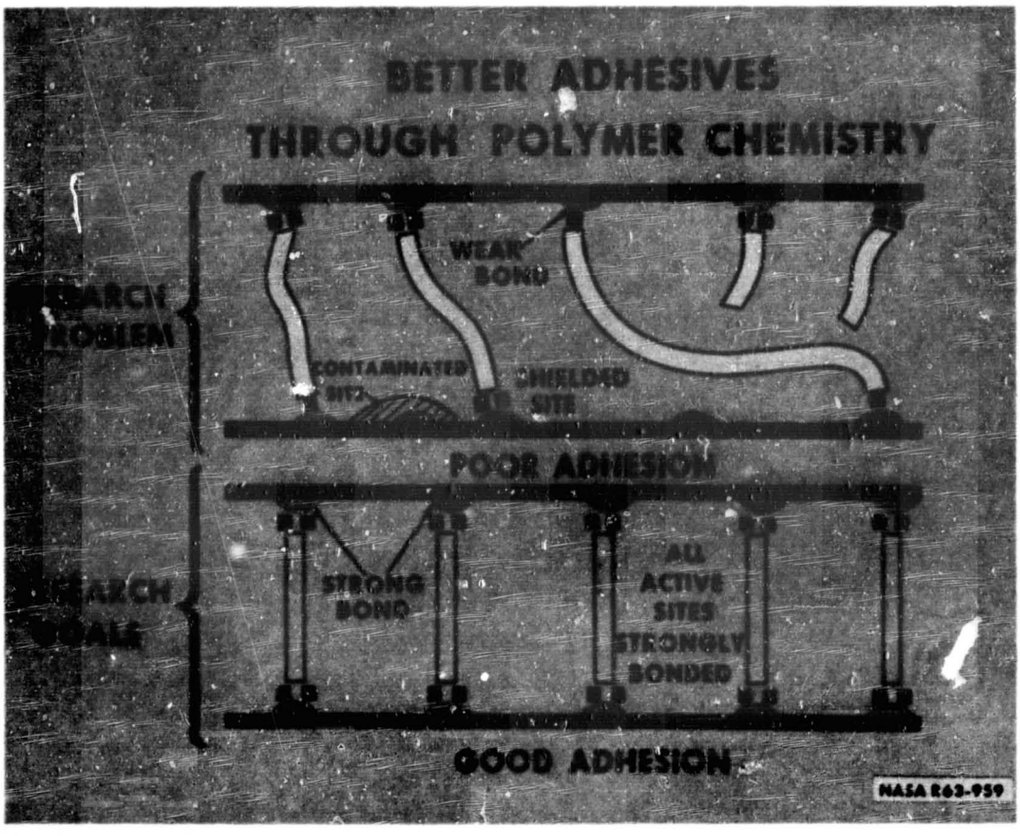

FIGURE 150

cally, polymer molecules attaching to a surface. The upper sketch shows poor adhesion caused by weak bonds, contamination, and shielding of potential bonding sites. The lower sketch shows, in an idealized way, how an improved adhesive would look by the elimination of these weak links. The actual conformation of these polymer chains and the types of interactions occurring at the surface are subjects of research. Maximum adhesion may very well be obtained when the maximum number of sites are occupied by strong bonds. Basic research is imperative to identify and understand the surface affinities, interactions between the adhesive and the material to be bonded, and the optimum conditions for maximum adhesion.

We now go from the concept of holding things together to the concept of permitting things to move relative to each other with

minimum friction. "The squeaky wheel gets the oil" is not applicable in space. In the vacuum of space, rubbing surfaces which are not properly lubricated will weld together very readily and quickly. Lubrication depends not only on the presence of oil or other lubricants but also on the existence of contaminating surface films on the adjacent surfaces. These films serve to protect the rubbing surfaces from each other and also to help in the adsorption of lubricants and their retention upon the surfaces.

In the vacuum of space, not only are our lubricants likely to evaporate but the natural coatings themselves may evaporate. We must therefore consider the possibility of applying artificial solid films which adhere to the surfaces and also exhibit considerable resistance to evaporation. Such solid lubricants could have application for mechanisms in inaccessible locations. These include control-surface bearings embedded in aircraft and spacecraft structures and bearings for satellites or space vehicles which much of necessity operate in a vacuum environment, completely inaccessible during their lifetime.

It is with such applications in mind that NASA began the study of the chemistry, physics, and lubrication capacity of dry-film lubricants several years ago. These materials must be stable in the environment, must provide surface protection, must adhere to surfaces, and should preferably have low shear strength so that layers slide one upon the other readily. It has been found that a layered structure of materials frequently is helpful in providing a good lubricant. It is not sufficient to find a material which, as a powder, slides readily. We must find out under which conditions it does or does not lubricate. Graphite, which we all know as a good solid lubricant, is not satisfactory for use in space. Graphite depends for its lubricating properties upon the existence of an adsorbed layer of oxygen or water. In space, oxygen and water evaporate, and graphite no longer lubricates. Figure 151 shows the progress of our research. Graphite, which is not shown, roughly overlaps in temperature capability the molybdenum disulphide area shown at the left. The lead-oxide ceramic is a NASA development which is now commercially available. Notice how we have improved our temperature capability for this material. We had to learn what the conditions of adherence for the lead-oxide ceramic were. We found that it was necessary to add materials to make the lead oxide more plastic so it would slide more readily and found it necessary in some instances to add special oxides to promote adherence to some surfaces.

A few years ago, we decided to go ahead and investigate other possible high-temperature ceramics. Calcium fluoride appears to be one of the most promising solid lubricants. Very recent studies also show promise of effective boundary lubrication in liquid metals (used in space power systems). Examination of the crystal structure alone is not sufficient proof of whether or not a material will be a good dry-film lubricant: we have to adjust the composition. Some materials just will not lubricate despite the theoretical advantages of the structure; we are studying why this is so. We are studying means of bringing our temperature capability up; we hope to be able to run bearings for useful periods of time at 2,200° F. in a few years. We are rapidly approaching the time when the limitation in the high-temperature bearings field will not be the lubricant but the material it is supposed to lubricate.

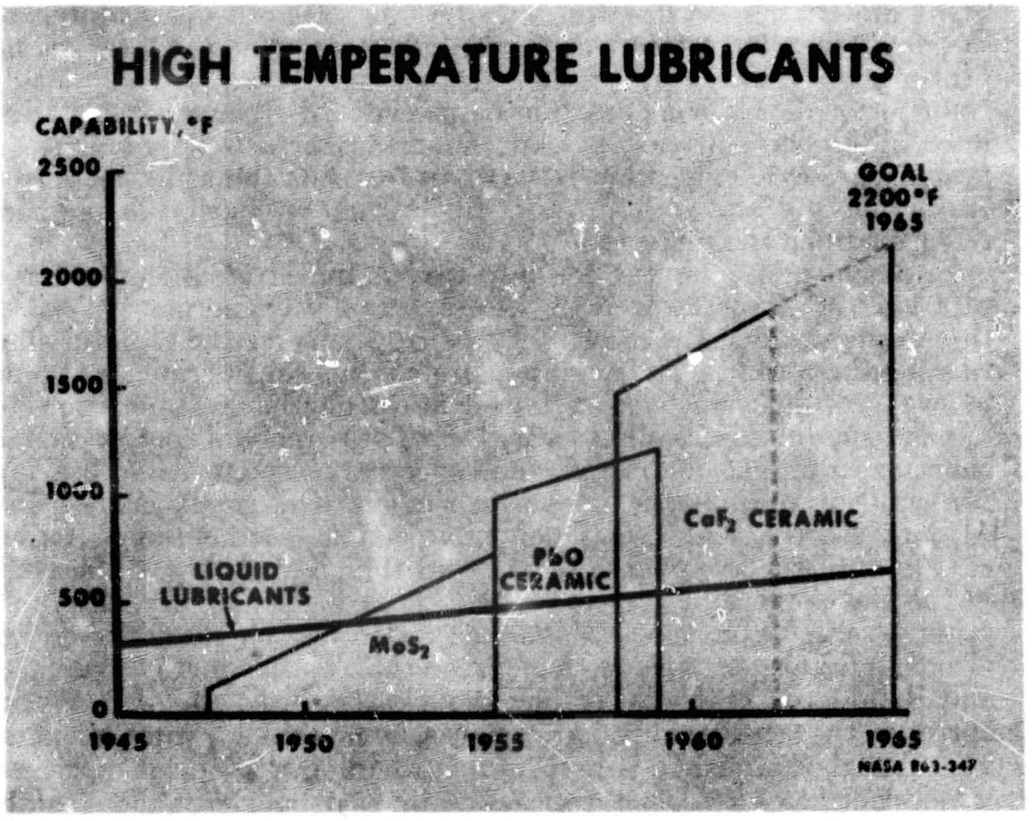

FIGURE 151

With the better understanding of the behavior of the materials we can satisfy the variety of special requirements which grows continuously. A decade ago we could ignore many materials properties which, in today's vehicles, are vital properties. For example, the creep strength, that is, the resistance of a material to stretch under load at elevated temperatures, is of no importance in modern subsonic transport planes, because the structure does not become hot. But the supersonic transport will have to operate at temperatures as high as 650° F., so we must use a material that will not creep. Consequently, the material has a new requirement which must be satisfied. This example could be multiplied many times, for as our vehicles increase in speed, range, and complexity, many new requirements and restraints arise. Figure 152 shows how, in the past decade, the number of properties that are significant is increasing.

A special area of concern to material researchers is that of fatigue. Although fatigue resistance has been investigated for many years, we know very little about its mechanisms and the fatigue properties of materials in the space environment. To advance the knowledge in this direction the Langley Research Center, active in fatigue research for many years, has proposed a fiscal year 1964 facility item, the Fatigue Research Laboratory.

The scope of this report does not permit me to add more examples of our materials-research activity which reaches practically into all fields of the physical sciences and technology.

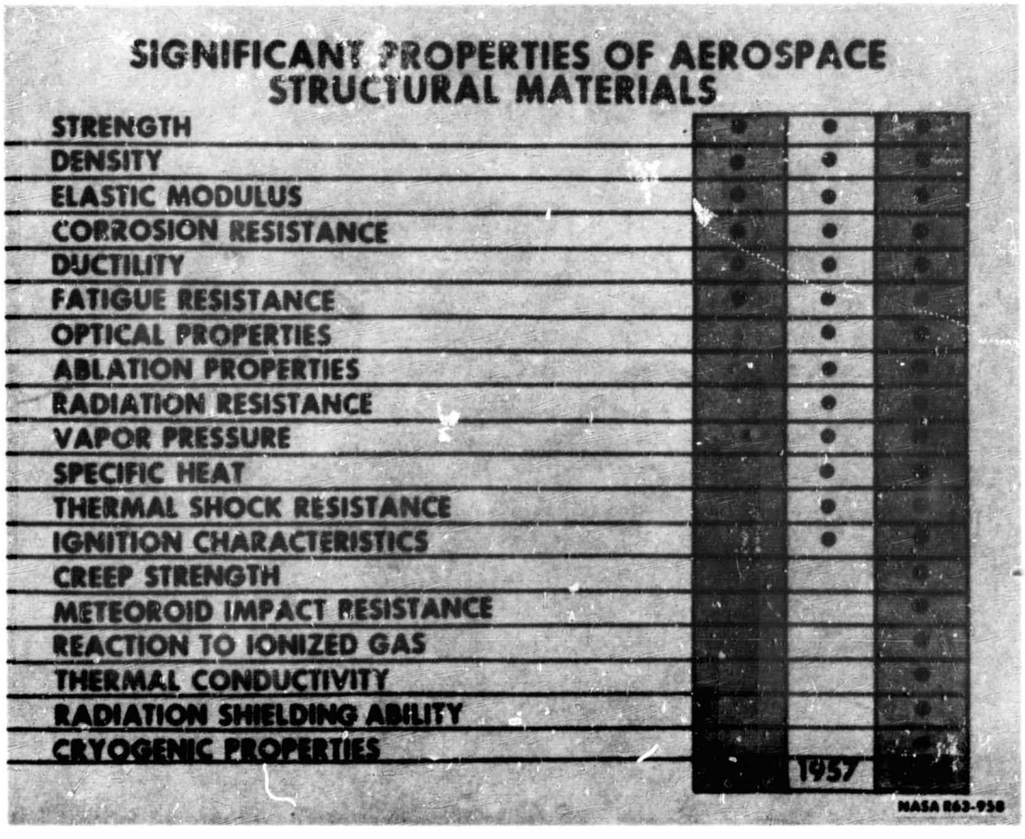

FIGURE 152

APPLIED MATHEMATICS

A physical problem can be considered satisfactorily solved if it is possible to describe and explain it in mathematical terms. The goal of the research program in applied mathematics is, therefore, to solve mathematically the complex problems which appear in the investigation of natural processes. For this purpose, it develops new mathematical techniques and applies new principles of calculation. Figure 153 shows how applied mathematics contributes to the advancement of research and technology—

(1) By predicting results of interests from possible experiments;

(2) By discovering shortcuts in technical designs; and

(3) By theoretical discussion of optimum designs and experiments which yields maximum results at minimum expense.

Such mathematical investigations can provide information (especially on expected conditions in outer space) which by direct experimentation would be impossible or prohibitively expensive to attain.

Typical types of applied mathematics oriented with respect to NASA's leading problems are:

(*a*) Gravitational and orbital mathematics, that is new methods for predicting and discussing the motions of rockets and spacecraft under gravitational forces.

(*b*) Tracking and data processing mathematics, including numerical analysis and digital computer applications for obtain-

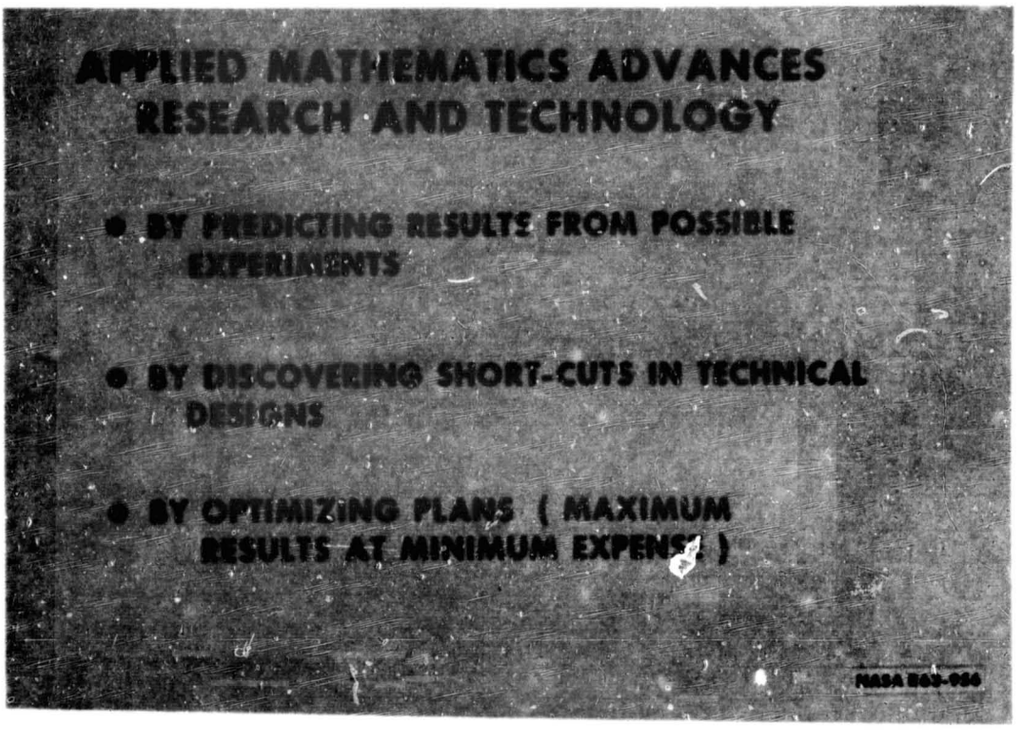

FIGURE 153

ing the fastest as well as most precise and convenient handling of the tremendous amounts of data continually being received from space vehicles, and to reduce it all to simple but scientifically sound summaries.

For instance, in order to plan and program the recently successful Mariner II probe to the planet Venus, the Jet Propulsion Laboratory had to solve such problems as shown in figure 154.

(1) Accurate calculation of trajectories by special perturbation methods. This was carried out as an application of one of the basic processes of numerical analysis to celestial mechanics.

(2) Devising mathematical techniques for obtaining position and velocity ephemerides of Venus and the Earth-Moon system over a 10-year arc, from July 1960 to July 1970. These results made possible the 1961 and 1962 Jet Propulsion Laboratory radar measurements of the distance to Venus, and design of the present Mariner II project, and will provide the foundations for future plans.

(3) Using the computer to improve classical theories for getting general perturbation solutions for motions of planets, their satellites, and spacecrafts. The bulk of labor needed for this consists of algebraic manipulation of long, double-argument Fourier series. Short cuts in this are extremely desirable, and this requires logical and algebraic operations as well as numerical operations to be specially arranged, if possible, for computer processing. Results so obtained at JPL will also make possible more successful future probes to the planet Mars and to the Moon (Project Ranger).

Another example of a significant contribution by applied mathematics is a recent NASA investigation of what possible orbits of a satellite would be stable so that it would circumnavigate the moon many times in a path close enough to be useful and also pass close

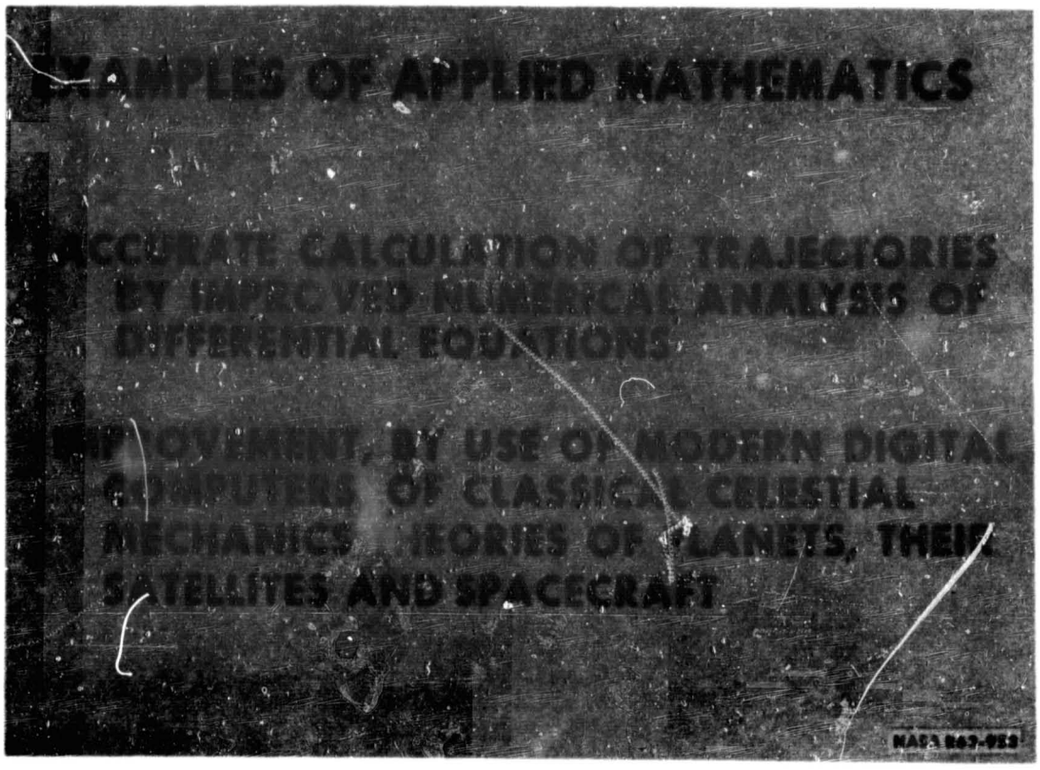

FIGURE 154

to earth for telemetry. This problem is complicated by the fact that such a satellite will be strongly pulled by the Moon's gravitational forces at each encounter.

By special application of numercial analysis to this three-body problem of celestial mechanics in which gravitational forces of both Earth and Moon are taken into account simultaneously, the various orbits followed by a satellite launched in different ways has been traced out over many revolutions.

Thus it has been found that a satellite travelling around the Earth in the same direction as the Moon would be so strongly perturbed at each encounter with the Moon that after four or five encounters it would get too far out of synchronization to be useful.

On the other hand, as shown in figure 155, a satellite traveling in a direction opposite to that of the Moon would suffer gravitational disturbances of much shorter duration so that the path would be relatively unchanged by the Moon's gravitational field. Thus, such a retrograde orbit has been shown to be substantially unchanged after a year of encounters, and what changes there are would actually contribute to the chances of its having many years of useful life, during which, for instance, many television observations of the far side of the Moon could be obtained.

In the above examples it is really the interaction between the two disciplines, celestial mechanics, and numerical analysis, which is of most fundamental interest. Cross fertilization between these disciplines has, in the past, farthered much of modern mathematics, and even the recent special problems of NASA has already yielded significant progress in each. There is no question but that there are many

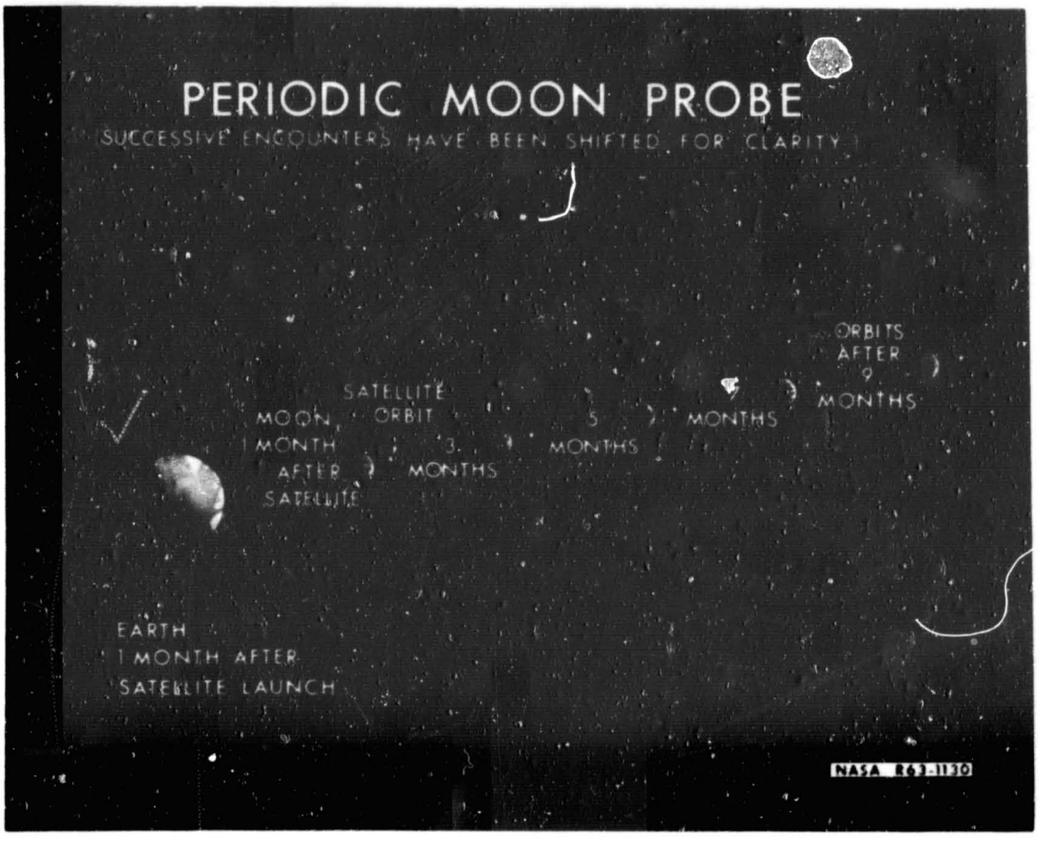

FIGURE 155

important and opportunity-filled topics for further research along these lines.

A final example will illustrate how mathematics, applied to predicting electrical and magnetic effects on the rotation of spacecraft in the magnetic fields of outerspace, may lead also to new ideas for special design of spacecraft to take advantage of these effects. Since the weightless and frictionless rotation of satellite in outer space is extremely difficult or impossible to simulate by experiment, mathematical discussion of the problem is the most feasible approach.

Any spacecraft of conducting material may be considered mathematically as being sliced into a very large number of thin rings of various shapes, depending on the cross section of the structure at the plane of slicing, as shown in figure 156. Now, if the effect of an external magnet field is known separately for each ring, the combined effects on the whole spacecraft can be calculated by application of the integral calculus to general algebraic expressions for the effect on a ring, figure 157.

Application of this mathematical technique has yielded new general expressions for magnetic slowing of rotation of spacecraft of various shapes. General formulas for such braking of rotation is experimentally known for thin rings of conducting material but the effect on large and unusual shapes can only be achieved by application of the integral calculus or numerical integration.

This mathematical approach has already been checked by its application to three or four artificial satellites actually in orbit and for

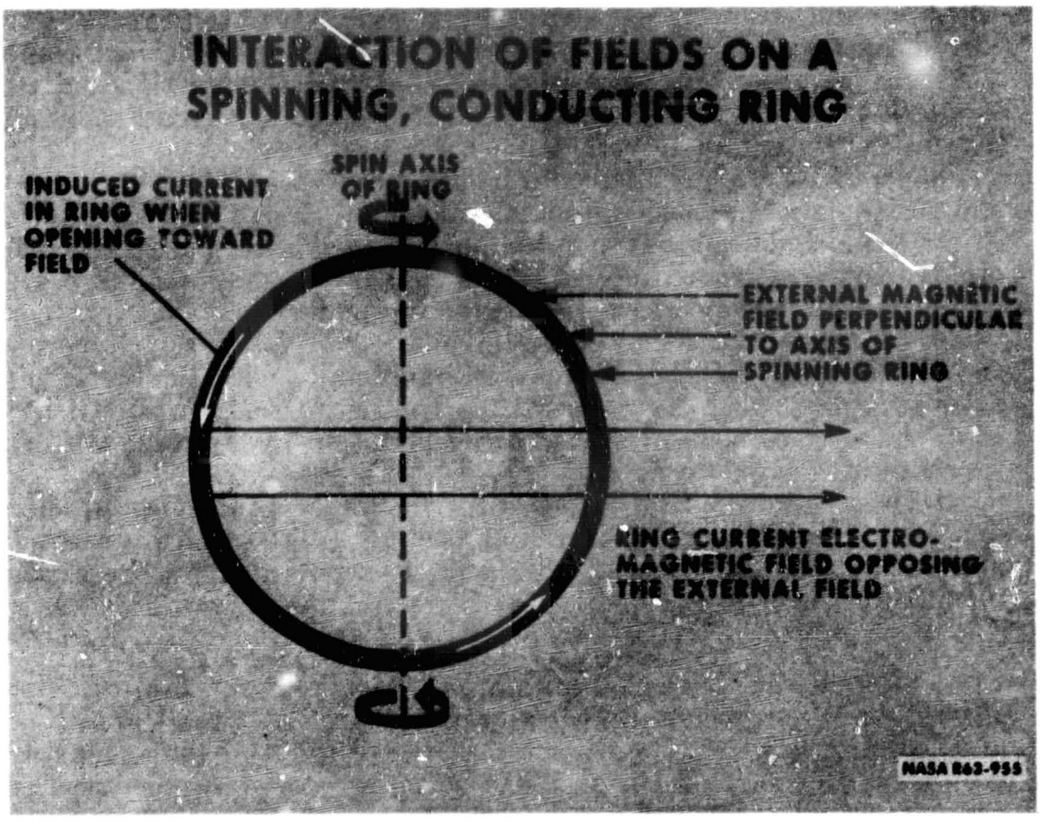

FIGURE 156

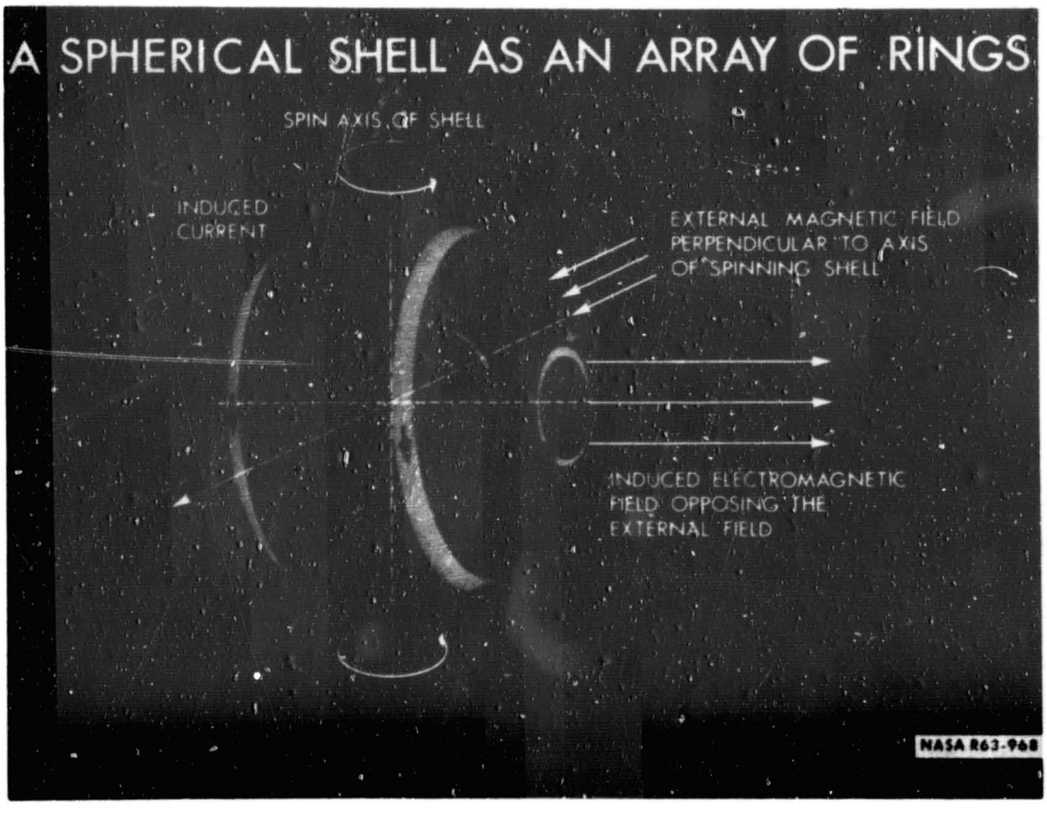

FIGURE 157

which changes of spin rates about their axes have been carefully observed by tracking stations on the ground. The numerical results show the satellites to have been affected by a magnetic field, the strength of which agrees closely with that to be expected from magnetic surveys on the Earth's surface.

Thus a spinning satellite could be used incidentally as a magnetometer. However, the most important potential use of this application of mathematics would be to principles of design of spacecraft, principles resulting from the deduced formulas for magnetic forces on odd shapes of highly magnetic conducting materials.

For instance, the formula for magnetic torque on a slender tube shows that this force would increase indefinitely with the increase of ratio of tube length to diameter, so that a tube of variable length could be used to control spacecraft orientation by reaction with the surrounding magnetic field.

In these examples and in many other ways applied mathematics has exploited physical science and technology to contribute results and predictions not so easily discovered or obtained by the experimental approach.

CONCLUSION

I hope that the above examples of our basic research program have shown you the scope and complexity of our problems and the methods and techniques we employ to solve them. While the above four disciplinary divisions of the research program are shown as separate entities, actually you could notice many concepts where two or more disciplines are intimately involved.

This interdisciplinary approach requirement is becoming the rule rather than the exception making it necessary to utilize interdisciplinary teams to solve problems. This, of course, makes it necessary for the scientific and technical personnel to become competent in the fields of science which are allied with their particular specialty.

As I stated earlier, results from basic research are the very backbone of knowledge and in our particular case, the foundation of all work leading to space exploration. Therefore, the activity in basic research must be maintained at a high degree of competence and must grow commensurately with the objectives of NASA.

Supplementary Statement of Dr. Kurzweg

BASIC RESEARCH

Dr. Kurzweg. The word "research" is used for a great variety of work within NASA's activity. Covering a wide spectrum, it reaches, on one side, far into the hardware, engineering, and technology and on the other side in to the realm of the fundamentals of the physical, mathematical, and biological sciences.

Without exploring, understanding, and mathematically formulating the phenomena in these areas, progress in the building of vehicles, in astronautics and in cosmology would be very slow indeed, that is, if our present reservoir of knowledge is not continuously replenished. We have recognized that this kind of basic research must be integrated in the overall program and vigorously pursued.

Although this basic research is not directly connected, in general, with a vehicle under design, some of the newly obtained results are rapidly absorbed by the vehicle designers, thus preventing costly technological errors in empirical approaches. Generally, the results are of benefit to research in advanced concepts for vehicle design.

I would like to outline our program briefly in the physical and mathematical sciences, ilustrated by a few examples. I would like to point out that this kind of basic research is usually expressed by scientists in equations, integrals, formulas, and quite sophisticated words. I will eliminate these and rather stress the side where potential applications to our space program can be recognized.

Basic research is carried out in the fields of general physics, in particular fluid physics, electrophysics, materials and applied mathematics. Contrary to some person's thinking, there are still plenty of serious problems connected with the motion and interaction of fluids and solid bodies.

Aerodynamic stability, transition, flow separation, wake, and noise phenomena of a space vehicle during flight in the terrestrial and other planetary atmospheres have unknowns which must be explored before vehicles, which are able to land and take off, can be designed. Figure 158 shows the results of theoretical studies and experiments on an aerodynamic stability problem in carbon dioxide-air mixtures.

As can be seen this flared body shape loses considerably its degree of aerodynamic stability in CO_2 enriched atmospheres which might lead to its tumbling unless properly controlled. The white dots are the experimental results. It is interesting to note that the probable

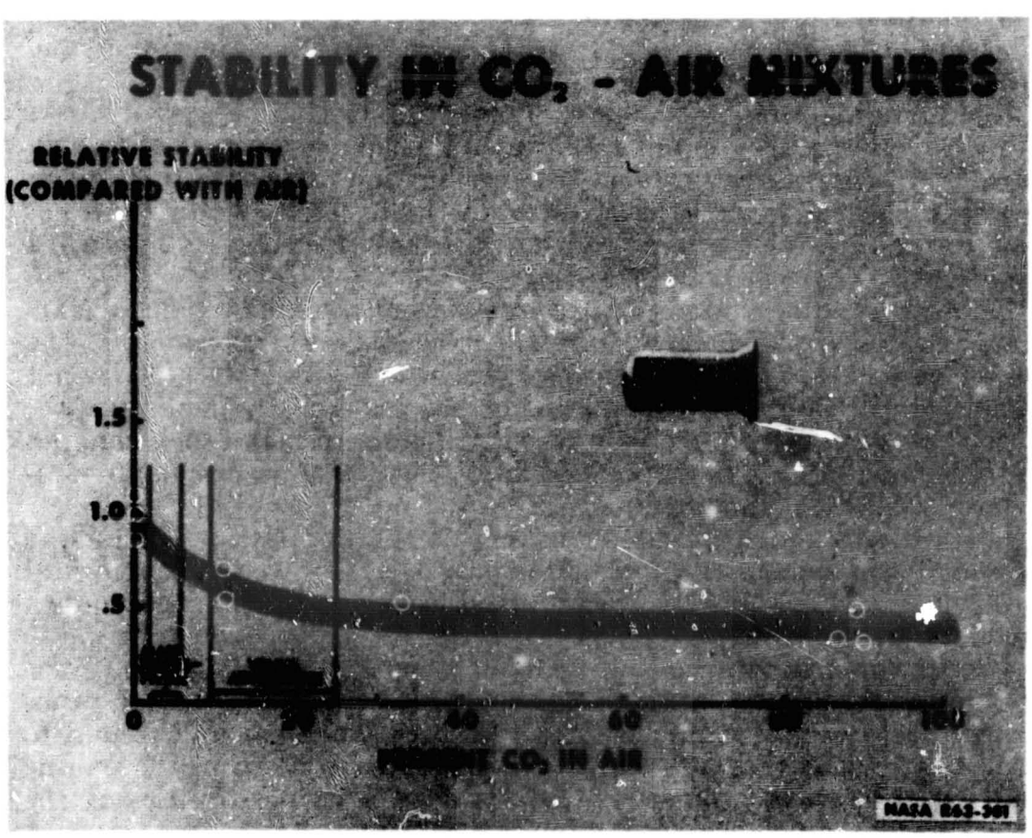

FIGURE 158

amounts of CO_2 in the Martian or Venusian atmosphere have a pronounced effect on this stability.

The high temperatures and associated heat, produced by friction and compression of the air at the ever-increasing speeds, continue to create severe difficulties with respect to heat transfer and body protection. A great deal of effort was spent on this problem. Ten years ago when these investigations were strictly on an unrelated research basis only few people knew that long range missiles or space vehicles—at that time well in the future—would run into considerable trouble unless the heat transfer problem could be solved.

Today, the designers have many useful data which determine shape and heat shields. But new problems can be seen in the future. Figure 128 (p. 1985) shows how much we don't know about the effect of heat radiation on high speed space vehicles entering CO_2 enriched atmosphere, for example, on Venus and Mars.

Experimental results from the firing range in the laboratory at the Ames Research Center are scattered in the red band on the slide which shows the present uncertainty in the prediction of the magnitude of the heat problem of the entry process into either one of the atmospheres of these planets.

Figure 127 (p. 1984) shows new typical progress in the basic exploration of the effects of thermal radiation at speeds beyond those of Moon missions which a returning space vehicle will experience during Earth-reentry. According to this chart the blunt body shape on the left for our present needs considered to be the final solution of the heat transfer problem—must be slenderized again—as indicated on the right side—in order to reduce air compression and thus keep the radiation component of the heat transfer small. The upper curve on both sides indicates the total heat rate, the area between the upper and lower curves the amount of thermal radiation.

Such a return to more slender shapes is interesting because it shows impressively the progress of thinking and the advancement of knowledge in basic research. It is interesting and amusing that cyclic changes, back and forth, between blunt and slender bodies are not new in the race for higher speeds at all times of history as figure 161 shows.

Going through history, compact rocks were replaced by slender arrows, the concept of powder guns created blunt cannonballs, the rocket age produced slender forms again which, ironically, finally got blunt noses. Now a new slenderizing process is in the making.

It is also interesting to see how long it took to make such changes empirically and how rapidly these variations have been made by following scientific principles.

We are very much in the beginning of the application of nuclear power to spacecraft engines. Many of the involved technological problems could be solved, if the involved basic phenomena were understood.

For example, again the heat transfer, this time on the inside of the engine, limits the output of a nuclear engine. The two major problems, first to get sufficient heat into the propellant gas and second to keep the heat at the very high temperatures away from the engine walls will be solved some day. But the various possibilities of the solutions need much basic study in the meantime.

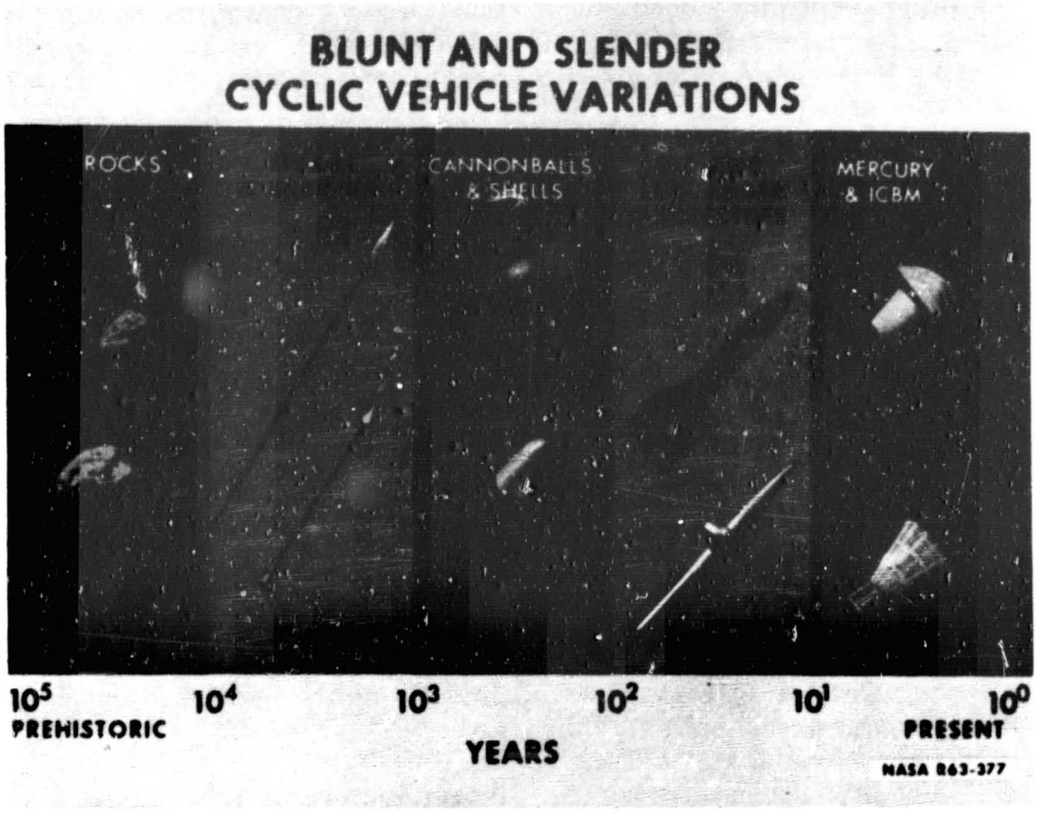

FIGURE 161

Figure 131 (p. 1989) indicates a conceivable solution by mixing particles in the hydrogen propellant. Hydrogen, in some respects is an ideal propellant but it cannot be heated by radiation. It is translucent as the atmosphere is for sun rays. Therefore, it must be heated by convection. The mixed-in particles absorb the heat radiated from the atomic reactor and transmit it to the gas by contact. At the same time they shadow the walls and keep them from being exposed to too much heat. Trial and error methods have to be used unless the basic involved phenomena are understood.

An example of our efforts in electrophysics is shown in the next slide (fig. 138, p. 1996). A few years ago, even though the structure of the atom and the internal mechanism of producing light was known, nobody knew how to force waves to emerge from a light source in an orderly fashion as radio waves do from a radio transmitter.

Such devices which we have now, so-called lasers, are a typical product of basic thinking in atomic physics. Our basic research people are quite interested in lasers, not so much what we can do with them—another group in the OART takes care of that—but to explore further the physical phenomena associated with the atomic and molecular structure of matter and to study the pertinent interactions of atoms and electrons.

In this way, we hope to find better or new ways to stimulate radiation in new substances with frequencies in the wide open spectrum. The left upper corner shows an atom with electrons orbiting at different distances from the nucleus. It is a physical fact that electrons make certain, little explained, spontaneous or stimulated jumps from

an outer orbit into a lower orbit thus releasing energy in the form of an electromagnetic wave, such as visible light, after being pushed from a lower to a higher level by a mechanical force or a light wave of suitable energy.

A control of this electron movement is achieved in the laser, resulting in unique characteristics of the emitted light beam. The uniqueness can only be explained by very basic physical concepts but its consequences are: Very stable frequency, narrow beam with very little electric losses, et cetera. I would like to draw you attention to the logarithmic frequency scale at the lower part of the slide which indicates the tremendous basic potential of the lasers for communications in a millionfold extended frequency region.

Basic work is going on in the field of superconductors which might become important in many space technology areas. Superconductors are, for example, electric wires cooled down to temperatures close to absolute zero which have no resistance and consequently no losses. The advantage for any electrical instrument and equipment is obvious, for example, to produce strong magnets with little weight, to build drift-free gyros, et cetera.

The basic phenomenon is known since half a century, the physical understanding, necessary to make practical use of it, is just in a state of promising progress. Our guiding thoughts in this research are based on questions such as:

What makes a material superconducting?

What possibilities are conceivable for increasing the magnetic flux in a material in the superconducting state? and

What are the areas where superconductors might find their way into applications?

The research program aims toward the answer of such questions.

Work on materials is quite active in NASA with a strong reliance on the work in the industrial laboratories. This area of research is usually thought of as more applied in character because materials of all kinds are needed immediately in structures for vehicle designs which are presently on the board. Therefore, a great deal of our materials work is done in connection with special projects.

Figure 143 (p. 2001), for example, shows the research on light structures made from metal foils. In the upper part of the slide three possible uses are indicated with suitable materials. The lower part shows some of the problem areas. The requirements for strong, high-temperature resistant materials with a minimum weight are of a continuous nature and receive special attention by the Office of Research. There is, however, a great effort spent to explore the basic characteristics and behavior of pure elements, especially in the solid state, alloys, and chemical compounds. For a correct prediction of change of properties, one must have a basic understanding of the atomic and molecular structure, the forces between atoms, and the processes by which atoms move. With pictures like figure 141 (p. 1999), obtained with a fieldion microscope, showing directly the position of atoms in a tungsten surface, new concepts of atomic relationships are bound to appear in the future, which will allow variations of properties as needed for a special purpose. Space-age materials interests lie, of course, not only in the area of metals. Ceramics research and polymer chemistry play an important part in our materials program.

Polymers, generally composed of carbon, hydrogen, nitrogen, sulfur, and other elements in heavy long-stretched molecules appear as natural polymers, such as natural rubber, wood, wool, and animal tissues. They play an increasing role in their synthesized forms which have in many cases much superior properties. They are often even superior to metals and ceramics. Basic research in polymer chemistry is required to understand the fundamental mechanism so that materials can be created to meet the challenge and to prevent the loss of time, money and talent inherent in an empirical approach to provide the answers.

Polymers are used as bonding agents or adhesives for example on inflatable structures such as in the Echo satellites. Here thin films of aluminum are bonded on both sides of a thin Mylar film which must hold together in the space environment, that is in vacuum, under radiation and meteroid impacts. Figure 150 (p. 2008), shows diagrammatically polymer molecules attaching to a surface. Basic research is imperative to identify and understand the surface affinities, interactions between the adhesive and the material to be bonded and the optimum conditions for maximum adhesion. Another example, lubricants to withstand high temperature and high vacuum, shows the need for special characteristics and that requirements become continuously more severe. Figure 151 (p. 2010), shows the trend during the last 15 years and the expected goal for 1965—Lubricants of a liquid base are replaced by such materials as metal compounds and ceramics. The goal being in 1965 a temperature resistance of more than 2,000° F.

It is interesting to see how the number of significant properties of the materials grew during the last 10 years. Figure 152 (p. 2011), shows the increasing requirements for space-age materials.

Let me briefly mention our activity in applied mathematics within the basic research area. As has been pointed out before, the mathematical formulation of the laws governing physical processes is a prerequisite for systematic and rapid progress in the technical world. It is therefore necessary to introduce mathematical methods and principles at an early stage in physical investigations. Many of the modern problems cannot be solved at all without mathematical approaches and especially without the use of high speed computing machines. But, on the other hand, we don't always need complex computers to obtain information from analytical deductions which give our thinking a new twist. To maintain this mathematical ability in our research people is the purpose of the special division of Applied Mathematics.

A large part of our basic research is carried out in our own research centers. In this way a close contact with current NASA projects is possible, a contact which is necessary to stimulate the basic research trends towards the goals of the agency. It is mandatory, however, that NASA's scientific people stay in close contact among each other and also with the corresponding groups in the other governmental, industrial, and university laboratories to obtain and disseminate the most advanced knowledge in the field. This relationship and the active participation in governmental committees, teaching in universities, etc. is shown in figure 169.

I hope that the above examples of our basic research program have shown you the scope and complexity of our problems and the methods

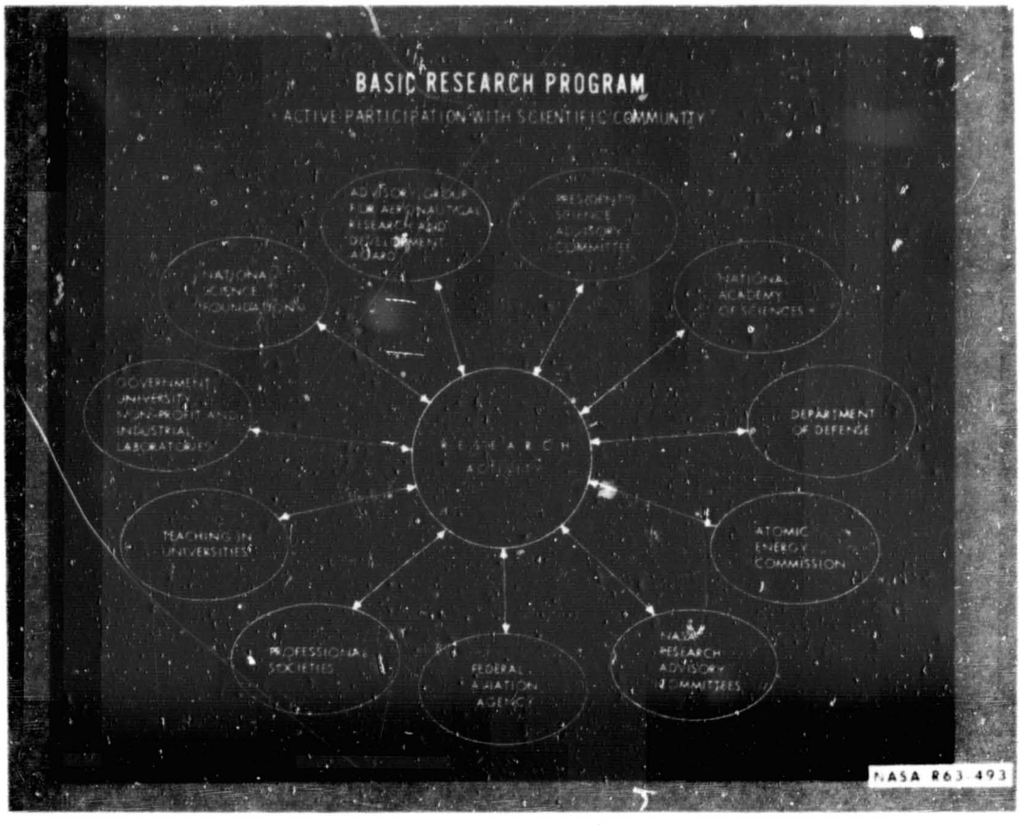

FIGURE 169

and techniques we employ to solve them. While the above four disciplinary divisions of the research program are shown as separate entitles, actually you could notice many concepts where two or more disciplines are intimately involved.

This interdisciplinary approach requirement is becoming the rule rather than the exception making it necessary to utilize interdisciplinary teams to solve problems. This, of course, makes it necessary for the scientific and technical personnel to become competent in the fields of science which are allied with their particular specialty.

As I stafed earlier, results from basic research are the very backbone of knowledge and in our particular case, the foundation of all work leading to space exploration. Therefore, the activity in basic research must be maintained at a high degree of competence and must grow commensurately with the objectives of NASA.

Thank you.

Mr. KARTH. Thank you very much, Doctor.

Mr. Mosher?

Mr. MOSHER. No questions particularly, though I am curious—you are leaving for Europe tomorrow. Is that related to what you are testifying on here at all?

Dr. KURZWEG. In a way it is. It is one of these boxes here on the charts. I am a member of the Advisory Committee for Aeronautical Research and Development, AGARD, in NATO, I am the vice chairman of one panel, and we have a particular meeting in Brussels next week on the noise produced by the turbulence in air.

In this meeting we will have all people participating from the NATO countries, scientific people, about 200 people, having a symposium on this subject. I will be chairman at that meeting.

Mr. MOSHER. Do you find that other NATO scientists are making valuable contributions to some of these problems you are talking about here?

Dr. KURZWEG. Yes. This is a very interesting subject, and actually there is some history in it. If I go back 10 years, when we first established AGARD, this first coming together of the scientists was more or less a one-way operation. But in the last 5 years, or so, these people have become pretty well established, and there is a feedback. We get quite a bit from over there. All work on practically the same type of work, but everybody does it a little differently, and these little differences sometimes make really a big difference. The British people, the French people, Germany, Italy, all contribute very much in this basic area.

Mr. MOSHER. What is the source of their financing?

Dr. KURZWEG. They are financed by their own governments.

Dr. BISPLINGHOFF. Congressman Karth, Dr. Kurzweg gave only a partial summary of his statement. I am wondering if he could introduce his complete statement in the record.

Mr. KARTH. I think so. I think this is really appropriate.

I want to thank you, Doctor, for the fine job you did in the short period of time you took. But I think for everyone's benefit we should have this in the record.

If there are no objections, it is so ordered.

Thank you, Doctor, very much.

And thank you, too, Dr. Kurzweg.

Dr. Bisplinghoff, we will meet with your office again Tuesday morning at 10, is that satisfactory?

Dr. BISPLINGHOFF. Fine. We will be here.

Mr. KARTH. The meeting is adjourned.

(Whereupon, at 12:10 p.m., the subcommittee adjourned, to reconvene at 10 a.m., Monday, April 1, 1963.)

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1964 NASA AUTHORIZATION

MONDAY, APRIL 1, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SPACE SCIENCES AND
ADVANCED RESEARCH AND TECHNOLOGY,
Washington, D.C.

The subcommittee met, pursuant to adjournment, at 10 a.m., in room 304, Old House Office Building, Hon. Joseph E. Karth (chairman of the subcommittee) presiding.

Mr. KARTH. The committee will be in order. Dr. Seamans, last week we had made a request of the Office of Space Sciences for additional information related to the construction of facilities request at the Goddard Space Flight Center. Do you have a prepared statement?

Dr. SEAMANS. Yes, I do, Mr. Chairman.

Mr. KARTH. Proceed. You have additional copies, Doctor?

Dr. SEAMANS. I thought we did.

Mr. WYATT. They should have been delivered to your staff, Mr. Chairman. We are checking now to find out where they are, sir.

Dr. SEAMANS. Do you wish me to proceed, Mr. Chairman, or would you like to wait until they come?

Mr. KARTH. Just proceed, Doctor.

STATEMENT OF DR. ROBERT C. SEAMANS, JR., ASSOCIATE ADMINISTRATION, NASA, ACCOMPANIED BY MR. WASELEWSKI, ASSOCIATE DIRECTOR, GODDARD SPACE FLIGHT CENTER

Dr. SEAMANS. Mr. Chairman and members of the subcommittee, I am pleased to have this opportunity to discuss with you our facility planning with particular reference to the manner in which facility requirements are established and facilities are used. As you know, Dr. Newell, Mr. Cortright, and Mr. Ulmer reviewed these matters briefly during their appearance before your committee on March 21, 1963. In that hearing, Mr. Ulmer noted that from the time a facility requirement becomes known in the field until the facility becomes operational, varies from 18 months to as much as 5 years. In addition to facility planning and requirement development, I will discuss some of the factors that make this kind of a timetable inherent to our research and development program.

Mr. Waselewski, Associate Director of the Goddard Space Flight Center is here with me today. His center has responsibility for unmanned spacecraft development in the areas of space sciences and applications. He is intimately familiar with the problems involved

in this effort and can discuss facility matters with you, if you so desire, after my statement.

There are several basic agency guidelines under which the program directors establish their facility requirements. In addition to money constraints, always present, every effort is made to meet requirements through modifications to existing facilities and the use of Government-owned facilities and sites in lieu of new construction and land purchase. As a result, facilities and sites which otherwise might be obsolete or unused become effective tools for the conduct of our programs. I think NASA has an unusually fine record in this respect.

For example, the old seaplane towing basins at the Langley Research Center were modified to permit astronaut training in water landing techniques and to conduct water impact tests of the Mercury capsules. A Lewis Research Center wind tunnel originally built for reciprocating engine research was modified for turbojet engine research, and modified again to serve as an environmental test chamber for Centaur development. Aerodynamic wind tunnels at the Langley Research Center were used to test the Gemini capsule paraglider recovery technique and the escape capsule for the Apollo command module. These are a few cases of timely conversions and modifications of existing facilities to meet new problems without the need for constructing new facilities. You will note in nearly every NASA facility budget many projects involving modernizations, extensions, modifications, or improvements. The budget before you is representative in this regard.

Existing Government-owned facilities and sites are utilized to the maximum extent feasible. You are aware of how this policy has been implemented in the acquisition of the Plum Brook Station near the Lewis Research Center for nuclear systems studies; the Chincoteague Air Station for rocket model and light spacecraft launchings near Wallops Island, Va.; the Michoud Plant near New Orleans, La.; for large launch vehicle construction; the development of the Goddard Space Flight Center on land obtained from the Department of Agriculture near Greenbelt, Md.; and the range-use agreements with the Department of Defense at the Atlantic and Pacific Missile Ranges. A further example is the recent agreement that makes available land at the White Sands Missile Range for the construction of facilities for support of the Apollo development program.

Our assessment of fiscal year 1965 facility requirements has begun. You can begin to appreciate the difficulty of the assessment task when you consider that many of these facilities will not be operational until 1966 or 1967. To the best of our ability we must begin now the complex process of assessing: research and development requirements; suitability and availability of in-house and external facilities; and if needed new facility requirements including cost estimates and construction schedules. Because of the leadtimes required by the budgeting and construction processes, the task is difficult even for research facilities where time is not as pressing a problem as for development facilities.

It is the intimate relationship of mission and facility requirements that led to a decision that primary responsibility for the facility assessment process must rest with our program directors. For example, you have before you the fiscal year 1964 facilities budget. These estimates of facility requirements based on the careful judg-

ments of our program directors and their supporting field centers, are submitted to Congress after review and coordination by my office and Mr. Webb's office.

In spite of the attention given to projected facility needs, past experience shows that changes will be required in the facility construction program the Congress authorizes. Some facility requests may be modified, others dropped. It may prove necessary to request facilities that had not been anticipated. For example, our current fiscal year 1963 budget includes funding for the construction of a radiation effects facility for the Nuclear Rocket Development Station. Developments subsequent to the budget submission proved requirements could be met more economically by modification of the Air Force's Nuclear Aerospace Research Facility at Fort Worth, Tex., than by constructing a new facility. This was accomplished through the reprograming of C. of F. funds. Thus, you see the reprograming procedures you have provided in our authorization act are very essential to the intelligent conduct of an R. & D. program. I want to assure you that this authority is used with considerable care and caution. It has not and will not become a substitute for careful planning by NASA.

Facility design and construction time can set the pace of a program. This point is illustrated on figure 170 which represents the time phasing of critical milestones for the first Saturn IB vehicle, SA–201. Two major elements of the Saturn IB are the S–I stage and the S–IVB stage. Facilities that support this development are the S–I stage assembly facilities at Michoud, the S–IVB assembly facilities at the Douglas Aircraft Co. at Santa Monica, Calif., the S–IVB static test complex at Sacramento, Calif., and launch complex 37A at the Launch Operations Center, Fla.

It is a simple fact that assembly facilities must be available before assembly can begin, as illustrated by the S–IVB and S–I assembly facilities for their respective stages. It is a simple fact that static test facilities must be available before static tests can be conducted as shown here for the S–IV stage.

We have an attachment to my statement which clearly shows how these schedules tie together. I regret this is not before you at this time.

Finally, it is also a simple fact that launch complex 37A at LOC must be ready to accept the launch vehicle for assembly and checkout before the stages of the launch vehicle are delivered. However, it is not always appreciated that facility design and construction or modification requires significant lead in time. Although the start times for facility design are not indicated on the figure, you can see that they must be initiated at about the time that design decisions are made and in many instances earlier. Similar but more detailed charts are prepared for all R. & D. programs and for related key facilities whose operational dates are critical to the mission schedule. Progress and problem areas are reviewed and discussed in monthly program status reviews.

I would like to say a word now about the relationship of facilities to the roles and missions of our various centers. In earlier testimony, I outlined the roles and missions of the Centers. These are summarized in the budget backup books. Generally, facilities at a given center reflect the mission of that Center. However, in some instances it

SATURN IB SA-201 VEHICLE

FACILITY SUPPORT

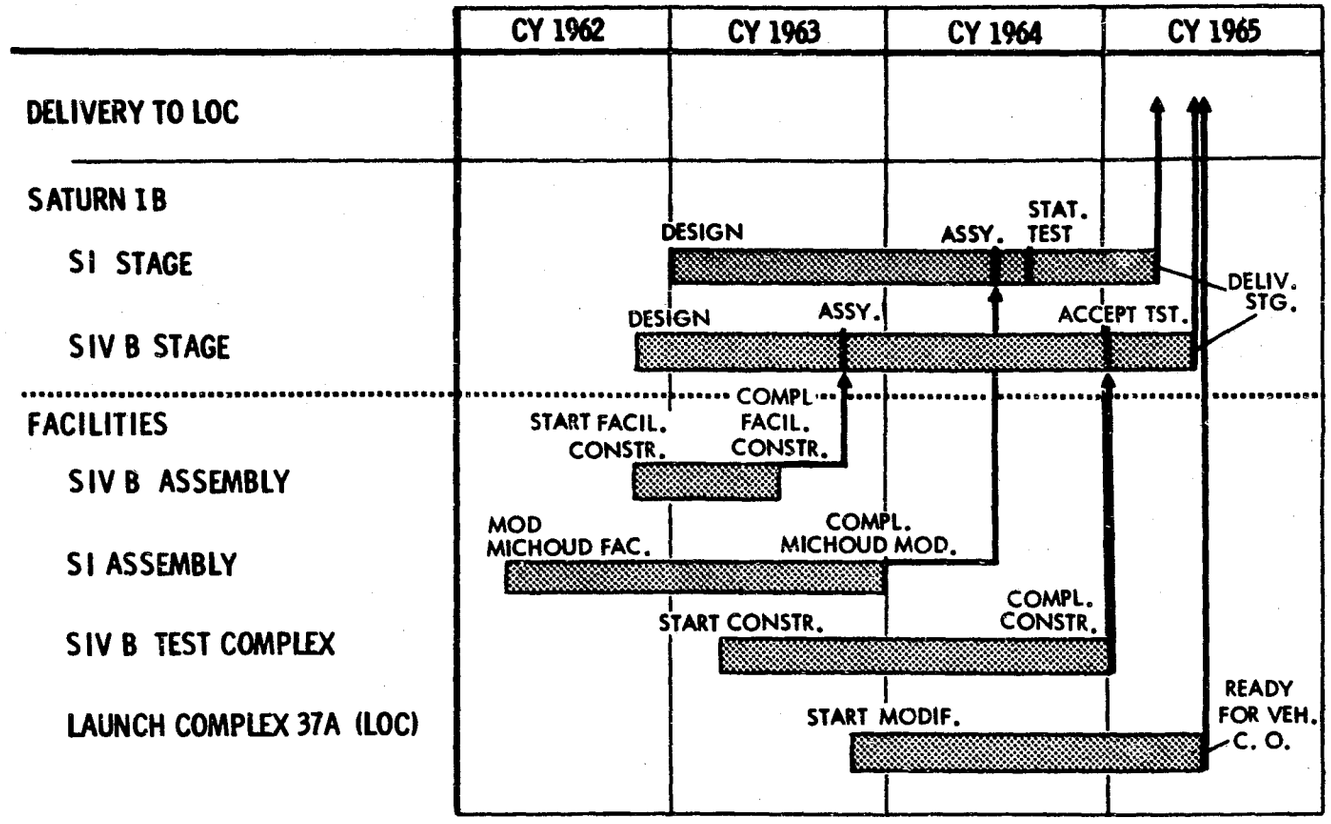

FIGURE 170

would appear a facility is improperly located; since we have found it necessary, from time and economic considerations, to modify existing existing facilities regardless of their location, in order to save time and minimize cost. An example is the use of the old seaplane towing basins at Langley to which I previously referred.

The same apparent conflict may result from a management decision to provide an existing team with a particular facility rather than relocate the established team to another center. These types of decisions invariably must be made in the execution of R. & D. programs.

Another matter that I know is of concern to you is what might appear to be the duplication of environmental facilities within NASA and for that matter, within the Nation. As the older NASA centers changed orientation from aeronautical research to space research and development, and as new centers develop to support the agency's manned space flight and space science programs, the environmental facility has emerged as the workhorse tool of the space program. The environmental chamber, similar to the wind tunnel in the aeronautical program, is such a basic tool that it is required in many sizes and capabilities not only within our centers but within other Government and private groups engaged in space research and development.

On a second chart (fig. 171), you will see the actual work schedule of the Goddard Space Flight Center's 8 feet diameter by 8 feet high thermal vacuum chamber. The chart also shows the projected work schedule for the next fiscal year. The 8 feet by 8 feet thermal-vacuum facility was developed to support the Explorer XII project. Since this time it has and will service the projects listed—Explorers XIV, and XV, Ariel, Topside Sounder, ionospheric probes, and atmospheric structures. The projects involved represent a cost of over $25 million. This facility has contributed to the success of all of these space science missions. The cost of the entire facility—$200,000—is less than the cost of one unsuccessful flight. This is an important point to keep in mind as we proceed to more advanced space projects involving individual costs that exceed $40 or $50 million.

You can see that this facility has been and will continue to be busy for some time to come. Similar schedules are available on all currently operating facilities. Operating time is already being scheduled on facilities under construction. We are proud of the effective utilization we have made of our facilities. An idle facility at one of our centers is a rarity. I believe this speaks favorably for the conservative nature of our facility planning.

You are all aware of the wide use made of industrial facilities in the execution of our development programs. The great majority of our work is carried on by contracts with industry. The responsible execution of the programs, however, requires that there be available at the Government centers facilities adequate to insure the reliability and performance of industry developed hardware.

In the case of scientific satellites, there has and will continue to be a difficult operational problem in the environmental facility area. Spacecraft are made up of many experiments, developed and constructed at different industrial, university, and Government facilities. In many instances environmental chambers must be available at the individual experimenter's station for subsystem tests and, of course,

GODDARD 8' x 8' THERMAL VACUUM CHAMBER

WORK SCHEDULE

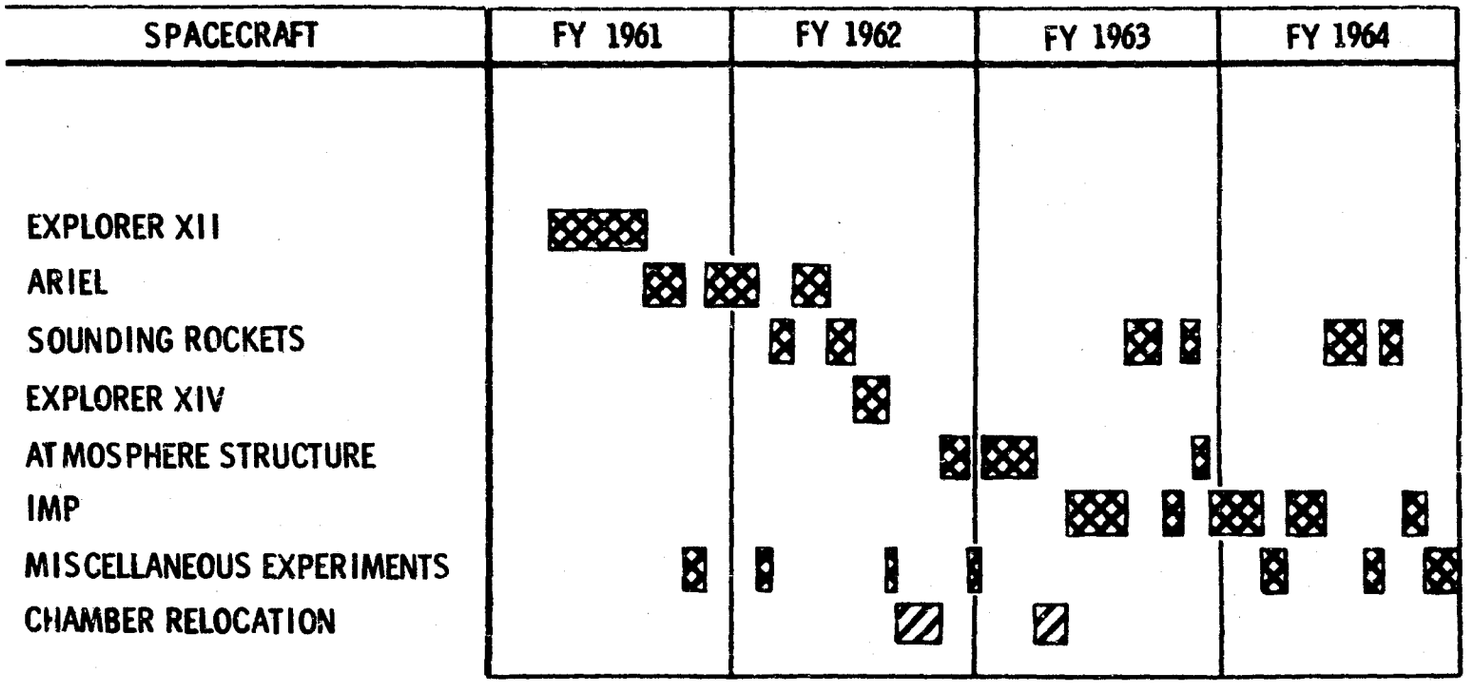

FIGURE 171

facilities must be available for tests of the assembled spacecraft, to identify difficulties, calibrate equipment, insure integrity, and thus provide a proof test of the complete satellite prior to shipment to the launch site for launch preparation.

Requirements exist for environmental facilities of many sizes and technical capabilities. The success of our scientific satellite programs is in large measure the result of extensive ground tests in environmental facilities.

It is important to have adequate environmental facilities available at the locations that have final integration and checkout responsibility so that shipment and handling of delicate components and systems can be minimized. Thus, you find final checkout environmental facilities in our centers and at contractors depending on where it has been deemed necessary to place this responsibility.

In the overall assessment of our facility requirements we do try to take into account the commercial availability of facilities in which to do our work. We are aware of existing industrial facilities and in some cases their projected facility programs. To the extent feasible we try to assess the availability of these facilities. Several of our major programs involve extensive use of existing contractor facilities. For example, the Nimbus satellite, being developed by the General Electric Co., is undergoing environmental testing in a wholly owned facility of the General Electric Co. in Philadelphia.

I am sure you are aware that the availability of industrial facilities is one item that is weighed by source selection boards in the competitive negotiation of certain R. & D. contracts. Many programs, of course, require the construction of additional facilities at contractor plants.

In an attempt to insure our maximum utilization of these facilities R. & D. contracts now contain a provision that notes where nonseverable industrial facilities are located on land not owned or controlled by Government, consideration will be given to obtaining a written agreement by the contractor on whose land the facilities are to be placed that the Government or Government contractors will have the right to operate the facilities upon termination or completion of the contract for which the facilities were acquired; and in cases where such an agreement is not obtained, the negotiation effort will be documented to justify the alternate proposal.

Project managers are frequently tempted in the initial stages of a program to minimize test effort and thus facility requirements. This attitude is desirable provided the designers and fabricators are able to achieve more adequate designs by so doing. However, as technology advances, and as the new technology is incorporated into the design of space flight hardware, more testing is invariably needed. In addition, early optimism is often dulled as real problems arise. The lack of an available test facility has the same delaying effect as the late delivery of an essential part. To minimize this possibility, our program directors and technical facility planners work as an integral team in the overall spacecraft and mission development plan to assure that adequate attention is given facility needs. We urge your support of this very vital element of our overall space program.

I have touched only briefly on some of the complex relationships involved in attempting to establish our facilities budget. I have attempted to indicate the close tie between project implementation,

scientific and technical manpower location capital and operating costs, and NASA's long-term responsibility to insure this country's continued preeminence in space.

Should you wish, I can discuss specific questions in greater detail.

Mr. KARTH. Thank you very much, Doctor. I appreciate your statement. I hope that you realize it's rather difficult for the committee, with their limited knowledge of shorthand, to write down questions as you read, without having a copy of the statement.

Dr. SEAMANS. I regret you did not have a copy of the statement last Friday.

Mr. KARTH. There are places where questions might come up which we might mark, and later we could refer back and ask questions from them.

I certainly don't expect you, Dr. Seamans, to know all of the rules of the House. I do, however, expect that some of your liaison people would be aware of the fact that there are some House rules that are very pertinent and, certainly, I would assume they would be aware of them, just as a result of the responsibility they have been given by NASA.

One of the House rules, for example, says, and I shall not try to quote it verbatim, because I don't think I can; but the essence of the rule is that testimony that's to be given before a committee, wherever it is practical, should be preceded by a prepared statement which should be in the hands of the committee members at least 24 hours, I think, before the hearing begins

Now, on occasion, I know this is impossible, and on other occasions, I know it is difficult. But I think in most instances it's feasible and probably practical.

It does make it much easier for the committee. I think on many occasions we could be more efficient if we had some advanced information as to what the testimony is going to be. To begin with, we could have taken some time to look it over and probably be better prepared ourselves which could conceivably lead to the elimination of future meetings.

So, I wonder if this could just be kept in mind. I don't say this with any malicious intent at all, Doctor, but I have found that for my own personal experience this has made it rather difficult for me and I assume the other committee members have had the same experience.

Mr. MORRIS. Mr. Chairman.

Mr. KARTH. Mr. Morris.

Mr. MORRIS. I'm sure, in regard to what you have said to Dr. Seamans, someone whose responsibility it was to get those over here, will hear about it. I am sure Dr. Seamans gave instructions to them and I think they probably won't forget it the next time.

Dr. SEAMANS. We are familiar with the requirements, Mr. Chairman.

Mr. KARTH. We have a lot of confidence in you, Dr. Seamans.

Dr. SEAMANS. Just let me say, I was familiar with your concern for this whole matter of facilities, early last week. I went over the material for the discussion today, early last week. Went over a final draft of this statement last Wednesday and I am very surprised you did not have this statement in your hands last Friday.

That was certainly our intention and we will do our best to see this does not happen again.

Mr. KARTH. We are concerned about facilities, Doctor.

I think, from my discussions with my fellow committee members, there is greater interest in construction of facilities requests than the other requests in the budget.

As I listened to your testimony this morning, I gathered that the facility directors; that is, those who are in charge of a particular facility, such as Goddard, are responsible for making requests to your office for additions.

Is this proper understanding on my part?

Dr. SEAMANS. That is essentially correct. However, it does not come directly from the Center Director to my office. It is reviewed by the Program Director—as for example, Dr. Newell and Mr. Cortwright—in those cases where the facility is in support of an unmanned scientific investigation, so that the material that comes to my office has been thoroughly reviewed by one or another of our program offices and by Mr. Wyatt, Director of the Office of Programs.

Mr. KARTH. Now whose responsibility is it, Doctor, to make a survey, to make sure that there are no duplications or will be no duplications in the event the facility should be allowed?

Who is responsible for that? The Director at the facility location or the Director of the Office of Space Sciences or your office?

Who is responsible for making that survey?

Dr. SEAMANS. I believe this is something that has to be, in effect, everyone's responsibility.

First of all, the Center Directors must insure that they are not building up excessive facilities. They must also be conscious of the availability of facilities at other NASA centers, and must also know about the Department of Defense facilities and contractor facilities.

The headquarters program directors, in turn, must consider whether it is better to carry out a certain project at the particular Center or whether, in fact, resources including facilities are available at another Center, and if it wouldn't be better to shift the responsibility to one of our other Centers.

The final responsibility must be that of the Administrator of NASA, Dr. Dryden and myself, and we have, as a staff, Mr. Wyatt, who is in charge of the Office of Programs and he has within this Office a facilities group under Mr. Ulmer which works side by side with a small staff of technical people and a budget group in order to give us a total integration of our NASA activities.

Now, I might say that in addition, Mr. Wyatt's Office works closely with a similar office in the Department of Defense so that when we review our budgets, we can see whether there is any duplication of new facilities.

Mr. KARTH. Now, we Americans are a very "paper conscious" people, I guess you could say. It doesn't make any difference whether it is private industry or whether it is government. We do a lot of paperwork, keep a lot of records, make a lot of files; so I assume we have made a nationwide survey of industry which supports the needs of the facilities requested?

Do you have such a survey that you'd like to give to the committee at this time? A survey you made of private industry, in regard to what capability they now have, or would have at the time you would have a need for it, in all of these areas such as the hazardous test facility or the Quality Assurance Laboratory or the Meteorological

Systems Development Laboratory, or whatever the facility request is? I assume you made a very thorough and a very comprehensive survey.

Dr. SEAMANS. Let me, if I may, just start answering that question and then refer it to Mr. Waselewski for more detail.

There are all kinds of facilities available in this country which can be used in a project (depending upon its complexity, size, and so forth). Some facilities are relatively small vacuum chambers.

All systems contractors and even subsystems and component contractors do have at least limited facilities to test their own products.

Then there are the much larger facilities, the large vacuum chambers, that can contain complete spacecraft like the Ranger and the Surveyor and the orbiting astronomical observatory.

There are relatively few of these very large facilities.

I am sure we are completely familiar with the large facilities. However, we do not have a complete inventory of all the smaller facilities that a great number of contractors have at their disposal.

Mr. KARTH. Don't you think we should have a complete inventory of this, Doctor?

Dr. SEAMANS. I think it would be a prodigious effort to have as complete an inventory as that.

Mr. KARTH. It might be, but I think if we made a very thorough inspection we would find that in many cases we have duplicated facilities just in the letting of contracts for work to be done where the person to whom we let the contract did not have a particular facility, for example, so the cost of that contract was increased by the cost of the installation of that facility; when that facility was, in fact, available elsewhere.

I know this has happened in several instances where a particular facility was available in private industry elsewhere and we could have saved quite substantial sums of money.

Now, how often this has happened and to what extent it has happened, how broad in scope the problem is, I really can't say, because we haven't made a thorough investigation. It might be well we undertook the effort to do this. I don't know.

If we don't have a running inventory of some of these facilities that we are finding that we've got to use, I suppose this would make it rather difficult for us to use good judgment even in the letting of contracts where a certain amount of this testing has got to be done and the people who are qualified to bid might be those people who don't have this test facility but the test facilities might well exist someplace else; and where the test facility does exist those people might not even be qualified to bid on the total projects just because they have a test facility, you see.

I'm sure you follow me on that. So, you can see the possibility of us spending huge sums of money duplicating facilities, be they ever so small, in private industry as well as in-house, at substantial cost to the taxpayers.

I would ask this, too: Take the case of the large facilities where we know that they do exist, both in government and in private industry, have we in these instances solicited these people?

Have we asked them whether or not their test facility would be available to us during the month of June, July, and August, or whatever our time schedule might happen to be?

Have we ever done this?

Dr. SEAMANS. I can give you several examples.

Mr. KARTH. Yes, sir.

Dr. SEAMANS. First, let me say that when proposals come to NASA for a particular project, we have to judge the proposal on the basis of the information that's presented to us by the contractor and often times a contractor who does not have a particular facility, will indicate in his proposal that he has made arrangements with another company for the use of such a facility, and that the schedules will permit him to get on with that particular project.

Mr. KARTH. Yes, sir, but where the work is going to be done in-house, you don't have proposals by industry, so it might be in these instances, Doctor, that we are concerning ourselves with today.

We are specially ignorant about the availability of facilities. Isn't this a fair assumption from you?

Dr. SEAMANS. There is always, certainly, the possibility that we are not using all facilities in this country as efficiently as we might. We recognize this and recognize it's something we have to continually work on.

I was going to give you one example.

Recently, I visited the Space Technology Laboratory on the west coast which does have its own vacuum facilities, that they have financed themselves. I found that in the case of the Syncom I, for which the Hughes Co. has project responsibility, Hughes had used the STL facilities because their own facilities were not available and this was done at no cost to the Government.

On checking, however, with the responsible management at STL as to whether they would—they could, make available these facilities on sort of a rental basis to contractors who might wish time, they indicated that they had really built these facilities for their own use and that it would be very difficult to schedule time for projects which they were not responsible for and they weren't really in a position to make guarantees of that sort; but they would, of course, assist wherever they possibly could.

Mr. KARTH. But, I think that unless we specifically told them what we have in mind and a date that we might have in mind, I doubt if we can really say that we have made an effort to ascertain if this facility is available in private industry.

Dr. SEAMANS. There is always a very difficult balance that must be achieved between the cost of the facility, written off over a period of time and the extra R. & D. cost which would be involved if a particular facility is used in the contractor's plant that is not directly associated with the project.

There is always the necessity for personnel familiar with a component or the subsystem or the spacecraft, to be present and actively participate in any of the testing and these people would have to be moved to the location for periods of time in order to run these tests.

Mr. KARTH. Of course, we carry this out to the logical conclusion then using that theory we are going to make everything "in government."

Dr. SEAMANS. No, because I'm talking here about the responsibility of a prime contractor for the development of a particular spacecraft. I'm talking about really out-of-Government work as well as in-house work.

The Government must have some facility to provide a check and a balance.

Mr. KARTH. Yes, I agree. I couldn't agree more. As a matter of fact, I think it is imperative the Government have some facilities without which one company would have a monopoly. I think the Government must not allow a company to go ahead and invest tremendous sums of money so that future contracts go to them as a matter of necessity just because they have this capability.

I agree, for example, on the facility that you are requesting for the Atlantic Missile Range for the big Saturn; I don't think there's any question about it; we have to have facilities like this in-house. This doesn't mean we have to have all facilities in-house or a large portion of them.

The point I'm making is that we would like to have as few as we need, because we have so many other needs in the space program and elsewhere that where private industry can do this or where other agencies of Government can do it, even though it may inconvenience us a little bit, and on occasion probably even inconvenience them a little; we just feel that maybe we should make an effort to see it is done this way.

That's really what we are saying and nothing more.

Dr. SEAMANS. I agree with you, Mr. Chairman, and this is the difficult balance that we attempt to achieve.

Mr. KARTH. My question is, Who makes this survey now?

Who really makes the first survey? Does Mr. Waselewski make the first survey, for example, if this is a request by the Goddard Center?

Does he contact all the companies that he knows has a facility such as this or are constructing a facility such as this, giving industry the benefit of Goddard's needs, and the time schedule when they have need for these facilities, and then ask the question whether or not they would be available for NASA use?

Are you the one who does this, Mr. Waselewski?

Mr. WASELEWSKI. I think that in accordance with Dr. Seaman's statement, yes. We feel it our responsibility to be very familiar and our personnel are personally familiar with the facilities of the various contractors around the country.

We have available, for example, you are talking about printed material on this and we do periodically update our knowledge of contractors' facilities. I have a few sheets showing the kinds of things we have. We have here pictures, for example for facilities at Lockheed, Republic, and RCA. We do document these major facilities.

Mr. KARTH. Yes, I understand.

Mr. WASELEWSKI. These are the larger facilities and we document our knowledge of the major facilities in the country and we follow this up very carefully because our people who are involved in the testing evaluation are, in fact, spending a lot of time at the contractor's plant so they are thoroughly familiar with such equipment as he does have, not only the major equipment, but they usually know it in considerable detail.

I can't say we have documented each piece of equipment, but we are generally aware of it.

When a contractor makes a request for a facility or it becomes obvious to us that such a facility is needed, we have the talent in-house

who are generally aware of this. In some cases, for example, one case that's of interest, the S–52 satellite where Westinghouse was doing the job and they are just down the road from us at Baltimore Airport, we elected to have them come in and use the Goddard facilities because the contractor otherwise would have had to build up this capability.

In another contract we have, for example, transferred a piece of vibrational equipment from STL to Ball Bros. so that Ball Bros. could use it in the OSO contract.

We do feel and try to be constantly aware of what the availability is throughout the country. When we do have an in-house requirement, we feel that the need for the facilities are the product of considerable study. It's a creative effort in a sense and we are always striving to make better facilities. When we have a need for another facility we try to examine the existing facilities in terms of the job we want to do to make sure that such capacity as we might build is not already available or conversely that as we gather from talking with contractors that they don't have in mind to build such a facility. Sometimes, the leadtimes being what they are we have to know a little bit about what the contractors have in mind.

Mr. KARTH. Did you solicit industry last year—insofar as your budget requests for facilities are concerned this year?

Mr. WASELEWSKI. Did we go out specifically and ask them whether they have such a facility?

Mr. KARTH. Yes.

Mr. WASELEWSKI. No, we did not, but we are generally aware of the facilities they do have. We feel we have built up a backlog and maintain a knowledge of what kind of facilities are available and we look at our requirement based on what is available. It's always in the framework of what is going on in the industry and what, to the best of our knowledge, the usage is for the chambers which already exist that we try to make our decision.

Mr. KARTH. Are you saying because your requirements are peculiar to the facility that exists at private industry, you have not solicited them in any case for any of your budget requests for 1964?

Is that what you are saying?

Mr. WASELEWSKI. Well, no, I wouldn't say that.

Mr. KARTH. It's got to be for some reason.

I'm just trying to find out which one it is.

Mr. WASELEWSKI. First of all, when you use the word "solicit," is rather a formal thing. We are continually talking with the contractors and are aware of their general capabilities. We are generally aware what they are going to use their facilities for.

In the general sense, though, we don't send them a letter saying we have need for such-and-such a facility and we expect to use it between the time frame of so-and-so and how much of this time could you give us in order to make this facility.

Mr. KARTH. You might be surprised at the answer you got if you did make a formal solicitation. They might even offer to update the facilities that may be somewhat peculiar to your need at the time you make your very formal solicitation.

They may be able to update the facilities and make them available to you at just a fraction of the cost it's going to be to the taxpayer to build the whole thing from scratch, including the construction of a building to house it.

I'm not sure we shouldn't be more formal. As I say, we are a great paper filing nation. We have got more files, I guess, in this country than all of the other countries put together, and I don't think it would hurt us to do a little paperwork on some of these areas where it really might save us some money.

Mr. MOSHER. Mr. Chairman, may I ask a closely related question?

Mr. KARTH. Yes, sir.

Mr. MOSHER. As I understand it, there was an Executive order from President Eisenhower, dated March 17, 1954, Executive Order No. 10521 and, in part, it says:

> A Federal agency shall procure new major equipment or facilities for scientific research purposes, only after taking suitable steps to ascertain that the need cannot be met adequately from existing inventories or facilities of its own or of other agencies.

Now, the Chairman has been talking about the possibility of duplicate facilities in private industry and then closely related to this is the possibility of duplicating facilities in other agencies.

Do you specifically and formally query other agencies, the Air Force, for instance, as to the possible availability of facilities they already have; when you consider these items that, for new facilities that are in the budget for fiscal year 1963?

What is the machinery for specifically ascertaining what the Air Force has, for instance, or any other agency?

Dr. SEAMANS. We have used the Aeronautics and Astronautics Coordinating Board for this purpose.

This is done not on a service-by-service basis, but it's done at the Department of Defense level, and we work with General Cooper in DDR. & E. on this matter.

Mr. MOSHER. This Executive order is still in existence, I assume.

Mr. KARTH. Oh, yes, it is.

Dr. SEAMANS. It is.

Mr. MOSHER. Yes.

So, you do take suitable steps and specific steps before you come to us or go to the Bureau of the Budget?

Mr. KARTH. Would the gentleman yield, so that I could probably get a more specific answer?

You take formal steps?

Mr. MOSHER. This is exactly what I'm asking.

Dr. SEAMANS. The answer is, we do, and what is equally important, there are many, many ties between NASA and the Department of Defense.

Mr. KARTH. Doctor, would you tell me how you take formal steps?

I mean, do you have something to submit for the record so we know you took a formal step in soliciting from other agencies of Government regarding the availability of facilities?

Dr. SEAMANS. The formal step is the meeting of the Aeronautics and Aeronautics Coordinating Board where we require two specific individuals, one in NASA and the other in the Department of Defense to review the 1964 budget for facilities.

Mr. ULMER. There is a formal report available on that, Mr. Karth, and we will be happy to supply it for the record.

The group reviewed some 220 facilities in the Department of Defense and NASA and weeded out certain ones that obviously did not involve duplication.

For example, we are not concerned with housing for military personnel.

This group looked in detail at some 62 facilities which warranted additional study. These were examined in detail, and the technical characteristics were reviewed by the two teams.

Out of this, I believe, came some three or four facilities that warranted much closer examination at Dr. Seaman's level. There is a formal report available on it.

Mr. KARTH. At this point, unless there are further questions, I ask it be submitted for the record.

(The information requested is as follows:)

FEBRUARY 7, 1963.

Memorandum for Dr. Harold Brown, Director of Defense Research and Engineering, and Dr. Robert C. Seamans, Jr., Associate Administrator, NASA, Cochairmen, Aeronautics and Astronautics Coordinating Board.

Subject: Coordination of NASA–DOD fiscal year 1964 construction of facilities budgets.

References: (*a*) Letter from Dr. Dryden to Dr. Brown, dated September 25, 1962, "Designation of NASA Representative To Coordinate NASA–DOD C. of F. Budgets." (*b*) Letter from Dr. Brown to Dr. Dryden, dated October 9, 1962, "Designation of DOD Representative To Coordinate NASA–DOD C. of F. Budgets."

In accordance with references (*a*) and (*b*), the NASA and DOD fiscal year 1964 facility budgets have been reviewed to insure that no unwarranted duplication exists. Lists of fiscal year 1964 facility construction items were exchanged between the NASA and DOD and a total of 217 items were reviewed.

Preliminary examination of the facility budgets indicated that no apparent duplication existed for a majority of the planned projects. However, a total of 62 items warranted more detailed study. Facility descriptions were exchanged for these items. Upon detailed review of these items it was agreed that no unwarranted duplication existed in the fiscal year 1964 facility plans of NASA and DOD. Specific comments are appropriate on three of the NASA items as follows:

Calibrations and Standards Laboratory (Launch Operation Center), $2,867,000

This facility was originally proposed on the basis that it would serve all NASA and Air Force calibration requirements at Cape Canaveral. In subsequent discussions between LOC and AMR personnel, it appears that the Air Force calibration work may be handled more effectively by expanding an existing facility. Further review of the NASA-Air Force requirements in this area will be required before the final scope of the proposed facility is approved.

Central instrumentation facility (launch operations center), $31,508,000

This facility was proposed to include electronic tracking equipment ($4,950,000) and telemetry equipment ($4,150,000). The plans for the functions and equipment to be incorporated into the central instrumentation facility should be reviewed to insure consistency with the provisions of the January 17, 1963, DOD/NASA agreement regarding management of AMR and Merritt Island.

Instrumentation ships, $90,000,000

A question was raised as to whether the three tracking ships requested by NASA should be considered as peculiar to the support of the Apollo missions or whether these ships should be included as a part of the total national range instrumentation ship capability. It was agreed that this matter of policy should be explored further in the immediate future, as a special case, between the Associate Administrator, NASA, and the Deputy Director of Defense Research and Engineering, DOD.

WILLIAM A. FLEMING,
Director of Technical Programs, Office of Programs, NASA.
PAUL T. COOPER,
Brigadier General, U.S. Air Force, Assistant Director (Ranges and Space Ground Support), Office of Director of Defense Research and Engineering.

Mr. MORRIS. Mr. Chairman, I ask that it be submitted to each member of the committee, two copies.

Mr. MOSHER. Mr. Chairman, at some point, not necessarily right at this moment, I'd like to ask specifically about certain facilities.

Mr. KARTH. Why doesn't the gentleman proceed?

Mr. MOSHER. Just to test things a little bit.

First, to get back to the old question the committee has chewed over quite a while in past years, the life sciences research facilities, $4,480,000 requested.

Is that correct?

Dr. SEAMANS. That is correct. It is an Ames Center facility.

Mr. MOSHER. At Ames, yes.

Now, exactly what formal—to use the chairman's words—what formal machinery made this determination that this was necessary for NASA in view of the fact that the Air Force has certain large facilities in this area?

Can we review that for a moment?

Dr. SEAMANS. Yes, this gets into the whole matter of biastronautics.

Mr. MOSHER. I understand.

Dr. SEAMANS. A very broad field, going all the way from fundamental space biology to the development of environmental support equipment for astronauts, and the Department of Defense has built up capability for the use of pilots under extreme conditions and they have competence at such places as the Wright Development in Ohio, at Brooks Field in Texas, and various places where we wanted to assure this capability should be available and would be available in the schedules not too heavy at these places for NASA effort.

Mr. MOSHER. Can I interrupt right there?

Dr. SEAMANS. Yes.

Mr. MOSHER. Has the Air Force, or whoever is in charge of the DOD facilities, have they specifically offered these facilities to NASA for your use?

Dr. SEAMANS. Responsible individuals at these Centers are very anxious to assist NASA as are others in the Department of Defense. However, we must insure we don't in any way jeopardize defense projects in lieu of NASA projects so this must be considered at the top level of the Department of Defense. In this case, it was of sufficient importance for Mr. Webb to request that Dr. Dryden survey the matter. Mr. McNamara selected Mr. Rubel. These two individuals carried out an inspection of several DOD resources, particularly the ones I've already mentioned.

As a result of this survey we have, for example, provided Brooks Field with a grant of $500,000 so that there at that location they can use their competence to assist NASA in some of our fundamental problems.

We are also using the other DOD installations in a similar manner.

Dr. Graybiel of the Navy is also working for NASA—on NASA projects, so this is the manner in which the overall coordination took place in bioastronautics.

Mr. MOSHER. But the new lab for Ames is definitely needed? That is, you are absolutely convinced there aren't any facilities in DOD which would satisfy your need?

Dr. SEAMANS. The decision to go ahead at Ames followed the review to which I've already referred and is on a basis that more research-type work, in such areas as space biology, is needed and that there

is a need for in-house NASA capability to coordinate various activities going on primarily in universities and that the Department of Defense did not have this competence.

This was something that had to be added to the national resource in order to proceed with the NASA responsibilities.

Mr. MOSHER. And it couldn't have been added to the national resource, more economically or efficiently by adding it at the point of the Air Force?

Dr. SEAMANS. That is a judgment that was made, that the Air Force and the Navy have considerable competence in the development of life support equipment in this area but had really not progressed far enough in space biology that the NASA work would not be in duplication.

Mr. MOSHER. Mr. Chairman, I have obtained——

Mr. KARTH. I wonder if the gentleman would yield right there.

Mr. MOSHER. Yes.

Mr. KARTH. Now the Air Force has this facility, primarily, for the use of the Air Force; isn't that correct?

Dr. SEAMANS. That is certainly true.

Mr. KARTH. If not exclusively to meet the needs of the Air Force.

Dr. SEAMANS. This is a good point, Mr. Chairman.

Mr. KARTH. This is correct, isn't it?

Dr. SEAMANS. Yes, it is.

Mr. KARTH. But, at the same time, the Air Force does not make the decision as to whether or not they can allow those facilities to do some of your research work.

It's the Department of Defense who probably doesn't really have as much information about the Air Force facility and the need of the Air Force, who makes the decision.

Is that what I understood you to say?

Dr. SEAMANS. I am not in a position to judge the competence of DOD to review their own facilities.

Mr. KARTH. I say, is this how it is done?

The man in the Department of Defense makes this decision. In this case it was John Rubel.

Dr. SEAMANS. The final decision has to be by the Secretary of Defense on the advice of his staff.

The Air Force would have required additional manpower in order to support the NASA in this area of space biology, in order to have additional manpower they had to have the approval of the Department of Defense.

Mr. KARTH. Is a study made, Doctor, of this specific request to NASA? Was a report filed by Mr. Rubel and Dr. Dryden on this particular request that the gentleman from Ohio speaks of?

Dr. SEAMANS. Following their survey, a very detailed review was made by Mr. Rubel and myself, of a very large number of specific R. & D. tasks and this is in report form.

Mr. KARTH. My specific question, though, was whether or not Dr. Dryden and Mr. Rubel filed a specific report or a report on this specific project requirement or this facility requirement.

Did they, or didn't they?

Dr. SEAMANS. They did not.

Mr. WYATT. Mr. Karth, to my knowledge, they did not.

I think this is one of the areas where we might depart from the Government, in general, in regard to the paperwork to which you have alluded.

We have found that when you have a meeting of the minds of the people who make the decisions we don't necessarily follow this up with thick documentation.

In this instance, Dr. Dryden as Deputy Administrator of NASA and Mr. Rubel both carried this out individually and on the part of their staffs. To my knowledge there was no formal report issued that established a requirement for NASA to put several hundred people at Ames.

Now the facility that we have here is, however, the outgrowth of the need to house these people and to provide them with the kind of in-house laboratories that they would need in order to execute their principal function of guiding research efforts throughout the country.

This was reviewed as part of the review with the Department of Defense. It happened to be a noncontroversial item, because it was for a function that was already decided should be carried on at the Ames Laboratory and did not duplicate any existing research function. That was already resolved. When it was resolved, it was determined that the life sciences research effort would be carried on at the Ames Laboratory.

Mr. KARTH. Had the Air Force at any time made known to NASA that they could probably fulfill your need and if you agreed, what additional manpower or whatever funds were necessary, they would need to fulfill the requirements; did they ever inform NASA in any shape, manner, or form?

Is there any notification that you are aware of, that's been made or given to NASA by the Air Force in this regard?

Mr. WYATT. I cannot, personally, state whether there was formal notification from the Air Force. I know Mr. Rubel and Dr. Dryden talked with Air Force people about this. The net result was, as Dr. Seamans already indicated, for them to perform this function, would require a corresponding enlargement of their own staffs and a corresponding set of facilities for their own staffs. The judgment was that since it was NASA's program and NASA's program objectives, which depart somewhat from the objectives of the Air Force, that this effort should be conducted by NASA since there was not an existing capability.

Mr. KARTH. Was this conclusion written up in the form of a document or report, an exchange of understanding, or anything?

You have made quite a statement here.

You said, No. 1, the Air Force would require additional personnel and an additional facility.

Now, has this been written up anyplace so we can ask you to submit a copy for the record?

Mr. WYATT. I do not know of a specific document.

Mr. KARTH. Dr. Seamans.

Dr. SEAMANS. The document, I referred to earlier, resulted from a formal joint study of proposed projects under way in the DOD and NASA in the life science area. It includes a detailed listing of each one of the tasks projected for both the DOD and NASA.

Mr. KARTH. Now, I understand that this is kind of a hearsay understanding.

I would, therefore, not want to apply any credence to it, so I asked you the question.

I understand that the Air Force made some kind of a list which in their opinion represented duplication of facilities that were being requested by NASA in the 1964 budget. Are you aware of any such list or have you heard of any such list?

Dr. SEAMANS. I am not personally familiar with this list.

Mr. WYATT. No, sir, I am not either.

Mr. KARTH. Mr. Mosher?

Mr. MOSHER. Mr. Chairman, do I understand Mr. Wyatt correctly, that it was determined by the responsible people in both departments, DOD and NASA—it was determined that in order to supply these necessary facilities—I'm talking now of the life science and research facility, no matter which department did it; NASA or the Air Force, it would make little difference so far as the fiscal year 1964 budget was concerned—either way it would require a budgeting of additional funds for new facilities of $4,880,000.

Was this a specific determination? Is there a record of this?

Mr. WYATT. Mr. Mosher, there was not a specific determination, that a facility could be built some place which would cost $4,880,000. The determination was that the kind of effort proposed for the Ames Laboratory, the DOD agreed, was a proper NASA effort and was not a duplication of their effort.

The specific request is for the facility required to house the people and to provide them necessary equipment for an in-house laboratory effort after having made the decision we were going to place this kind of effort at the Ames Laboratory.

This is a budgetary estimate on our part of the facility required to house the people and the function at the Ames Laboratory. It came up for a review as items on one list of NASA facilities in our talks with General Cooper. It was not, to my knowledge, in question because the question had been resolved, from the agreement that it would be built or the work would be done at Ames. This is a facility required to carry out that premise.

Mr. MOSHER. It's your judgment that had the decision been for the Air Force to do this, they would have had to spend roughly equivalent of this same amount of money?

Mr. WYATT. It is my understanding they would have required similar facilities.

Mr. MOSHER. New facilities?

Mr. WYATT. Yes, sir.

Mr. MOSHER. But there isn't any specific study that says this, this item itself?

That is, the mechanics of the thing don't get down to that——

Mr. WYATT. No, sir, because this was not the topic of the discussion. The discussion was whether NASA should have a life science unit at the Ames Laboratory or whether these services could be provided by existing elements of the DOD.

Mr. MOSHER. And then this procedure, you feel, does meet the requirements of Executive Order 10521?

Mr. WYATT. Yes, sir; in my judgment it would meet the spirit of the order.

Mr. MOSHER. Mr. Chairman, I do have some material here which suggests other possible duplications.

I don't know whether you want me to pursue it item by item at this point or you want to come back to it at this time.

Mr. KARTH. I think the gentleman should use his own judgment.

Mr. MOSHER. I don't want to disrupt what you planned at this session.

Mr. KARTH. The reason I scheduled this meeting, Mr. Mosher, was so questions in the minds of the committee members could be answered—so, you proceed.

Mr. MOSHER. Well, okay, if I have your permission.

What about the Space Materials Laboratory. This involves $3,600,000, and how is your request related, say, to Air Force Materiels Laboratory at Wright Patterson?

What mechanics were gone through in making that decision?

Mr. WYATT. Sir, can you identify the center at which that facility is to be built?

Mr. MOSHER. The note I have here doesn't indicate that, to tell you the truth, and I haven't researched this well enough to know. It is a $3,600,000 item.

Mr. WYATT. Yes, sir. I have it identified now, sir.

Mr. MOSHER. Will you identify it for the record?

Mr. WYATT. The space environment research facilities at the Ames Research Center.

Mr. MOSHER. I should have said this was under Ames. I did know that.

Mr. MORRIS. Where is it in the backup book?

Mr. WYATT. Page CF 1–20 in the "Construction of facilities," part I, which is volume 3 of our backup material.

Mr. MOSHER. Is this an item where the spirit and the actuality of Executive Order 10521 was observed?

Did you specifically check with the Air Force, for instance, to determine this is necessary and not a duplication of their facilities available to you?

Dr. SEAMANS. We follow the same procedure on all of these facilities that I earlier discussed, namely, to review all of these projects with the Department of Defense.

You have to remember that prior to the time that it reaches my office it has first been studied at our center level and our centers are familar with what's going on within the Department of Defense at the various laboratory—in their various laboratories, so that there must be a coordination at all levels of NASA and DOD. We certainly believe that we must know what resources are available to that we can put them to good use.

Mr. MOSHER. You want to discuss, just briefly, then your proposal for Ames here as related to the Air Force Materiels Laboratory Complex at Wright Patterson?

Dr. SEAMANS. I am not, myself, familiar enough with the facility at Wright Field.

This is not just the materials facility, however.

Our real materials work is done at Langley—Lewis.

Mr. MOSHER. I know.

Dr. SEAMANS. This is space environment facility for more than just the material work.

Mr. MOSHER. Yes.

Mr. WYATT. If I may address myself to this question, Mr. Mosher; here we have a circumstance in which we have built up over the past

20 years, a certain line of specialized research competence at the Ames Center, an area of competence that is, perhaps, preeminent in the United States in the investigation of the effects of small particles in space, and their impingement on materials that we must fly in space.

It is a group that in the past 10 years, has done very extensive work with a number of facilities including the light gas guns for achieving simulated velocities up within to 40,000- to 50,000-feet-a-second range—very basic work on properties of micrometeoroids, on the effects of micrometeoroids in penetrating materials that would be exposed in space.

This facility here is to give additional research competence, not development or proof-testing competence, but to give additional research competence to this group which already exists at the Ames Center. The facility requirement was initiated in this manner.

We look upon research facilities of this nature as very distinct tools, but tools which are absolutely worthless unless they are manned by the proper kind of qualified individuals. So, actually, in the cases of this sort, the tool, generally, follows the competence of the group.

In other words, we don't consider the tool as something that might be placed any place; but rather, the tool arises from the needs of the group, from the visions of the group, and is tailored to the competence of the group.

Mr. KARTH. We pretty much do it both ways; don't we, Mr. Wyatt?

Mr. WYATT. In this instance, this is very specifically tailored to the group.

Mr. KARTH. I am not speaking just to this one instance. Do we do it both ways?

Mr. WYATT. In other instances we have to be specific. I don't have a specific case in mind. I am sure there are some.

Mr. KARTH. We first make the request for the facilities and then we try to find the people to man it, don't we?

Mr. WYATT. No, sir; that is generally not our custom. I think we have a very great realization in this agency that facilities, as such, are worthless.

Mr. KARTH. Wouldn't you say that is pretty much the situation as relates to NASA's request for the Electronics Research Centers?

Do we have all these people working for NASA now?

Mr. WYATT. No.

Mr. KARTH. Because of their competence, we have to take care of the capability they have to offer.

Mr. WYATT. No; this is a distinct instance in which we feel there is a void in the scene and we are appearing before the Congress with the request we fill the void.

Mr. KARTH. We have the manpower, then we can use greater facilities to make better use of what they have to offer, if we build the facility or request it.

Mr. WYATT. Yes, sir.

Mr. MOSHER. Mr. Chairman, Mr. Wyatt was talking about the competence that's been built up at Ames, this area.

Is there a duplicate competence at Wright-Patterson? Are they duplicating your work in this area?

Mr. WYATT. I am not familiar in detail and do not say this in a derogatory fashion, but, in general, Wright Field, is not a research center engaged in research work. It is a development-evaluation

center for the Air Force and, as such, does very valuable work, but not in the basic research field.

Mr. MORRIS. Did you check? Is there any Air Force facility which may be involved in basic research of this nature you may be duplicating their efforts?

Mr. WYATT. To my knowledge, there is no facility existing any place that is a facility of this type.

We are starting this at the state of the art now.

Mr. MORRIS. The state of the art that the country will have, when you get this facility.

Mr. WYATT. Yes, that the country will have when we get the facility.

Mr. RANDALL. In that connection, we have the testimony here of Mr. Wyatt. He says not to his knowledge in this particular instance.

I'd like to know whether there was something done other than Wright-Patterson Field since it's turned on that, whether we have followed the provisions of this Executive order?

Mr. WYATT. Mr. Randall, this was one of the lists of 62 facilities Mr. Ulmer referred to that was reviewed by a representative of the Department of Defense and was determined, because of its character that it did not represent a duplication of anything that the Department of Defense has or is building.

Mr. RANDALL. Your former testimony was, of all those 62 there were only 3 or 4 you reviewed again——

Mr. WYATT. Which needed further study.

Mr. RANDALL. For the record, who made the first report? John Rubel?

Mr. WYATT. No, it was a joint report by William Flemming, the Director of Technical Programs of my office and General Cooper, Assistant Director, O.D.D.R. & E.

Mr. MORRIS. And is that what the report said?

Mr. ULMER. Yes, sir.

Mr. WYATT. To my knowledge, yes, sir.

Mr. KARTH. Well, if the committee members would feel better if the Chair would instruct the staff to check with the Air Force regarding these facility requests, and whether or not the Air Force now has the ability to do the work——

Mr. MOSHER. I think it could do no harm, Mr. Chairman and rather than go through all these items, let's approach it that way.

Mr. MORRIS. I so move. I make the motion to the chairman of the subcommittee that the Air Force be contacted on NASA's proposed construction of facilities for 1964, facility by facility, center by center, to determine whether or not the Air Force is capable of doing any or all of this effort in existing facilities. If not, in existing facilities could they modify existing facilities with less cost to the taxpayers than the NASA 1964 budget calls for.

Mr. KARTH. Only in those facilities projects under the jurisdiction of the subcommittee.

Mr. MORRIS. I doubt if we could get any others.

Mr. KARTH. Any objection to that motion?

(No response.)

Mr. KARTH. If not, so ordered.

Mr. MORRIS. We might request the other subcommittee chairman——

Mr. MOSHER. I will defer any further questions along this line pending that report.

Mr. MORRIS. Mr. Chairman, could I have unanimous consent to make an addition?

I think it should not only be the Air Force but I think it should be the Army and the Navy.

Mr. KARTH. If there are no objections—so ordered.

Mr. MORRIS. I am sure there is also some capability in both the other services.

Mr. Chairman, could I ask a general question?

Mr. KARTH. Mr. Morris?

Mr. MORRIS. Could you tell me about your facilities organization in NASA? Dr. Seamans had mentioned the centers have their facility people and then the project office has facility people.

Is there someone who could be called head of NASA facilities?

Dr. SEAMANS. Yes, in a sense. I have a principal staff director, Mr. Ulmer, who is here with us this morning.

Mr. MORRIS. What is your background in facilities, Mr. Ulmer?

Mr. ULMER. I am an aeronautical engineer by education, Mr. Morris, University of Michigan, 1938. My early career was with NACA, Langley Research Center, Va., in a research facility. I subsequently had experience in the administrative organization at the Langley Center and was then transferred to the NACA Headquarters where I served in various technical and administrative capacities, becoming Budget Officer in 1950. I was appointed to the same position, when NACA was converted to NASA in 1958 and then became Director of Facilities Coordination in Mr. Wyatt's office in 1961. I have been involved in nearly all aspects of the NACA and NASA facility construction programs during my 24-year career.

Mr. MORRIS. Sounds like you know what you are talking about. When the facility request comes up from Goddard and, say, up through the channels and gets up to your office; can you say "No, you can do it somewhere else?"

Mr. ULMER. I, personally, can't say "No," but my staff work is to recommend to Dr. Seamans "Yes or No."

Mr. MORRIS. Who can say no?

That's what I want to know.

Dr. SEAMANS. I can say "No." I do say "No."

Mr. MORRIS. All right. Well, now——

Mr. KARTH. Would the gentleman yield there?

What facility requests did you deny for fiscal 1964, Dr. Seamans? Would you give us an indication of the size and scope for the record?

Dr. SEAMANS. I am not sure I can give you the exact figure, but I would say that the request for facilities in 1964 were substantially over what you have here in this budget, by a factor, something like two times.

Mr. KARTH. I see. Thank you.

Mr. MORRIS. Doctor, I notice at Cape Canaveral the Corps of Engineers worked with NASA on facilities. Now, I understand that at the western operations in California, the Corps of Engineers does not work with NASA. Why is that?

Dr. SEAMANS. We are utilizing the Corps of Engineers at specific locations. We have within our research centers, Langely, Lewis, Ames, and the flight centers for example built up an in-house com-

petence for handling this type of effort. We have not had an opportunity to build up this competence at our Launch Operation Center.

The scope of the job there is vast. The experience of the corps, working with the Department of Defense at AMR is great and we propose to make use of this competence and not attempt to do it with our in-house personnel.

Mr. MORRIS. Well, Doctor, this is a part that I can't understand about the whole NASA setup.

At Ames and western operations and these other operations you have built up your own competence in this area.

Why do you need competence in this area when you have the Corps of Engineers who have competence in the area.

This is the part I don't understand. It would seem to me this would be a nuisance. NASA is a scientific organization and should be happy to get rid of facilities construction and——

Dr. SEAMANS. I think the thing that has to be kept in focus is that these facilities are scientifically oriented. They are not simple brick and mortar buildings.

When we construct a facility it's the whole facility, including all of its instrumentation systems, not just the brick and mortar.

Mr. MORRIS. I realize that. The Corps of Engineers do the same things for other agencies, the armed services are in the scientific business to a small extent.

Mr. RANDALL. Will the gentleman yield?

Along those lines, this member happens to have some personal knowledge of a very excellent job the Corps of Engineers is doing on a Minuteman complex that involves some 200 units. So far as scientific know-how is concerned they seem to have demonstrated it at the latest Minuteman complex.

That's all.

Dr. SEAMANS. We recognize the competence of the corps. However, they do not have all the background that our people do at our research centers and it would seem to us to be unwise to fire the people in the research centers and then hire the corps to do the same thing.

However, down at the cape where we are going to build up facilities of over a billion dollars in value, where we don't have the competence, it is highly desirable to use the corps.

We are using the corps at the Mississippi test facility, and at Houston, Tex.

If it's approved, we will use the corps for the electronic research center in Boston.

Mr. MORRIS. That's something we will have to get into later, but have you ever compared your construction cost where you are using the Corps of Engineers, with costs where you are not?

Dr. SEAMANS. It's very difficult to actually segregate the cost of doing it within NASA, because you don't have one complete entity that does nothing but facility construction. You have research teams that are working with people with construction backgrounds. It is difficult to actually draw out the total cost within one of our centers for comparison with the cost of utilizing the corps, but so far as we know, the costs are comparable.

Mr. MORRIS. What I was trying to get to, Doctor, when I asked who was the head of construction of facilities, Mr. Ulmer said he was.

He said he couldn't say "No" but that you could.

This is why I thought you had made some kind of comparison between these costs.

Mr. ULMER. We are attempting to get these figures for you. Mr. Morris, in response to a written request from your staff.

As Dr. Seamans pointed out it is very difficult to segregate costs of that type. We have construction groups at our centers. A good share of their time is spent in designing modifications and alterations to the existing facilities. This work is done at a dollar level that does not require congressional authorization.

Now these staffs work on these jobs as well as supervising the construction of the new projects under the C. of F. appropriation that may be assigned to that particular center.

Now, granted, you could take all of the C. of F. jobs from these people and turn them over to the corps and then reduce our staffs. The corps, however, would have to increase its staff to handle this workload.

We would still need groups at these centers to handle our alterations and modifications because this is one of the really important elements in the operation of our research centers. This must go on all the time.

Mr. MORRIS. These are the things that cause a lot of us to get a little bit confused, Mr. Ulmer.

You say the corps would have to increase their staff—well now, do you know that from your own personal knowledge?

Mr. ULMER. Yes, sir.

Mr. MORRIS. Do you have a letter from the district engineer in Los Angeles and from the district engineer in Houston or wherever it is that say, "Now, if we do NASA work we are going to have to take the same budget you have and put on more people"?

Mr. ULMER. I don't have a letter saying that, Mr. Morris, but I am in very close contact with General Hayes in the Corps of Engineers. I know they are about to set up a new district in Jacksonville just for handling NASA work.

Now, perhaps, they might not have to add additional personnel in certain locations to take on NASA work, but they might have to let some of their people go if we don't give them work.

There is this kind of thing involved; but they have added to their staff to handle NASA work.

Mr. MORRIS. Well, there isn't any doubt in my mind, probably every time somebody does something in the agencies they have to have more people.

Mr. ULMER. Yes, sir.

Mr. MORRIS. Have half a dozen or dozen or so sitting around but if you are going to do one more chore, you are going to have to have more jobs.

I think it would be well for NASA to check very closely into the feasibility of having the Corps of Engineers——

Mr. ULMER. Mr. Morris, frankly, they supervise about 70 to 80 percent of our construction now.

Mr. MORRIS. You still have another 20 percent left. What is your facilities budget this year?

Dr. SEAMANS. $800 million.

Mr. MORRIS. $800 million. Maybe that isn't too significant, but $160 million is a fairly significant amount of money. In fact, that is almost one-fourth of the Interior Department's budget.

Mr. ULMER. I'd like to point out there is not necessarily any savings of cost in this mechanism.

Mr. MORRIS. The opposite is not necessarily true either, Mr. Ulmer.

Mr. ULMER. We didn't mean to imply that, Mr. Morris.

Mr. MORRIS. The opposite is not necessarily true.

Mr. ULMER. I think we will find the costs are comparable.

The elements involved wherever it's done are relatively similar. You have to select an architect engineer. You have to have plans and go to bid and then analyze the bids and select a contractor. You have to supervise the construction with good inspectors. Regardless of who does this job the same functions must be performed. The cost of carrying out these functions by NASA or by the corps should be similar assuming the equal competence of both parties.

Mr. MORRIS. That is your conclusion. Personally, so far as I am concerned, it does not represent mine.

Dr. SEAMANS. Let me say, we are always alert to the possibility of doing the job more efficiently even if it should mean reducing our own staff. However, the particular places where we are using the corps are those that would have involved large buildups inside NASA in order to take the responsibility.

We felt it advisable in those cases to use the corps because they have the flexibility to work with us during this buildup of these major facilities and then to draw back when this effort is completed. This seemed to be much more appropriate from the overall Government standpoint than to add staff to NASA.

Mr. MORRIS. I think that is very reasonable, Doctor, and I frankly thought that the launch operations at Cape Canaveral had the quickest and most feasible answers of anywhere that I've ever talked facilities with NASA.

They had the launch facilities there at the cape. I don't mean, just because they had what sounded like reasonable answers to me they are reasonable or they are good, but in my opinion, they certainly knew what they were talking about.

History may prove I am entirely wrong. The future may prove I am entirely wrong.

Dr. SEAMANS. We certainly expect you are right and we are counting on them. If they are not successful, our whole space program will suffer.

As Mr. Ulmer stated our research program is well established and in addition to new facilities, we do have a requirement for modifying existing facilities. It is necessary to have a constant level of effort inside NASA to assume this responsibility.

Mr. KARTH. Mr. Morris?

Mr. MORRIS. Mr. Chenoweth?

Mr. CHENOWETH. I just want to ask one question.

You mentioned, Doctor, you are using the Engineers at the cape. Have you always used them there?

Dr. SEAMANS. No; because until recently we have not had any requirement for them. It's only recently that NASA has had a major construction program at the cape.

Mr. CHENOWETH. I was at the cape the other day—met a Colonel Finley, I believe was his name. He used to be the chief engineer there. Is he the man in charge there?

Dr. SEAMANS. Yes.

Mr. CHENOWETH. It was a new office. I believe he indicated it was a new office. I forget his exact title.

Dr. SEAMANS. With such a major program at the cape, the corps has added an office just to handle NASA work.

Mr. CHENOWETH. He is a new officer there.

How much money are you going to spend at the cape?

Dr. SEAMANS. The total investment of the cape will probably run about a billion dollars.

Mr. CHENOWETH. Going to build a billion dollars more?

Dr. SEAMANS. I'm talking about the total investment at the cape.

Mr. CHENOWETH. In other words, the engineering is going to have the responsibility of constructing about a billion dollars' worth.

Dr. SEAMANS. That is my estimate.

Mr. CHENOWETH. How much you spending at Houston?

Dr. SEAMANS. The first request for Houston was $60 million. The next request in the 1963 budget was for $30 million. In the budget before you we are requesting $37 million.

In addition, we have under "Various locations" in the 1963 budget, a Mission Control Center for approximately $22 million. The total including the 1964 program is about $150 million.

Mr. CHENOWETH. At Houston?

Dr. SEAMANS. At Houston.

Mr. CHENOWETH. How much will that go to, do you think; that is, actual construction?

Dr. SEAMANS. The $120 million represents our capital investment in facilities. I can supply a breakdown of this if you wish.

Mr. CHENOWETH. How far along are you, Doctor, there at Houston?

Dr. SEAMANS. We are going to occupy space this year.

Mr. CHENOWETH. All the buildings ready?

Dr. SEAMANS. No; all the buildings are not ready. Utilities have been installed and construction is well underway. Several of the buildings will be ready for occupancy at the end of this year.

Mr. CHENOWETH. What are you going to use those buildings for at Houston?

Dr. SEAMANS. This is the Manned Spacecraft Center. Personnel now located in something like 10 rented buildings in Houston will be brought together in this new facility.

Mr. CHENOWETH. This is the operation that was at the cape, you transferred over to Houston.

Dr. SEAMANS. No; they were principally in the Space Task Group at Langley Field. This space task group, 900 people, were transferred to Houston, approximately a year ago. They provided the nucleus for the new center.

Mr. CHENOWETH. What is this billion dollar construction you are talking about at the cape?

Dr. SEAMANS. It includes a number of projects; for example, complex 39 at the cape which will be used for the launching of the Apollos.

Mr. CHENOWETH. You are on 37 now, I believe.

Dr. SEAMANS. We are firing right now from complex 34.

The next flight is complex 37.

Mr. CHENOWETH. I thought they showed us 37 the other day.

Dr. SEAMANS. Complex 37 is essentially complete.

Mr. CHENOWETH. It looked like it was pretty well along.

Dr. SEAMANS. Complex 39 will permit us to assemble the total vehicle, including Apollos, all its module and the Saturn V, inside the vertical checkout building.

Mr. CHENOWETH. Is that where you are going to shoot Gemini?

Dr. SEAMANS. No; Gemini will be launched from another pad. Complex 39 alone requires funding in excess of a half a million dollars.

Mr. CHENOWETH. Sure you're not getting too many pads down there?

Dr. SEAMANS. One of our limitations is, of course, right now, a pad availability.

We are building complex 39 to have flexibility so that fewer pads can get off more flights. Gemini, of course, uses a Titan II pad while complex 39 is for Saturn V.

Mr. CHENOWETH. Just bought more land down there, as I recall.

Dr. SEAMANS. That is right. That was in the NASA fiscal year 1963 authorization—some 85,000 acres of land which includes Merritt Island.

Mr. WYATT. Pad 39 will be on this new land, Mr. Chenoweth.

Mr. CHENOWETH. On the new land?

Mr. WYATT. Yes, sir.

Mr. CHENOWETH. That's on Merritt Island, they call it?

Mr. WYATT. That is right.

Mr. CHENOWETH. How many acres you get in that?

Dr. SEAMANS. 85,000.

Mr. CHENOWETH. 85,000. You are not going to need that much land, are you?

Dr. SEAMANS. Not all of it immediately. However, we will need a substantial part for the manned lunar landing program.

We have provision for the expansion of the space activity in the years ahead. In addition, part of this area will be used for launching the Titan III by the Department of Defense.

Mr. CHENOWETH. That isn't even reclaimed yet. It's still a marsh, isn't it?

Dr. SEAMANS. The northern part of Merritt Island does have swampland that hasn't been reclaimed.

As a matter of fact, they are reclaiming land for the Titan III.

Mr. CHENOWETH. Does that land belong to NASA?

Dr. SEAMANS. It belongs to the U.S. taxpayers, in custody of NASA.

Mr. CHENOWETH. That's the only land NASA has title to. The other land is in the title of the Air Force.

Why didn't you let the Air Force take title to this?

Dr. SEAMANS. Because it was the judgment of the Congress that since the responsibility of the program was vested in NASA, NASA should have title to the land.

Mr. CHENOWETH. No difference on this than there is the other pads. You using all that land.

Dr. SEAMANS. 15,000 acres of land at Cape Canaveral.

Mr. CHENOWETH. No particular difference in it. It's all part of NASA's operation.

I can't quite get the line of demarcation where you're going to leave NASA land and move on to Air Force land.

When I was down there, I couldn't quite get it cleared up. I thought maybe you could clear it up for me.

Dr. SEAMANS. At Cape Canaveral you have two operations—have the operation with the responsibility to the Department of Defense for launching a prototype and development missile and then the Launch Operation Center which is the NASA responsibility for conduct of the space program.

Now, there has to be coordination between the two groups—both can't fire at the same time.

Mr. CHENOWETH. Well, you've had that all along, haven't you, Doctor?

Dr. SEAMANS. Yes.

Mr. CHENOWETH. You shooting the Pershing, or is that the Air Force or Army?

Dr. SEAMANS. That is the Army program carried out by Huntsville, but is not a NASA responsibility.

Mr. CHENOWETH. That's not yours?

Dr. SEAMANS. No.

Mr. CHENOWETH. You all get along pretty well down there—don't have any conflicts, overlappings, any serious problems, overlappings of any serious nature.

Dr. SEAMANS. It's a very major program, both our part and DOD and there is bound to be differences of opinion when you get two such large groups of people together.

Mr. CHENOWETH. My only concern, Doctor, is that we may get too large.

That's all, Mr. Chairman.

Mr. KARTH. Dr. Seamans, last year the isolated hazardous test facility had been requested, was approved, money was reprogramed. Where did you have this test work done, last year, that you found need for and that you will again find need for in this year's budget request?

Dr. SEAMANS. I can refer that question to Mr. Waselewski.

Mr. KARTH. Mr. Waselewski?

Mr. WASELEWSKI. The isolated hazardous test facility involved in testing of small rockets and devices.

Mr. KARTH. I have a pretty good idea what it involves. Where did you have the testing done?

Mr. WASELEWSKI. This was a research program at this facility, so largely research work if we had had the project authorized we probably wouldn't be complete at this time with it anyway, but the research work has not been done in this area that we would like.

Mr. KARTH. You just haven't done anything in this area. Is this what you are saying?

Mr. WASELEWSKI. We have done things at other facilities where we could. They have not been in a program or program sense.

Mr. KARTH. Your answer is, Wherever program work has been done that otherwise would be done in the hazardous test facility, it is being done at the various NASA centers. Is that right?

Mr. WASELEWSKI. I'm just trying to think.

Such work as we have done has probably been done at other NASA centers.

Dr. SEAMANS. I'd like to make a comment, Mr. Chairman, if I could.

Mr. KARTH. Dr. Seamans?

Dr. SEAMANS. On this point, we have put together to the best of our ability a budget request that is in balance and consequently we say to you here that everything in the budget is essential.

It's essential if we are to carry out all the projects and programs either developmental or research in nature that are included in the book.

Mr. KARTH. Doctor, wasn't it essential last year?

Dr. SEAMANS. It was essential to the work Dr. Waselewski has just described.

Mr. KARTH. I say, wasn't your budget request last year, essential?

Dr. SEAMANS. Yes, sir.

Mr. KARTH. You reprogramed the money for the hazardous test facility to something else?

Dr. SEAMANS. At the time it was essential to have it in order to carry out the research work described in the 1963 budget. However, that work was not carried—will not be carried out. possibly at the same level without the facility as with it, so we have had to reorient to a certain extent our research objectives in order to satisfy other higher priority needs that developed in the course of a 12-month period.

Mr. KARTH. I see. You don't expect that to happen during the next fiscal year, do you?

Dr. SEAMANS. Yes, I expect it will. Nevertheless, we have put together a balanced program to the best of our ability and we have indicated the interrelationship between manpower facilities and R. & D. funds. Some changes are bound to result in the next 12 months as they have in the past.

Mr. KARTH. I am sure there will be some—I would assume that would be not quite extensive.

Is this a fair assumption on my part?

Dr. SEAMANS. This is certainly our objective. I believe this will be the case because we have gone through a period of a very great buildup and change. Our major projects, such as the Nova, which we had planned to carry out a year ago, have been deferred. Consequently, as our major projects have firmed, as for example the manned lunar landing, I believe the budget will not show the same changes on a percentage basis that has been the case in the past.

Mr. KARTH. For construction of facilities at Goddard Space Flight Center, your request this year is roughly $21 million.

Is this the total cost for those facilities or is this a downpayment and, if so, what percentage of the total cost is it?

Mr. WASELEWSKI. No, this is a turnkey concept.

When we propose a facility we always ask for all of it. We visualize that.

Mr. KARTH. What has your experience been on this turnkey concept? Have you been pretty close to actual cost in your estimate, or 20 percent off or 30 percent off or 5 percent off, or what?

Can you give me an estimate?

You must have made some kind of a study of this.

Mr. WASELEWSKI. I would say we are pretty close. I don't have any particular figure in mind. Generally, it's our experience we are fairly good at estimating these things.

As these programs go along, there may be detailed changes in requirements and we may shift things along—shift the objective, that is, in the sense that as the facility becomes more fully defined it becomes more obvious what you should do so that these kinds of changes are occurring but we do end up doing the job within the money.

Very seldom we have to——

Mr. KARTH. There is one of these facilities, a facility request that is an expansion of one that was authorized last year, I assume.

Mr. WASELEWSKI. You are talking about the—I think that was authorized in 1961.

Mr. KARTH. 1961, all right.

Mr. WASELEWSKI. Modernization of payload test facilities.

Mr. KARTH. That is not yet completed.

Mr. WASELEWSKI. Yes that facility is in operation.

Mr. KARTH. That facility is in operation? We are modernizing it?

Mr. WASELEWSKI. We are modernizing it as described in this project.

Mr. KARTH. What then are the growth possibilities of these other facilities requests that you make.

Here is a facility which would have taken care of your needs in 1961, but we are now expanding it.

What about all these other requests? You think you are going to have to expand these?

Mr. WASELEWSKI. I think the history has demonstrated this is an art just like the art of testing satellites is in itself and you would expect you would have to enlarge these facilities. It's hard to predict at any time what the experience will be because we don't know.

Mr. KARTH. What about obsolescence, referring to these vacuum chambers testing facilities.

Mr. WASELEWSKI. Very often you have to modify them because they would become obsolete.

Therefore, you do modify them very often to prevent them from becoming obsolete. It can happen the facilities do get obsolete because it doesn't pay to modernize them.

Mr. KARTH. This is necessary as the state of the art progresses, I suppose.

You can't build this into the facility and construction as you build them.

Mr. WASELEWSKI. We try to build the facilities as flexible as possible because it's been our experience things do change and where we can see some means of constructing these things where there is a choice of doing it more than one way, we try to do it in the fashion that would make such changes as we might guess might occur easier to do at a later date because this is a matter of detailed design, if you will, trying to anticipate what may happen.

Mr. KARTH. Have you ever leased time in an industrial vacuum chamber?

Mr. WASELEWSKI. I don't know. As a matter of fact we have—we have had occasion to test several items at industrial facilities.

Mr. KARTH. This has been rather infrequent, I take it.

Mr. WASELEWSKI. It hasn't been very frequent.

Mr. KARTH. Have you had difficulty when you made these requests of the privately owned facilities?

Have you had to bargain with them, 6 months or when you made the request, did they say, yes, we can take care of you. After a few preliminary conversations, it's done.

What has been your experience?

Mr. WASELEWSKI. Our experience is we go to the people we know have had experience in this specific problem.

Where we had a problem, I don't know of any difficulty we have had, specifically, in getting them to do this.

We have selected the ones in advance whom we knew would have some available capability for us.

Mr. KARTH. How about Government facilities? Have you ever leased vacuum chambers belonging to other Government agencies?

Mr. WASELEWSKI. Vacuum facilities, yes. We ran tests at Tullahoma at the Air Force facilities there.

Mr. KARTH. You had difficulty making the arrangements so you could use those facilities?

Mr. WASELEWSKI. Those are, in fact—we don't have a capability for testing in-house, so they are unique facilities and we have used them and they have fitted into the program as required.

Mr. KARTH. When you required the use of the facilities, you had no difficulty making the arrangements for the facilities?

Mr. WASELEWSKI. There is usually a scheduling problem. Sometimes we have to adjust ourselves to what then is happening in the chamber or when it may be available.

It hasn't, up to now, been the cause of any major difficulty. It would cause us to rearrange things and, of course, we'd try to do these things as early in the game as we could. We also used other facilities.

We have used a centrifuge at White Sands, for example, and we are going to use it in our Eagle spacecraft work and such arrangements are already in process and some testing has been done.

Mr. MOSHER. Mr. Chairman.

Mr. KARTH. Mr. Mosher?

Mr. MOSHER. You said where you have used private industry vacuum tank facilities the experience has generally been good.

What about the cost there? The experience is good—What about the cost experience?

Is it exorbitant? Is it what's necessarily much higher than your own costs or is there any basis for comparison?

Mr. WASELEWSKI. Well, it's difficult to compare.

I think, usually, very distinct they are writing off their facilities on a 5-year basis or soon as they can. This is the major cost.

How soon do you write these facilities off? This creates this kind of cost.

I don't know how it compares with in-house costs.

I imagine the manpower is difficult when you do things in this sense, this is true of anyone doing a thing of this kind.

When you do it out-of-house there is a greater coordination effort that has to be done in order to transmit knowledge back and forth, if you will.

Mr. MOSHER. You are saying, generally speaking, this is a more expensive way to do it than if you have your own in-house facilities and they are kept busy.

Mr. WASELEWSKI. Oh, yes, especially if you are—if this is marginal to your own facilities in a sense that it does enable you to use your facilities full time.

Then I'd say it would be probably cheaper to do in-house because you have a certain amount of coordination you could save.

Sometimes, it may be appreciable. Sometimes it may be very small. I think this is the consideration. It's a matter of doing the work in-house and the reason for doing it in-house is so you can bring all

your skills to bear in the shortest possible time; because a test is not generally well defined to the extent you can give somebody instructions to do it and this is the way it is.

A test involves difficulties, a failure sometimes that has to be repeated.

It is necessary to bring to bear the design engineers, the design involved, the testing evaluation, the people who run these facilities and bring them together in work of designing and producing a new center.

Mr. MOSHER. When you have a center doing this type of work, I suppose you let the contract. It can't possibly be on a competitive bid basis.

Mr. WASELEWSKI. You have to negotiate them because admitting situations difficult under the circumstances, because it's hard to find two people who have the same facility.

Mr. MOSHER. Is there enough competition available in your actual experience in this area? Have you been able to choose between several contractors?

Mr. WASELEWSKI. Oh, I don't think there are a great number of contractors we can generally make available and the choice, I would say, is narrow.

There may be some choice sometimes. I think it is usually a case of being aware that such and such a company has a facility we might use in going to him and saying "Can we negotiate a way of doing this?" and, of course, in our negotiations we establish the basis of price and then, of course, it's subject to audit later on.

Mr. MOSHER. You mean you usually rely on your own awareness of the availability of facilities? You don't put out to the industry a broad sign saying, "We want this kind of a job done. What do you have available?"

Mr. WASELEWSKI. We haven't advertised a specific test as such because they are generally something we feel we must do in connection with the project and, generally, the need for these arises because of a change in plans, difficulties with the satellites, and we then have to go out very often on a short-term basis to provide this kind of testing capability.

Dr. SEAMANS. Could I emphasize one point, Mr. Mosher?

I think you have to differentiate what might be called "Go," "No go" kind of testing.

Mr. MOSHER. What kind?

Mr. RANDALL. What was the word?

Dr. SEAMANS. "Go," "No go," the kind of testing a standard component undergoes, say, a light bulb or something—either it has quality or it doesn't.

Our type of testing is intimately connected with a development process. A test one day will reveal a design weakness and make it necessary to modify a design and introduce a new component or a new method of making an electrical connection. We have to do that very quickly in order to continue testing. Delays will increase the cost very appreciably and, of course, delay planned flights.

It's very important that the testing be done in intimate relationship with those who have the overall responsibility for the hardware. In some cases this is a contractor, and in other cases it's a NASA team.

Mr. KARTH. Mr. Randall?

Mr. RANDALL. In the remark made by Mr. Waselewski, about the charge off—the 5 years, seems to me, you might be able to get some real bargains down toward the end of that 5-year period. Have you investigated that?

Mr. WASELEWSKI. Aren't many of these chambers 5 years old?

Mr. RANDALL. Let me give an illustration.

We had an opportunity during recess, to visit several of the plants. We were particularly impressed by the one at Tulsa, of Douglas. They are doing everything under one roof there—almost everything—working on airplanes, working on Air Force modifications, and space work.

Now, here was a very elaborate tower, at least, supposedly could test the reliability and durability and efficiency of space capsules at any level of environment all on the outside.

I am wondering if you found out what work they can do there. It was a great test stand. I was very impressed with that.

Have you explored that?

Mr. WASELEWSKI. Not specifically.

Mr. RANDALL. That raises the next question.

That was for purposes of quality control, their own purpose. I suppose. Do you get any reports as to what they are doing and what they are not doing?

I want to make it plain, Mr. Chairman, I am an advocate of testing. It's necessary.

The little comment you made in your statement, the cost of a test is slight as compared to an unsuccessful launching, and so forth—on an unsuccessful venture—but what are you doing to find out what people like Douglas or North American are doing and do you have any story of how much is available of these facilities?

Mr. WASELEWSKI. Well, to respond, as I said, I am not aware of this myself, but I am sure a lot of our people at Goddard are aware of these facilities and the way we learn of them, of course, is by actually visiting these contractors.

In fact, in the case of Thermalvacuum chambers, I think somebody in our staff has visited every one of the major Thermalvacuum facility locations at some time or other during the last year and we feel that we are well aware of these things and we document, as I pointed out before—we document some of them, the major ones, so that, yes, we do welcome the possibility of somebody else's facilities when it applies to our problem.

Mr. RANDALL. You are probably the wrong witness, but after that trip, I was convinced there must be other instances about the very thing we are talking about that take in plants throughout the country.

Mr. KARTH. May I ask, you have never tried to use the facilities; have you?

Mr. WASELEWSKI. This facility, without knowing about the facility, I don't know whether it would be applicable to the problem.

Mr. KARTH. Have you ever tried to use any of these?

Mr. WASELEWSKI. Yes; we have used contractors' facilities in our testing.

Mr. KARTH. So far as your request is concerned, and the use you have for the facility that you request, have you tried to negotiate the use of private facilities that would take the place of the in-house facilities you request in the 1964 budget?

Mr. WASELEWSKI. Well, that gets to be a rather specific question that has to be addressed to the specific facilities.

Well, the answer to your question is, we have not only negotiated, but also have bought such time.

For example, the S–48 satellite we are currently engaged in, has had a considerable amount of work done at Bendix at Ann Arbor, Mich., and we can use their Thermalvacuum facilities in this process.

Mr. KARTH. These people who have payload test facilities, have you attempted to negotiate with them for the use of these facilities which would negate the need for the 2½ million payload test facility you requested in this budget?

Have you tried to do that? That is my specific question.

Mr. WASELEWSKI. If we take one of those items at a time; for example, to the best of our knowledge one of the items we mentioned as part of this improvement——

Mr. KARTH. I just mentioned the payload test facilities. Could you answer that?

Mr. WASELEWSKI. I am trying to address myself to the payload test facilities modification.

There are several things in it. You will note one of the things calls for a solar simulator.

This just isn't available any place, to the best of our knowledge, in sufficient amounts to lead us to go out to contract.

We have, ourselves, just recently solved to our own satisfaction the problem of getting a satisfactory solar simulator, and one of the reasons we are building this one, we are trying to advance the state of the solar simulator as well as one can be used in our test work. It has a dual purpose here—not only the developing and testing of satellites, but our trying in this case to provide an improved facility that will do a better job of a solar simulator and thereby make our spacecraft more reliable.

So, this is the kind of facility this particular item is.

Mr. ULMER. Mr. Chairman, I think the point Mr. Randall raised is a very good one.

I'd like to emphasize this coordination process we have been discussing here does not occur at the time of the budget preparation. It occurs all the time as a going thing within the agency.

This is the kind of thing Dr. Seamans tried to get across in his statement.

This $7 million facility was in our budget this year. After further examination we found time could be made available on existing Government facilities. This was not the case at the time we prepared our budget.

We removed the $7 million facility on the budget and by a modification, $3 million, we are now able to accomplish the same testing by using an existing Government facility. This goes on all the time.

It's not just a thing done once at the time you put the budget together. After the budget is approved and the appropriation is passed and the budget is past, there is the time a director must come in and defend his facilities before the money is released and this goes on all the time.

This is why the reprograming authority is so essential. It's not just adding things to the program. We also delete.

Mr. KARTH. We are aware of the fact you are continually working on these problems.

We are also aware of the fact you probably already started to work up your 1965 budget request.

Mr. ULMER. Right.

Mr. KARTH. So, this is a never-ending process, too. We appreciate that.

We appreciate that NASA, with the tremendous growth that has had to take place, has really done a magnificent job.

We would like, if possible, to help you do an even better one.

Mr. ULMER. I understand.

Mr. KARTH. This may be impossible. The only thing I am saying is we are trying to help you do a better job.

On some occasions I assume this is not appreciated, and on others, I think it is.

Mr. ULMER. I think it is, Mr. Chairman.

Mr. KARTH. We are very serious about the contribution we are trying to make. If not, we go through the exercise that causes there to be a legislative branch of the Government. At least, we have satisfied ourselves that the proper thing has been done.

I wonder if I could ask again, referring again to this facility I asked you, specifically about a moment ago.

Mr. Waselewski, the payload test facility, I see in your description this language and I'd just like to ask you about this.

The centralized data analysis system to be installed in the building will be expanded to provide additional high-speed and low-speed channels.

What are high-speed and low-speed channels?

Mr. WASELEWSKI. These are channels of information. Means by which you take the information from the test floor to a computer and associated equipment, the data up to the control room, where it is analyzed.

You need an instrumentation, if you will, which is capable of picking up certain kinds of data from the spacecraft or the object on your test.

Dr. SEAMANS. Low speed might refer to a temperature change which is usually somewhat gradual where high speed would involve the effect of shock, something that happens within a thousandth of a second.

Mr. KARTH. Are they computers?

Mr. WASELEWSKI. No this is an instrumentation. It is an electronic device providing a means of measuring.

Mr. KARTH. Its work is recorded by computers?

Mr. WASELEWSKI. The computer takes the information and does something with it. It combines various qualities. This is an expansion of our data-taking capabilities. is what it really is.

The low-speed channels enable you to explore what happens to this gradually and the high speed takes care of the things that happen further and involve a control which must react promptly and you need a very rapid trace of what's happening in the phenomena we are studying.

Mr. KARTH. Thank you.

I think we are going to have to adjourn the meeting today, Dr. Seamans.

It may be that we would like to speak with you or some of your people further at a later date.

Dr. SEAMANS. I'll be happy to return any time you wish.

Mr. KARTH. Let me just ask you one question in conclusion.

I think I've asked this question before, but I never thought of it when I had one of the top people of NASA here, so I'd like to ask you the question that seems to me to be rather important, and I can't quite understand why more serious consideration hasn't been given to it.

Everyone speaks of ties between NASA and DOD, liaison, coordination, exchange of information; and I find that this is good. In my opinion, I think it's extremely good, and is extremely helpful to both NASA, DOD, and the taxpayers.

The DOD, for example, has 200 people working in NASA, and this, I think allows the Defense Department to take this information that these people gain in NASA and really integrate it into the Department of Defense.

They are able to take it right back to the specific areas and very direct channels, feed it back into the stream of knowledge that is so necessary in both agencies.

Now, we don't reciprocate.

We don't have any NASA people working directly in the Department of Defense. It seems that there might be more information going one way than is coming back.

I don't say that this is bad from any standpoint other than the fact that it would be of great benefit to the Nation, it seems to me, if we had this exchange of information, this very direct exchanging, going in both directions.

Why don't we have some NASA people assigned to some of these projects in the Department of Defense?

Dr. SEAMANS. Well, the agreement is a matter we discussed and consummated about a year—year and a half ago, with the Department of Defense.

NASA legislation specifically permits DOD personnel to be assigned to NASA. We don't have an exactly similar—as I understand it—relationship that would permit us to assign people to DOD. However, I am sure we could work something out along this line.

Mr. KARTH. Have you ever proposed, Dr. Seamans, that some of your people actually go to DOD? Have you ever attempted to assign them to the Department of Defense and DOD refused?

Have you made the request—I guess is my question.

Dr. SEAMANS. We have not proposed this. I am sure we would be as responsive if possible if the DOD had such a requirement.

Mr. KARTH. Is it the general attitude in the Department of Defense and various branches of the service this is not something that is acceptable to them?

Dr. SEAMANS. There are several problems.

One is the very practical one, at the moment NASA is having a difficult time, you might say, in hiring enough talented people to manage its own affairs. We do not have an excess of key personnel. If NASA details to DOD were to be really effective in this role you have described, they would have to be key personnel. It has been seriously considered and we will continue to review the possibility.

Mr. KARTH. That's your personal opinion on it, Dr. Seamans?

You think it's a good idea we should make every effort to encourage this?

Dr. SEAMANS. I think, myself, it would be a very healthy thing to do if we can find the right role or the NASA people in the Department of Defense.

We have to remember, however, that——

Mr. KARTH. Would it be any more difficult than finding a role for the DOD people in NASA?

Is this a real insurmountable problem?

Dr. SEAMANS. It's not an insurmountable problem. There is the problem of what role our civilians would perform in the military and so on, which would have to be worked out.

Mr. KARTH. The Military Establishment is full of civilians.

Dr. SEAMANS. That's what I mean——

Mr. KARTH. You mean it's too full?

Dr. SEAMANS. No, I am referring to the responsibilities they would assume.

Mr. KARTH. I was just being facetious.

Mr. WYATT. Mr. Karth, if I may, I think along this line, NASA has a very definitely assigned mission. I think, as Dr. Seamans indicated, we just keep our nose above water at times in trying to accomplish that mission. We do have a situation at the moment in the military, where their final and ultimate missions in space are not too well defined, and it is very greatly to their advantage to take some of their very key people and have them work on the live going field to build up experience, to share the active projects in anticipation of when they will have a more clearly defined space role.

I think the reverse is not true and as Dr. Seamans indicated, at this time we have so many specific things to do, it would be a dilution in a sense of our people to put them over there.

In other words, we have no charter to operate military systems, per se. The military do have a charter to operate space systems, but they don't know just what these space systems ought to be yet.

There is this difference.

I think it is to their very great advantage to acquire firsthand understanding what we are doing and what the allout benefits might be.

I don't think the reciprocal is true at the moment.

Mr. KARTH. Is this your idea, it is not a good idea to explore with some hope of success in the near future of placing NASA people in some of the Air Force programs?

Mr. WYATT. I would not say it is not a good idea.

Mr. KARTH. Might tend to give NASA ideas on what they are doing.

Mr. WYATT. We use other channels. We use advisory channels on which various elements of DOD are represented, as services in attempting to get fed into our activities a knowledge and an understanding of the service problems—what they are looking for.

I would not say it is not a good idea. I would qualify as Dr. Seamans did. I would say we'd have to look at it very carefully because of the different perspective of this.

As to exactly what the advantage would be to take a NASA man and place him in the Department of Defense, we would have to look at it very carefully.

Mr. RANDALL. Mr. Chairman, may we have for the record, how much money is the Air Force spending on space?

Mr. WYATT. Approximately $1.6 billion.

Mr. RANDALL. That's right.

Should we not know, not generally but every detail, every facet, what they are doing—NASA should at all times?

Mr. WYATT. We are trying to strengthen that at all times.

Mr. RANDALL. You get this from the Air Force don't you?

We don't have anyone riding herd or making a detailed close careful survey of all these activities.

Dr. SEAMANS. I'd like to just note there are NASA people located in Wright Field in support of the Dyna-Soar program. They are still on the NASA payroll, haven't been reassigned to the DOD, but they are working in the Dyna-Soar project office; so there is a case where there is a research and development program in the DOD where we want to have maximum coordination. Our policy is to supply technical advice and counsel whenever it can be made available in response to a request.

Mr. RANDALL. I think in supplement of what the chairman said, this session of Congress is going to be marked by a reduction of all budgetary requests. We just want to be sure we are going in the right direction and doing the very best we can when we make a reduction that there is some possible duplication or overlapping and we are trying to help.

It's not a question of a conflict here. We are simply saying that this is a case where we might really pick up some overlapping or duplication.

Dr. SEAMANS. I would like to come back to a point I made earlier; that is, to do this effectively, we must review carefully the assignment of the individual in order to insure maximum utilization of his talents and capabilities.

I could see NASA people working either in the services or DOD as members of planning groups. This involves an understanding of current state of the art and what might be accomplished technically or scientifically.

On the other hand, there are places in the DOD that involve immediate military capability. These are areas in which NASA may not be in a position to really provide personnel who would be of any great assistance.

Mr. KARTH. Unless it involves very basic research, Doctor, I suppose in these areas, might even be helpful.

Dr. SEAMANS. It could be.

Mr. KARTH. Well, I guess the answer then to the question is that NASA has been able to do this in areas where they felt that it was to their advantage and a case in point is the Dyna-Soar program. Is that correct?

Dr. SEAMANS. This is not exactly the same, though, as the situation of the 200 military people who have been assigned to NASA.

Mr. KARTH. Yes; I understand that the need, the overall need may not be as great.

I am still trying to find out whether it is the NASA who has objected to doing more of this or whether it is the DOD that has been objecting.

Dr. SEAMANS. I don't think anybody is objecting. If such an arrangement were advantageous to both parties, I am sure it would take place.

Mr. KARTH. But where you found the situation, you have been able to do it and Dyna-Soar is the prime example.

Dr. SEAMANS. Yes.

Mr. KARTH. Fine. Thank you very much.

The meeting is adjourned.

(Whereupon at 12:20 p.m. the subcommittee was adjourned.)

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HEARINGS

BEFORE THE

SUBCOMMITTEE ON SPACE SCIENCES AND ADVANCED RESEARCH AND TECHNOLOGY

OF THE

COMMITTEE ON SCIENCE AND ASTRONAUTICS

U.S. HOUSE OF REPRESENTATIVES

EIGHTY-EIGHTH CONGRESS

FIRST SESSION

ON

H.R. 5466

(Superseded by H.R. 7500)

MARCH 6, 7, 8, 11, 12, 13, 14, 19, 20, 21, 27, 28; APRIL 1, 2, 3, 4, 5, 8, 9, 10, 11, 24, 26, 29, 30; MAY 1, 6, 1963

[No. 8]

Part 3(b)

Printed for the use of the Committee on Science and Astronautics

1964 NASA AUTHORIZATION

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NOTE.—The chairman of the full committee and the ranking minority member, Hon. Joseph W. Martin, Jr., are ex officio members of all subcommittees.

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1964 NASA AUTHORIZATION

TUESDAY, APRIL 2, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SPACE SCIENCES
AND ADVANCED RESEARCH AND TECHNOLOGY,
Washington, D.C.

The subcommittee met, pursuant to adjournment, at 10 a.m., in room 304, Old House Office Building, Hon. Joseph E. Karth (chairman of the subcommittee) presiding.

Mr. KARTH. The meeting will come to order.

Dr. Bisplinghoff, I understand that today, Mr. Charles Zimmerman who is the Director of Aeronautical Research Division of your office would like to present a statement to the committee.

I would like to suggest, as I did to you privately about 10 minutes ago, that Mr. Zimmerman give us a 10 or 15 minute summation of his prepared statement and then the members may have questions.

The reason I suggest this is because I recall that on the aeronautical research section of your presentation we went into considerable detail.

Dr. BISPLINGHOFF. Yes, sir.

Mr. KARTH. There was a good deal of interest on the part of the subcommittee members, and I think, perhaps, they are fairly familiar with it.

If there are no objections on the part of you or Mr. Zimmerman we will proceed in that way.

Dr. BISPLINGHOFF. We will be glad to proceed in any way you see fit.

Mr. KARTH. Mr. Zimmerman.

STATEMENT OF CHARLES H. ZIMMERMAN, DIRECTOR OF AERONAUTICAL RESEARCH, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. Chairman and members of the subcommittee, the NASA is conducting research in aeronautics with the following broad goals which are in accordance with the national interest and consistent with the policies set forth in the National Aeronautics and Space Act of 1958 and in the President's message on transportation of April 4, 1962. Our goals are to provide the research and advanced technology which will—

1. Enable our aircraft industry to produce aircraft which will, to the greatest practicable extent, make the convenience and speed of air transportation available, and economically feasible, to the people of this country;
2. Enable our armed services, working with our industry, to develop military aircraft superior in performance, in utility, and in requirements for logistics and manpower support to those of any other country.

In working toward these goals, we coordinate our efforts closely with the Federal Aviation Agency, the Department of Defense, and other government agencies. We maintain liaison with these agencies and with the aircraft manufacturers and their customers not only through personal contacts at all levels and

numerous ad hoc groups and panels set up from time to time to deal with special problems, but also through a system of committees. Our aeronautical program is regularly reviewed, criticized and augmented by committees on aircraft aerodynamics, operating problems, structures, and air-breathing propulsion. These committees are made up of qualified experts from the aircraft industry, the airlines, the Federal Aviation Agency, and the Department of Defense.

Before going into a discussion of our program, I would like to make a few general comments. Aviation no longer offers the glamour and excitement which so strongly influenced its growth in its early years. We are not striving for speed and altitude records. Men have circled the Earth at orbital speeds. The X–15 has flown practically out of the atmosphere. Our objective now is transportation, economically feasible transportation for commercial purposes, militarily superior transportation for military purposes. I would like for you to consider our program as directed toward maintenance and enhancement of our leadership in air transportation.

In order to assist you in your assessment of our program, I will discuss it in terms of four aircraft categories, as shown on figure 172, page 2074.

1. Conventional subsonic aircraft.
2. Supersonic aircraft.
3. Hypersonic aircraft.
4. Vertical and short take-off and landing aircraft.

SUBSONIC AIRCRAFT

There is a tendency to assume that, since our present jet transport aircraft operate across the continent and around the world with apparent ease, the problems associated with such aircraft have all been solved. This is far from true and one of the principal areas of research in the aeronautical program is directed toward aiding in the solution of some existing problems. Major problems include the provision of better flying and handling qualities, the alleviation of engine noise, the multiple aspects of flight safety, all-weather operations, and other environmental aspects and flight instrumentation accuracy. In addition, a reasonable level of research support is maintained to provide aerodynamic data which will make possible improvements in performance and efficiency in this speed range.

Many continuing programs support the subsonic aircraft effort. Among these is the NASA VGH (V for velocity, G for acceleration, H for altitude) data collection program which has provided research information on operational practices and environmental parameters for several types of commercial turbine-powered transports. This information has provided a basis for assessing the adequacy of current design criteria and also a body of information applicable to the design of future transports. Current and projected programs are aimed at extending the scope of the measurements to cover new types of commercial transports, cargo airplanes and light airplanes in the personal category. The data to be obtained will provide statistical information on airspeed-operating practices, ground and flight loads experienced, and pertinent environmental parameters, such as the atmospheric turbulence encountered. The integration of this information into design criteria will result in improved and more efficient airplane structures and operating practices.

In another program of great importance in the subsonic aircraft field, the NASA in late 1961 assisted the FAA in conducting full-scale tests to determine the drag on a jet transport operating on a runway covered with slush or standing water. Additional supporting tests were carried out at the NASA's Langley landing loads track. The slush drag problem and its importance can be visualized by figure 173, page 2075, where the effect of runway surface condition on aircraft stopping distance is illustrated. The results are for a large jet transport using basic data obtained from friction coefficients determined during the aforementioned FAA–NASA slush-drag program. For a touchdown speed of 150 miles per hour, it is seen that this particular airplane requires 1,800 feet to stop on a dry runway, 2,800 feet on a wet runway and 4,800 feet on a runway covered with one-half inch of slush. Research on various types of landing gears and into basic means of improving braking under adverse conditions will be continued in fiscal year 1964 at the Langley track.

An area of aircraft operations generally recognized as one of great potential danger, is the traversing of the wingtip vortex field of one aircraft by another. The CAB recently has attributed three fatal light-aircraft accidents which occurred in a 4-month period to such a probable cause. The NASA has done some experimental and theoretical work in this field which has pointed up the magnitude

of the danger and offered some relatively simple operational procedures for pilots to follow. Somewhat less well recognized has been the potential danger to light aircraft traversing the vortex field generated by helicopters. Recent flight tests have been made with the results illustrated by figure 174, page 2076. The upper portion of the figure (which is not to scale) shows the tip vortex cones generated from the outer edges of a helicopter rotor disk and the flight path of the penetrating test airplane. As the test airplane gradually crossed the helicopter wake from 1,000 feet behind and 100 feet below, the airplane response was such as to cause it to roll violently first to the left and then to the right. These motions had to be counteracted by the use of full aileron control. In fact, as the lower portion of figure 174, page 2076, indicates, the stick was against the stop for a short period of time. If the test aircraft had been lighter or the weight of the helicopter greater, the maneuver would have been uncontrollable. The test program graphically demonstrated the dangers to light aircraft and resulted in a wide dissemination of cautionary advice to pilots. Studies in this area will be continued and assistance will be given to the FAA as further operational aspects are explored.

The aircraft engine noise problem will be attacked on two fronts in fiscal year 1964: (*a*) an investigation of the noise source, i.e., the engine components, to obtain basic information to ferret out any engine-design techniques that might reduce engine noise, and (*b*) the investigation of operational techniques to move the source of the noise farther away from the people on the ground.

Modifications are being made to the noise research facilities at Langley which will permit the evaluation of various means of reducing the noise from ducted fans and compressors and the correlation of these results with engine performance data.

The noise generated by the ducted fan engines used by the modern jet transports is an important factor in community planning. To illustrate this, figure 175, page 2077, shows the noise level on the ground below an aircraft as it proceeds along an instrument landing approach path. It will be noted that even 5 miles out the level is 97 decibels, while within 1 mile of the touchdown point it has increased to 125 decibels. Any level above about 112 decibels can be considered as intolerable. If the approach angle can be raised to 15 degrees, there will be a noise decrease ranging from 24 decibels 5 miles out to 14 decibels 1½ miles from touchdown. These are significant improvements since a 14-decibel decrease means that the noise intensity is 25 times lower and a 24-decibel change is equivalent to decreasing the noise intensity by a factor of 250.

Figure 175, page 2077, has indicated the improvements which could be effected by using steep approach techniques. The development of such techniques applicable to V/STOL and transport aircraft for the purposes of noise abatement and also airspace conservation is part of the NASA aeronautical research program for fiscal year 1964. Present effort includes work with helicopters to represent V/STOL-type aircraft and a variety of fixed-wing aircraft. Future work is planned using a variable-stability fixed-wing aircraft to represent additional aircraft types including supersonic transport designs.

SUPERSONIC AIRCRAFT

Supersonic aircraft have advanced to the point where military fighter and bomber aircraft are currently in operational status; however, these aircraft are somewhat deficient with regard to range and endurance and are uneconomical to operate. Research must therefore be directed toward improving the state of the art in aerodynamics, structures, materials, and propulsion.

Advancements in the state of the art will not only permit the improvement of existing aircraft but will also show the way to new advanced military and civil aircraft.

In the military field significant achievements have recently been accomplished that effectively illustrate the value of a continuing fundamental research program. The research conducted by our research centers, and in particular the Langley Research Center since 1959 culminated recently when General Dynamics was selected to develop the variable-sweep F–111 biservice tactical fighter. We described some of our goals and work in this area last year, and I have here a model of one of the promising configurations we investigated. The F–111 will serve both the Air Force and Navy and will provide extreme versatility. This aircraft is a direct result of the NASA's aeronautical research program. When our research program in this area was initiated, there was no specific requirement for such an aircraft, since it was not realized that such versatility was possible. Now our effort in this area must turn to the problems of the specific F–111 design

to assist the military in obtaining a vehicle to meet its mission requirements. In this regard our work in fiscal year 1964 will increase in this area to provide required information in sufficient depth of detail to assure that the military agencies acquire the best possible vehicle for the defense of the country.

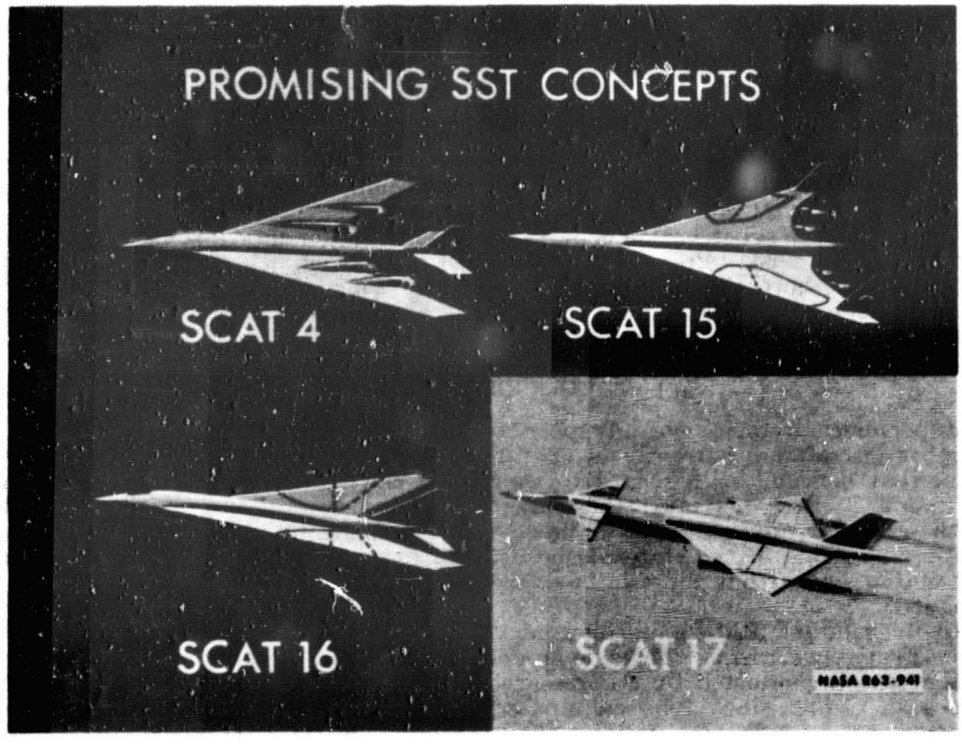
In the civil area, as part of the joint FAA/NASA/DOD national program of assistance to the industry for the development of a commercial supersonic transport airplane, the NASA role is to provide technical support and conduct the basic necessary research. For about 4 years, we have been engaged in applying our current technology to demonstrate the broad technical feasibility of an aircraft meeting anticipated requirements of the airlines, financial interests, and the public.

A concentrated research effort involving the Ames, Langley, Lewis, and Flight Research Centers on the problems posed by the supersonic transport has brought this project to the stage where industry will very soon have sufficient information to choose among several design possibilities.

When the designers' choices are narrowed, the NASA effort will concentrate on the problems related to the specific chosen design and research will necessarily increase in depth of detail in all technical areas.

Many supersonic transport configurations have been investigated in the past 2 years. These investigations have allowed us to conclude that at least on the basis of wind-tunnel tests and analytical studies, four basic design concepts appear capable of providing the characteristics required of an efficient, economical, safe, and reliable supersonic transport aircraft.

The four basic design concepts are shown in the next chart, figure R63–941. These four, the arrow-wing, two variable-sweep configurations, and the Canard-Delta are currently under study by the aircraft industry to determine their practicability as design concepts and to define any problems in need of further research. The aerodynamic problem is to achieve cruise efficiency with adequate range and reasonable operating cost and still achieve good takeoff, landing, climb, and acceleration characteristics.



A supersonic propulsion system which will meet the economic and reliability requirements of commercial aviation is not presently available. The next chart, figure 176, page 2082, illustrates types that appear to satisfy these requirements, the turbofan, the turbojet, and a composite engine. The problems associated

with these various propulsion systems have been defined but more work on specific problems must be done before the best system can be selected.

Minimum structural weight is imperative to the development of a reliable, efficient supersonic transport. Because of temperature environment of the supersonic transport more efficient structural techniques and long-life materials are mandatory.

Operating problems include a myriad of areas requiring continuing work, for example: sonic boom, landing approach techniques, air traffic control, and flying and handling qualities. Past research effort on the sonic-boom problem has indicated the need and direction for further research. Landing approach techniques and piloting problems must receive increased attention in the future. A ground-based flight simulator for advanced aircraft is a necessary tool for investigating with adequate realism, critical areas of a pilot's capability. Flying and handling quality requirements must be defined and solutions found to provide adequate dynamic stability and control in all operating regimes of the supersonic transport. The results of research effort in the area of operating problems have a direct influence upon the aircraft configuration and the propulsion system.

During fiscal year 1964 we will approach the time when design choices for a U.S. supersonic transport will be made and the NASA's performance and mission studies, wind-tunnel studies, simulator studies, and associated flight studies will change from the general character they now have to more specific studies in greater depth of detail. Since the effects of even small changes in design or operation can have a significant effect on the whole machine, due to the strong mutual interdependence of the various components of the vehicle, it is necessary to carry on a carefully coordinated and detailed research program.

I have been talking of the problem of two specific examples of supersonic aircraft, one in the military field, the F–111, and one in the civil field, the commercial supersonic transport. I will now direct your attention to some examples of our general work which is applicable to all supersonic aircraft. For example, in the field of structures, because of our present lack of ability to predict accurately the fatigue life of aircraft structural members, a fail-safe philosophy has been widely adopted in the aircraft industry. This philosophy accepts the probability of fatigue cracks, and the structure is designed so that a single crack will not unduly weaken the structure. In support of this philosophy, systematic programs are underway to study the rates of progression of fatigue cracks and the reduction in residual static strengths due to such cracks.

The series of accidents which befell the Comet aircraft is an example in which a relatively small fatigue crack in the pressurized fuselage led to a catastrophic failure. As a result of structural tests of pressurized cylinders and complementary theoretical work, NASA developed principles for making fail-safe fuselages. These principles have been adopted by U.S. aircraft industry and are employed in all our current jet transports.

The fuselage of a supersonic transport cruising at 70,000 feet poses a much more severe problem. If a fuselage crack develops and pressure is lost, provision for dropping oxygen masks to the passengers, is no longer adequate. At these rarefied altitudes a passenger really needs a pressurized space suit. This being impractical, the fuselage must be 100-percent fail-proof. This is no small task in view of the heating, noise, and other loadings to which the fuselage is subjected and the requirement that the structural weight be kept to a minimum.

Despite the continued existence of all the old structural design problems and the addition of new foreign environments which the structure must withstand, notable progress is being made to overcome the new obstacles, and yet provide methods for building structures with lower weight fractions than have been attainable in the past.

A program of intense effort, and one which is of tremendous significance in planning for the supersonic transport, is the sonic-boom research carried out principally by the Langley Research Center. The intensity of the sonic-pressure wave registered on the ground, and community reaction to it, will influence supersonic transport cruise altitudes and flight plans and thus to a large extent the design of the airplane.

During the past year much information concerning the sonic boom has been obtained from a joint USAF/NASA/FAA flight program. In this program B–58 and other supersonic aircraft have been flown over instrumented ranges at various speeds and altitudes to obtain ground-pressure measurements. Extensive wind-tunnel studies have been made and are continuing. At the present time, techniques are being developed to permit a determination of the effects of aircaft configuration on sonic-boom intensity. The next chart, figure 177, page 2083,

illustrates the status of this work. The ordinate is a measure of sonic-boom intensity and shown here are curves that indicate the intensity of the sonic boom that will be felt on the ground with a transport-size aircraft flying over at three times the speed of sound. The two upper curves are each for a different design-concept aircraft. The dashed curve is a lower bound that can be approached and is a result of current theoretical and experimental work on the problem. The theory that has evolved from this work permits the study of the effect of aircraft configuration on the sonic boom. The important fact to be noted in this chart is the significant effect of model configuration on boom intensity as shown by the difference in level of the two solid lines. For the first time, a theory is now available to permit study of these efforts. Much work remains to be done and will continue in fiscal year 1964.

A vital part of the simulator program is the variable-stability aircraft to be operated at the Flight Research Center. Flight research is required, in order to: (*a*) Check analytical studies, (*b*) validate and correlate results from ground simulator programs, and (*c*) investigate problem areas which cannot be studied in ground facilities.

The next chart, figure 178, page 2084, illustrates schematically the aircraft chosen for this work and some of the modifications required. A test pilot will fly the aircraft and will be presented with a simulated instrument display which, coupled with the modified aircraft motion, will appear to the pilot as having the characteristics of the aircraft being simulated. A safety pilot will have a standard instrument display to indicate the real aircraft flight conditions. The safety pilot will thus be able to take over if needed. The aircraft will also contain the simulation system computers, a test director's console, and displays for observers as well as the more or less standard NASA flight sensors and recording equipment.

Materials for the construction of aircraft to fly more than twice the speed of sound must be investigated to provide the necessary information to permit a selection to be made. The materials problem became very acute about 2 years ago. At that time a search of available information revealed that no information existed to permit the selection of skin materials that would withstand the temperature associated with speed greater than twice the speed of sound with the reliability and endurance capability required for commercial operation. An intensive program was immediately undertaken by the NASA to provide such information. A large number of candidate alloys were selected for a screening program to eliminate those not suitable. The next chart, figure 179, page 2085, shows a rough approximation of the relative rates at which the strengths of some of these materials deteriorate with time. Today the number of candidate materials has been reduced to about seven alloys which have passed the necessary tests. These metals must now undergo extensive tests before final selection of the materials for the supersonic transport is made.

HYPERSONIC AIRCRAFT

The X–15 research airplane program was initiated in advance of the space age as a joint effort of NASA and DOD to pioneer in the hypersonic flight regime. It has fulfilled its original purpose exceedingly well and the flight research program on this manned maneuverable hypersonic aircraft is still in progress.

The next chart, figure 180, page 2085, shows the altitude-speed flight envelope of the X–15 already explored in relation to the region of interest for continuous flight in the sensible atmosphere. The X–15 is providing valuable inflight data for the development of future suborbital and space-vehicle systems. "Follow-on" phases of the program having space technology as well as aeronautical objectives are currently underway.

With the solid success of the X–15 program, the point has been made to the Congress that we are looking ahead in aeronautics to advanced research and technology needs of the Nation in the area of airplane-like hypersonic vehicles. The place of such vehicles in the aeronautical transportation spectrum is shown in the next chart, figure 181, page 2086.

The lower end of the range-versus-speed plot is covered by subsonic aircraft of both rotary-wing (helicoptors) and fixed-wing types including the familiar subsonic jet transport. The projected supersonic transport will extend this lower end up to 2,000 miles per hour or so and perhaps 5,000 miles ultimate range. There remains to be exploited, although already spanned by the expendable rocket booster, a wide range of useful higher speeds and ranges up to halfway around the earth. There also are emerging needs for transferring personnel and their equipment to or from space stations in orbit, and there is the possible need for military control of near-space for national defense.

The cost of present rocket technology for bridging the gap in the pathway to space is high. These are reasons to believe that a hypersonic airplane with air-breathing engines using the oxygen from the atmosphere shown here for global range earth transportation or for boosting a second stage like the X–20 (Dyna-Soar) into orbit will be much more economical. It is likely that this area of the spectrum will eventually be filled in the manner outlined.

One attractive concept for a combined earth-to-orbit and earth-to-earth transportation system is illustrated in the next chart, figure 182, page 2087. The first-stage booster is a HTOHL hypersonic-cruise airplane with turboramjet air-breathing propulsion. At the optimum hypersonic speed and altitude, it launches a second-stage rocket-propelled carrier capable of orbital rendezvous with a space station or an alternate vehicle for the simpler earth mission. Either second-stage carrier is capable of horizontal landing at a preselected point. The HTOHL feature with suitable abort capability permits the transfer or ordinary people as well as highly trained astronauts.

Now I have a model here to illustrate what such a system might look like. In this model the second stage is carried internally to improve performance on the way to the staging point; it might alternately be carried externally on top of the hypersonic airplane.

As listed on the chart, the potentialities of the system include a wide rendezvous launch window and a wide choice of operational sites. The vehicles can be fully recoverable and reusable to save costs on a long-term and high traffic density basis.

The current NASA program is outlined in the next chart, figure 183, p. 2089. It embraces conceptional, operational, and economic studies to establish the practical desirability of the concept, and research and development effort in the critical areas of propulsion, structures, materials, and aerodynamics to provide the information necessary to permit long-term development decisions. I will amplify briefly on the effort in these technical areas.

The question of what part air-breathing propulsion should play in the systems being studied is being intensively examined. Initial results in this area are encouraging, at least up to hypersonic mach numbers of 10 to 12.

Above the speed of the supersonic transport the ramjet engine appears to be the most promising solution. Two types of ramjet are shown in the next chart, figure 184, p. 2089, the subsonic-burning type for operation up to perhaps mach 8 and the more advanced supersonic-burning type for operation up to mach 25 or so. The upper range of usefulness of subsonic-burning ramjets is limited by excessive pressures, temperatures, and exhaust nozzle losses. With the supersonic-burning principle, the temperatures and pressures are less severe and there is theoretical indication that nozzle losses due to recombination of the products of combustion will be less severe. However, experimental research over a wide range of pressures, temperatures, and fuel-air ratios is required to determine the practical potentials of hydrogen-fueled supersonic-burning ramjets.

You are aware that flight vehicles are subjected to aerodynamic heating at high speeds. For this reason the materials and structures problems become extremely critical at hypersonic speeds as shown in the next chart, figure 185, p. 2090. Here is shown the structural weight percentage of total aircraft weight as a function of speed. (The structural weight percentage is in effect an inverse indication of the structural efficiency.) At the lower speeds the familiar aluminum alloy airframes weigh something like 20 percent of the total; the present-day effectiveness of civil and military aircraft is in a large measure attributable to this low weight fraction. As the speed and heating increase, aluminum and steel are no longer suitable materials because of deteroriation of their strength, and heat-resistant refractory metals or ceramics must be used. As can be seen, these are inherently heavier and less efficient so that at hypersonic speeds of 10,000 miles per hour the structural weight will constitute something like 50 percent of the weight of the aircraft unless marked improvements can be achieved.

Our goal in structures research is to offset this adverse trend by means of basic improvements in structural design. What we seek are more efficient methods of utilizing less efficient materials. It is imperative that ways be found to decrease what we have here labeled the "heating penalty."

One example of a structural concept that is evolving from NASA research effort and may provide the needed improvement is shown in the next chart, figure 122, p. 1975. On the left is shown a construction typical of present-day technology. On the right is shown a type of structure where the reflectivity of the material is combined with a vacuum to insulate the very cold inner (hydrogen tank) surface from the very hot outer skin. The structure is composed of very thin dimpled

metal sheets welded together at matching dimples thereby restricting the area available for heat flow from sheet to sheet. This concept also provides a means for inert gas purging to prevent any leaking hydrogen coming in contact with the hot external surface and causing a destructive explosion.

The aerodynamics problems for the hypersonic vehicle systems are very much like they have always been except for their complexity due to the wide range of subsonic, supersonic, and hypersonic mach numbers encountered. In order to have low-enough drag and high-enough lift-drag ratio while maintaining reasonable stability and control characteristics over this wide range of speeds, advanced variable-geometry features may be necessary. The fundamental problem of the hypersonic-cruise vehicle is one of configuration synthesis, of determining how the large-volume body associated with hydrogen fuel tanks, abnormally large air inlets, and other components can be put together in an acceptable arrangement.

We are planning for the near future an investigation of mutual interference and component arrangement effects on wing-body-stabilizing surface combinations. We are also planning at a later date to initiate a flight-test program to evaluate skin friction and heat transfer for complex lifting configurations. These items cannot be adequately studied except in the actual high mach number, Reynolds number, and enthalpy environment of the space corridor.

V/STOL AIRCRAFT

Most of our research effort on subsonic aircraft is concentrated on vertical or short takeoff and landing (V/STOL) types. For military use in limited war, the requirement for an aircraft capable of rapidly transporting troops, support equipment, and supplies to and from areas close to the combat zone has emphasized the need for VSTOL aircraft. This chart, figure 187, p. 2091, illustrates some of these needs—the tilt-wing transport being used to connect conventional jet transports operating to conventional airports to helicopters and VTOL fighters operated from relatively unprepared landing strips in the combat zone not able to handle conventional aircraft.

For commercial aircraft, practical use of the VTOL or STOL transport is foreseen, as indicated on this chart, figure 188, p. 2091, in providing faster service in regular intercity shuttle flights of medium-range vehicles from relatively small, close-in airports where steep climbout and approaches are desired to avoid noise nuisance and building interference. Such aircraft could also be utilized in transporting passengers to terminals servicing supersonic-transport aircraft; this feeder-line transport would provide more rapid transit to these terminals (which will be few in number and remotely located), with little interference to other transport operation. There is a tremendous potential market if noise, traffic control, and cost problems can be solved.

With regard to concepts for obtaining VTOL—the conventional helicopter will continue to be a practical aircraft for military or civil missions of relatively short range in which vertical takeoff and landing and hovering are required. Substantial improvements in the performance of the helicopter are considered desirable and possible and will receive continued study during the next year. For example, several research studies at Langley and Ames have recently been initiated on models using nonarticulated rotors, with the objectives of reducing complexity and maintenance problems and improving performance and flying and handling qualities. The problem of all-weather terminal-area operation (for the helicopter as well as other V/STOL types) will be studied with a variable-stability research helicopter in which combinations of flying qualities, panel-display information, signal sources, and approach techniques permitting transition from steep approaches to vertical touchdown under instrument conditions, will be investigated.

The helicopter is, at present, the only operational VTOL aircraft, at least in this country. As stated previously it is likely to remain a very practical vehicle for VTOL missions that are of very short range or require extensive hovering capability. When this is not the case, other V/STOL concepts appear more promising because of their greater operating efficiency, speed, and range capability. The NASA has, for several years, undertaken extensive research programs on models of a variety of such V/STOL aircraft in its low-speed wind tunnels and with five flying "test beds" provided by the military services. It is believed that, although additional research is still required, most of the concepts utilized on the test beds could be incorporated into the design of a successful operational aircraft. Research is continuing on these concepts in such areas as ground interference and recirculation effects, wing stalling, and control requirements, to

provide information enabling the design of V/STOL aircraft having the greatest utility and productivity for a given mission. In the immediate future, emphasis will be placed on investigations of three specific configurations of current interest to the military services, shown in this chart, figure 125, p. 1979, the Vought XC–142A triservice assault-transport which utilizes a tilt wing; the Bell X–22 tilt duct; and the G. E. Ryan XV–5A fan in wing. Particular attention will be given to studies of the XC–142A, scheduled for flight in 1964. Large-scale model studies have already been initiated to determine the aerodynamic characteristics of this vehicle and, where required, to investigate methods of alleviating undesirable or marginal characteristics, such as wing stalling. Similar studies are being made or planned for the other two vehicles. In the near future, more emphasis will be placed on studies of higher speed concepts—such as those using lifting and vectored-thrust engines—considered feasible for supersonic V/STOL application.

Although only a small part of our total V/STOL research effort is directed specifically to study of purely short takeoff and landing (STOL) aircraft, many of the results of the VTOL studies have direct STOL application. It is expected, for example, that the tilt-wing type will be an excellent STOL aircraft and will be used that way for economy and safety reasons unless the operating site demands VTOL. Particularly valuable information on required handling qualities for a large STOL aircraft has recently been obtained from NASA flight studies of the C–130C airplane which utilizes boundary-layer control to obtain increased lift and steeper takeoffs and landings. Further flight studies will be made with this aircraft in the next fiscal year to investigate the effects of a modification to the control system, which NASA simulator studies have indicated to be desirable to improve handling characteristics during the steep descent.

With regard to powerplants for V/STOL application, there are a number of propulsion concepts under study and development by the military and the industry which can be categorized as follows:

(1) Lift engines: These are engines which provide lift thrust only for VTOL aircraft.

(2) Lift-cruise engines: These engines provide both lift and cruise thrust for VTOL aircraft and incorporate a system for vectoring thrust from the vertical to the horizontal direction.

(3) Augmentation systems for obtaining increased VTOL thrust from conventional and advanced powerplants with a minimum added weight penalty: These systems include rotors, free and ducted propellers, ejectors, and lift fans.

In the area of augmentation systems, NASA will conduct testing of lift fan and ducted propeller systems at the Ames and Langley Research Centers. These programs will be carried out in conjunction with the evaluations of the various VTOL aircraft being conducted by the military.

Additional work is planned in areas of research applicable to lift and lift-cruise engines as well as in the areas of augmentation systems applicable to VTOL propulsion. This work will include research, evaluation and testing on basic engine components as well as on fans, propellers, ducted propellers; etc.

It is our strong conviction that the use of air vehicles for purposes of civil and military transportation will continue to grow and expand. We believe that the welfare of the country will be best served by maintaining a strong program of research and development of advanced technology in this field. The program I have just described represents our best judgment as to what that program should be.

Mr. ZIMMERMAN. Mr. Chairman and members of the subcommittee, we are continuing our aeronautical research program very much in the vein in which it has been carried on for many years by the NACA and now NASA. However, we have had to make a change in emphasis. We are no longer trying to achieve higher speeds or higher altitudes.

The X–15 has flown practically out of the atmosphere and we have achieved orbital speeds in missile and manned spaceflight. We are, however, interested in two goals.

One is to bring about the technology necessary to permit efficient, economical and available air transportation for the civilian population and the other the advanced technology necessary for the most effective possible air transportation for our military services.

Now, in doing this we work closely with the DOD and the FAA. We work at all levels of coordination, but our primary coordination is through four committees; one in aerodynamics, one in loads and structures, one in operating problems and one in propulsion. Members of the Armed Services and the FAA and representatives of the industry serve on these committees and our programs are reviewed regularly.

In accordance with your request, I will go through my presentation fairly rapidly and just skip through some of the charts. I am going to discuss our program in terms of four categories as indicated by the first slide (fig. 172).

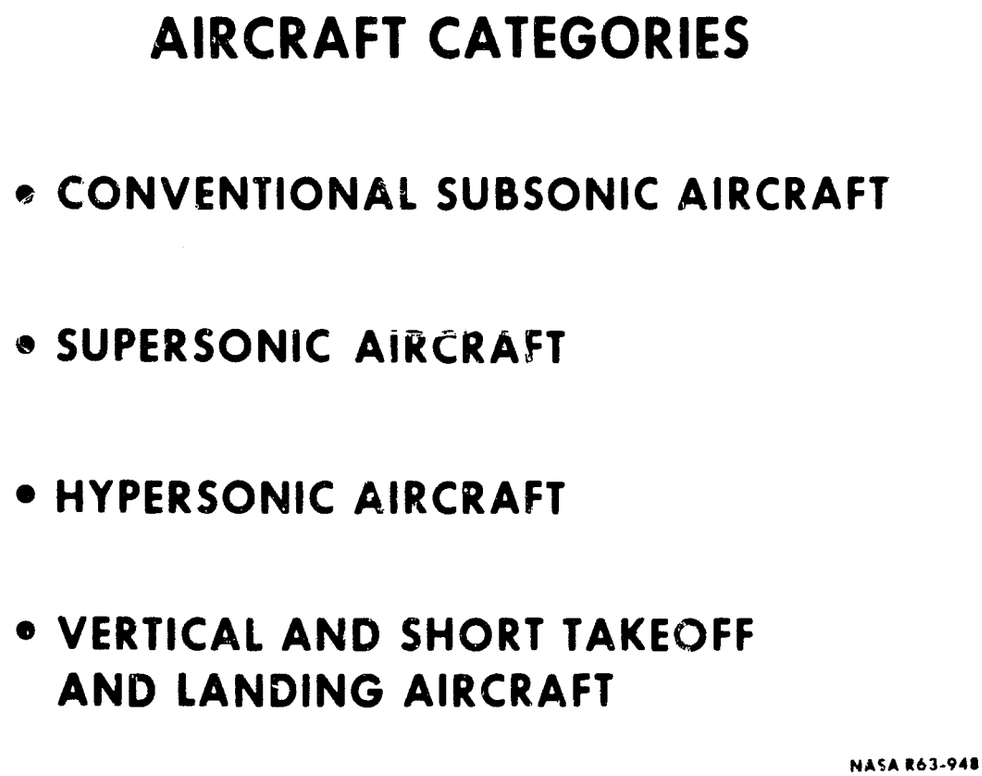


FIGURE 172

Subsonic aircraft, supersonic aircraft, hypersonic aircraft and the special category of V/STOL aircraft.

In the subsonic area we are working with the objective of continued improvement in flying and handling qualities, in noise reduction, flight safety, all-weather operations capability, performance and efficiency; and we are continuing our VGH program which we have been carrying on for many years and which gives us data for new designs and for improvements in operational practices.

In order to illustrate a couple of typical examples of what we are doing in connection with the subsonic aircraft I'd like to show first the next slide, please.

This slide (fig. 173) illustrates some work we have done in connection with the FAA on the stopping distances of aircraft under different conditions. This aircraft stopped in 1,800 feet on a dry service; 2,800 feet on a wet runway and 4,800 feet in slush.

We are continuing this type of investigation on our landing roads track at Langley.

Mr. KARTH. What kind of an aircraft was it?

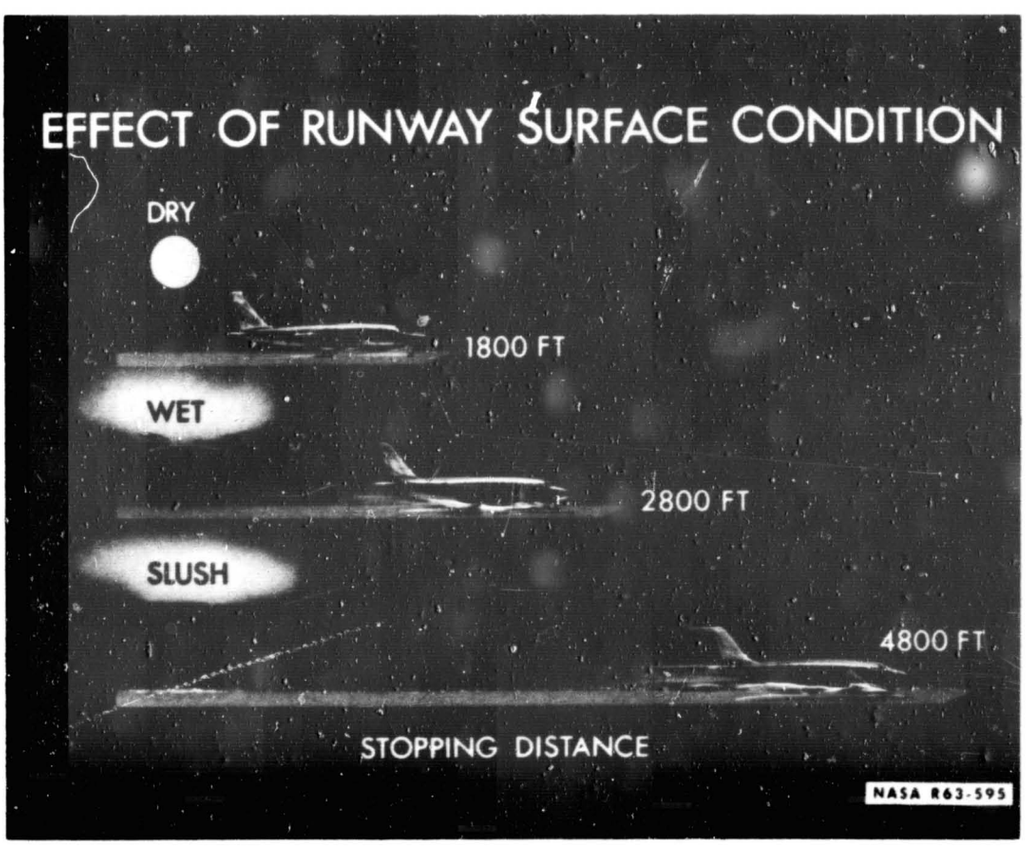


FIGURE 173

Mr. ZIMMERMAN. This was a jet aircraft, an 880.

Another example of the sort of thing we are doing is shown in the next slide (fig. 174) which illustrates a problem that has been encountered in operation around airports where light aircraft have performed unanticipated maneuvers and gotten in trouble.

In fact, some people have been killed. It was suspected it might be due from down wash from helicopters. We ran tests on this and this shows a situation in which a light airplane was flown through a helicopter wake. You will notice from the illustration at the bottom that the pilot actually had the stick against the stop for a short period of time. If the wake had been more intense he would have lost control and might have lost the airplane.

Now we are studying this phenomenon and have given the FAA data from which they can establish rules and regulations for flying around airports to avoid accidents which might result from it.

Another area in which we are very much interested and we are doing work, is the matter of noise. I am sure you are all familiar with the seriousness of this problem. We are doing work at Langley Field, particularly in two areas. One is to try to understand and do something about the noise generated by engines and the other is try to develop operational techniques that will minimize the noise from the aircraft.

One of these is illustrated—one of these approaches—by the next slide (fig. 175) which shows the effect of making a steep approach as

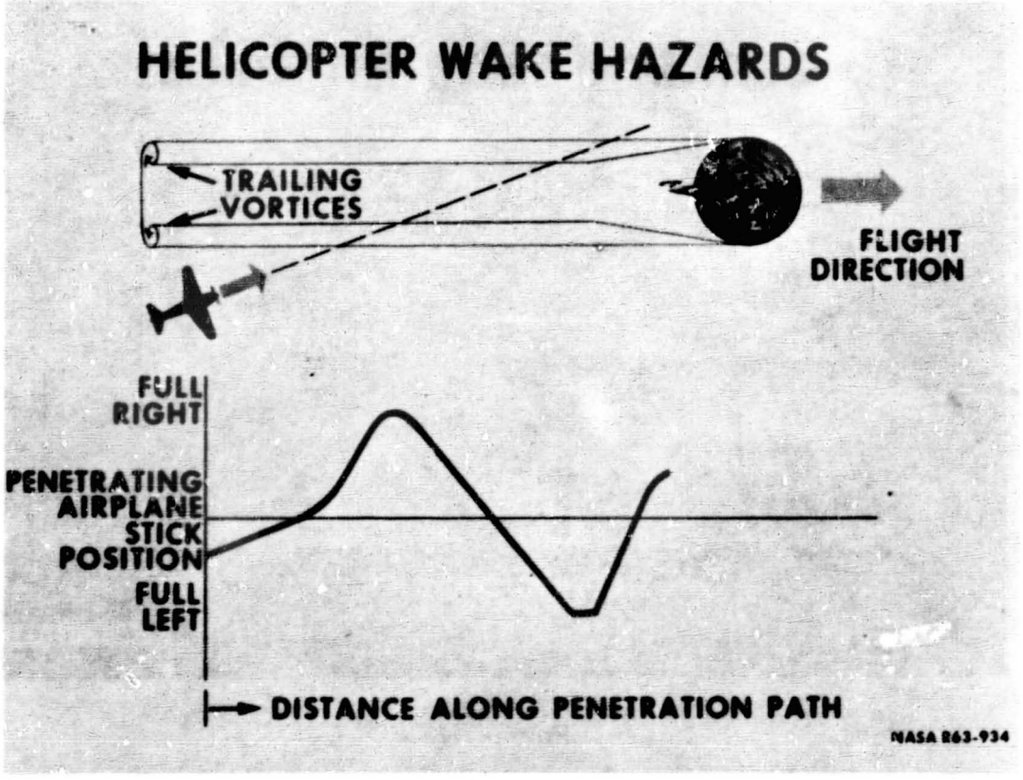


FIGURE 174

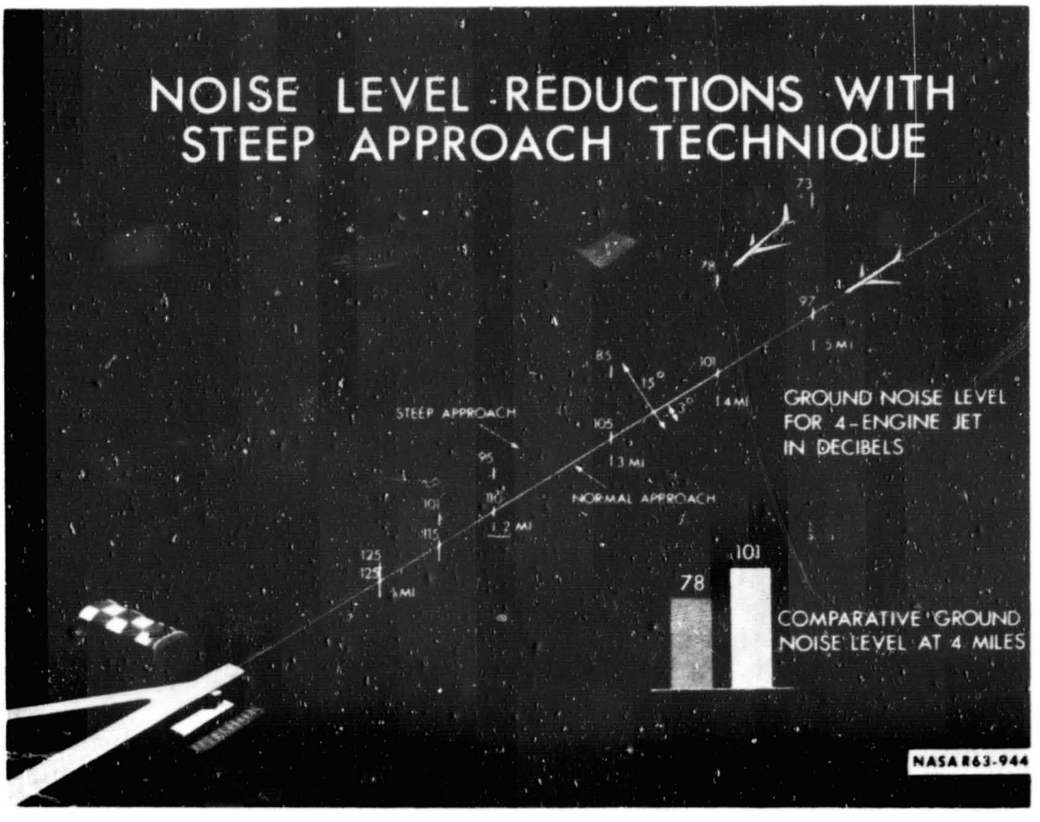


FIGURE 175

compared to a normal shallow approach on the reduction of the noise level.

As you can see, at the distance of 2 miles out the decibel level is lowered from 110 which is about the limit of acceptability, down to 95, simply by using the steep approach technique. However, this is not a simple thing you could just go ahead and do. It requires a lot of development and understanding of the problem and development of traffic control procedures and aircraft.

Now, we are investigating this with helicopters which can make this steep approach and give us data on the problem.

Mr. MOSHER. Mr. Chairman, may I ask a question at this point?

Mr. KARTH. Mr. Mosher?

Mr. MOSHER. Are pilots reluctant to make this steep approach?

Mr. ZIMMERMAN. They much prefer the other. Existing aircraft are not well suited to the steep approach.

Mr. MOSHER. Even where you have some FFA regulations, the pilots tend to break these regulations?

Mr. ZIMMERMAN. No.

Mr. MOSHER. I have heard this said around O'Hare Airport.

Mr. ZIMMERMAN. I wouldn't say pilots never break regulations. Actually they haven't asked for steep—established such steep approaches as this.

Mr. MOSHER. But the pilots attitude would be a reluctance toward this steep approach.

Mr. KARTH. We are told that the sonic boom has been quite a problem.

Is there any way to avoid this or eliminate it, other than to fly at subsonic speeds?

Mr. ZIMMERMAN. We don't know any way it can be eliminated.

Mr. KARTH. Any work being done on that?

Mr. ZIMMERMAN. I was going to mention it a little later; but we are working on this.

Going to the next aircraft area, the supersonic area, there is a great deal to be done. We have only scratched the surface as regards the aircraft in the supersonic area.

We have no aircraft yet we can call really a truly supersonic aircraft. There is a great deal of work to be done. Now, we have done a great deal of work in this area and this particular model shown here illustrates one of many that have been tested in a general research program to try to achieve a machine that has reasonable efficiency both at supersonic speeds and subsonic speeds.

This configuration—it's a subsonic airplane with the wings forward and when we put the wings back, it becomes an efficient supersonic airplane.

As I say, we have done a great deal of work in this area and we are continuing.

Now, one of our major efforts in the supersonic areas is in connection with the possible supersonic transport. We started about 4 years ago and we anticipated the possibility of the desirability of such a machine. We have been working on it for some years.

Mr. KARTH. Mr. Zimmerman, are all these in the area of transport designs?

Mr. ZIMMERMAN. This particular model represents one tested leading to the development of a machine now receiving quite a lot of publicity—a fighter machine.

Mr. KARTH. I am sure we have heard of it.

Mr. ZIMMERMAN. You have heard of it.

Mr. KARTH. Was it NASA that did the design work on the rather famous TFX? Is that what you are saying?

Mr. ZIMMERMAN. NASA did almost all of the preliminary research and development of the idea.

Mr. KARTH. Thank you.

Mr. ZIMMERMAN. We didn't do the design work.

Mr. MOSHER. Your research went into both of the two companies?

Mr. ZIMMERMAN. That is right, sir, as our research comes out of our wind tunnels it is made available even before it's published—the information is made available to our manufacturers who have a need to know and they knew of our data.

Mr. KARTH. Just one further exploratory question; doesn't the organic act establish NASA as the real research agency of the Government? Isn't this correct?

Mr. ZIMMERMAN. This is correct.

Mr. KARTH. The basic research agency.

Mr. ZIMMERMAN. This is our understanding, yes, sir.

Mr. KARTH. I see four or five supersonic transport designs on the table before you. What do you call these—models?

Mr. ZIMMERMAN. These, sir, are concepts that have been developed in our wind tunnels as a result of a great deal of study and model testing.

Now this machine is known by our people at the laboratory at Langley as SCAT–15, supersonic commercial air transport—model 15. It is the 15th configuration that they had tested.

This model is SCAT–17 and was developed at the Ames Laboratory.

This other model is SCAT–4, developed at Langley, and SCAT–16. Those are model numbers.

Now when we say what we have done is with our general knowledge of the requirements of a transport and our general knowledge of the problems of aerodynamics and propulsion, we have worked up wind-tunnel conditions to test out our ideas and to try to arrive at an efficient design.

Mr. KARTH. Can we say that NASA has four designs for different supersonic air transport airplanes?

Mr. ZIMMERMAN. We can say, of the 17 or more configurations that we have investigated, the 4 that appear to be most promising on the basis of the aerodynamics and propulsion configurations are these 4 here.

Now, we are not designers, as such, and we know that when these machines are converted into actual practical aircraft they are going to be changed somewhat.

Mr. KARTH. Well, who came up with the 17 different concepts that NASA has tested and concluded that 4 are better than the other 13?

Mr. ZIMMERMAN. Primarily, NASA personnel, although you realize we are in contact with the rest of the aeronautical community so that some of these ideas, for example—this aircraft is very similar to the B–70 in a general sort of way. On the other hand, the basic ideas in the B–70 came from NASA in some cases, so it is a back and forth interchange sort of thing.

Mr. KARTH. But that is a design, isn't it?

Mr. ZIMMERMAN. This is, I would say, an aerodynamic configuration that represents our wind-tunnel people's impression or conception of what a supersonic transport could be like.

Mr. KARTH. That is a step beyond design, isn't it? Doesn't design come first and then configuration?

Mr. ZIMMERMAN. Well, it's a matter of degree.

One might arrive at this configuration on the basis that one needs an efficient wing and needs a canard tail and tail surfaces back here. That would be a configuration.

Then when we go to—we have to add propulsion to it so then it begins to take on some of the aspects of a complete aircraft. You are combining the propulsion so it begins to take on a design. Then our people look at it and say, well, when the manufacturer builds it, he is going to want to put six people abreast in here so we can't just have a narrow fuselage, just a spindle. We have got to represent a practical body. So, we represent a body that's about the right dimensions for a final aircraft. When we do this, we try to arrive at the right outside configuration but we don't do all the detail design and make sure the landing gear is going to fit right and all that sort of thing.

Mr. KARTH. I understand that.

So you could call this preliminary design.

Mr. ZIMMERMAN. In a sense, this is.

Mr. KARTH. Then we turn this over to some manufacturer and he ruins the whole thing.

Mr. ZIMMERMAN. Yes. [Laughter.]

Mr. KARTH. I mean, all of the tests we had in our wind tunnel really go for naught because it's got to fly with people in it. We can't just make it look fancy in an air tunnel.

Seriously, are we wise, coming up with four or five or six preliminary designs before we actually submit one of them to a manufacturer and let him take it from there, when he will probably take it apart and start all over?

Mr. ZIMMERMAN. I think in order to do this, to the best advantage, it is wise for us to build a number of these before a manufacturer tries to design something that's practical with one of them.

As I say, we have tried a number of models before arriving at these four.

Now, when the manufacturer gets one of these he will change this some and change it some in detail, but we will learn the rules that apply and we will not have lost all we did by any manner of means.

Mr. MOSHER. Mr. Chairman?

Mr. KARTH. This was of interest to me and I'm very happy you cleared it up.

Mr. Mosher.

Mr. MOSHER. I guess it isn't so much the design as the wind-tunnel data he is interested in.

Mr. ZIMMERMAN. This is right. The wind-tunnel data gives us a general comparison of these things and gives the manufacturer a basis for working out his design. It's a back and forth sort of thing.

Mr. KARTH. Except as soon as he broadens the fuselage, for example, the wind-tunnel data is not of much value.

Mr. ZIMMERMAN. We have to run more tests. This is right, sir.

As you possibly are aware, we have contracts with Boeing and Lockheed to study these four designs, compare them from a standpoint of practical design requirements to advise us which way we should go in our future work.

We are trying to get this input from them.

Mr. KARTH. Mr. Randall?

Mr. RANDALL. Just curious about the term you used. You referred to the thing up front as a "tail." I thought you said a "Canard" tail. Did I hear you right?

Mr. ZIMMERMAN. That is right. That's a rather odd term, I'll admit, but that is the terminology that is used.

This surface performs the same function as this horizontal surface back here which has always been called a "tail."

Mr. RANDALL. While we are on the models, may we have the description between a delta wing and the CR-7 over here?

Will you get to that later?

Mr. ZIMMERMAN. I expected to get to that later.

Mr. RANDALL. All right. Fine.

Dr. WEAVER. Maybe this is coming later, too, Mr. Chairman, but I wonder if these are designed for ordinary airport takeoff without long jet runways?

Mr. ZIMMERMAN. The objective is to operate these machines so they will operate from our same airports as do existing jets—such as the 707 and DC-8.

Dr. WEAVER. Not the ordinary landing; you wouldn't expect to take off at an ordinary airport such as National?

Mr. ZIMMERMAN. No, sir.

Dr. WEAVER. Thank you.

Mr. MOSHER. Mr. Chairman, could I ask a question?

Mr. KARTH. Mr. Mosher.

Mr. MOSHER. Are there any other agencies duplicating this work in any way?

Mr. ZIMMERMAN. This work? No, sir.

Mr. MOSHER. FAA has no research and development facilities of its own?

Mr. ZIMMERMAN. That is right.

Mr. MOSHER. And you are the agency used by FAA for this type of work?

Mr. ZIMMERMAN. For this sort of thing we do the work for the FAA. That's right.

Mr. MOSHER. Are there any industrial facilities that are being used for parallel or duplicating purposes?

Mr. ZIMMERMAN. Some of the larger companies have their own facilities—Boeing, for example, has very extensive wind-tunnel facilities and they do work also in this area using their own funds.

Now, they do not duplicate our work; in a sense—they try to do better. They know what we are doing and they try to come up with something better, and we hope they will, actually.

Mr. MOSHER. What about an outfit like Cornell at Buffalo? Does industry employ them to do some of this type of thing, too?

Mr. ZIMMERMAN. They have, at times, but I'm not aware that they are employing them on this particular effort.

Mr. KARTH. Proceed.

Mr. ZIMMERMAN. I believe my next slide shows the configurations.

We'll just go right on by that. In connection with the development of the supersonic transport there is not only the problem of

getting an efficient configuration. There is a tremendous problem getting an efficient powerplant to go with it, and one of the major problems is the development of a powerplant as indicated by the next slide (fig. 176).

A great deal of work has been going on in the last couple of years, studying the engine problem. The engines that have been developed for the B–70 are not really suitable for use in a commercial supersonic aircraft because they are not designed to have the low noise level and the efficiency under certain conditions that are required for commercial work. So, we are doing work on—studying not only engines, but possible engine cycles and three of them are illustrated in this slide.

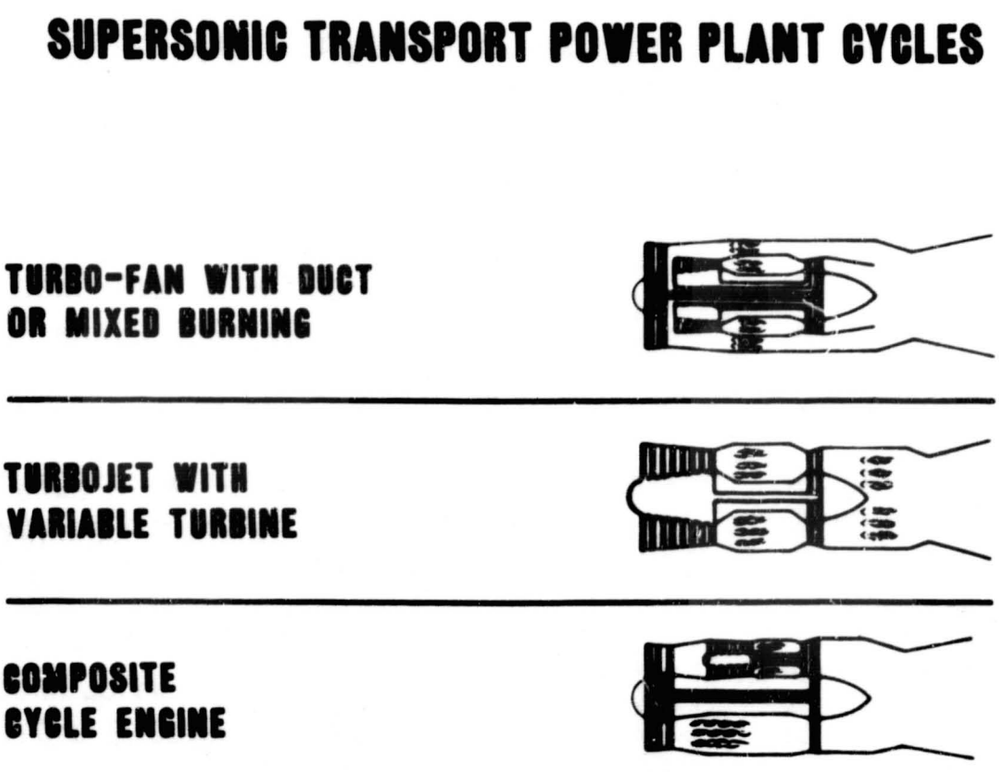


FIGURE 176

I think in the interests of time I will just go on to the next slide (fig. 177) which refers to the matter of sonic boom which was brought up by your chairman a few moments ago. We have done a great deal of work in the area of sonic boom not only from the standpoint of trying to understand what causes it, but also to try to understand how we can design the aircraft to minimize it and how we must operate the aircraft to minimize it.

Now, as the slide shows, there is a difference in configurations in the amount of boom that they produce and we indicated on the slide a theoretical lower bound that you might achieve if you designed the aircraft with nothing else in mind.

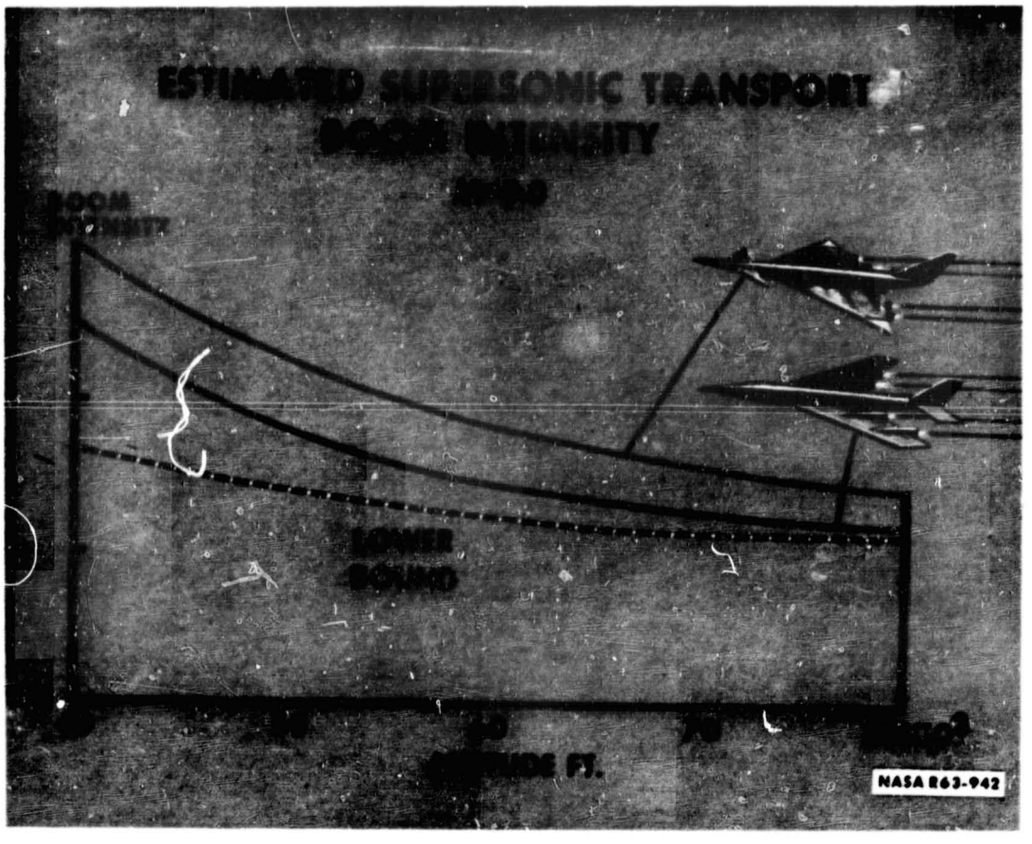


FIGURE 177

Also shown is a level for one of the configurations we have shown you and another level for one of the other configurations. As I say, we have done a lot of work in this area.

We fairly well understand what causes the boom, but we have no solution to the boom. It is still a very serious problem that we are working on.

Also in connection with the supersonic transport and in fact on all of our supersonic aircraft regardless of whether it is a fighter, a bomber, or a transport being considered, there is a serious problem of flying and handling qualities and how one works the aircraft into the air-traffic-control patterns, and so forth—the stability required.

One of the things we are doing, we have purchased a Jetstar airplane, a secondhand one, incidentally; and are equipping it with variable stability equipment as indicated in the next slide (fig. 178) which can be used to cause the airplane to be something else.

In other words, with this aircraft, we can simulate a supersonic transport or we can simulate a 707 and let the pilot find out what he can live with, what he can't live with, and what we ought to build into the aircraft that's coming along.

Mr. KARTH. From whom did you buy the secondhand Jetstar?

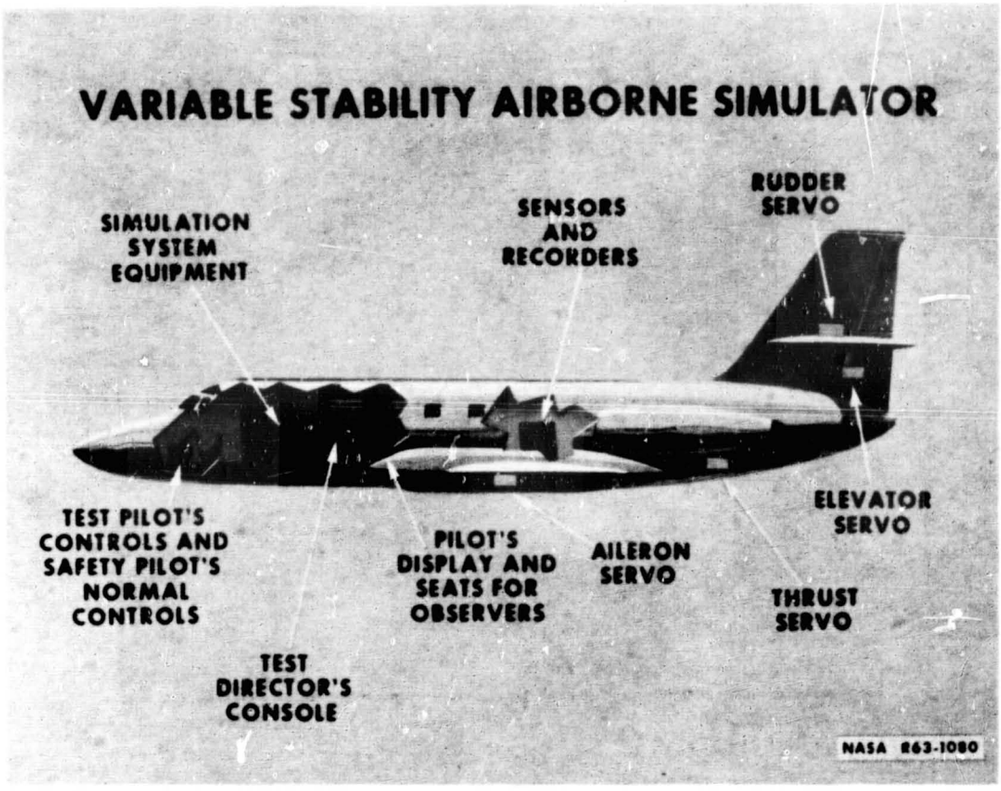


FIGURE 178

Mr. ZIMMERMAN. I think we got it from the company itself. I don't know the details.

NOTE.—Morten; Marietta, Ga.

One of the very serious problems which we run into in the design of supersonic transports, is the high temperature to which the aircraft is subjected. We find if we are going to mach 3 we are dealing with a temperature of 550 degrees. Aluminum alloy is not satisfactory. We are confident it can be done with stainless steel or with titanium. The next slide (fig. 179) indicates the kind of lifetime that we find with these various materials.

Now, stainless steel has been tested for 4,000 or 5,000 hours with no indication of loss of strength and we are confident it will go out to the 30,000 hours eventually that we are asking of the aircraft. The same sort of thing is true of titanium, but aluminum we know falls off rapidly and cannot be used.

Now, going on to another area of work, moving into the hypersonic field, and as you are well aware, we have been flying the X–15 for several years.

May I have the next slide please (fig. 180).

And we have flown as indicated in the region on the chart which is in the lower part of the hypersonic flight regime. We have had very good success, as you know, with this aircraft and we are now studying what we might do in going on into this field.

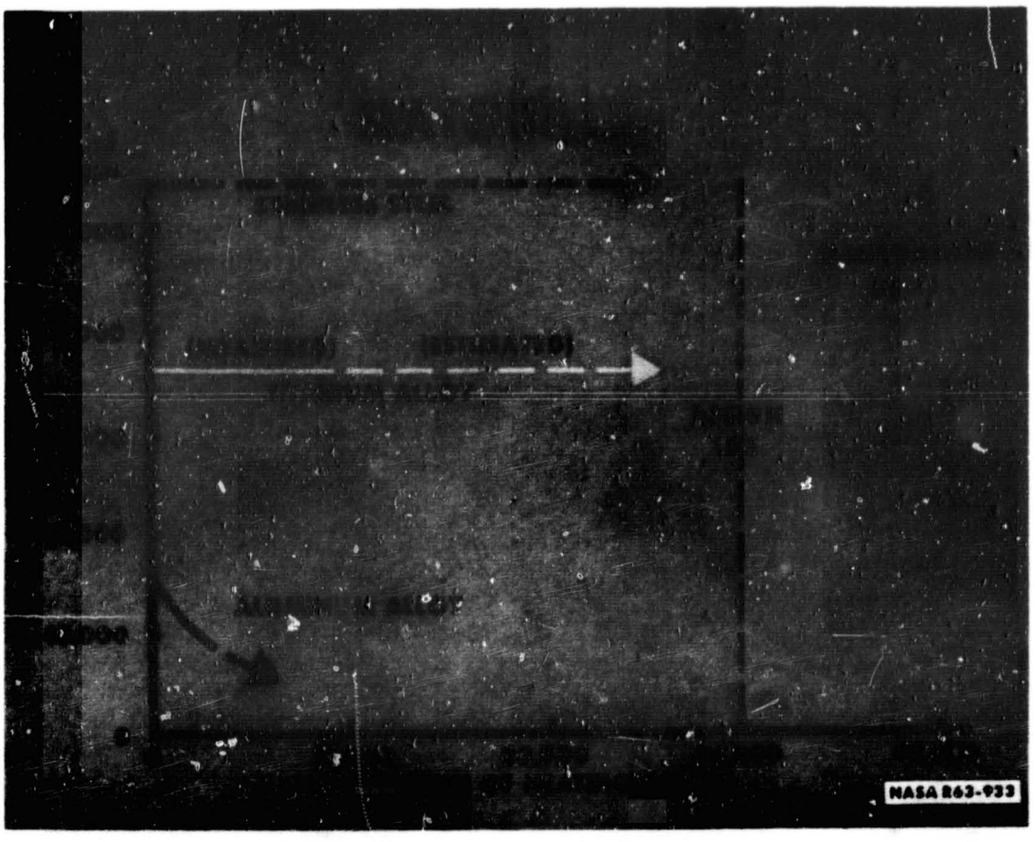


FIGURE 179

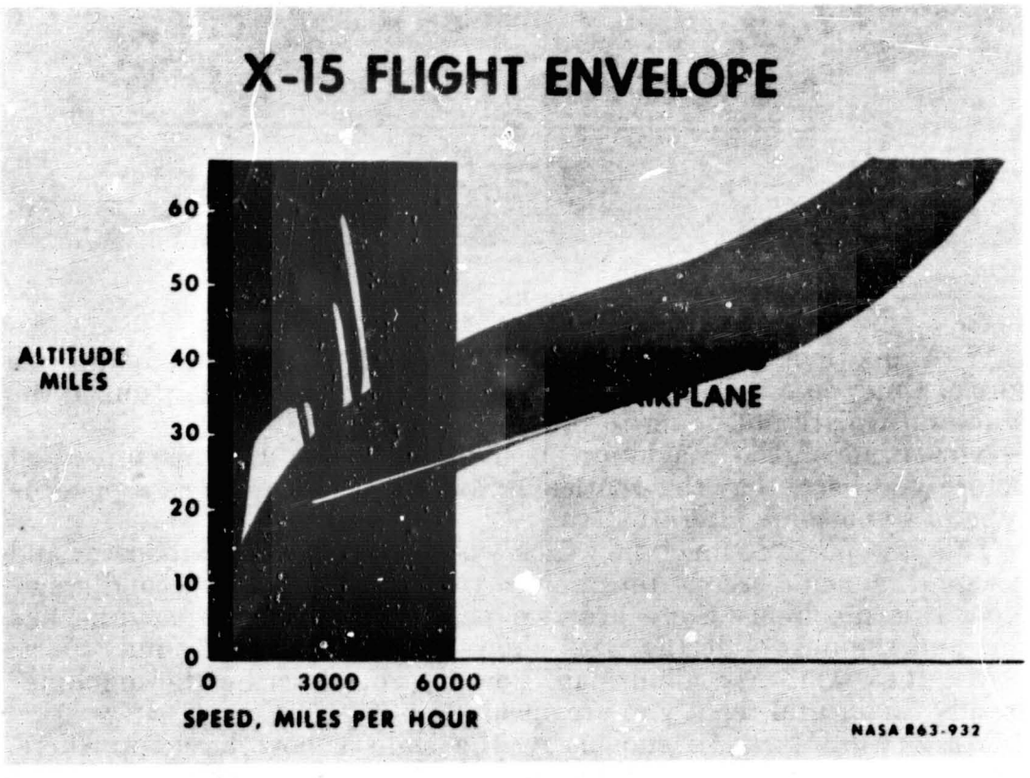


FIGURE 180

The next chart I have (fig. 181) indicates the future flight spectrum as we visualize it.

Here we have the helicopter or other type VTOL vertical takeoff and landing aircraft, which operates at slow speed for short ranges.

We have our conventional subsonic aircraft for intermediate ranges. We are going on, we hope, to the supersonic aircraft for speeds of 2,000 miles an hour and up to 5,000 miles range and then we are beginning to look into the future of what we might want to do. We know that with the present state of the art we can put a man half way around the world in a Mercury capsule in an hour's time.

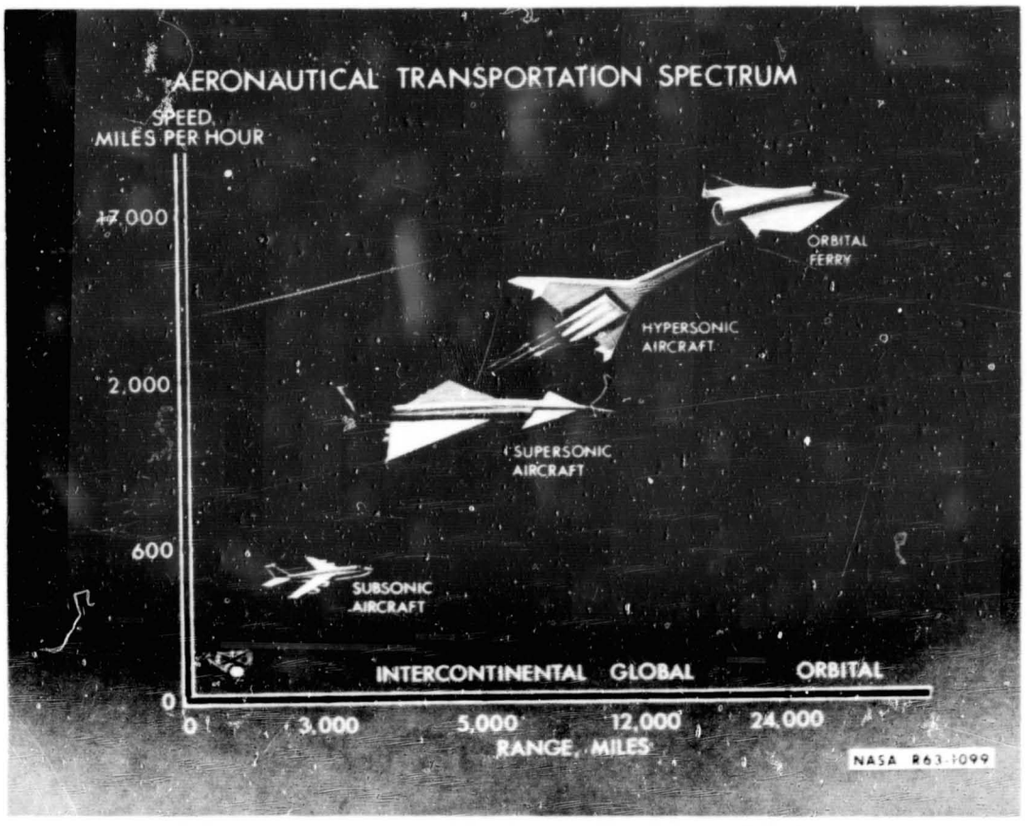


FIGURE 181

We think, eventually, after a long period of time we might do this sort of thing on a commercial basis. This, of course, is way out in the blue and we are not going to promise to do it right away.

Now, one of the machines—this brings us to the machine just before you here, that the gentleman asked about earlier as a possible type of hypersonic aircraft.

This is a possible machine which would be, in effect, a booster and it would launch a second machine carried internally as a second stage. Now this machine—there are two possible uses for a machine like this and the next slide (fig. 182) shows what we have in mind.

Mr. RANDALL. Mr. Chairman, how do you describe the machine? Is this the orbital ferry you are speaking of?

Mr. ZIMMERMAN. As shown by the slide I now have up there, this is a dual purpose machine and this is an area where we might have a real meeting between our space and our aeronautical objectives.

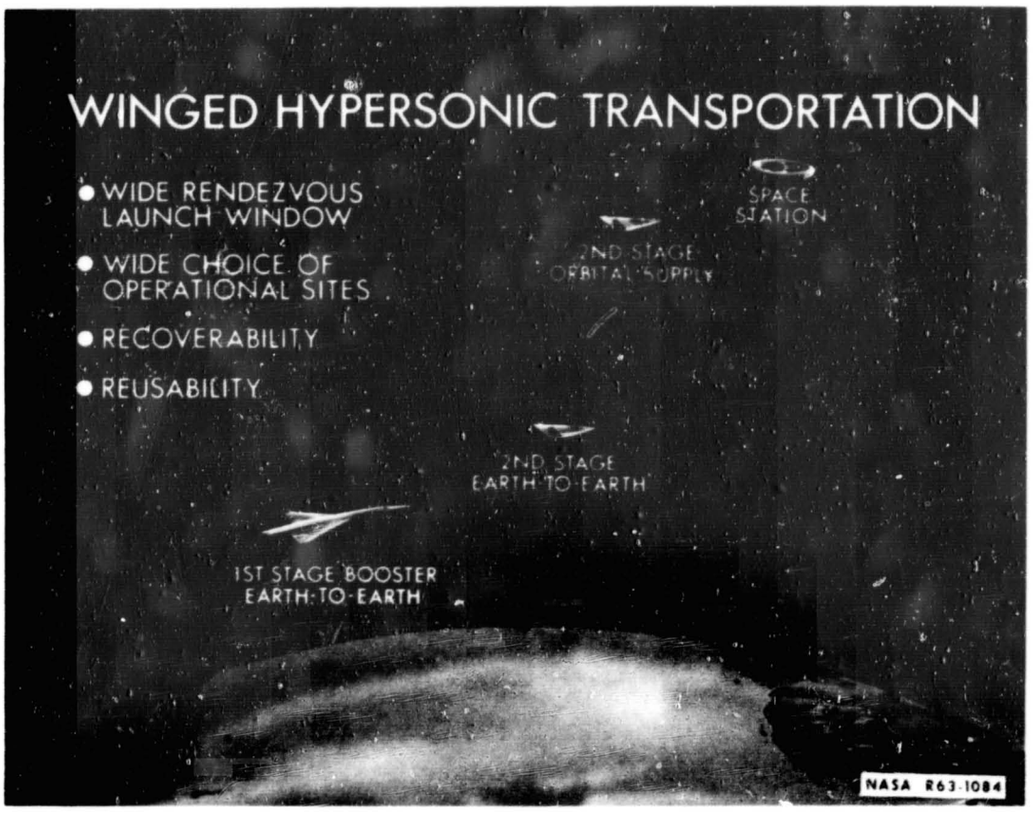


FIGURE 182

Mr. RANDALL. And what do you call it?

Mr. KARTH. Hypersonic transportation?

Mr. ZIMMERMAN. That's a good description. As we visualize it now, we see a first stage booster which goes up to a mach number of 6 or 8. Then it launches a second stage which in one modification can go into orbit and come back again and land, or it can launch a second stage which will go from 6,000 to 12,000 miles around the earth.

The same technology will support either kind of vehicle. The chances are that the second stage for going to orbit would be a different one than the second stage that might be used simply for transportation around the earth; but the technology basically would be the same.

Mr. RANDALL. Just call it the machine?

Mr. ZIMMERMAN. Call it a hypersonic aircraft, is the best name we have for it at this time.

Mr. KARTH. Mr. Zimmerman, I guess it's been decided that our national goal should be set by 1965 on which direction we should go in this so-called supersonic transport field.

What are NASA's feelings at the moment as to which one of the several routes we should follow?

Mr. ZIMMERMAN. We set the objective of attempting to arrive at a decision as to which way we should go and we are working very hard on that problem.

Mr. KARTH. But we have not yet made a decision?

Mr. ZIMMERMAN. We have not yet made a decision as to which way we should go, but we are hopeful, however, we can make a wise decision in the timeframe you have mentioned.

Mr. KARTH. You have discussed this with the Air Force, I suppose.

Mr. ZIMMERMAN. We have, last fall.

Mr. KARTH. Do you find a difference of opinion existing at the present time, as to what concept we should follow?

I assume the Air Force would probably feel strongly about the single-stage-to-orbit-type plane and you might feel at the present, I understand, there are some feelings in NASA about the suborbital design.

Is this true?

Mr. ZIMMERMAN. We have been working closely with the Air Force.

Mr. KARTH. If this kind of difference of opinion should develop, how are we going to rectify it?

Mr. ZIMMERMAN. I was going ahead to explain. I don't know the answer to your question as far as that goes, but the Air Force has a very difficult objective of a single-stage-to-orbit vehicle.

This is an objective that they would like to achieve.

Now, there's a vast difference, sometimes, between what you would like to do and what is practically possible. Our studies tend to indicate that this is going to be very difficult to do with a practical machine. We are trying to arrive at a decision as to whether we should go for a single stage to orbit, whether we should go to some version of this two-stage vehicle, whether we should build simply a hypersonic research aircraft.

We are considering all these things. Now, the technical people of the Air Force who are facing the realities in the same way we are facing the realities, I don't think there is substantial disagreement among us about these things, and the difficulties involved. Now, how the decision will be made, of course, this is still——

Going on to our next slide (fig. 183), which I will pass over fairly quickly, we are working as I said with the Air Force to carry on a program which will hopefully move us along as rapidly as possible and will not get us involved in duplication of effort and we are studying the problems of propulsion, structures, materials, aerodynamics, the common problems we always run into in aircraft development.

Now, one of the very serious problems in a machine of this sort is the matter of propulsion and the next chart (fig. 184) indicates two types of propulsion systems we are studying seriously.

The one shown above is the subsonic-burning ramjet which runs into very serious problems when you get to mach numbers greater than 8 and the one shown below represents a supersonic-burning ramjet. Now, when I say "supersonic burning," I mean that the air—the gas—flows at supersonic speeds through the combustion chamber.

We do not slow it up to subsonic speed. This has certain theoretical advantages. It sounds very good if we can really make it work, but we haven't—so far, haven't really solved this thing to the point we can say for sure it will work, but it's so attractive it's worth a great deal of effort to try to make it work.

Now, a very serious problem, and it bears on the matter of earth to orbit in one stage, is indicated by the next slide (fig. 185) and shows what we are up against in the matter of structural weight.

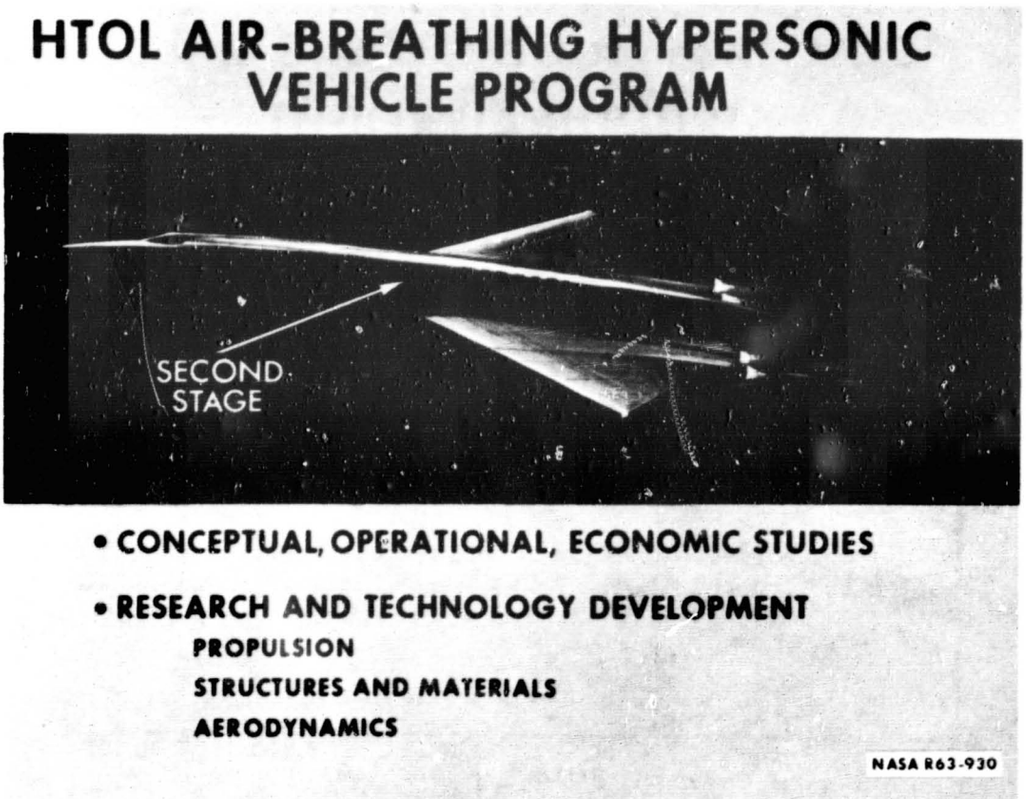


FIGURE 183

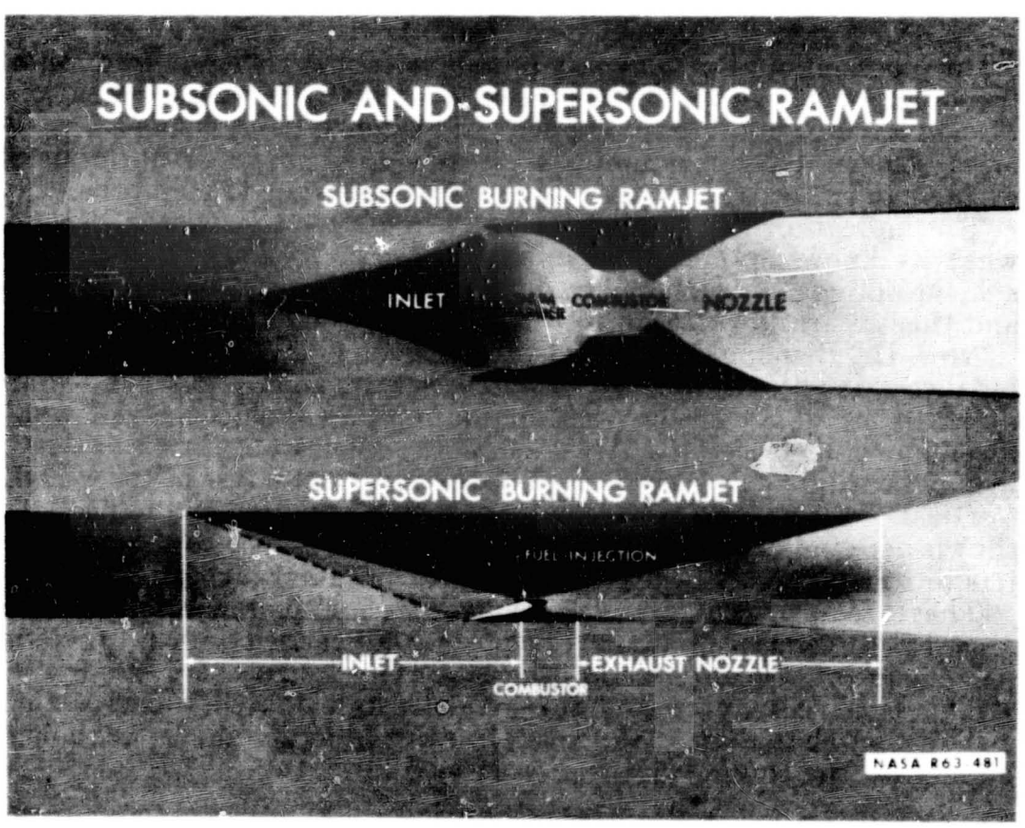


FIGURE 184

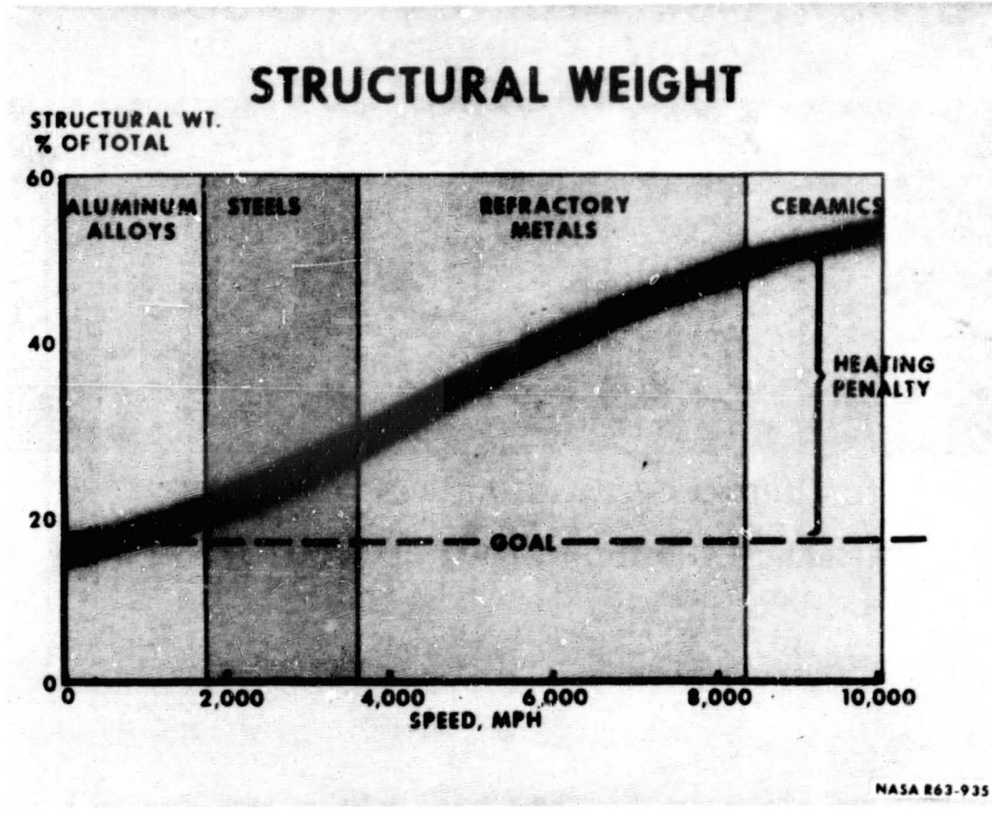


FIGURE 185

Our conventional jet aircraft have a structural-weight fraction of the order of 20 percent of the gross weight. There are indications we will have to do at least this well or better to get a single-stage-to-orbit vehicle and yet as indicated by the slide as we go up in speed we have to go to structurally less desirable materials to stand the heat.

The indications are the structural-weight fraction on the basis of what we know now must go up and we have to work very hard to achieve our goal of getting back down to the 20 percent weight fraction and this we are working on to the best of our ability.

Now, Dr. Bisplinghoff showed you the next slide (fig. 122, p. 1975) in his discussion the other day. This was with regard to what we are doing to try to get better construction for these vehicles and I won't dwell on that further.

Now, our final category I want to cover is the matter of the VTOL, Vertical Take Off and Landing aircraft. My first slide (fig. 187) shown here indicates the situation that we envision where long-range jets or other aircraft bring materials into a regular airport.

They are then ferried over a relatively short distance to a staging area by so-called V/STOL transports and carried out into actual battlefield by helicopters and other V/STOL designs.

This is a very important development in a limited war situation.

The next chart (fig. 188) shows the same kind of vehicle technology applied to the commercial transport field.

FIGURE 187

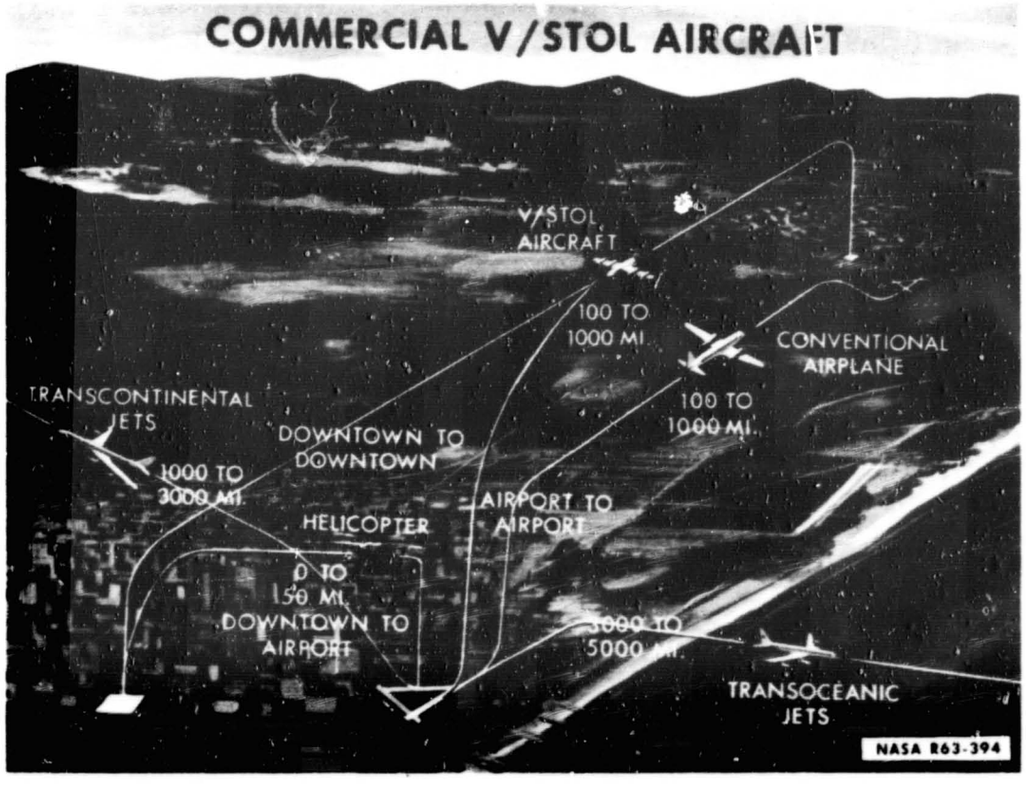


FIGURE 188

96-504 O—63—pt. 3b——3

We feel, eventually we are going to be using the V/STOL aircraft operating from small close-in airports between cities not separated by long distances and also between the large jet airports and city centers to give us a more efficient means of transportation. There is a great deal to be done before this can be achieved. I won't try to go into it today, but I'll be glad to discuss it at greater length, if you should desire.

We have done a great deal of work in the V/STOL area and my next chart (fig. 125, p. 1979), the final chart, indicates the three types being studied at the present time.

The services, the armed services, actually are building full-scale vehicles of these types and we are working closely with them to develop the aircraft so they work satisfactorily.

Gentlemen, I think I have taken longer than I should. I will close at this time. Thank you very much.

Mr. KARTH. Thank you very much, Mr. Zimmerman. I would like to submit to you some questions in writing and if you would then prepare the answers and submit both the questions and the answers for the record, I would appreciate that.

Mr. RANDALL. Just one question. We went over that rather hurriedly. You went over these metals, the aluminum to the steel and the refractory alloys which I think you described as ceramics.

Mr. ZIMMERMAN. This is "ceramics."

Mr. MOSHER. Mr. Chairman.

Mr. KARTH. Mr. Mosher?

Mr. MOSHER. Do I remember from testimony last year the British are doing a terrific job in this V/STOL business or am I mistaken, and is that a joint project with us?

Are we helping finance that?

Mr. ZIMMERMAN. The British are doing a great deal in the V/STOL area. They have developed the Short SC–1 airplane which uses lifting engines. That has been done, so far as I know, on their own funds. They have also developed the P–1127 airplane, which is the one you have probably seen publicized, using the vectored-thrust engines. Now, my understanding is the aircraft was developed on British funds.

The engines have had some support through the MWDP from this country.

Mr. MOSHER. NASA is not involved?

Mr. ZIMMERMAN. NASA has not been involved from the standpoint of supplying funds. NASA has done some work on testing a model, a free-flying model, of this aircraft to assist in working out some of its flight problems—stability problems.

Mr. MOSHER. I think this committee, necessarily, has to be interested in whether or not the British work makes unnecessary some of your work. Is there any?

Mr. ZIMMERMAN. No, sir; I don't think this is true. We have been fully aware of what the British were doing and we do not duplicate what someone else is doing if we know about it.

No, sir; this is not true.

Mr. MOSHER. Has the British work been primarily military in its direction?

Mr. ZIMMERMAN. It has been so far; however, the British are working on designs that might possibly have commercial application.

Dr. WEAVER. Mr. Chairman.

Mr. KARTH. Mr. Weaver.

Dr. WEAVER. Again, I want to go back to what I started to talk about before about the use of airports, our existing airports.

Are we concentrating on designs on commercial planes designed to use our existing facilities, without going into these long jet airports and the cost and expenditures?

I know the vertical plane will do that.

Mr. ZIMMERMAN. We are, as I brought out in the earlier part of my discussion on the subsonic aircraft, we are continuing a level of effort to improve our conventional aircraft to make them better.

We are also working on the V/STOL concept which will not only make it possible to more efficiently use our existing airports, such as national, but also go to smaller airports.

You realize that we do a very poor job of utilizing the airspace that we have available. It's really too bad to see 10 airplanes sitting on National Airport, waiting to take off when if we had the proper system, they could all take off and go, without delay.

We are a long way from——

Dr. WEAVER. In this field it is difficult to conceive of this.

Mr. ZIMMERMAN. When we go to this aircraft—I won't say we can't, but it is conceivable the supersonic transport of the future might be a vertical takeoff and landing aircraft, but this is too big a step at the present time.

Dr. WEAVER. Thank you. Thank you, Mr. Chairman.

Mr. KARTH. If there are no further questions, I want to thank you very much, Mr. Zimmerman. It may be that we would find reason for calling you back.

I would hope you could accommodate us at that time.

Mr. ZIMMERMAN. I will be glad to.

Mr. KARTH. Thank you very much.

(The information referred to is as follows:)

GENERAL

Question. In the past the United States has been the major supplier of aircraft to the world's airlines. In your opinion, is the Nation's investment in aeronautical research sufficient to retain U.S. leadership?

Answer. The United States is still a major supplier of aircraft to the world's airlines. However, I can see indications of a weakening of the U.S. position. The U.S. position today may have been much different if the early Comet aircraft had not encountered structural difficulties. Also in the last 6 to 8 years we have seen many foreign aircraft introduced on the U.S. domestic airline routes; the Viscount (British), the F–27 Friendship (Dutch), and the Caravelle (French). In V/STOL aircraft development the British Hawker P–1127 and P–1154 and the French Brequet 941 and the German Dornier 31 show considerable promise. It is noteworthy that all the above foreign aircraft can be classed as short-haul vehicles. Of course, the British/French Concorde supersonic transport effort is a real threat to U.S. leadership. Your question is a very difficult one to answer and I cannot say assuredly that the threat to U.S. leadership is due to insufficient U.S. research investment. I do not think, however, that we should rely on another error like the Comet to maintain U.S. leadership.

Question. With the current emphasis on space, aeronautical research constitutes a rather small effort in NASA relatively speaking. How does the present effort compare with the effort of the old NACA?

Answer. Dollarwise the funds requested for aeronautical research for fiscal year 1964 ($45 million) are comparable to NACA budgetary figures which amounted to about $60 million in the mid-1950's. However, at that time there

were approximately 5,000 NACA personnel engaged in aeronautical research. Today the number estimated in the proposed budget for fiscal year 1964 is 2,068.

Question. Are the developments in the V/STOL being done primarily for the military? What are the funding arrangements?

Answer. A substantial portion (about 30 percent) of the NASA V/STOL program is on projects either specifically requested by the military services or closely related to vehicles of current interest to the military. It is believed, however, that the results of most of these studies are of equal interest to potential commercial aircraft designers and operators. In some cases, the models tested on specifically requested projects are provided by the military services. Funding requirements are provided entirely by the NASA.

Question. It appears that there is some duplication of effort among the various NASA centers engaged in aeronautical research; particularly Ames and Langley. What is the policy of NASA in assigning specific specialized roles and missions to the various centers?

Answer. There are four research centers engaged in aeronautical research; namely, Langley, Ames, Lewis, and Flight.

To my knowledge there is no undesirable duplication of effort in aeronautical research among the centers engaged in this work. Working level research committees, made up of representatives of the research centers, are actively coordinating the research effort and continually discussing detailed problems in the areas of V/STOL aircraft research, supersonic transport research, and hypersonic research. Also a representative of each research center is a member of each of the NASA Research Advisory Committees on A/C Aerodynamics, A/C Loads and Structures, A/C Operating Problems and Air-breathing Propulsion.

With regard to research it is the view of the NASA that problems requiring solution are best defined by the scientists and engineers working in the field and these professional people are encouraged to propose research projects to management for approval. The roles and missions of the research centers have developed as a natural result of the particular interests of the professional people in certain areas and as a consequence of the availability of certain research facilities at the center. As a result, competence in particular areas has developed in the various centers.

Question. Why is it that NASA has come up with four different designs of the supersonic transport, when the ultimate design will be done by the industrial builder of the plane? Is this wasted effort?

Answer. The NASA has not come up with four different designs of the supersonic transport.

The NASA has studied a number of different aerodynamic configurations and of these one each of four basic design concepts which from extensive wind-tunnel tests appears to be the best with regard to flight efficiency has been selected for further detail study. The NASA does not design airplanes but has the responsibility to provide the research information and the technology to permit the U.S. industry, the airlines, and the military to maintain U.S. leadership in aviation.

The four configurations referred to in the question are being studied to provide such information to permit sound decisions in the future with regard to the ultimate design of the supersonic transport by the industry. Without such technical information sound decisions could not be made.

Question. Your statement indicates that further research effort must be done on the sonic boom problem. Is there anything really that can be done, other than to fly at subsonic speeds?

Answer. As a result of recent work we have progressed to the point where today we have a good understanding of the sonic boom phenomenon and have developed an analytical method of prediction that indicates methods of aircraft design that will reduce the sonic boom. In other words sonic boom can be minimized by proper aircraft design. The size of the aircraft also affects sonic boom, a small size aircraft will produce less boom overpressure on the ground than a larger one for given flight conditions. The most effective means of reducing sonic boom is to fly at high altitude. However, today there is no known way to eliminate the sonic boom.

Question. It seems clear that the airframe manufacturers cannot undertake the development and manufacture of the supersonic transport individually. Has there been any program for cooperative development among the major industrial companies, and to what extent will the taxpayer have to underwrite such a development?

Answer. In a sense the joint FAA/NASA/DOD program of assistance to the industry funded through the FAA in fiscal years 1962 and 1963 has been a program of cooperative development between Government, the manufacturers, and the

airlines. Certain manufacturers have teamed up in a cooperative effort in this research program and may continue such associations in any future development of a supersonic transport. It is my opinion that the Government will be required to underwrite the cost of development of a supersonic transport to the point of FAA certification. When this is accomplished then I feel the airlines will be able to afford the per copy cost and maintenance of the aircraft and realize a reasonable profit from its operation.

Question. The popular press reports that NASA and the Air Force are cooperating on an investigation of the feasibility of hypersonic aircraft, as a possible follow-on to the Dyna-Soar (X–20A) program. Would you enlarge upon the agreement between NASA and the Air Force?

Answer. A joint NASA–USAF technical team was organized on August 1, 1962, to "Review and agree on NASA and USAF research programs aimed at providing the technology necessary to evaluate the practical possibilities of hypersonic flight utilizing air-breathing propulsion systems." The intent of the study was to formulate additional programs so that sufficient research information would be generated during the remainder of fiscal year 1963 and fiscal year 1964 to permit evaluation of the technical feasibility of developing an Earth-to-orbit vehicle system. As a result of the work of the joint team, the NASA and the USAF identified and coordinated the additional research effort on the part of both agencies required to meet the 2-year deadline, and determined the additional resources in manpower and funds to implement the effort. These additional resources have been largely programed by both managements and key programs have been initiated.

Question. It is understood that the goal of the joint program is to arrive at a national position by 1965 on the form of the hypersonic research aircraft: i.e., should it be—

An air-breathing cruise vehicle.
A single-stage-to-orbit aerospace plane.
A combination of the two concepts.
Or a new concept.

Would you present NASA's views on the probable form to be recommended?

Answer. NASA's view is that the probable form, characteristics, and mission of a forthcoming hypersonic air-breathing vehicle system cannot be determined specifically at this time. In addition to a tentative research mission, the joint NASA/USAF team focused on two basic operational missions as follows:

(*a*) An Earth-to-orbit and return transportation system for either military or NASA functions.

(*b*) An Earth-to-Earth transportation system as supported by the technology for (*a*) for either military or commercial purposes.

In order to provide further focus to the research, general concepts conforming to the following ground rules have been identified:

(*a*) Minimum staging.

(*b*) At least the first stage manned and takeoff and land by conventional aircraft techniques.

(*c*) Primary emphasis on air-breathing propulsion in the first stage.

Question. The NASA budget presentation indicates that the hypersonic research will be conducted under the general heading of "Supporting research and technology." Will you indicate the dollar value of the hypersonic aircraft program for fiscal year 1964? Are all four laboratories going to take part in the hypersonic program? How is the work coordinated within NASA and with the USAF effort? What has the USAF invested in their program already? What is the USAF anticipated funding for fiscal year 1964?

Answer. The dollar value of the NASA hypersonic aircraft program for fiscal year 1964 is approximately $4 million in R. & D. costs, and $6 million in personnel costs and operation of installations, or a total of $10 million. This total comprises 40 percent of the aeronautics S.R. & T. estimate. The Ames, Flight, Langley, and Lewis Research Centers will all take an active part in this program. The various research tasks ir the centers will be coordinated within NASA by the Office of Aeronautical Research in Washington, and with the USAF effort by the panels of the NASA/USAF joint team. Each of these panels in aerodynamics, propulsion, structures, materials, and performance analysis have a NASA and USAF cochairman and members from both agencies. The team itself is headed by joint leaders in the same way. Thus, the desired coordination will be effected at the working as well as the management level. The accurate information on USAF current and anticipated funding can best be obtained from the USAF.

Question. It is understood that the USAF hopes a direct single-stage-to-orbit vehicle will prove feasible, while NASA thinks it will be necessary to investigate

a suborbital vehicle before going to the space plane concept. Is this conflict of objectives reflected in the NASA hypersonic aircraft research program?

Answer. NASA and USAF are both directing the current programs to throw more light on these questions. It is possible that a suborbital first stage will be the logical initial step in the development of an orbital system. As a result of the joint team coordination, there is no apparent conflict of technological aims in the definitive 2-year program.

Question. Is there a central authority for the conduct of research on the hypersonic aircraft? Are NASA and the USAF restricted to the performance of research in their designated areas, or can each agency control its own research program?

Answer. While NASA and USAF each controls its own research program, the joint technical team is retained in existence for the 2-year period to coordinate the work and advise the managements as to technical effectiveness as the programs develop.

FACILITIES

Question. A sum of $347,000 has been requested for a model construction building at Ames. The purpose of the building is to house the model fabricating facilities at Ames under one roof. The function is now carried out in scattered locations within Ames. Would delay of the construction of this building prevent the research work necessary? Or would it only make the work easier? Is continuation of the present arrangement impossible or only undesirable?

Answer. Models required for research on advanced spacecraft and aircraft have become complex and costly. In many instances Ames does not have the equipment necessary to build the models which are needed. Construction of this facility, while obviously making the work easier, will eliminate a large percentage of the costly procurement of models on contract. In other words, the expense of the facility will, to a great extent, be self-liquidating. In this respect, delay in the construction of the building is undesirable because it will lead to further expenditures for out-of-house procurement of models. On no occasion, however, would lack of this facility prevent necessary research work. Lack of the facility could prevent timely research work, though.

Question. In view of the decreasing number of new aircraft programs, why is it necessary to expand the flight simulation capability at the Flight Research Center? The proposed new Flight Research Laboratory includes a great deal of expensive equipment as well as a whole new building for this function. Is the anticipated workload for the future sufficient to justify a $2,924,000 facility?

Answer. The Flight Research Center is involved in full-scale, free flight research using advanced "flying mockups" of spacecraft as well as actual advanced aircraft such as the X–15A. The Center has performed research on the Paraglider, similar to that proposed for recovery of the Gemini spacecraft, and is just beginning flight tests of the wingless M–2 lifting body reentry vehicle, possibly typical of an Apollo-follow-on vehicle. It is anticipated that this type of work will be greatly accelerated in the future. And because these vehicles are manned, as they would be in the case of the actual vehicle returning from circular—or supercircular—velocity flight, each test must be adequately simulated on the ground before flight.

In addition, the Center will investigate the piloting and operational aspects of new aircraft types such as the supersonic transport and, later, items which will have a direct bearing on the possible requirement for a hypersonic air-breathing research vehicle. In this regard, the Center is already actively participating in the joint USAF–NASA hypersonic research program. The workload of the Center is increasing in all of these areas, and an increased simulation capability is vitally required.

Mr. KARTH. Dr. Bisplinghoff, whom do you have next?

Dr. BISPLINGHOFF. Dr. Albert Kelley, our Director of Electronics and Control, is here today, prepared to tell you about his program.

Mr. KARTH. Dr. Kelley, I wonder if you would follow the same procedure that has been followed by Mr. Zimmerman.

Give us a 10- or 15- or 20-minute summation of your prepared text and then the subcommittee, I'm sure, will have some questions.

STATEMENT OF DR. ALBERT J. KELLEY, DIRECTOR OF ELECTRONICS AND CONTROL, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

(The prepared statement of Dr. Albert J. Kelley is as follows:)

The electronics and control program encompasses several functional areas. To simplify nomenclature we often use the broad generic term "electronic systems" or simply "electronics" to include all of these.

Guidance and navigation.—Determining, predicting, and directing a vehicle's position along a flightpath or trajectory. This includes inertial guidance, radiation trackers, guidance computation, and flight mechanics.

Control and stabilization.—The control of a vehicle along and about the flightpath. This includes manned and automatic flight control systems, control theory, and advanced component techniques.

Communications and tracking.—The transmission of commands to and the recovery of data from an aerospace vehicle. This includes communications, tracking, and data acquisition systems, and advanced electronic techniques and devices.

Instrumentation and data processing.—The detection, generation and measurement of information or phenomena, and reduction of this information to intelligible and useful forms. This includes physical and biomedical measurement techniques, data processing, and advanced computing devices.

As part of the normal functions of NASA program management, we continually analyze the state of the art together with projected mission needs in order to establish research and technological requirements in these areas. This is a two-way process between ourselves and industry. For example, in our operation at headquarters, we have recently been averaging approximately 40 contacts a day from the industries and universities with which we have common interests. In the time available I will discuss only a few selected items from this broad spectrum of interests.

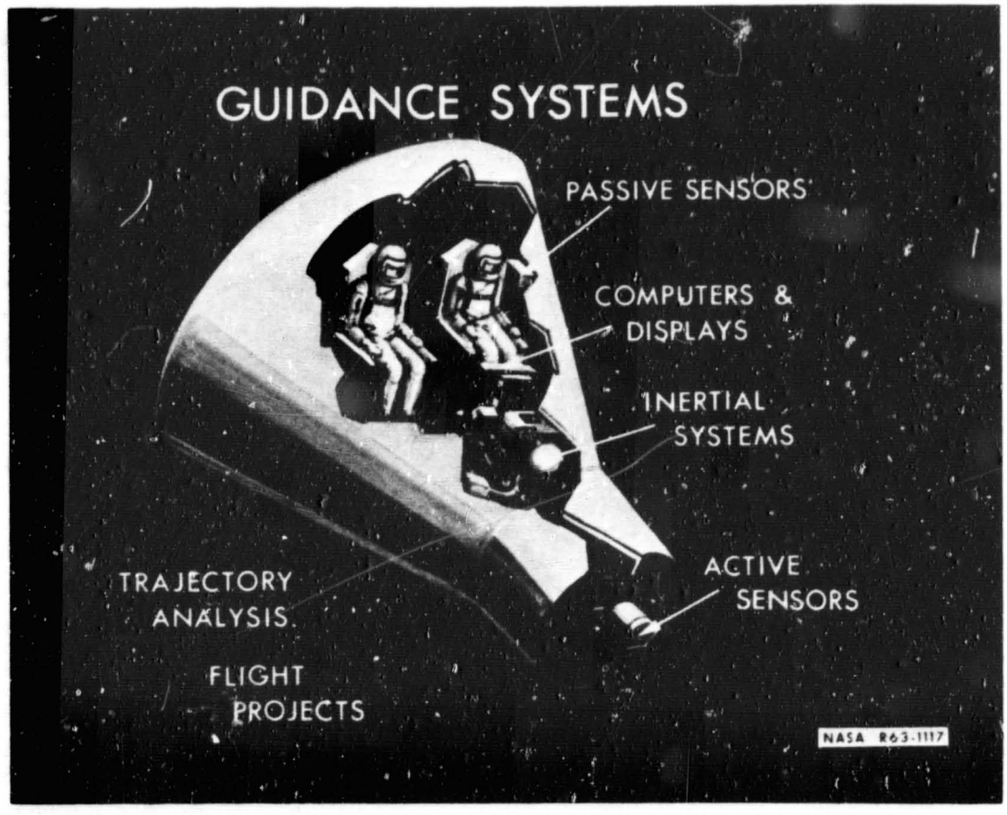
The importance of electronics in aeronautics and space is quite apparent. Electronics and its associated disciplines constitute the brain and nerves of flight vehicles. Although it is estimated that about 70 percent of our major spacecraft dollars go into electronics, unfortunately, in the same context, a much higher percentage of our flight failures arise from electronic component failures. Success in this area is obviously a major factor in overall mission accomplishment since a dead or unintelligent vehicle is useless if it cannot measure data and send it back to Earth.

GUIDANCE AND NAVIGATION

NASA advanced research and technology efforts in guidance and navigation encompass spacecraft, launch vehicles, and advanced flight vehicles. The principal technical areas of guidance and navigation include passive sensors, computers and displays, inertial sensors and systems, active sensors, trajectory analysis, and supporting research flight projects to assist in our ground-based studies and experimentation (fig. NASA R63–1117).

Inertial guidance sensors

NASA inertial guidance development has, in the past, drawn heavily on missile programs. However, space mission requirements for inertial guidance sensors have produced unique requirements in terms of lifetime, reliability, environment, accuracy, and thrust profiles. Two promising inertial sensor concepts are currently being pursued. The cryogenic gyro utilizes the principle of superconductivity wherein electrical resistance disappears at temperatures near absolute zero. This provides a magnetic field requiring no electrical energy input, after initial establishment, to support a rotating gyroscopic mass. Although a promising technique, such problems as that of obtaining suitable cryogenic materials require continued research before these devices can be considered feasible. The electrostatically suspended gyro (and accelerometer) differs from the cryogenic type in that it uses electrical rather than magnetic forces to suspend the inertial element. It does not require cryogenic temperatures but does need a high vacuum internal environment for its operation. This sensor is highly promising but is more sensitive to high acceleration environments and requires further effort to develop and demonstrate the ability to operate in or at least survive the launch environment without performance deterioration.



In addition to these concepts currently under development, we are interested in exploring other interesting phenomena such as the use of atomic size and larger (micron size) particles as gyroscopic and acceleration measuring techniques. These devices can be expected to have increased reliability in an environment of shock, vibration, and temperature extremes as well as long inherent operating lifetime.

Optical navigation

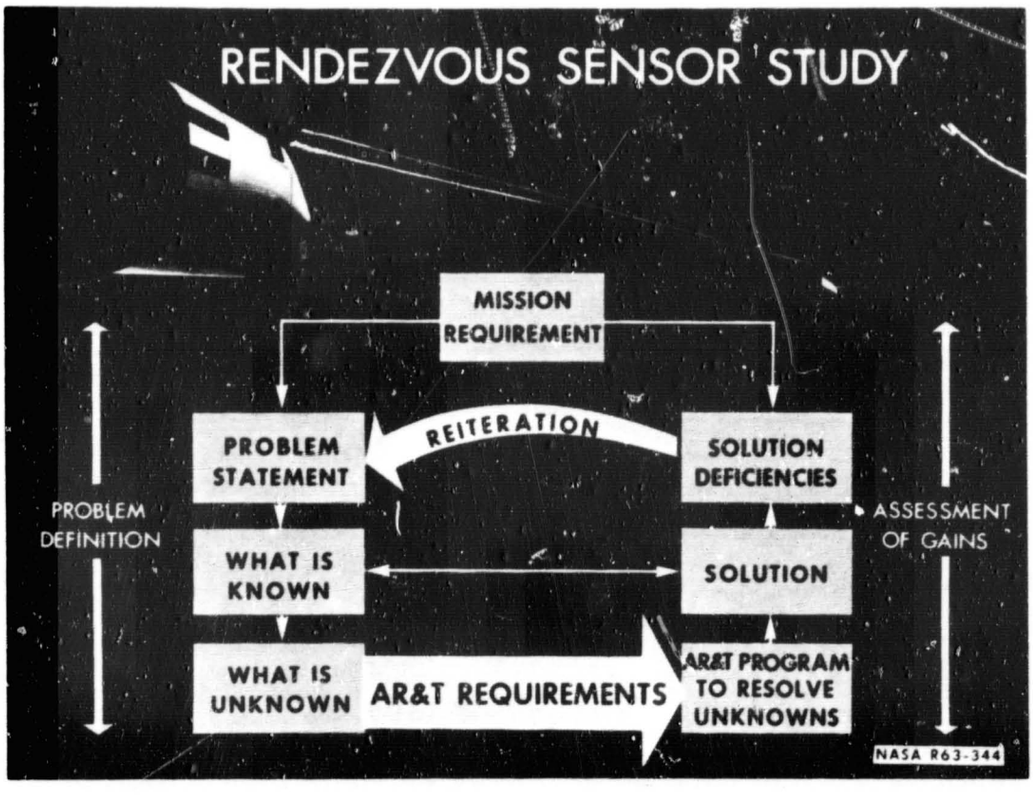
The optical sighting instrument is destined to play an important role in the future manned space missions beginning with Apollo. Such devices in configurations suitable for specialized uses will appear in unmanned spacecraft beginning with the Orbiting Astronomical Observatory. The availability of stars and planets as sighting targets on an all-weather basis in space, the inability of Earth based tracking and command systems to guide with reasonable accuracy as distances from Earth become great, and the desirability of having onboard navigation capability for manned systems, indicate the establishment of a strong role in spacecraft navigation for the space counterpart to marine and aircraft sextants and trackers.

Considerable inhouse study effort at Langley and Ames Research Centers has been devoted to various methods of using angles between stars and the Moon and Earth for lunar mission and abort position fixing. These studies have included the development of suitable methods for determining the position of a vehicle and analyses of the effects of measurement errors on the accuracies of the various methods. In addition, experimental investigations of the accuracy of the man plus instrument at Ames Research Center using precision sighting devices and simulated planetary bodies in full and partial illumination, have developed quantitative information showing that observations can be made with accuracies of a very few seconds (one thirty-six thousandths of a degree) of arc angular error. In addition, technology efforts on devices for use in optical space navigation are being pursued both inhouse and under contract. We expect to expand these efforts in fiscal year 1964. A precision theodolite tracker is being designed for the Ames sighting experiments.

In addition to research and technology efforts on precision instruments, studies are being made of simplified hand-held visual and photographic sextants for backup and emergency use. In these areas, we have made encouraging progress in the early stages of our programs.

Rendevzous sensor study

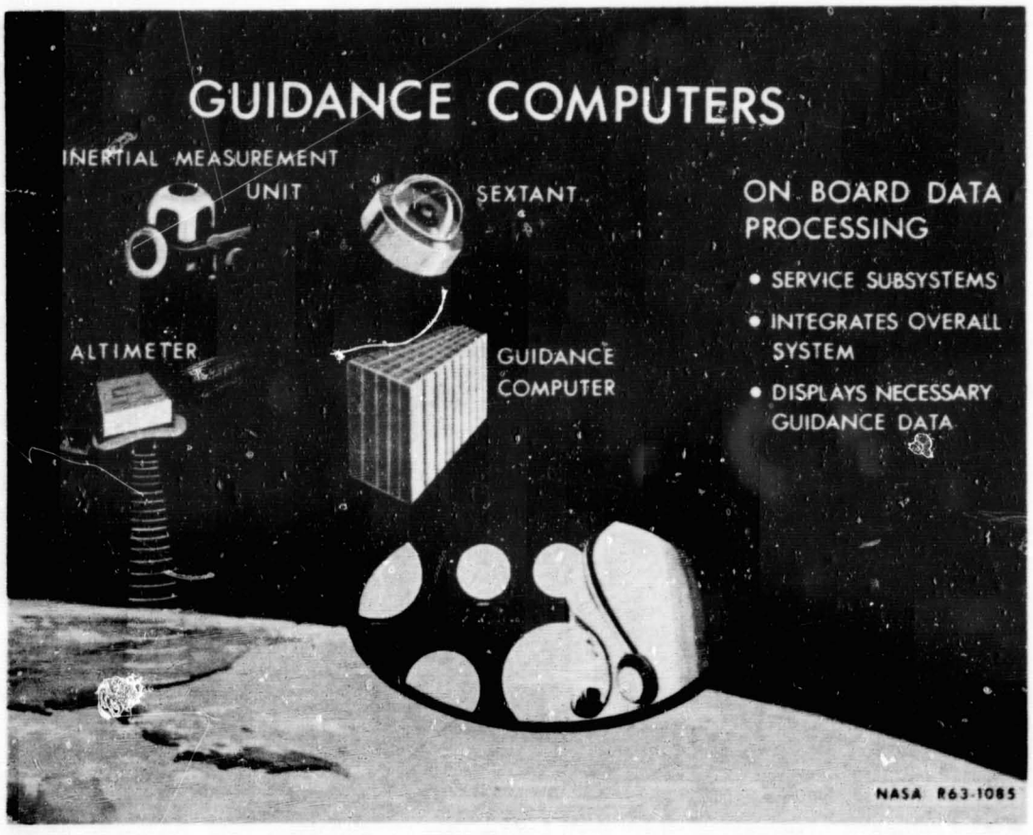
Part of our advanced guidance program is slanted in the direction of determination of future research and development requirements. Ideally this should be done on some more tenable basis than novelty of technique or intuitive judgment. There is a more formalized way of deciding what research is worth pursuing based on an analytic methodology (fig. NASA R63–344). We are currently engaged in a study with contractual support to determine advanced rendezvous sensor requirements. The purpose of this study is to identify parameters which best yield themselves to technological exploitation. The study process begins with



known or anticipated mission requirements. Given the requirement, a statement of the problem to be solved in any areas, such as rendezvous sensors, is derivable. From the problem statement, descriptions of the "knowns" and "unknowns" are developed. Of course, the known factors contribute directly to solutions. However, the unknown factors constitute the requirements for our long-range research and development programs. None of the possible real-life solutions will ever be without deficiency. Comparison of the mission profile with the solutions permits estimation of the solution deficiencies. Reiterating this cycle brings about a convergence on the research and development requirements and on predictably optimum solutions. At the least, this method should permit estimates of the result of any course of action before this action has fully committed us to an expensive program.

Guidance computers

The spaceborne digital computer is destined to play a major role in the spacecraft guidance systems of the future. The complex guidance equation solving and navigation data processing required for sophisticated space missions have made the digital computer a necessity for optimum mission performance. The guidance computer (fig. NASA R63–1085) serves as a coordinator for the guidance and navigation subsystems and processes pertinent information for display to the spacecraft pilot. In most instances, the guidance computer will perform

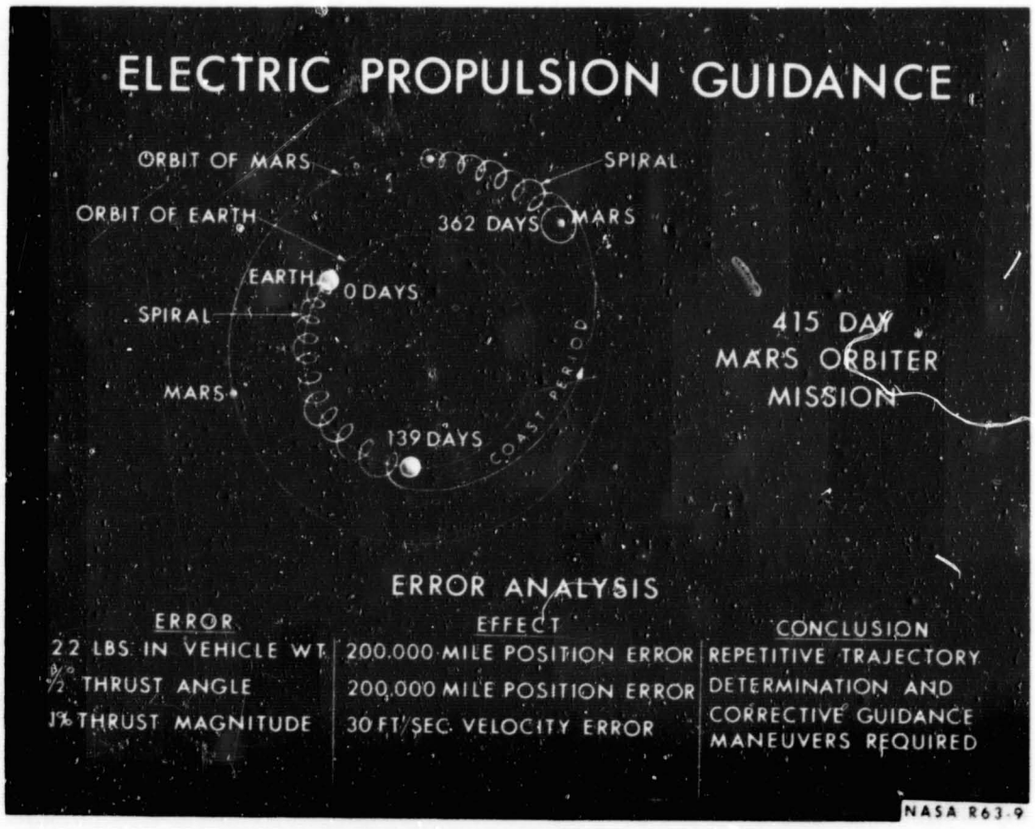


additional on-board functions. In parallel with the advances in component and circuit technology that are being undertaken to provide the capability of building computers with increased capability and improved reliability. In-house efforts are underway aimed at determining spacecraft computer requirements and investigating subsystem integration problems. The laboratory setup utilizes actual computer elements together with simulated guidance and navigation subsystems. This research will allow analysis of requirements such as speed, accuracy, memory, logic and mathematical techniques, which are basic to the design, selection and integration of hardware. It will also allow analysis of computation and interconnection requirements for such subsystems as the space sextant, inertial measurement unit, pilot's control, and pilot's display. In addition to efforts on complex computer systems, we are investigating simplified systems for backup in the in the event of primary system failure which will enable a mission abort to be successfully executed.

Trajectory analysis

Trajectory or mission flight path analysis has been and will continue to be an important area of in-house effort backed up by considerable university and industry research. While major recent emphasis has been on manned lunar mission guidance and trajectories for the early planetary flybys, studies of advanced planetary missions have been in progress.

An interesting example is the results of one of these studies made at Lewis Research Center of an electrically propelled spacecraft using the SNAP–8 power generating system performing a Mars mission culminatig in injection into an orbit about Mars (fig. NASA R63–9). The mission required 415 days involving 139 days in a spiral trajectory to accelerate to escape velocity, 223 days in a transfer trajectory partially thrusting and partially coasting, and 53 days in a captured spiral ending at the 415th day in a low orbit about Mars. It can be seen from the listing of effects of typical errors shown on the chart that these low thrust trajectories are very sensitive to relatively small errors. It can be concluded that repetitive trajectory determination and corrective guidance maneuvers will be required for this type of mission. Planetary guidance and trajectory analysis effort will be increased in fiscal year 1964 to meet the advanced design requirements of interplanetary spacecraft.

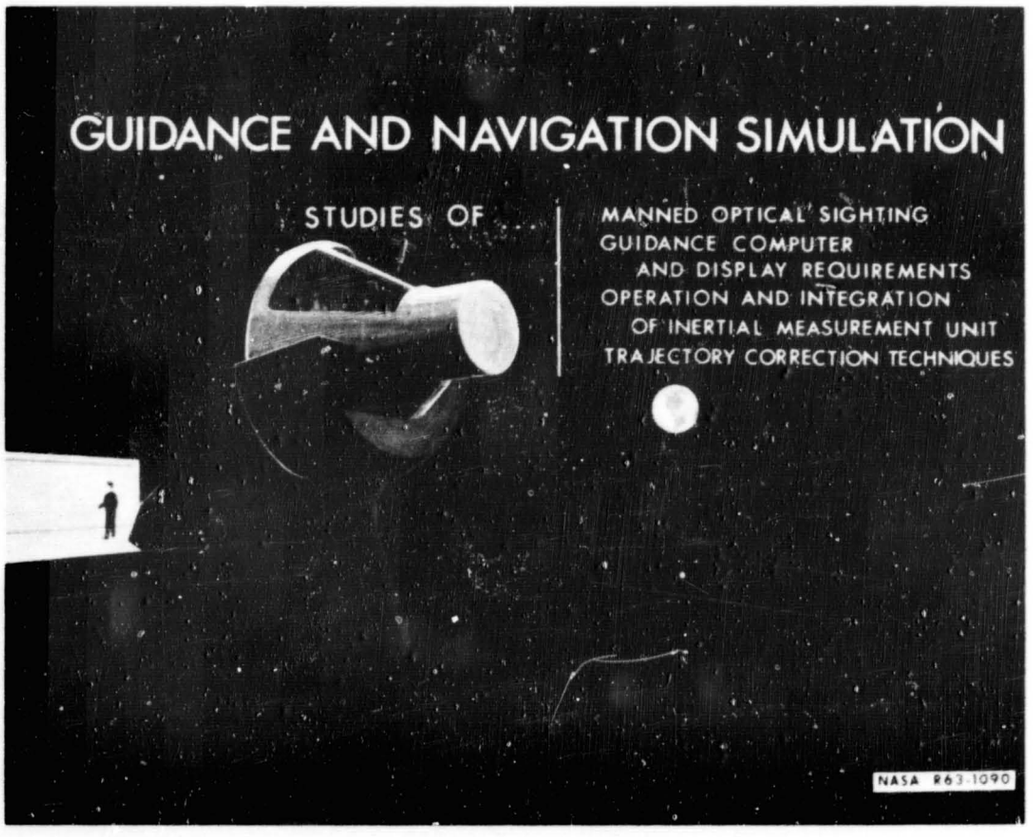


Guidance and navigation simulation

An important effort is being undertaken in guidance systems simulation. A midcourse guidance simulator is in operation at Ames Research Center to study the capabilities and determine the proper role of the man in the guidance and navigation of spacecraft (fig. NASA R63–1090). Current studies of the precision of the man plus optical instrument in sighting stars and planets mentioned above will, in the advanced simulator, be extended to the use of sextants and theodolites aboard a simulated vehicle. The simulator will be provided with appropriate angular motion and with lunar and planetary models and celestial background simulated with sufficient precision to make feasible the obtaining of quantitative information on the accuracy of the man plus instrument. The computer, inertial measurement unit, and displays will be simulated in order to determine overall system requirements and operation. The results of such studies will aid in resolving problems of integrating the elements of space navigation systems and in defining the proper role of the man in the navigation and guidance system. In addition, they will assist in determining the operations deficiencies of current technology and lead the way to more definitive determination of the directions in which advanced guidance technology efforts should move.

Horizon scanners

A subject of particular interest to us is that of earth and planetary horizon sensing, inasmuch as many satellites, both manned and unmanned, and the orbiting, approach, and reentry phases of lunar and planetary missions lean heavily on horizon sensing to determine the vertical direction to the center of the planet being orbited or approached. In addition, we can use the apparent change in diameter of the earth or other planetary body to determine the approximate altitude of the vehicle. While we are interested in developing the most capable and reliable devices we can for performing horizon sensing, our knowledge of the appearance of the horizon to spaceborne instruments is meager even for our own earth. Accordingly, we have initiated a flight project to determine the natural radiation gradients which define the earth's horizon in several regions of the spectrum. We will loft in a suborbital trajectory, a spinning vehicle with several precision telescopes, each of which has a sensor detecting a particular portion of the spectrum. Using relatively inexpensive modified Javelin vehicles, we



will view the horizon many times on each flight at varying altitudes. We hope to learn at least two important things from this project; now sharply is the earth's edge defined, which will tell us the limit of accuracy for horizon scanning, and what particular regions of the spectrum (near or far infrared, ultraviolet, etc.) should be utilized for horizon scanning devices. We have made a successful flight using instruments of limited accuracy to obtain preliminary data. Flights of improved instrumentation packages are expected to commence next year.

CONTROL AND STABILIZATION

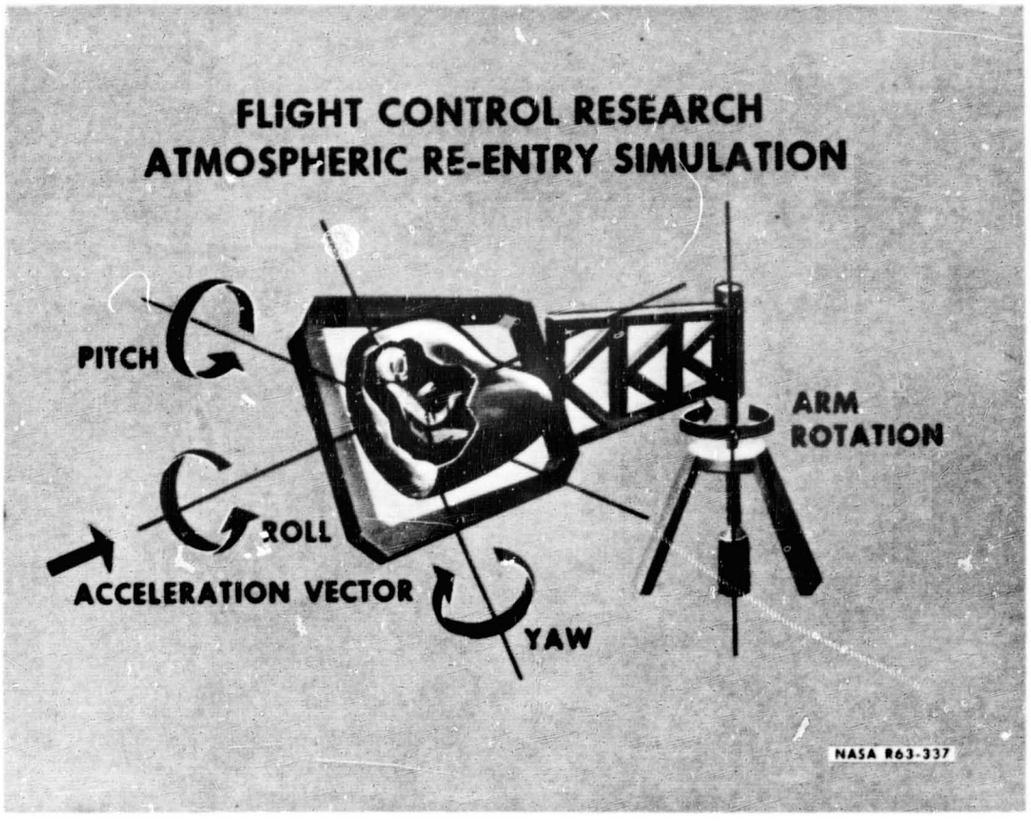
The technology of control and stabilization can be described as the means by which systems are made to respond to desired commands and ignore undesired disturbances. In its broadest sense it is often called automation. Control systems may be manned, completely automatic, or most often, a combination, in which the man is sometimes a controller, sometimes only a monitor.

Manned fight control

An important part of our control and stabilization effort is directed toward investigations of manned flight control systems. In order to develop control systems and displays which best complement man's capabilities, the contributions of various scientific disciplines must be brought to bear in an integrated fashion.

Man is a capable but complex control system element, and one that we cannot change very easily, at least not in the next few thousand years. Design of the entire advanced flight control and display system, tailored around the man's existing capabilities, is our goal. In this activity we work closely with our biotechnology and human research group.

By affording flexible, and repeatable flight time, ground based flight simulators (fig. NASA R63-337) are powerful research tools for collecting performance measures under a wide variety of selected and controlled conditions. If the real vehicle is replaced by a simulated vehicle, various control and display arrangements can be operated under many different conditions to determine control performance as it relates to the equipment which the pilot has to aid him. We are



thereby able to acquire large amounts of statistical data from which to predict capability under varying conditions, design equipment, and evaluate overall control system performance on a continually refined basis. The advantages of simulators in experimental flight operations have already been proven, as you well know, in the X–15 and Mercury programs.

Recent advances in simulator technology such as controllable centrifuges, projected displays, and precision air bearings now make them valuable research tools with which we can make large strides at minimum cost in dollars and life.

Flight display technology is being advanced in accordance with the foregoing research, with the aim of providing simple, reliable cockpit instrumentation that the man can effectively use. Optical projected displays, TV displays, discrete address digital displays, and displays consistent with pneumatic computers will be investigated and further developed.

System organization

Research and development is under way which will lead to vast improvements in the reliability and capability of electronic control devices through advanced microcircuit techniques. Application of these techniques without major revisions to the interconnecting circuit elements and system components will, however, yield only part of the potential benefit. We have, therefore, been investigating the feasibility and desirability of reducing component interconnection wiring to a bare minimum. A "before and after" picture (fig. NASA R63–987) illustrates this.

Studies have indicated that substantial reductions could be made in system complexity and weight if a partial application of telemetry principles were made. In the forthcoming year, we will apply discrete address pulse code data transmission techniques to a control simulation. Based upon the results of this work, it is expected that a new family of system components can be specified which will interconnect an entire flight control system with a single pair of wires.

Automatic flight control systems

The automatic flight control system area concerns itself with the development of control systems for the maintenance of attitude, station or position, and planned path of the spacecraft, as well as the control of internal systems. Automatic control systems are in operation from launch through mission completion. The objective is to attain reliability, lifetime and simplicity, consistent with a complete control function. Most of these systems are an outgrowth of theoretical feasibility studies. Other systems are a further development toward simplification or improved performance of existing systems.

Typical of the improved systems studies is an investigation at Ames Research Center to uncouple the yaw and roll modes while sensing yaw errors in satellites slaved to the center of the Earth. Ames Research Center is studying a new technique to provide passive damping when utilizing gravity gradient stabilization. Ames Research Center is also investigating error signal detection that is compatible with the high pointing accuracies required by telescope-spectrometer systems. Goddard Space Flight Center is developing a control system using a momentum sphere as an alternate to flywheels for attitude control, eliminating at least three flywheels. With the advent of large manned spinning spacecraft, precession damping and spin control devices are being developed and integrated into a system, to reduce, for example, errors caused by movement of men inside spacecraft.

The Langley Research Center has developed and flown a simplified attitude control system, miniguide, for a spinning satellite in a planetary orbit, consisting of a telescope and IR sensor and a reaction jet to maintain a prescribed attitude.

The Marshall Space Flight Center is developing a control system using secondary injection, where the main engine thrust is deflected by side injected gases. If injection thrust vectoring for very large engines proves feasible, gimballed engines may not be required.

The greater overall length and improved structural efficiency of aeronautical and launch vehicles planned for the future pose severe problems to flight control system designers (fig. 199, p. 2126). The structural bending modes are approaching the control system operational frequencies required for adherence to flight paths. It is desirable to steer these vehicles so that the desired flight path is maintained,

at the same time yielding minimum wind shear and turbulence stress on the vehicles.

An aggressive attack has been directed toward the solution of these problems, combining the efforts of university and private industry researchers, as well as the best flight control experts of our research and space flight centers. This work includes formulation and analysis of mathematical descriptions, the equations of motions of the vehicle and its control system, simulation of these body and control motions, and testing of models of vehicles and control elements to provide data for the analysis and simulation of the systems. The work often results in the formulation of requirements for new types of instruments to measure parameters to which the system shows sensitivity.

Advanced control theory

Advanced control theory efforts are primarily concerned with the mathematical approach to new concepts of control. Control theory uses mathematics as the primary tool to describe the components and composite characteristics of the entire system. With the correct programing of this information into a computer, the system may be simulated to determine the feasibility of such a concept prior to reducing it to practice.

In the past decade, adaptive controls have been developed in this country. This concept extends the dynamic operating range of a control system, and is being studied for applications in NASA programs. As an example, a study is now in progress at the Langley Research Center to study the use of automatic adaptive controls in missiles and hypersonic aircraft. One of the first adaptive controllers is now under test in the X–15 program. The concept of adaptation is also being studied at Marshall Space Flight Center for application to a large flexible vehicle, where the problem is complicated by structural flexibility and fuel sloshing disturbances.

Ames Research Center has been engaged in a study of optimizing the control along a planned course when the spacecraft may be subjected to unwanted disturbances or nonlinear (saturation) effects. Langley Research Center is also engaged in optimal, nonlinear control systems studies. Consideration of manned control systems in automatic control theory is being stressed.

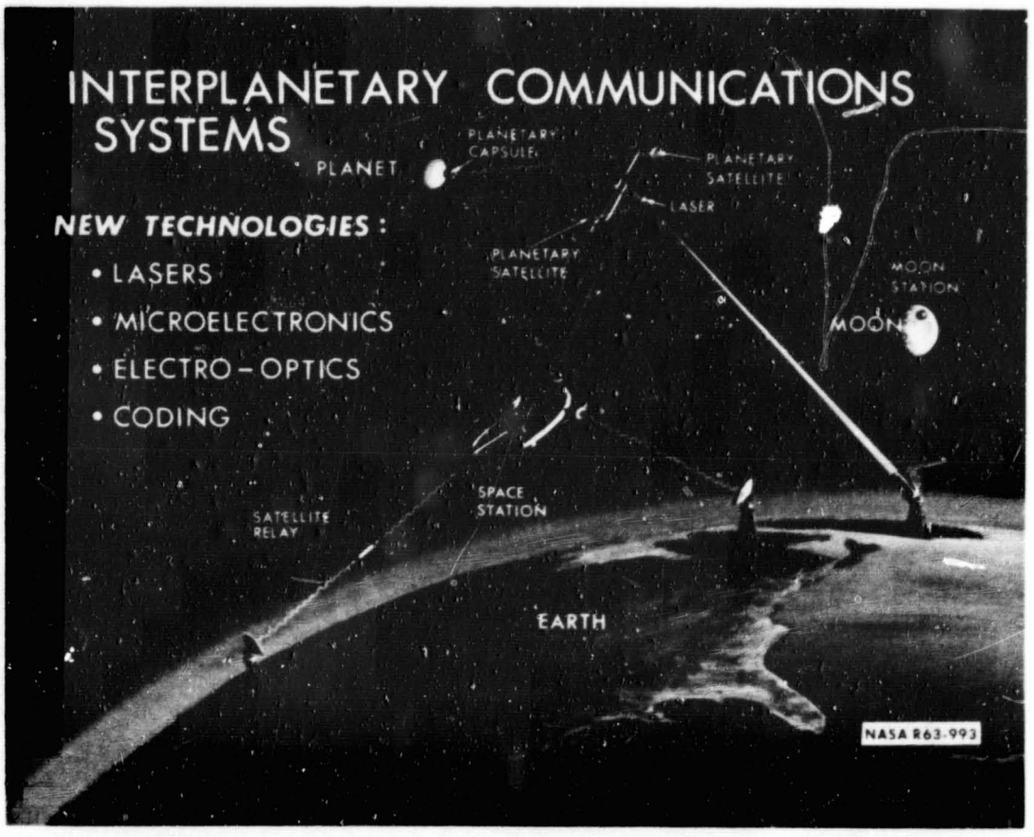
Research in control theory is also supported at universities and industrial research groups to meet the objectives of our program. As examples, Case Institute of Technology is studying the use of digital techniques in a closed-loop control system. From this, we hope to learn more about the efficient and improved methods of using pulse and coded numerical data converted in real time to permit a continuous control function. University of Connecticut is studying and analyzing feedback control theory for sampled-data systems in terms of realistic design considerations. At the University of Tennessee, the problem of improving measurement techniques by using two different methods or frequencies of sampling an input signal, are investigated. Use of digital or analog or hybrids are examined to produce the best intelligence in a noisy environment. Studies at Stanford University and Purdue are concerned with obtaining control system configurations based upon optimizing fuel or time with specific mission requirements.

As to the future, adaptive controls will require nonlinear compensation in the control process. Techniques of measurement must be expanded and new ideas encouraged, to be able to obtain as high resolution of measurement as possible, consistent with the optimization techniques being developed. Above all, control theory must be presented to design engineers in usable form.

COMMUNICATIONS AND TRACKING

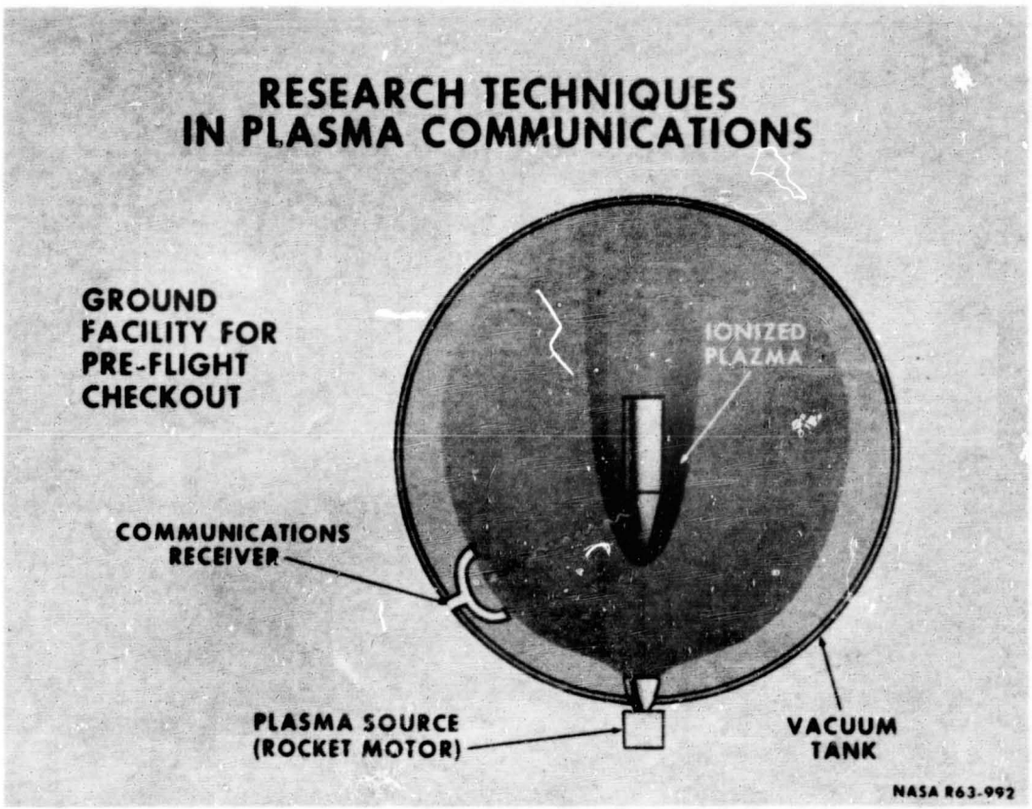
Our communications and tracking efforts are concerned with expanding man's capability for communicating complex information in his expanding explorations into the vast planetary regions. The art of space communications are tracking are closely related, for tracking space vehicles is often a prerequisite for communications. The scope of communications within the solar system is extremely vast (fig. NASA R 63–993).

The advent of significant new devices and techniques for communications will be the foundation of the future systems. Laser technology promises to open the tremendous range of the optical spectrum for man's use in communications. Microelectronic techniques suggest the use of vastly more complex and reliable space electronics systems for communications. Concurrently, work continues to go forward on information theory, which involves skillful and advanced techniques for translation of weak and noisy messages into meaningful information.



Communications through hostile environments

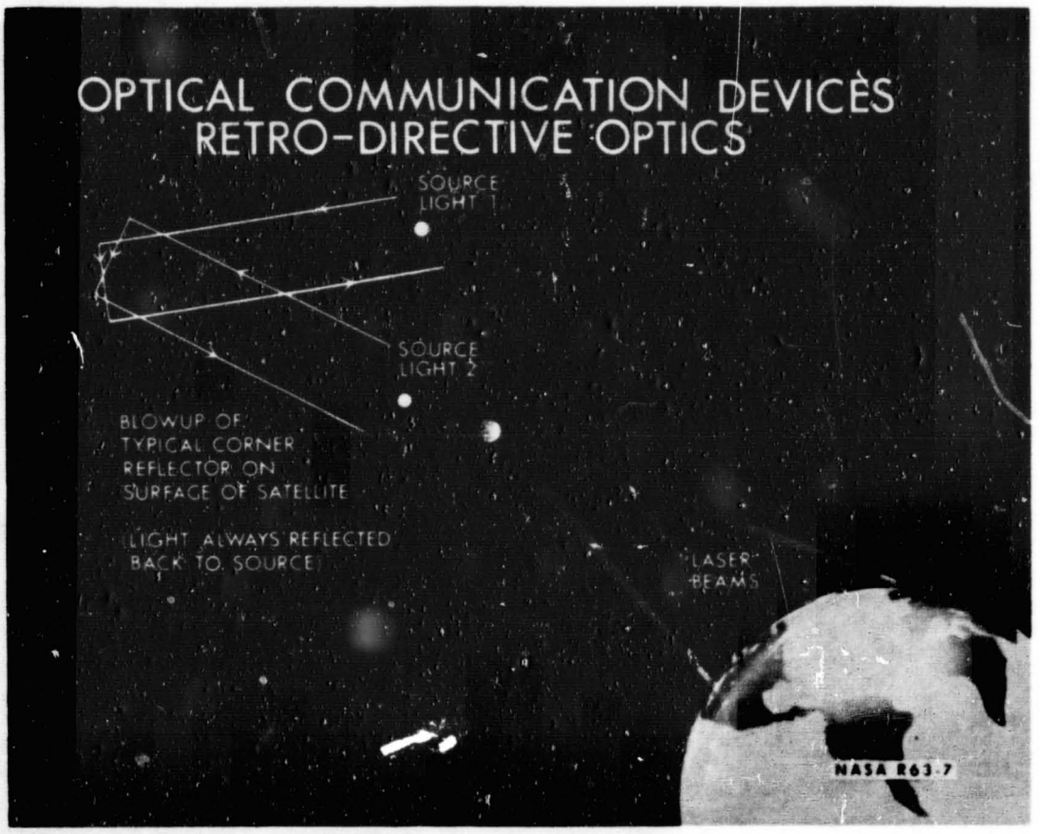
An important problem relating to our communications research is concerned with communicating through the hostile environment of ionized plasmas which are created when a body enters the atmosphere at high velocity, or as may be created by the exhaust products of a chemical rocket (fig. 214, p. 2145). Similar problems will occur when planetary spacecraft enter the unknown atmosphere of the planets, where the velocity of entry may be as high as 50,000 feet per second.) These plasmas act as a shield to black out communications which may involve safety considerations in a manned flight, or deprive us of significant scientific information at critical times. Significant progress has been made in techniques for solving this problem. We have laboratory evidence that when small amounts of atomized water are injected into the ionized flow field at the proper time the water acts to suppress the ionization in the plasma sheath, allowing radio communications channels to function normally (fig. 214, p. 2145). Ground tests make use of a large vacuum sphere in communications research (fig. NASA R 63–992). A small rocket motor is ignited and produces an ionized gas to simulate the conditions of reentry. Various experiments may be carried out, such as the injection of water materials or other chemical additives, or application of magnetic fields to suppress the ionization. Experiments will be made with material additives such as Freon and special gases; we will also try to find out what happens when ablative-type products from a heat shield intermix with the ionized plasma to further represent the problem at higher reentry velocities. Other laboratory techniques are being investigated for measuring the physical characteristics of the plasma, as well as for simulating the actual mission conditions more realistically. In addition to laboratory experiments, the RAM (radio attenuation measurements) flight project is designed for this purpose. In this project, Scout-type vehicles, equipped with engineering payloads, and fired from Wallops Station will provide data on the effect of actual blackout conditions at a variety of radio frequencies so that we may choose the optimum frequency for mission use. We will also seek to verify in flight some of the promising techniques for suppressing or eliminating the plasma. We have completed three flight experiments and four more are planned over the next 12 to 18 months. It is in support of such projects as this that we are requesting an addition to the vehicle antenna



test facility and an electronics instrumentation building at Langley Research Center.

Optical techniques in communications and tracking

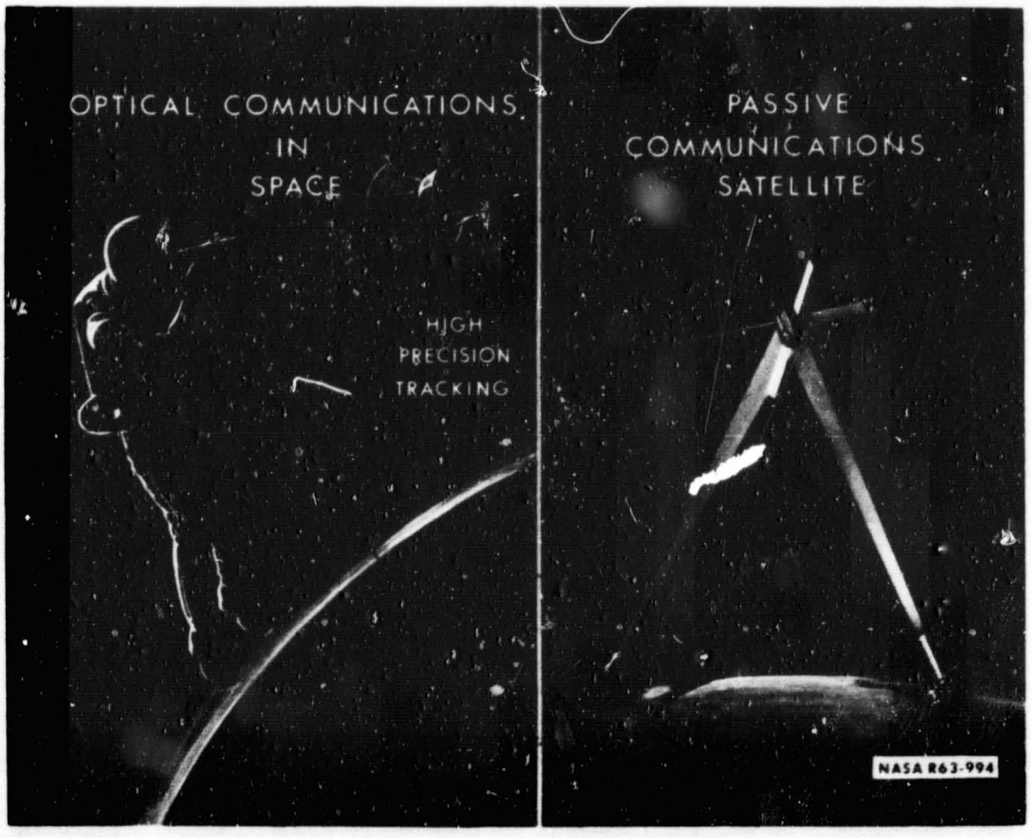
The optical maser, more commonly referred to as a laser, provides an exciting new means for generating coherent micromillimeter wavelengths (opical frequencies) for communications and tracking. When the laser is properly stimulated, as when exposed to a blast of high-intensity light, it emits a coherent stream of energy which, when properly harnessed, can open the vast spectrum of optical frequencies for communications and tracking. This spectrum is 100,000 times as large as the present spectrum in use of all communications. A laser experiment in optical tracking is being incorporated into the S–66 satellite (fig. 116, p. 1954). Tracking measurements in range to an accuracy of 30 meters, and in angular position to about 2 seconds are expected. This is about an order of magnitude better than any of the present electronic techniques. To accomplish this experiment, corner reflectors will be mounted on the satellite. The transmitted laser signal from the ground, which is concentrated in a narrow beam, will be reflected back to the gound from the corner reflectors into the tracking telescope which is mounted coaxially with the laser transmitter. Enough light will be reflected back to be received and detected on the Earth. This is not presently possible with ordinary light transmission techniques. The tiny corner reflectors mounted on the satellite make use of retrodirective optical effects as illustrated (fig. NASA R63–7), wherein any light received is reflected directly back to the source of that light. Much use of these devices is expected in optical communications sytems. In conjunction with laser research, atmospheric transmission experiments will be carried out to discover how the optical frequencies are attenuated by the atmosphere, including such fundamental factors as absorption, scattering, diffraction, and polarization. New and improved devices for tracking telescopes will be required and will be studied. Because of the velocity of the spacecraft relative to the tracking station, relativistic effects must be considered when using optical frequencies. For example, it is not clear that when optical frequencies are used whether the signal will be reflected directly back to the transmitter, or whether it will be deflected forward of the transmitter in the direction of motion of the spacecraft and thus completely miss the receiving antenna. The way in which



relativity affects this problem will be investigated through direct experiments in tracking.

The technology of lasers is only a few years old. Many practical problems remain to be solved. Some examples are: (1) The efficient generation of coherent optical radiation to produce a stable bandwidth frequency (i.e., narrow spectral bandwidth); (2) a means for efficiently modulating the optical energy or, in other words, introducing information content onto the basic signal; (3) more efficiently detecting the information at the recovery or receiving site (present day microwave devices and techniques are not directly applicable for detection and reception of signals at optical frequencies); (4) the affects of the atmosphere and other space environment on the transmission and absorption of optical frequencies (i.e., the propagation phenomena associated with these frequencies, including the relativistic affects noted above). Rapid and significant progress is being made in respect to these problems. A recent discovery has been made by several activities, including MIT's Lincoln Laboratory, of a technique for direct conversion of electrical energy into optical energy. A small piece of gallium arsenide, under the proper environment conditions, and properly designed can be stimulated by pulses of electric energy and convert these to light energy which can be used for communications. The significant thing here is that the conversion process is relatively efficient and the device can be theoretically operated with small amounts of power which can be easily modulated at the electric input. This is contrasted with the present laser devices which require large amounts of power and relatively large equipment to stimulate the emission of light and to modulate the signal. Ultimate application of such small devices in flashing light satellites for geodetic tracking, communications between manned spacecraft in rendezvous operations for guidance and control, and in space-to-space communications, are easily visualized.

A further example of communications with lasers is the case where a passive satellite may be used as a relay means for transmitting telephone and TV transmissions from one portion of the earth to another without requiring any electronic equipment in the satellite (fig. NASA R63-994). This may be possible because of the large amount of bandwidth and energy which can be transmitted by the narrow laser beam as compared to ordinary radar transmission wherein the bulk of the energy is not reflected, but rather dissipated into space. To accomplish this, highly precise tracking of the passive satellite will be necessary.

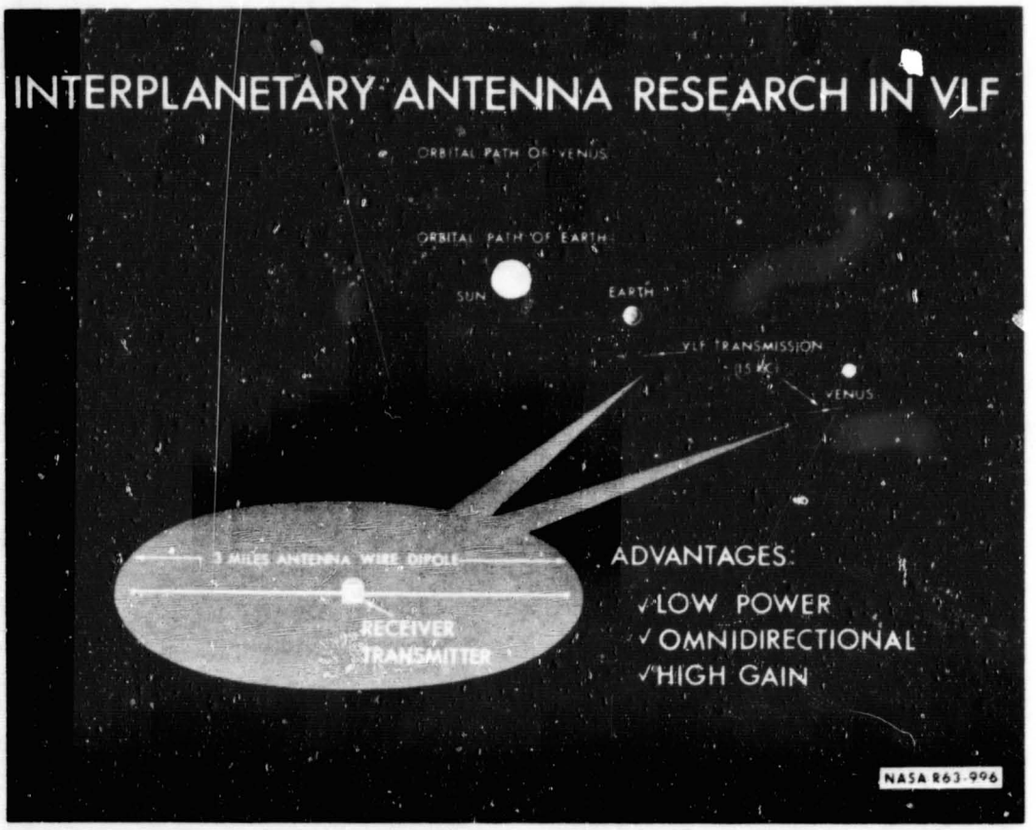


Antennas in space communications

For the distances involved in the planetary missions, there is a requirement for a communications and tracking capability in excess of any of our present-day ground systems. Although we are attempting to build even larger antennas on the ground, this approach has practical engineering and economic limitations when applied to single dish antennas. The alternative approach to achieving the high gain of large antennas on the ground is to construct an array of smaller dishes which will operate cooperatively to produce the equivalent (or better) gain and sensitivity of a very large aperture single dish antenna.

Experimental work has been going forward in the laboratory on the problem associated with multiple arrays and these have confirmed the feasibility in theory, of arraying a number of independently steerable antennas in a practical and economic manner. A number of relatively small paraboloid antennas can be connected electrically to do the job of a large single paraboloid (fig. 107, p. 1943). With the smaller dishes come certain advantages: They are easier to construct and more economical; higher frequencies may be used with higher gain; greater versatility is use is expected (i.e., they may be used individually or in array); a wider tracking beam width can be expected. However, there are a number of problems, such as: What is the effect of feed-line attenuation when the signals are brought together at a central receiver? What is the proper spacing of the individual elements of the array? Will it be possible to detect the signals in a coherent fasion (in unison)? What are the atmospheric effects which may produce propagation anomalies which will interfere with efficient signal recovery at the various antenna locations? To carry on further research and technology of this important work will require the construction of a realistic prototype system such that the design parameters, which are important and can be studied further in a realistic environment.

A research proposal for an interplanetary relay system involves the use of a very low frequency antenna oribiting the earth on the one hand, and orbiting around one of the planets on the other. This would be a dipole antenna involving a wire about 3 miles long, associated at midpoint with a receiver and transmitter and operating at the low frequencies of the order of 15 kilocycles (fig. NASA R63-996). The advantage of this technique, according to the theory, is that



there is very little interference to the very low frequency transmission in outer space as compared to on earth. Thus, with a relatively low power requirement, a very high-gain transmission system can be obtained between planets. This system has the further advantage of being omnidirectional; therefore, no pointing problem would be involved. One disadvantage would be the relatively narrow bandwidth, making for limited information capacity for such a system. What this does point up is the need for research experiments in connection with the very low frequency transmissions in outer space to confirm the feasibility of this technique.

Some research problems in fiscal year 1964 are: Research in signal and error detection electronic subsystems; improvement in low noise rf amplifiers (maser amplifiers); antenna servocontrol systems; efficient feed system designs.

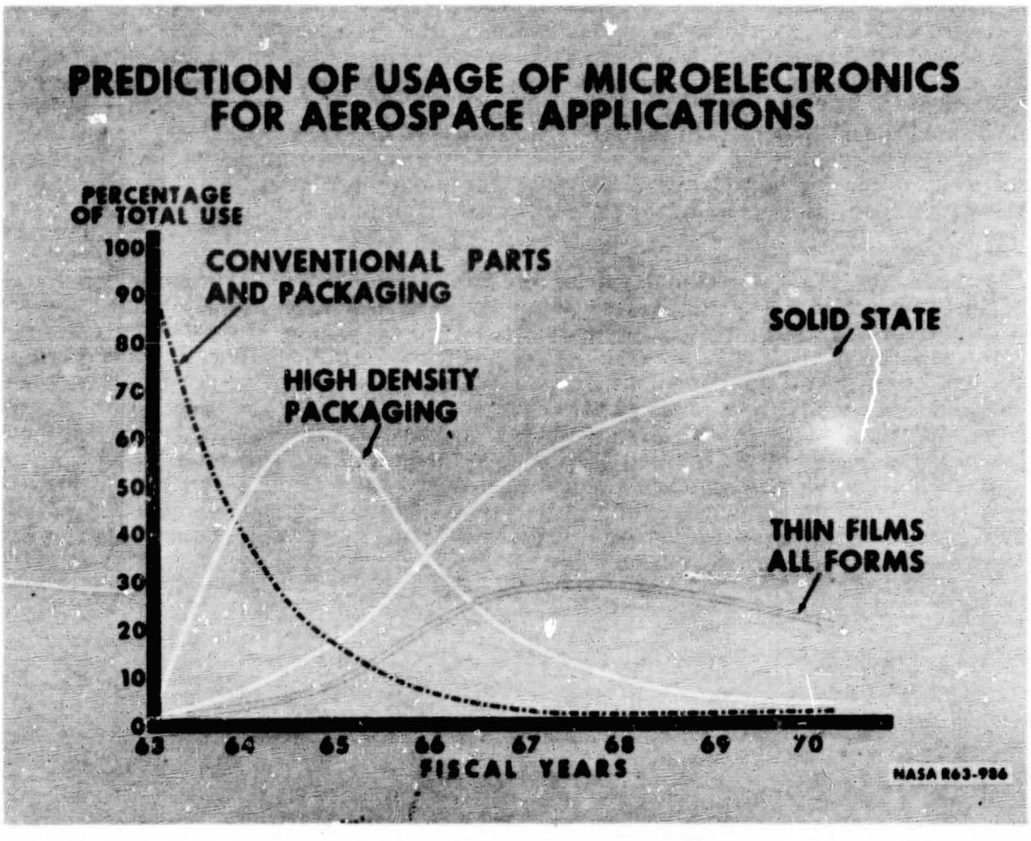
In addition, work in fiscal year 1964 will stress high-gain vehicle antennas, antennas for reentry conditions which involve surviving high heat, and work on omnidirectional antennas on spacecraft so as to minimize the tracking and data acquisition problem on the ground.

Advanced devices technology for electronic systems

The technology of microelectronics, wherein a single piece of material is designed to perform the functions of a number of individual electronic parts or elements, is an outgrowth of the technology of transistors. A single block of material about the size of a dime can now be fabricated to perform the functions of a conventional electronic blackbox of components many times the size and weight of the microelectronic element or integrated circuit (fig. 112, p. 1449). But the important reasons why microelectronic techniques and devices are important to the space program are not primarily because they are small and light, but more importantly for the reasons that a new order of reliability may be expected ultimately with these techniques. Inherent in the evolution of microelectronics is the wealth of knowledge gained in the transistor technology which has resulted in great strides in the understanding and use of solid-state physics in electronic systems. Also, the manufacture of a microelectronic integrated circuit can be accomplished by vacuum deposition processes, inherently involving fewer steps than the manufacture of a conventional electronics system. These processes can and must be

well controlled precisely; therefore, the result is a greater degree of reproducibility than otherwise possible. In conventional electronics, numerous parts are bought from different vendors who utilize different controls in the manufacture of the materials and parts.

Integrated circuits may be designed so that the number of electrical connections are minimized. One of the limiting factors in modern day technology involving the reliability of electronic systems is the number of connections which must be made, either by soldering, welding, or other techniques. It is widely agreed that the reduction of interconnections, either within integrated elements or between integrated circuits is of very great importance in achieving reliability. A further reason for increased reliability possibilities in micro-electronics is the potential radiation resistance of such devices when utilizing thin-film techniques. Radiation might easily pass through a thin-film microelectronic device without affecting the crystal or physical structure of the material (fig. 113, p. 1951). On the other hand, the impingement of this radiation on the more bulky structure of a conventional semiconductor device can result in displacement or disruption of the crystal lattice and result in some malfunctioning of the electronic circuit in which the device appears. Of course, it is also easier to shield the smaller microelectronic elements than the larger conventional electronic systems if shielding is necessary. Past experience has illustrated that when redundancy is employed in electronic systems, improved reliability is obtained. While it would be impractical to employ duplicate circuitry in systems employing conventional electronics, the whole idea becomes vastly more practical with the processes and techniques of microelectronics. For example, three identical circuits may be used



to convey identical information. This is known as majority-voting redundancy. That is, at the output, or box, the output of the two circuits which agree are considered to be the most reliable. It is probable that this technique will be employed more commonly as the technology of microelectronics expands. It is predicted that systems made of microelectronic parts or techniques will be 10 times as reliable as those made with conventional electronics, projecting the present rate of progress over the next 10 years (fig. NASA R63–986). Or, in other words, there will be 10 times more failures in any given system over a specified period of time which uses conventional parts, as compared to an analogous system utilizing microelectronic techniques. Prediction also shows usage in future systems will exceed 70 percent.

We are presently conducting advanced research into microelectronics including techniques which show promise of yielding inherent invulnerability to space radiation. Present effort is also concerned with learning how to manufacture reliable active devices which can be reproduced consistently. We are further interested in active devices which will consume smaller and smaller amounts of power, since power is a limiting factor in space missions. Investigations have begun and will continue into pertinent applications of state-of-the-art microelectronic technology to the NASA spacecraft electronic systems. We are coordinating our work with similar research in the Department of Defense. It will be necessary to augment facilities within the NASA, as well as build up certain categories of trained personnel in chemistry, solid-state physics, and materials research to carry out the space-oriented aspects of this new technology.

INSTRUMENTATION AND DATA PROCESSING

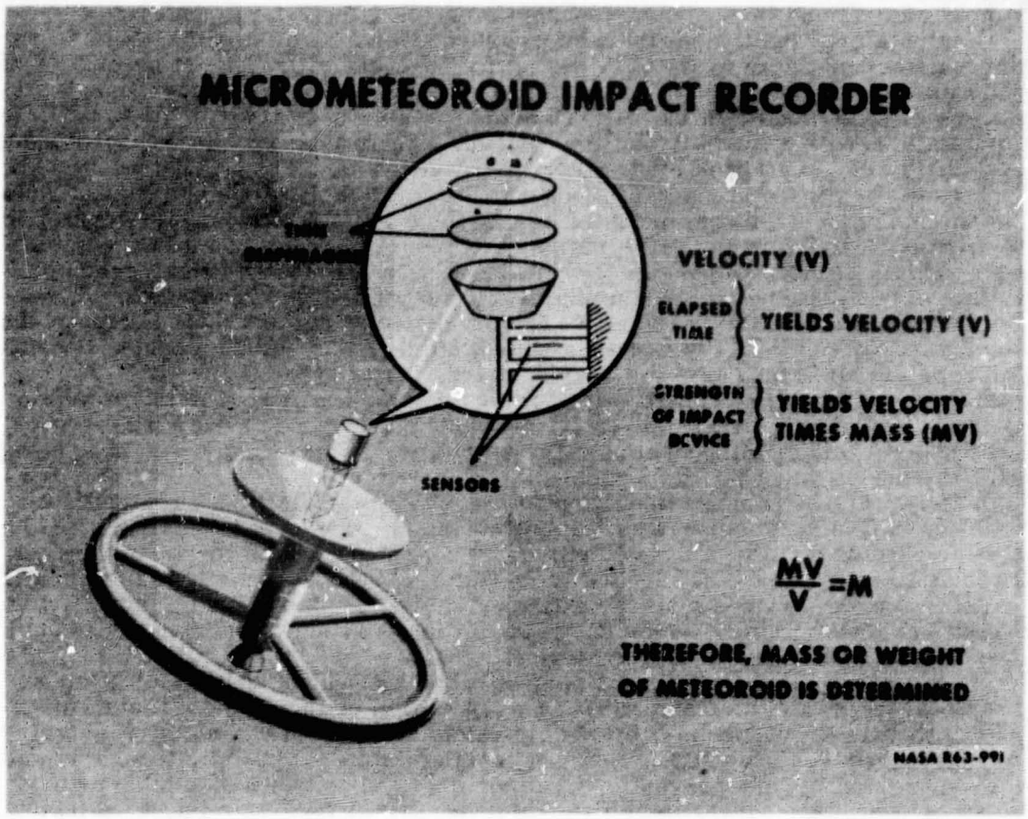
The fields of instrumentation and data processing involve generation of information and its reduction to usable terms. Instruments and man supply raw data; data processing equipment reworks or uses them in some fashion. The raw data may consist of enectrical signals supplied by instruments and indicative in some way of pressures, temperatures, or radiation levels. It may take the form of intensities of spots on the screen of an image tube in a TV camera, uncorrected distances to a planetary surface as indicated by a radar, or numbers resulting from research experiments. Data processing complexes are then used to reorganize the raw information so as to make it most useful to man and his machines.

Instrumentation

It has been found functionally desirable and feasible to establish three categories of instrumentation—astrophysical, engineering, and biophysical.

Examples of astrophysical instrumentation are evident from the many well-known terrestrial, lunar, and planetary projects now underway. It is known, for example, that many excellent measurements have been made of the Van Allen radiation belts, and it is probable that far stronger belts exist around Jupiter and other planets. For such advanced exploration, radiation measuring devices must be replaced by instruments capable of responding in a meaningful way to much greater atomic-particle velocity and mass ranges, and do this in situations in which there are tremendous changes in total numbers of such electrons, protons, and neutrons found in a given volume at any time. These numbers might vary between 10 or 100 and several billion.

These same considerations apply to the problem of measurement of the characteristics of micrometeoroids and interplanetary dust. The numbers, weights, directions, and speeds or motion of these bits of matter must be accurately obtained (fig. NASA R63-991).



Solar probes, extending our inquiries into regions within Mercury's orbit, will require electronic equipment, including instruments, capable of withstanding radiation and temperature levels well beyond state-of-the-art limitations. Temperatures, for example, will be generally above 1,500° F.

Magnetometers must be developed which maintain their accuracies over ranges of magnetic fields extending from those a hundredth as intense as that at the Earth's surface to fields hundreds of times as intense. At the same time, they must be capable of responding in fractions of a second to changes caused by various solar disturbances. New principles must be exploited to make such performance realizable.

Engineering instruments are being developed in the direction of measurement of the greater forces, strains, vibration levels, etc., of the larger and more powerful vehicles now under development. Specifically, for example, it is now very difficult to measure temperatures above 5,000° F., pressures corresponding to the near vacuums of outer space, and thrusts in the range above a million pounds. In part, the lack of suitable instruments is the direct result of lack of suitable calibration equipment.

Instruments to indicate ablation and charring rates of heat shields are required, as are thermometric systems which control and indicate the status of the heat balance within a body exposed to both solar heating and deep-space radiative cooling.

Mechanical measurements will require new sensors. The determination of liquid quantities, distribution, and flow rates is difficult under conditions of weightlessness. Liquid hydrogen quantities are not easy to determine by weighing alone even under normal gravity because liquid hydrogen weighs about one-fourteenth as much as water. The presence of minute cracks in cyrogenic liquid storage tanks must be somehow revealed, and the growth rate measured.

Conduction of light along fine fibers of good optical quality has lead to the development of the new art of "fiber optics." Light pipes consisting of tens of thousands of packed fibers will transmit images over twisted paths up to distances at present measured in yards. Improvement in fiber optical techniques and their combination with electro-optical devices will greatly increase the utility of such systems for observation of areas otherwise inaccessible.

The study of the impact of high-velocity particles—for example, at Ames Research Center—will soon be aided by the development of means for generation of ultrashort, but very powerful, bursts of light. A laser light source in combination with an electro-optical shutter called a Kerr cell provides bright light pulses lasting about one one-hundred-millionth of a second. On the other hand, solutions are not immediately in sight for the problem of obtaining more details of the small variations of density of gases flowing around a wind tunnel model; advanced optical techniques hold promise in this regard.

Instrumentation to be used within and near nuclear and electric propulsion systems is, by and large, still to be developed. In concert with the nuclear-propulsion-program office, applicable instrumentation techniques are being investigated.

Biophysical instrumentation monitors man's immediate environment with emphasis on the sustenance of man, monitors man himself, and assists in the search for life throughout the solar system. The determination of the quantities and circulation rates of carbon dioxide, water vapor, oxygen, and undesired impurities in space suits and cabins; and the necessity of accurate temperature indication in closed systems dictate development of small, fast, extremely reliable sensors and associated electronics and display devices.

With respect to instrumenting man, are devices which yield respiration and heartbeat rates, and indicate degree of oxygenation of the blood without encumbering the wearer. The application of ultraminiaturization techniques is expected to lead shortly to the creation of wireless combinations of appropriate sensors and low-power transmitters occupying approximately one-thirtieth of a cubic inch.

At present, raw data sensed by analog transducers go through a variety of transformations such as amplification, modulation, and digitization prior to data transmission or data processing. Since data is transmitted by telemetry and processed by computers largely in digital form, it is logical to go to the next step, direct digital readout sensors. Digital transducers have the obvious advantage that the instrument reading can be transmitted without the various conditioning steps now required, all of which serve to degrade accuracy and reliability.

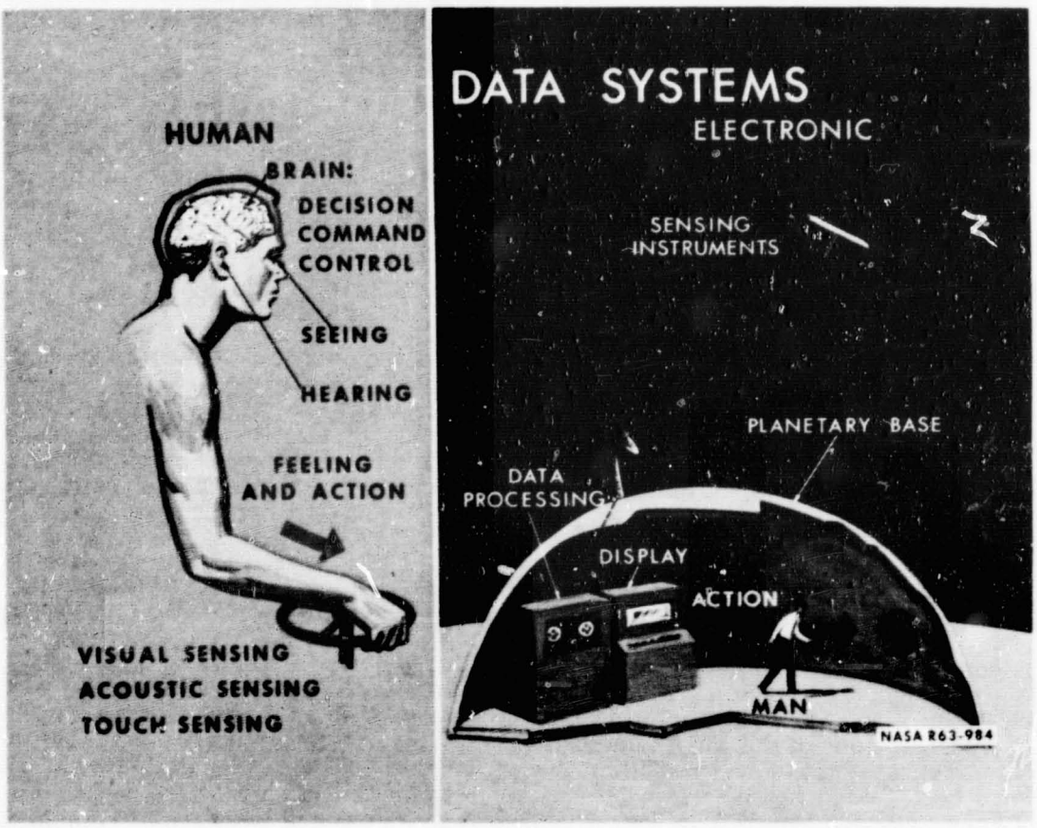
Such instruments tie in naturally with intelligent, adaptive on-board data processors which we also see as a fruitful area for research investigation.

Data processing

In the area of data processing, we include those devices and techniques required to insure flight readiness of vehicles and spacecraft as well as reduction of information from flight systems or from space.

A modern space computing complex involves calculation, control, communication, and monitoring functions (fig. NASA R63-984). Primary computation tasks include spacecraft control and prediction, and the conversion into useful form of scientific data transmitted from a space vehicle. Apart from the central computer complex, there are computers at other ground sites—for example, at tracking, telemetry, and launch sites—and computers aboard spacecraft. These are interlinked into an integrated system. The Jet Propulsion Laboratory is developing an automatic ground computing system which has many of the characteristics of the system described.

Until very recently, general-purpose computers have been large, heavy, and unreliable for spacecraft use. However, early versions of such computers have been developed which weigh only several pounds and occupy less than 1 cubic foot by use of microcircuits. The reliability of this kind of device is much higher than that of any computer element constructed in the past. Microminiature devices will enable us to make use of redundancy, that is, the presence of components over and above the minimum numbers just able to perform the task. It is,



in fact, possible to design such a system so that a certain number of components can fail without affecting system performance.

An additional way of insuring computer reliability is, of course, the use of inherently sturdy components. It has been found that components which make use of the magnetic characteristics of certain materials are exceptionally resistent to shock, radiation, and aging. Several centers are devoting attention to logical devices, including entire computers, constructed of such magnetic elements.

A wholly new approach, however, is the use of devices wholly nonelectronic in nature. The Diamond Ordnance Fuze Laboratory several years ago discovered that under certain circumstances a narrow jet of gas or liquid will tend to cling to one wall or the other of an exhaust nozzle. A separate control jet can cause the main jet to switch from one wall to the other, and this arrangement can provide the logical basis for entire computing systems. This work will be pursued at the Marshall Space Flight Center and within industry in the strong expectation of producing fluid computers and simpler control devices with very long lifetimes (fig. 210, p. 2135). Given the proper construction materials and fluids, proper operation would be achieved under extreme conditions of temperature and radiation over decades.

Examples of other techniques are micropower techniques whereby an entire transistor circuit will use a few millionths of a watt of power; circuits requiring only several billionths of a second for entire operations; low-power, light-weight computer memories of exceptional ruggedness.

During the past year significant progress has been made by the Marshall Space Flight Center and the Goddard Space Flight Center in the checkout and countdown of space vehicles. The Goddard Space Flight Center has initiated development of a system capable of checking out the 128 channels of information on the Orbiting Geophysical Observatory (OGO), scheduled for launch during the first quarter of calendar year 1964. As a measure of the amount of information and data which must be processed, and to indicate the tremendous complexity of this spacecraft, one channel of OGO is capable of transmitting 50 percent more data than the entire output from Explorer VII, one of the most successful scientific satellites to date. The Marshall Space Flight Center is incrementally introducing a computer controlled countdown and checkout in the Saturn series of

vehicles. By the time SA–10 is ready to be launched, the preponderance of the checkout and countdown function will be computer controlled.

The efficient use of computing systems in the reduction of quantities of information to be transmitted from one point to another is being investigated at several NASA centers (fig. 207, p. 2132). Data from the image acquisition unit are fed to a computer which compares present details with prior ones. Only significant alterations need be transmitted. A more sophisticated system would recognize entire patterns—for example, cloud systems—and transmit only very brief codes indicating when and where such patterns were being perceived. Industry is assisting in the development of such techniques.

ELECTRONICS RESEARCH IMPLEMENTATION

The NACA and the other components from which the NASA was created possessed a rich heritage of capabilities in aeronautical and propulsive sciences, capabilities which enabled us to easily effect the transition to space exploration. Although these naturally included some elements of electronics research competence, this area was represented by a relatively small cumulative effort, diffused throughout the Agency. At the same time, the space exploration task focused a very large, long-range emphasis in electronics. This is the reason why, nearly 2 years ago, NASA management began studying this responsibility and its associated organizational implementation. The effort led to the formation, late in 1961, of the Electronics and Control Directorate in the Office of Advanced Research and Technology, whose task was to formulate and pursue a research program in the electronics disciplines which would enable the NASA to fulfill its mission.

Constant and continuing review of the problems of electronics and associated disciplines have gone on since that time. The need for more reliable electronics equipment is one of our most famous problems—so well advertised in space activities that it need not be dwelled on here. This results from one simple fact, we have been forced by the pace of space exploration to use and operate electronic components which were not designed for the space environment. This problem begs for solution even as the performance demands on electronics continue to increase, due to the severity of the hostile space environment.

Much of the large, active, and capable electronics industry is turning to the NASA for research direction and support of their space-oriented activities. While NASA can take up part of the support role by providing funds, proper and effective agency direction can come only from a nucleus of experienced and knowledgeable engineers and scientists—just as direction in other disciplines comes from other NASA laboratory centers. Suffice to say, NASA simply must have qualified people on its staff who are well informed on space missions and their related electronic systems performance requirements, able to identify the problem areas, and competent to evaluate the research results of others. They must also exercise leadership in a favorable environment.

As a result of our review and study on the implementation of electronics responsibilities for future space missions, in our fiscal year 1964 budget we are requesting congressional approval for initial funding of $5 million to establish a new Electronics Research Center to be located in the Greater Boston area. Our long-range plans call for an installation buildup over a period of 6 to 7 years yielding a staff of approximately 2,000 personnel, of whom 600 to 700 would be professionals, and a plant value of approximately $50 million.

The rate of center growth will be gradual and represents an investment in the future of space flight, analogous to the investment made in the older research centers many years ago which is paying off so handsomely today. This rate of growth together with upgrading of Center personnel by continued graduate education after they are on board is expected to allow us to meet our staffing requirements with little or no impact on scientific and engineering manpower as projected during this growth period.

The NASA considered many potential sites throughout the country for location of the Electronics Research Center. On balance, the overall university-industrial strength and capability in electronics and guidance research in the Greater Boston area resulted in its selection as the location for the Center. This area, noted for its past and current heavy concentration on electronics research, both in industry and universities, provides a compatible, stimulating environment for growth of NASA capabilities in this important area of technology.

The Center will have the principal function of conducting and directing research and component technique investigations in the related fields of communications, data processing, guidance, instrumentation, and control. It will be staffed and

equipped to perform original work and to work closely with industries and universities with common interests. For example, component test facilities will be provided for evaluation of industrially developed experimental components. The Center will serve to focus the increasing NASA out-of-house efforts in the burgeoning area of electronics technology. Most important, it will provide a regenerative path for the early exploitation of advanced techniques or developments for space flight, whatever their source.

Dr. KELLEY. Our electronics and control program, Mr. Chairman, encompasses several functional areas. To simplify nomenclature we often use the broad terms electronic systems or simply electronics to include all of the following:

Guidance and navigation, which is determining, predicting, and directing a vehicle's position along a flight path or trajectory. This includes inertial guidance, radiation trackers, guidance computation, and flight mechanics.

Control and stabilization, the control of a vehicle along and about the flight path. This includes manned and automatic flight control systems, control theory, and advanced component techniques.

Communications and tracking, that is the transmission of commands to and the recovery of data from an aerospace vehicle. This includes communications, tracking, and data acquisition systems, and advanced electronic techniques and devices.

Instrumentation and data processing, which is detection, generation and measurement of information or phenomena, and reduction of this information to intelligible and useful forms. This includes physical and biomedical measurement techniques, data processing, and advanced computing devices.

Now, as part of the normal functions of NASA program management, we continually analyze the state of the art, together with projected mission in needs in order to establish research and technological requirements in these areas, and this is why we have an anaylsis and requirements group as a staff group shown in the upper right-hand side of the slide (fig. 190).

This analysis is a two-way process between ourselves and industry. For example, in our operation at headquarters, alone, we have often averaged as many as 40 contacts a day from the industries and universities with which we have common interests.

Mr. KARTH. Is this correspondence, telephone calls, et cetera?

Dr. KELLEY. Yes, sir. In fact, we have set up one man in that group as assistant for industrial development who deals almost exclusively with industries and universities.

In the time available, I will discuss only a few selected items from the broad spectrum of interest we have.

The importance of electronics in aeronautics and space is quite apparent. Electronics and its associated disciplines constitute the brain and nerves of flight vehicles.

Next slide (fig. 191) please.

Here we have an analysis, our analysis of project dollars—the portion that goes into electronics. These are on-going flight projects. Launch vehicles average 40 percent. A development vehicle could go as high as 60 percent. Spacecraft average 70 percent. Ground based tracking and data systems average 90 percent.

Unfortunately in the same context, a much higher percentage, oh—incidentally, these averages are overall throughout the projects. When you weight these, approximately 60 percent of our dollars are involved in electronics, as I defined it when I started.

OFFICE OF ADVANCED RESEARCH & TECHNOLOGY

ELECTRONICS AND CONTROL

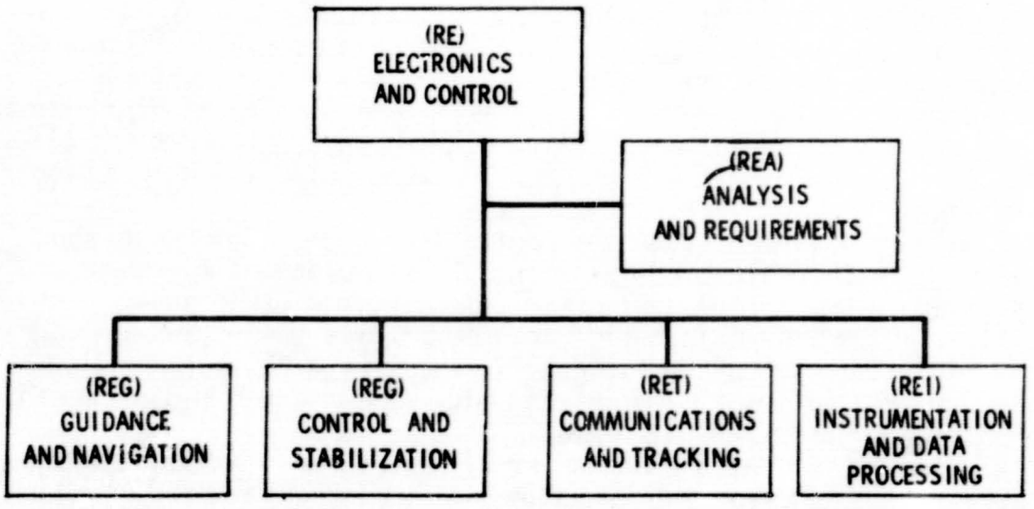


FIGURE 190

ELECTRONICS EFFORT IN MAJOR PROJECTS

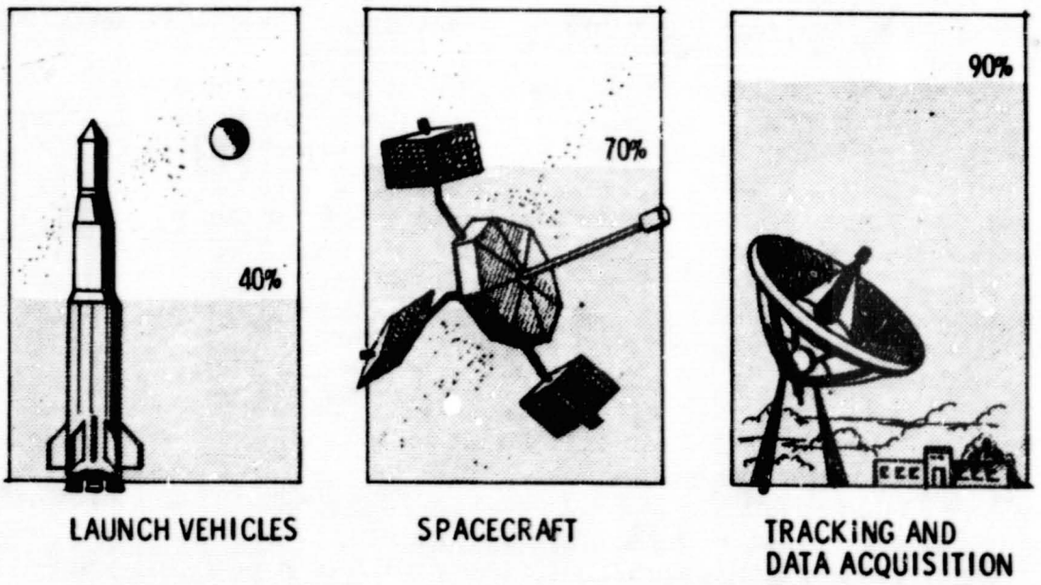


FIGURE 191

Unfortunately, in the same context, a much larger part of our flight failures arise from electronics, approximately 90 percent. Success in this area is obviously a major factor in overall mission accomplishment since a dead or unintelligent vehicle is useless if it cannot measure data and send it back to Earth.

I have often been asked the difference between Earth and space electronics. Electronics is electronics, I look in the back of my television set and that is electronics.

Some of the striking differences are high acceleration rocket launch followed by long periods of weightlessness, maybe up to years eventually, very often followed by a pretty hot reentry; not to mention the radiation environment; I think you are all familiar with some of the problems we have had lately with the radiation environment.

Micrometeorite fields, and we are getting more into the area of temperature extremes. If we hope to get in close to the Sun, we are going to have to develop components that can withstand temperatures in terms of thousands of degrees.

Extremely small size and weight, I think the reason is obvious, we can save on payload.

Low power consumption, here again we can save on payload if we can cut down the power requirements by having low power consumption in our electronics.

One of the interesting and unique aspects is sterilization, and I think most of the committee is familiar with the experience in sterilization problems we had in the Ranger program and we will continue to have a sterilization requirement if we want to land on the planets.

In the Mariner it was a flyby. We didn't have a requirement.

We don't want to upset the ecological balance on a planet and contaminate it, if you will, with germs on our planet.

We are also in a custom-tailored business. We have relatively few of a kind high-priced electronic items. We are not in a consumer production operation. We are in a job shop electronics operation.

Some of our reliability standards are also unique. We will want our equipment to operate unattended for periods of years. This involves not only reliability, but the safety of our astronauts and, I could give you figures like a hundred or thousands of times existing reliability; but I might just illustrate it with an example.

Most of us have a TV set in our house. This represents a very, very, small part of the complexity of, for example, a manned spacecraft. Some of our missions will last a year or more, including manned missions. I wonder how many of us here would bet that that television set in our living room would operate perfectly for the next year.

May I have the next slide (fig. 192) please.

I want to discuss now, briefly, some of the technical areas, taking the guidance and control area first, and hitting on these high points and then I'll hit on the communications and instrumentation area, briefly.

Some of the interesting aspects we have—unique aspects, are deep-space guidance, attitude stabilization requirements, manned flight requirements, and some of our peculiar automatic control requirements.

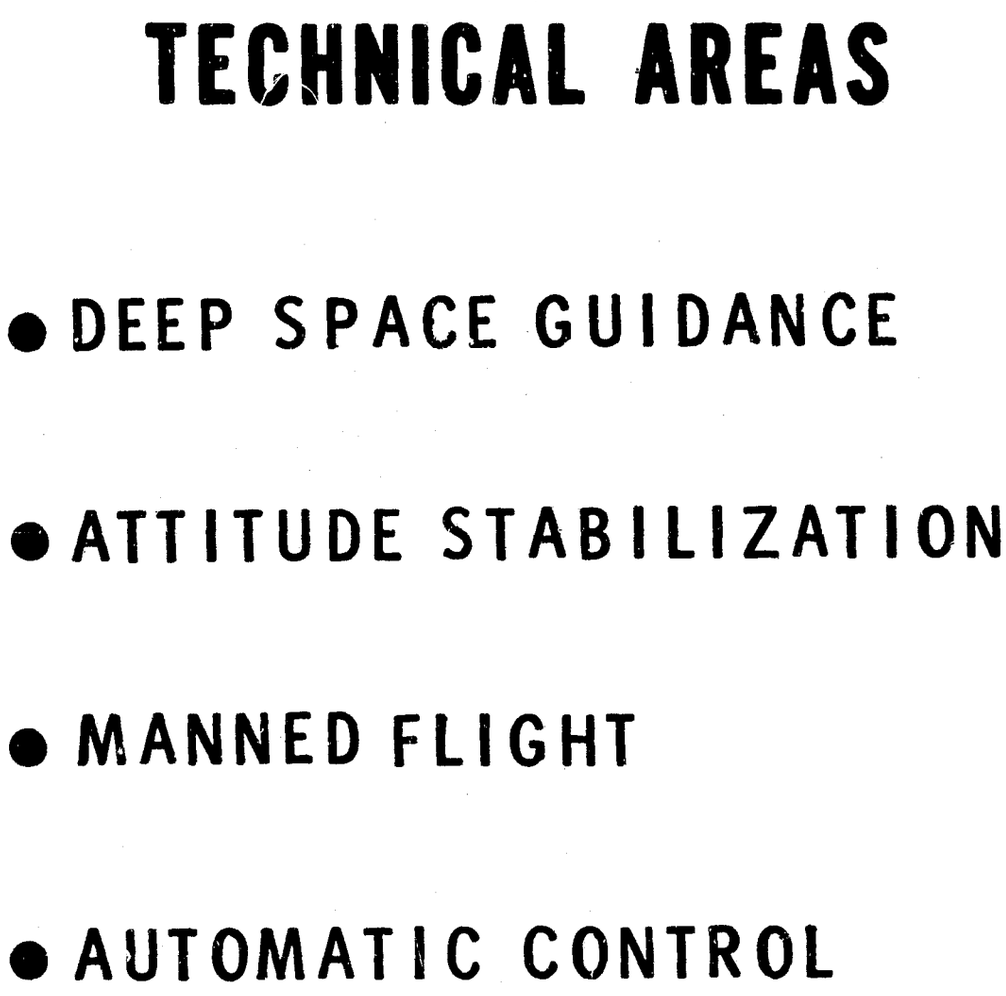


FIGURE 192

May I have the next slide (fig. 193) please.

How to get from here to there in space, presents a new problem. All our history of navigation is based on Earth requirements; on a spinning ball whirling through space.

Now, if we are out in the space itself, we have to determine which way is "up," what corresponds to latitude and longitude. For example, a mariner or an airman on the Earth can take three sights and get an unambiguous fix. It takes four sights in space. It's obviously a more difficult problem in space.

One of the developments that we are working on for space navigation is the so-called tethered optical inertial sextant. The sextant is stabilized away from the disturbances of the spacecraft. We can then save on the stabilization requirements for the spacecraft itself. We only have to stabilize a small light-weight article and we sometimes refer to this as the "dog on the leash."

Next slide (fig. 111, p. 1947) please.

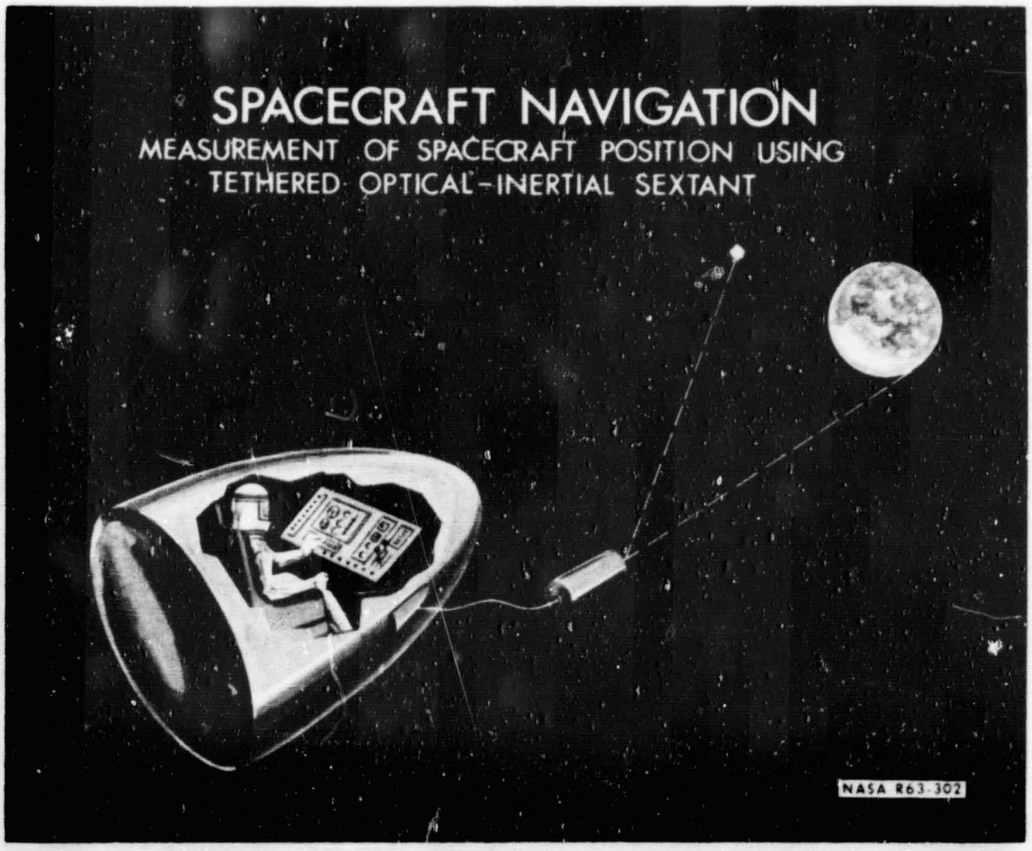


FIGURE 193

Dr. Bisplinghoff, showed you this slide when he discussed electronics and control. I want to refer to it again, briefly, to indicate why we are going into some of these cryogenic gyros or electrostatic accelerometers.

A gyro can tell you which way is up. It tells you your orientation with respect to the stars, as you carry it along with you.

Here we are trying to use the environment, to live off the environment. The cryogenic gyro doesn't make sense, all the extra equipment you have to carry around, unless you have a large cryogenic source available. If you have it available, why not bleed it off and use it?

Also the electrostatic accelerometer is a way of telling how far we have traveled. We multiply it by time. That is, the motion of the accelerometer by time and we get the velocity, we multiply it by time again and get the distance. That's what the accelerometer does.

Here we may have large sources of electric energy, such as an electric propulsion device. If we are going to have a large source of electric energy available, why not use it and thus build the electrostatic accelerometer?

Incidentally, there was an article in Business Week about a week ago, called "Star in the Bottle," which referred to the Navy development of this for the submarine. This is a joint development between the Navy and NASA with GE and Minneapolis-Honeywell as contractors.

Just to give you an example of why guidance is required, for example, an electric propulsion mission, 415 days to Mars. A 22-pound mis-

calculation in vehicle weight, or a half degree thrust angle error could end in 200,000 miles position error. Obviously, we have to keep taking fixes to find out where we are and recalculate, or redetermine where we want to go.

Next one, please (fig. 195).

Another interesting phenomenon in guidance, is the horizon. When we are in Earth orbit, for example, we can't drop a plumb bob because we are weightless. We have to determine which way is up so we can stabilize the vehicle.

One of the best ways is to measure the edge of the horizon. We have been doing this in a number of our space vehicles now for the

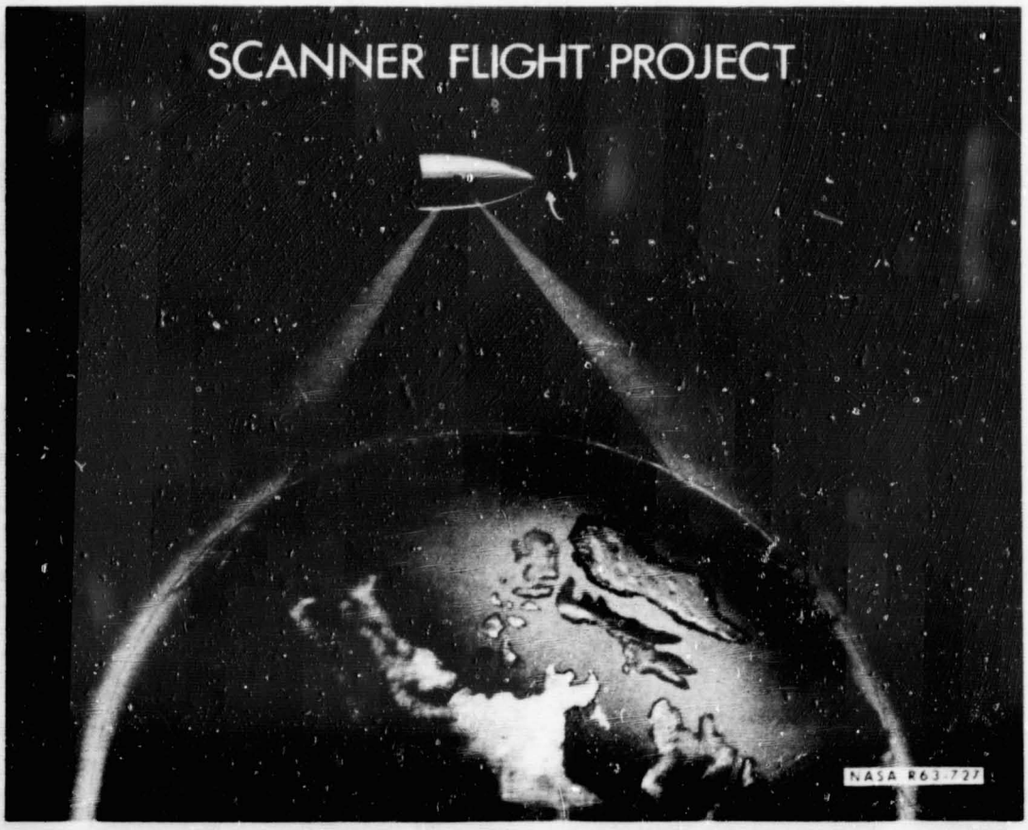


FIGURE 195

past few years, but we have come to the conclusion, based on some large errors we have discovered; for example, over tropical storms where the temperature gradients are not what we expected, that we should go back and take a look at the horizon. What really are we looking at?

We have a flight project at Langley where we will, by spinning this device take many, many measurements of the horizon at various portions of the spectrum, ultraviolet, infrared, and so forth, to see if we can find clean lines we can measure and then build instruments to be able to track those lines for our future space vehicle missions.

Next one, please (fig. 196).

Some of our attitude control research is quite intersting and here, again, we want to live off the environment. The standard we have

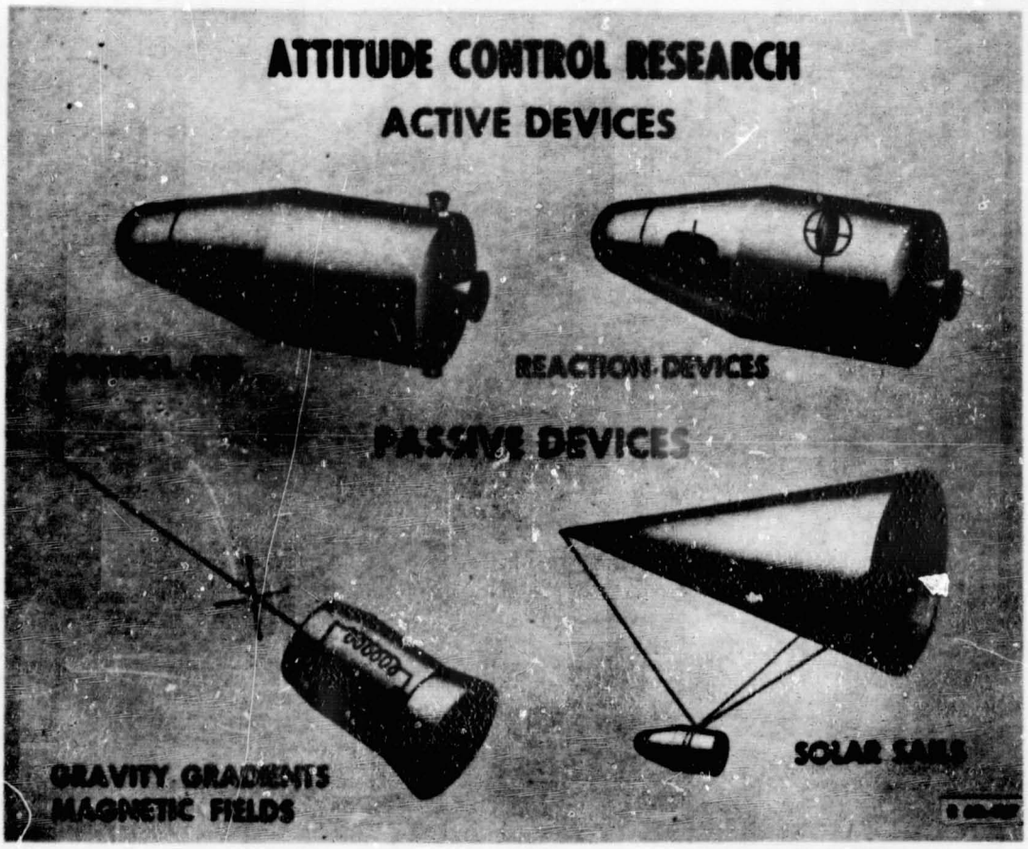


FIGURE 196

used up to now is control jets but this gets to be a pretty inefficient operation if we are going to go on long missions, because we are going to have to carry the energy source of the jet, that is gas or the fuel, along with us. We can use reaction devices, which we are using, as shown on the right, where, with electric energy we can spin up an electric motor. Really, what it is, is a wheel.

We don't think of this on Earth, but with space, with no resistance, if we spin up a wheel one way with an electric motor, then the base tends to spin the other way. Newton said this, "You push and it pushes back." "Action and reaction."

By winding up a wheel, with an electric motor we can turn the spacecraft around and control its attitude.

Again, using gravity gradients and magnetic fields, in the left-hand corner, we want to live off the environment. That is a phenomena in gravity where it is not constant as you go up in altitude and can be used as a stabilization device. The magnetic field around the Earth can be used in a similar way. Our approach is, don't try to fight it. Use it, if you can, to help you.

Solar sails are another good example. I think most of us are aware the Sun pushes on us. If we can put up a big enough sail, we can use this push to our advantage to help stabilize a vehicle or even propel it, if you will.

The next one, please (fig. 197).

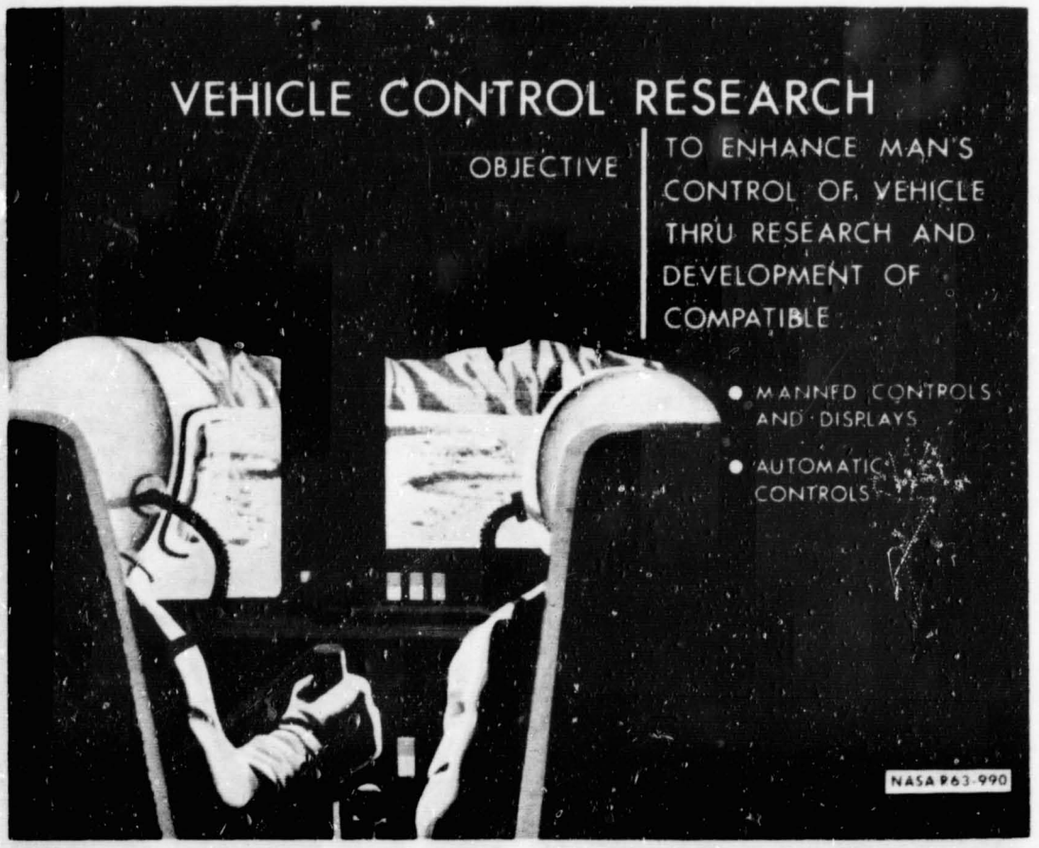


FIGURE 197

And, of course, in manned vehicle control research, some of our—most of our requirements are quite unique, landing on the Moon for example presents its own problems on controlling rocket thrust.

We are in a low g. environment, one-sixth of that of the Earth. We have no atmosphere for stabilization, and so forth, so the problems in vehicle control research are many, varied, and unique.

Next one, please (fig. 198).

One of the examples of our vehicle control research is the so-called foot print display. We began using this about 2 years ago with the X–15 at Edwards. Coming back in the reentry corridor as shown at the right-hand side, to the pilot's landing area, is sometimes called threading the needle.

He has a restricted reentry corridor. The landing area, available to him is a function of his position in this corridor and changes as a function of time as a result. It is a heart shaped or cardioid pattern on the ground. We found this display method to be very, very effective in the X–15. This now has the fancy name of "energy management." Most of us old pilots remember this as trading off altitude for air speed, but it is not quite as simple in a space vehicle. The pilot can't calculate in terms of 25,000 miles per hour—can't calculate mentally. You have to display it.

So, that is what we intend to do in the upper left-hand side, display to him the landing area available continuously and; for example, with an X mark on there the desired landing site, so he can then maneuver the spacecraft to the desired site.

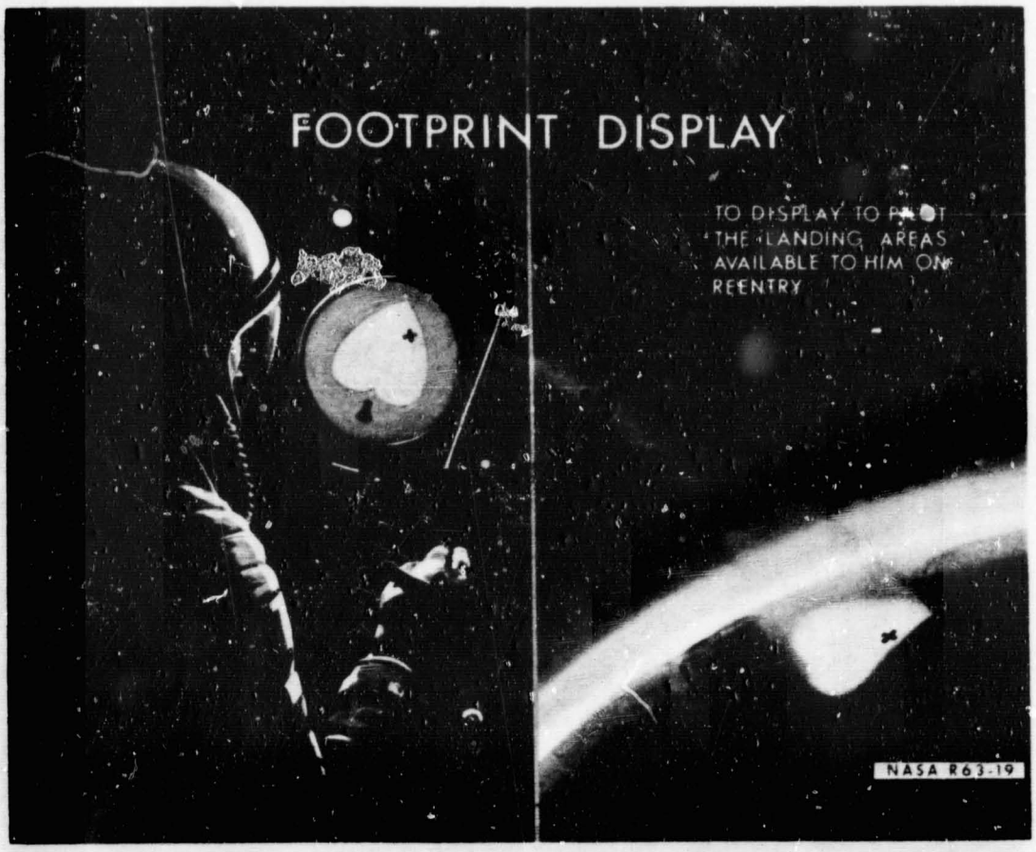


FIGURE 198

Our vehicle control research (fig. 199) involves some interesting problems of large, long, slender vehicles with great flexibility, severe aerodynamic loads as we are zipping up through the various wind gradients, and large thrust forces. On some of our vehicles, as a matter of fact, the bottom of the vehicle might move as much as 3 or 4 inches, before the top has begun to move as it comes off the launching pad and, of course, reliability.

This vehicle control research involves analysis, simulation, testing, instrumentation on both launch vehicles and spacecraft as well as aircraft.

Next one (fig. 200).

In automatic control itself, an automatic control can really be defined as giving a—automation is what some people call it—if you give a command to some device it will respond to that command and it will not respond to other disturbances called interference.

One of the interesting examples of automatic control, for example, involves lasers. I will mention lasers in more detail later.

Pointing a beam of a communications laser back to a spot on earth on a vehicle which is taking off, returning from the moon and is vibrating, shaking, being controlled itself as it's taking off—we want to hold the laser line of sight steady in this type of environment.

Next one, please (fig. 201).

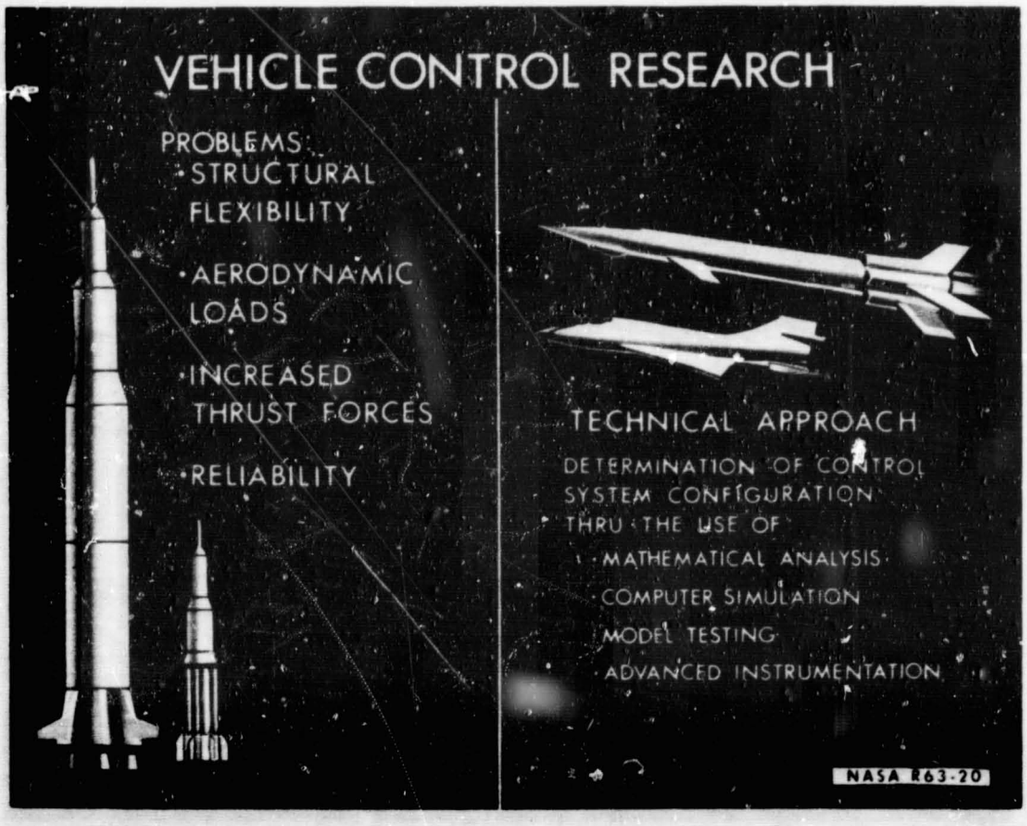


FIGURE 199

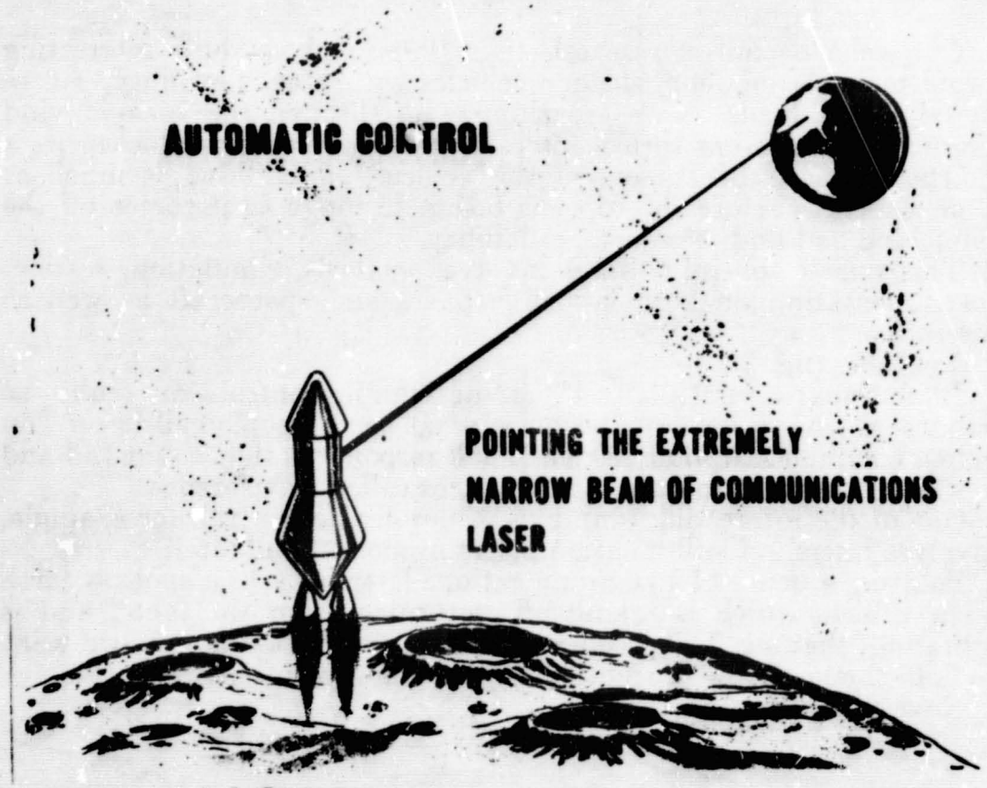


FIGURE 200

TECHNICAL AREAS

- INSTRUMENTATION
- DEEP SPACE TRACKING AND COMMUNICATIONS
- DATA PROCESSING
- OPTICAL COMMUNICATIONS AND TRACKING
- PROPAGATION PHENOMENA

FIGURE 201

Now, I want to briefly get into the area of communications instrumentation and data processing and discuss them in this order.

Our instrumentation requirements, some of our deep space tracking and communications work, data processing, optical communications and tracking people sometimes in specialized terms call it lasers and then propogation phenomena.

Next one, please (fig. 202).

In the field of biomedical sensors, the best bet seems to be microminiature sensors. Dr. Bisplinghoff mentioned this briefly. These involve the devices we can use without cords running from the astronaut or the pilot to some place in the cockpit. Instead the information can be transmitted right from his body to a receiver, then amplified and transmitted from the spacecraft.

Incidentally, the medical people here on Earth are quite enthused about these devices; some of which are very, very small because they can get unattended measurements from patients over long periods of time, monitor them even when they are walking around on the streets, without being continuously in the hospital, without any encumbrance to the wearer.

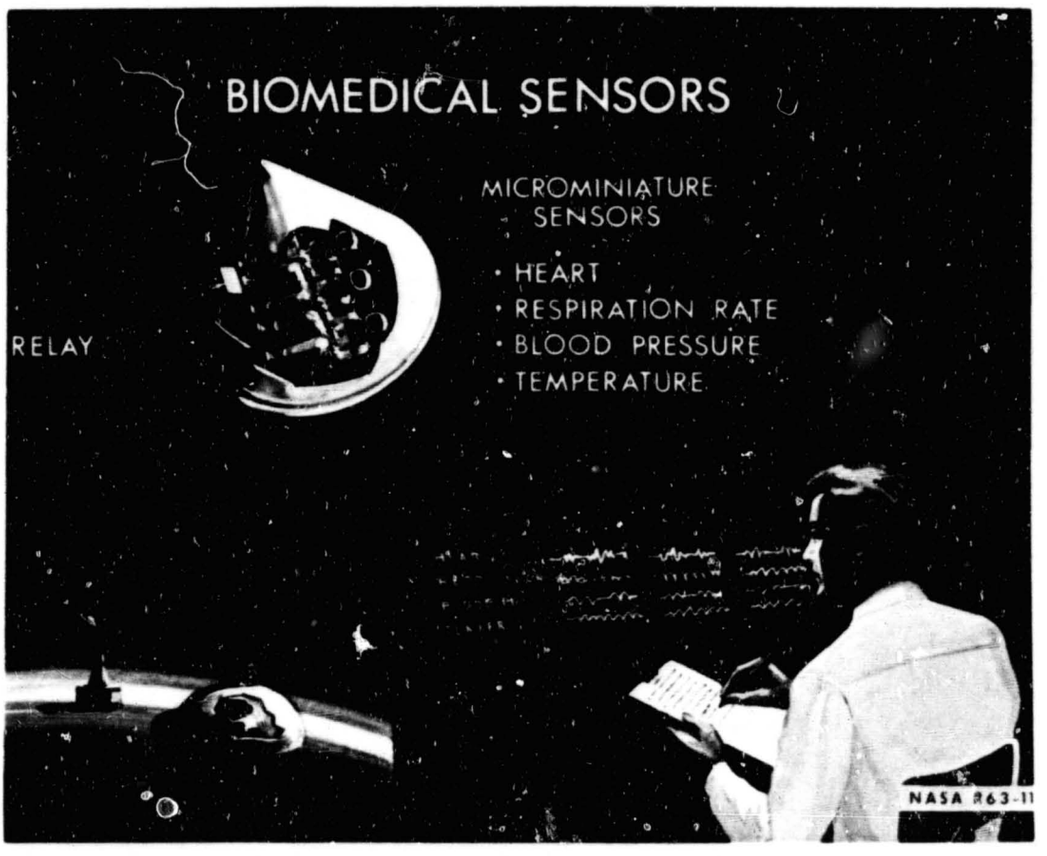


FIGURE 202

Next one, please (fig. 203).

Our great trend in instruments is to the digital device. Our trend in computers has been from the analog to the digital device. The analog device measures temperature or acceleration, or whatever, and gives a voltage or current proportional to whatever it is measuring.

A digital device, on the other hand, gives a digital count, depending on the number or the degree, or the extent of the phenomona you measure.

The complexity—and I won't go into all the details—the complexity of an analog device and analog instrument is indicated on the top of the slide. I want to point out specifically the analog to digital converter necessary to get to the telemetry transmitter.

In the telemetry transmitter, we send a message back in pulse, coded form. We process it in coded form or digital form.

It seems to make sense to us to get the instrument measurement strictly in digital form and then we don't have to go through all these other steps and get unreliability, and so forth.

We're putting a great deal of push into digital sensors. You see, on the bottom that the simplification of the whole process is obvious.

This doesn't come easy. We have to do research work on it, which we are doing.

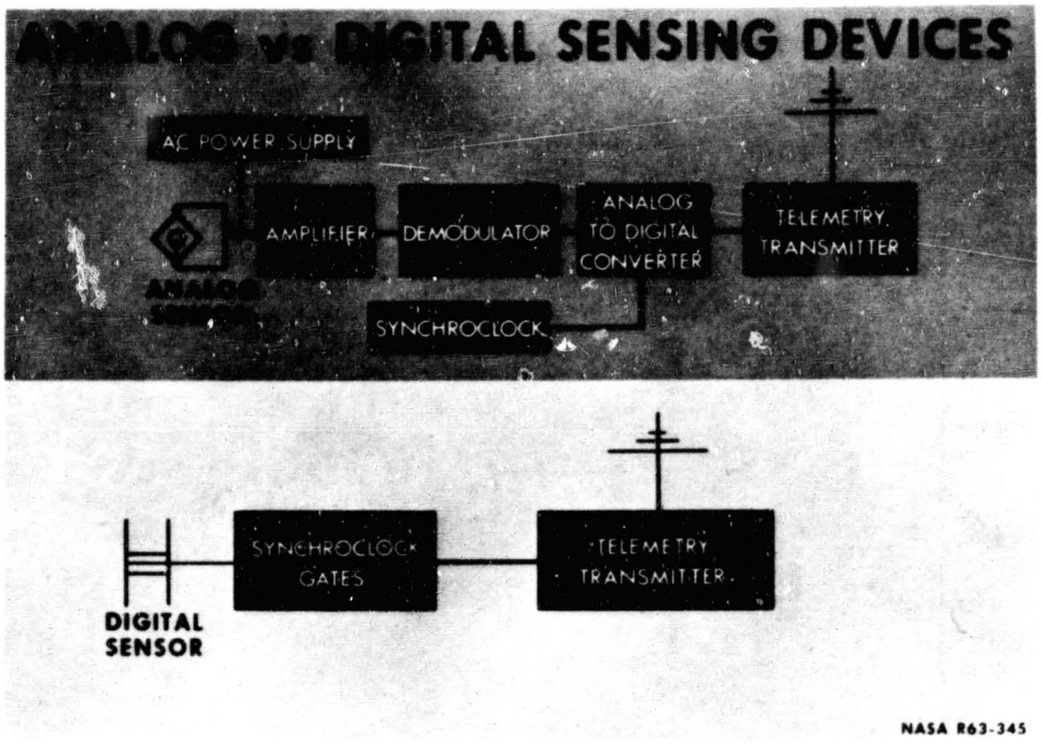


FIGURE 203

Next one, please.

I want to talk just a minute about communication capabilities in space. Here, we have the calendar year on the bottom and then the time required for a television picture transmission on the vertical scale.

Now, that is a nonlinear scale, so it is a logarithmic scale. You have to read it quite closely.

The television picture we get at home has 10 to the sixth power. or 1 million bits of information. It is composed of 1 million pulses.

We use this example to indicate the time of transmission.

For example, a television picture from Mars would take on the order of a couple of weeks, right now. Using all the technology that we know right now, that we can put into use, and these are shown by the steps—the year they would apply, the red being to the spacecraft, the white being to ground devices. This says that television pictures from Mars would stabilize in about 1969 at somewhat less than 1 minute transmission time.

With television pictures from Pluto, we would hope to do no better than a few days. That is the length of time for the picture—not the length of time for the transmission—and as an interesting comparison, Alpha Centauri, which is the nearest star outside our solar system, is 4 light years away, but it would take, in addition, 14 years to get a television picture through.

In other words, from the time the picture was sent from Alpha Centauri, would take 4 years for the initial portion of the message to get back here and would take 14 more years for the end of the message to get back here.

Mr. KARTH. Not worried too much about that one, are we, Doctor?

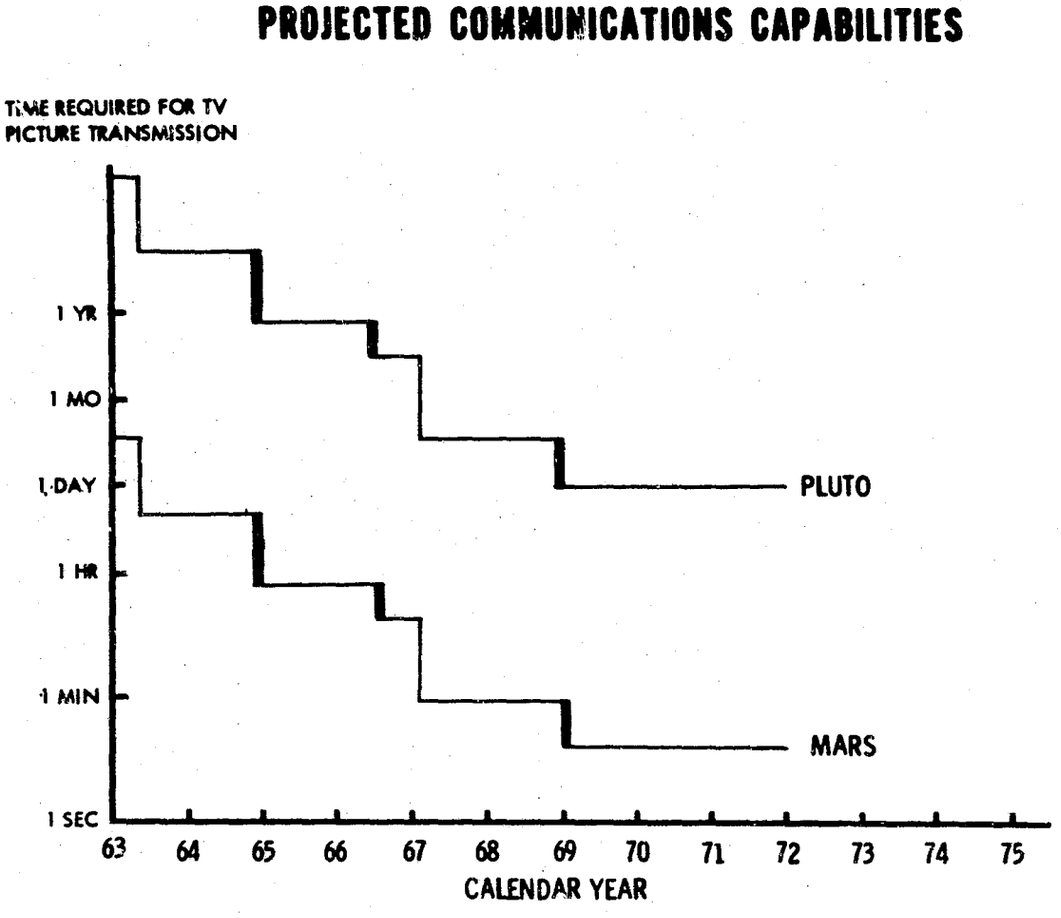


FIGURE 204

Dr. KELLEY. No, I'm just using, for an example, this comparison. We think Pluto is bad enough.

You see, if we get into reentry situations where the whole reentry might be over in a couple of minutes, obviously, taking a couple of days to transmit the picture is ridiculous, because the device has destroyed itself before the picture gets back.

This is illustrative, I would say, the exhaustion of our technology right now, as we see it.

We have to do something new and to do something different, if we are going to improve on the situation.

Next one, please (fig. 107, p. 1943).

One of the areas of capability increase—and this, in fact, is included in the graph I just showed, is the area of ground antenna technology and one of the devices we are working on—one of the techniques we are working on, is the possible replacement of a large single antenna which you see on the left with the multiple array on the right. That is, getting nine smaller dishes, perhaps, to do the work of one larger dish.

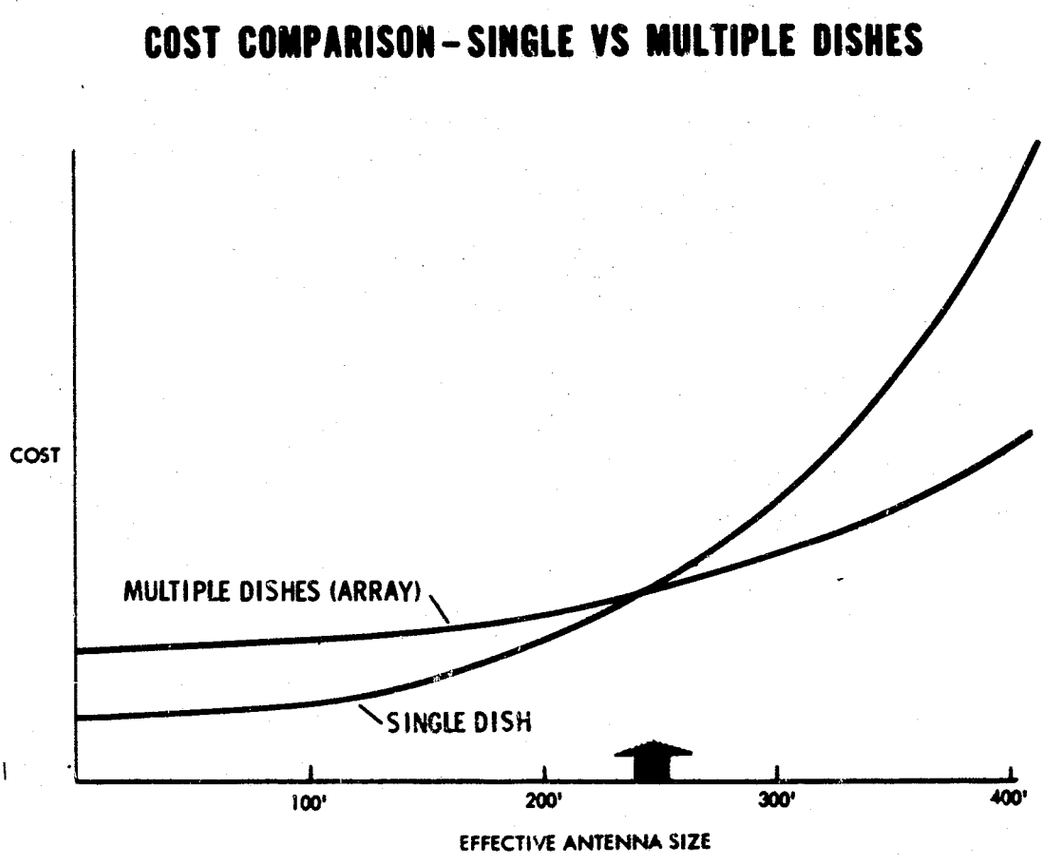
We really don't know how to do it yet. We see lots of payoff.

For example, there is a lot more flexibility. You can be using the dishes to do different things at times. You don't need them all for deep space.

If one of the dishes goes down, you have a malfunction—we are still on the air, so to speak.

The next slide (fig. 206) shows one of the more striking factors, the straight economic payoff. You see the single dish.

This is the equivalent antenna system. We can relate the big dish to smaller dishes by the effective antenna size. You see on the bottom, the effective antenna system of either method, and on the vertical axis the cost. You see a crossover point at around 250 to 300 feet effective antenna size where single dish costs begin to skyrocket, whereas a multiple dish array has hopes of staying in bounds.



COST MULTIPLE DISHES (ARRAY) SINGLE DISH

100' 200' 300' 400'

EFFECTIVE ANTENNA SIZE

FIGURE 206

Next one, please (fig. 207).

One of the more interesting ways of getting this information back, I mentioned—it took—14 years to get a television picture back, but maybe you don't have to transmit the whole television picture every time. It seems to make sense to transfer or send back only the new information on each succeeding picture.

Now we begin to tie in the area of communications and data processing.

See, on the left, the television camera looking at the Moon and we painted two billboards on the Moon.

You see on the left-hand picture, the bottom billboard has only one thing different, and that's a triangle in the lower right-hand corner and sort of a square.

Our conventional techniques, right now, say when the picture changes, we transmit all the information back again, both the old and the new.

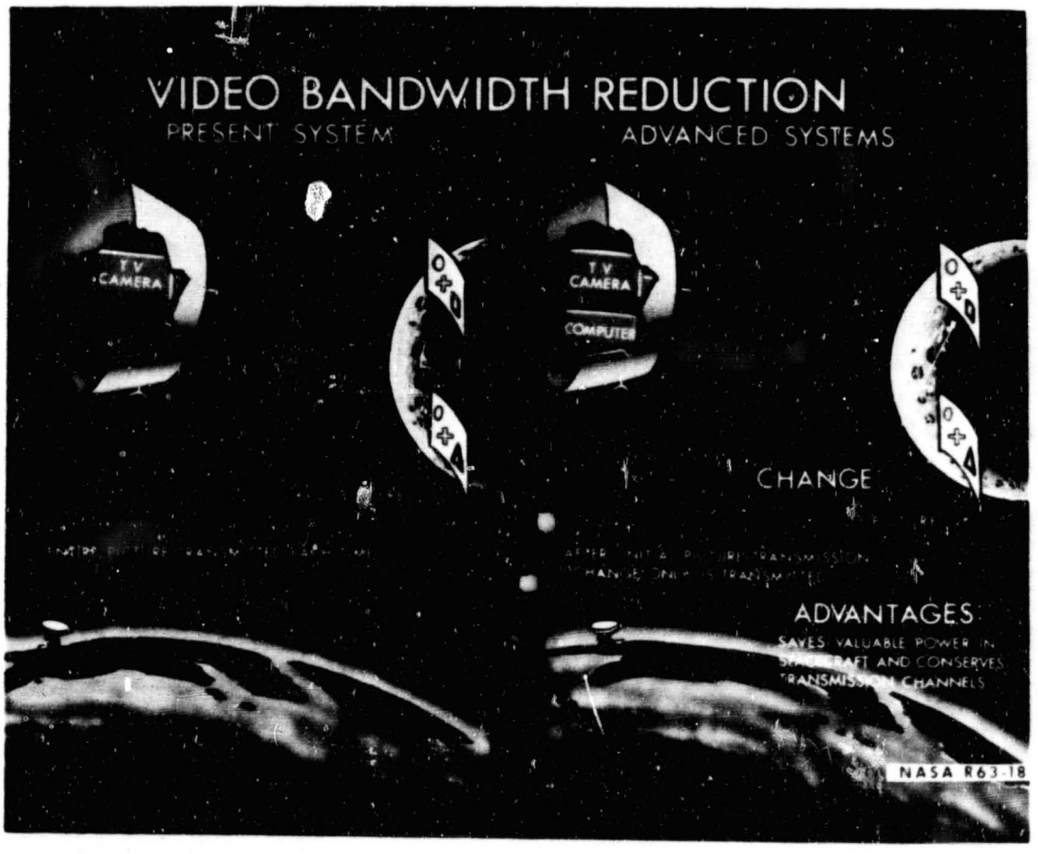


FIGURE 207

We are now very actively engaged in the video data processing business where we send back only the new information. We send back only the change in the billboard, but this takes computation. It takes investigation into how to use computers with television and so forth, and here now we begin to see a payoff for shortening the transmission time for television pictures.

Next one, please (fig. 208).

Our whole area of computation has been enhanced by the size of computers and this is coming about by miniaturization and microminiaturization is the word we use now, microelectronics.

Here, as a function of years, you can see the trend; talking about a device now which has a specific function in 1957 it would take 1 cubic foot and weigh—if you look over in the right scale, 150 pounds.

Again, this is a nonlinear scale, so you have to look closely. You see now we are coming down the curve and we are getting smaller and smaller.

If we get much smaller we are going to have to work that much harder. I suppose there is a limit as to how small we can get, eventually anyway; but we are beginning now to get down into very small devices but——

ON-BOARD AEROSPACE COMPUTERS

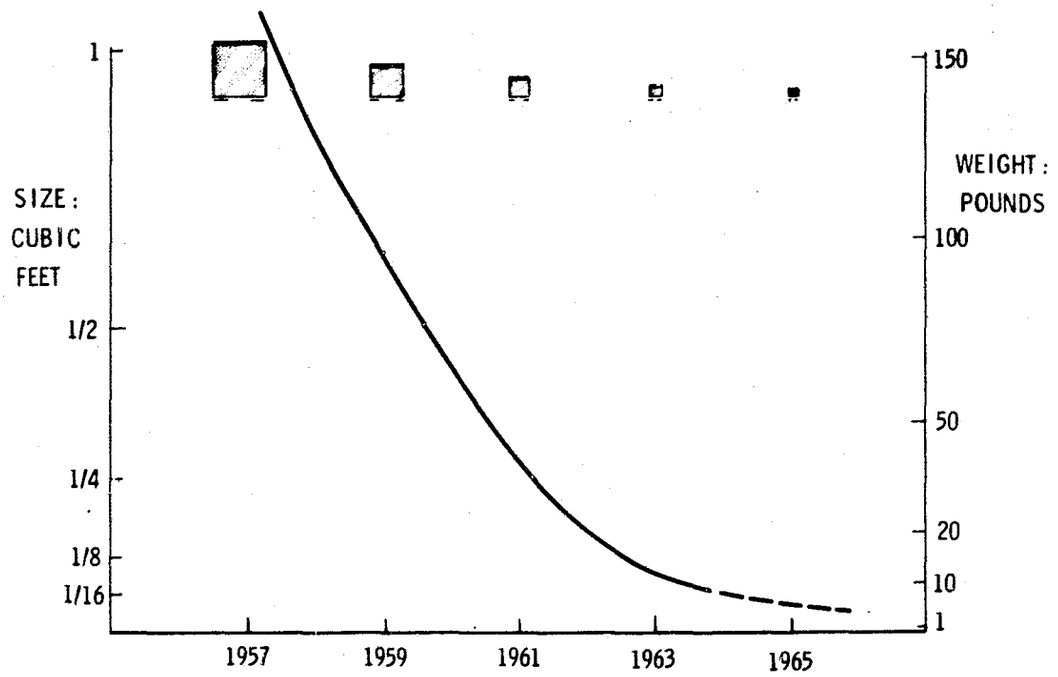


FIGURE 208

Next one, please (fig. 209).

That's only half the story.

After you get them small, what do you do with them?

How do you make them more flexible?

How do you adapt them to your need?

A computer is not a computer any more than electronics is electronics. You have different needs and different requirements.

Here you have the trend in computer memory and speed. These are the two factors or parameters by which we measure computers.

The left-hand vertical scale is the number of bits and it takes so many bits to make a word or message, depending on the computer and the bottom one is the speed of access, so these are two very important parameters.

You see, where the lurid green color is, where we are on present core memories. Then you see an area, present core developments. Now, you see on the two tails the push by various other agencies.

The future semiconductor devices are useful to people who have interest in large numbers of bits at fairly conservative speeds. This might be routine data processing, intelligence information, and so forth.

Other Government agencies are working over in that area, called tunnel diodes.

Here, they are not so much interested in the number of bits but are interested in the speed. Something like an anti-ICBM. You'd want to be over there.

COMPUTER RAPID MEMORY TRENDS

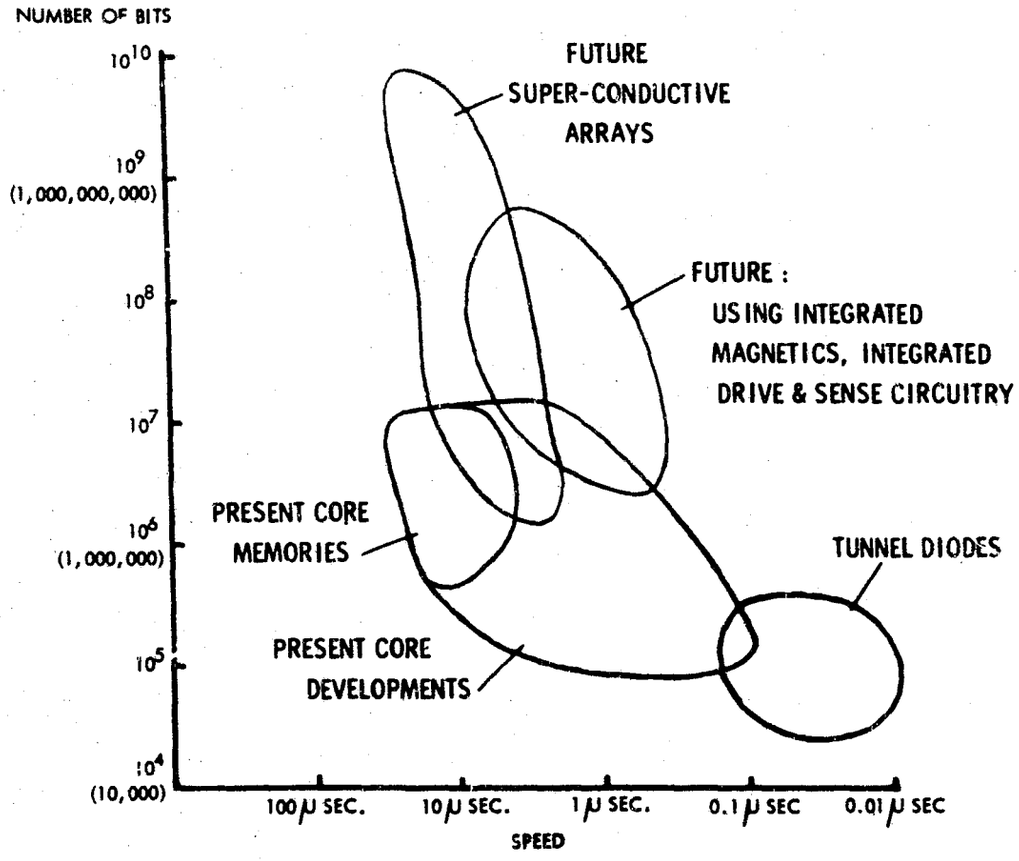


FIGURE 209

Now, space requirements force us to work in trying to improve both parameters and we are pushing out along the diagonal where you see future, using integrated dynamics, interdrive, and sense-circuitry, because we have a demand for both speed and bits.

Incidentally, as an example of how much information we get out, Goddard Spaceflight Center, alone, from its existing operating satellites, gets 140 miles of tape a day that it has to process.

Next one, please (fig. 210).

But the computer business is not solely involved in electrons.

One of the interesting aspects of it, involves the aerodynamicist and one of the important developments recently is the so-called pneumatic computer where we use air.

Remember, in digital devices we are interested in a digit or—not a digit, a one or a zero.

Here we see a gas on the left-hand side and the two control jets acting against each other by pushing and pulling in their various ways, you can make the air from the left-hand stream go to the digit "0" or digit "1."

Why do we get into devices like that? We get into devices like that because it is temperature insensitive. Remember, I mentioned the thousands of degrees. They are also radiation resistant.

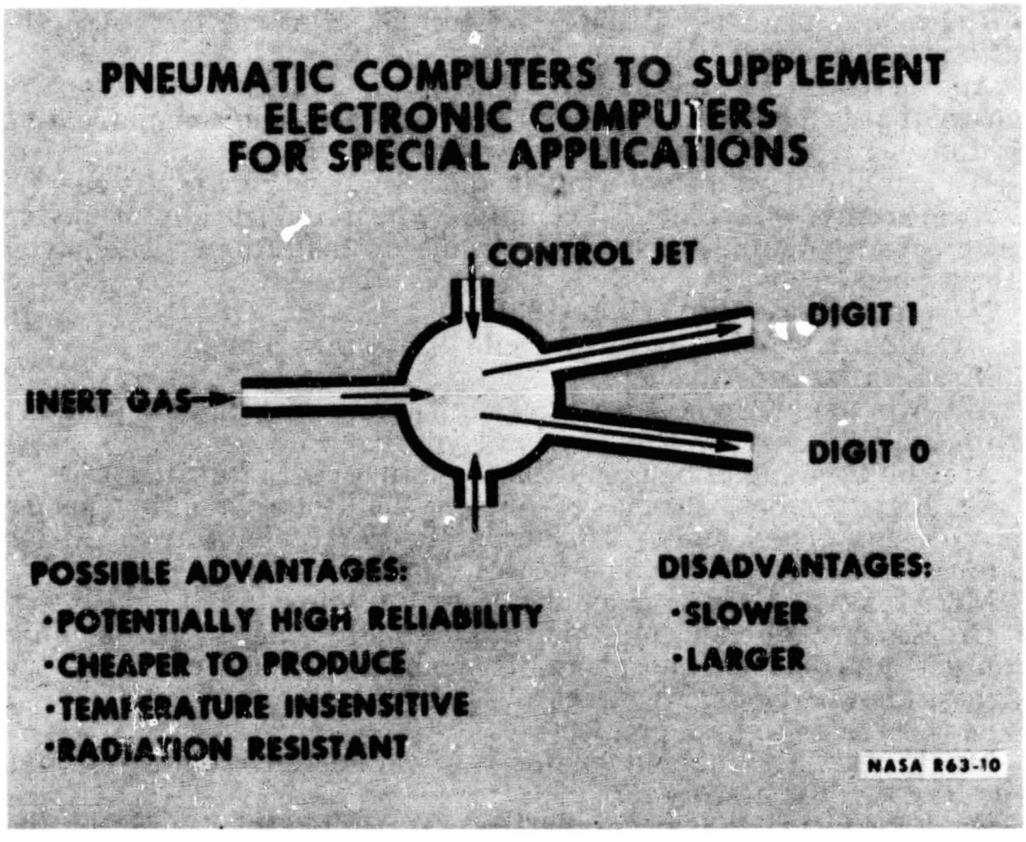


FIGURE 210

That is why we are putting a great deal of emphasis on devices like this to meet our needs.

Next one, please (fig. 115, p. 1953).

Now, lasers, we see as one of the great breakthroughs with very, very significant applications to us. Now you must remember that the laser technology is only about 2½ to 3 years old.

Some people, including the inventor, Dr. Towne of M.I.T., calls it the optical maser, but it's now commonly called the laser and this has tremendous possibilities and I must emphasize these are only possibilities.

It is a laboratory technique right now and much of the publicity and fanfare has been on concerning things we might be able to do and not on things that we can do.

We are interested not so much in cutting diamonds or death rays in our business. We are very seriously interested in it as a communication and tracking device for deep space.

Once we get outside the Earth's atmosphere it's clear sailing, if you like, for optical frequencies.

The amount of information you can put on these beams, potentially put on these beams, is just phenomenal.

I saw a figure the other day, all the radio and telephone transmissions could be put on one laser simultaneously; all those going on at any one time anywhere in the world—could be put on one laser beam, simultaneously.

This comes about not only because we are in a new frequency regime but also, you heard Dr. Bisplinghoff and Dr. Kurzweg last week, the laser yields coherent light and we can focus it.

And here you see the ability to focus the tremendous amount of energy that is involved. We don't have to waste it in communicating or diffusing it all through the whole space environment.

We can aim it where we want it and then concentrate the energy.

Incidentally, we see optical communications and tracking as having the greatest potential for space electronics in the future. The payoff is just phenomenal.

Next one, please (fig. 116, p. 1954).

Mr. MOSHER. Mr. Chairman, could I interrupt here?

Mr. KARTH. Mr. Mosher?

Mr. MOSHER. You still face great difficulties with the use of lasers within the atmosphere, though, don't you?

Are you thinking of being outside the atmosphere for these uses?

Dr. KELLEY. Both inside and outside the atmosphere, but people have been worried and will continue to worry about transmitting through clouds and fog and so forth in the atmosphere.

Mr. MOSHER. Rain causes difficulties, I'm told.

Dr. KELLEY. Or rain, anything that would bother light; but once you get outside the atmosphere, even above 50,000 feet, above the highest known clouds, it's clear sailing up to millions of miles.

So this ceases to be a problem.

Mr. KARTH. How about meteorites or micrometeorites—if one hits it, doesn't it destroy it?

Dr. KELLEY. If it hits the device. We think we can shield the device. If it hits the crystal, yes, it would destroy the device.

Mr. KARTH. Doctor, all these things you are talking about here, and showing us on slides are very technical in nature; how many companies—how many industries, how many people, how many Government laboratories are doing work in these areas now?

Dr. KELLEY. I don't know the exact number, but there is a large capable electronics industry in this country which is working with us on these particular problems.

Now these 40 contacts a day that I mentioned, represent what we at headquarters see of them—our field centers see more who are coming in to ask us what are the requirements, what should we be working on, will you guide us, how do we get into the space business?

Mr. KARTH. Oh, I don't think there is any question but what private industry can do if NASA wants them to do some work for them. If they are interested in a particular area of research they have got to go to industry and tell them what they want.

Dr. KELLEY. Yes, sir.

Mr. KARTH. If they don't go to industry and tell industry what they want, what they need, then I guess obviously it's up to the industry to come to NASA and say, "We'd like to do some of these things you have been talking about."

I can understand why you get 40 telephone calls and 40 letters a day. I was kind of surprised it was so low a number.

Dr. KELLEY. That is just our operation.

Mr. KARTH. I get that many calls from my wife every day—to give you an idea how busy I am.

But I understand your problem.

I would be interested in knowing how many companies there are within the industry, who they are, and where they are located; and how many laboratories, privately owned and Government owned, are doing work in each one of these specific areas now, and to what point in time or what point in advancing the state of the art they have actually reached.

Could you give this information for the record, Doctor?

Dr. KELLEY. I couldn't give it offhand, but I'll look into supplying it for the record.

(A list of small business concerns interested in performing research and development can be found in publication, entitled "SBA List of Small Concerns Interested in R. & D" (609 pages), Small Business Administration. This publication is on file with the committee.)

Mr. KARTH. Now, have you made a study of this?

Have we studied, for example, let's take this laser—made a study so that we know every name and address and the ability and the advancement in the state of the art that each company has made all over this country?

Dr. KELLEY. We have not made a specific study, but that is the business of my group in NASA as well as the electronic people who are in NASA, to know what is going on. We have the companies come in to talk to us, and we have research advisory committees in NASA.

We are on joint NASA-DOD committees, so that we know, I would say, very confidently, what the capability is in the country.

Mr. KARTH. Doctor, I hope you do, and all I ask at this point is—because I have great confidence in your knowledge in this field—is that you submit it for the record, all of it; all the information you have on every single electronics company in this country that does any work on lasers and all the other electronic areas of interest to NASA.

I think that it's well worth our while to make sure that this information gets into the record so that then the subcommittee later on can evaluate this information and in their considered judgment, decide whether or not there is duplication triplication or quadruplication or whatever it might be; or whether there is none.

(The information requested for the record is found in "Appendix A, p. 2151.)

Dr. KELLEY. Could I ask you a question on that, Mr. Karth?

Mr. KARTH. I am not a witness, but I'll change seats with you.

Dr. KELLEY. Well, a clarification.

There are many people working on lasers. Some are working on it for military application such as death rays. Some are working on it for welding. In fact, there are even medical applications—reattachment of eye retinas.

Are you talking about the whole laser industry or the ones working on the communications problem?

Mr. KARTH. I think it's almost got to be the whole laser industry, because, for example, he who discovered the rare earths; you know he didn't foresee the atomic energy program.

He who discovered the vacuum tube really didn't know what he was looking for, I guess. Maybe he did. Look what he found, by just going down a certain road.

I think that's why we have to make sure we understand what everybody is doing before we can understand plainly, and completely, whether or not we are going down a road of duplication.

This is the reason I request the information. It might not satisfy you, Doctor, but I really think we must have information of this nature; otherwise we can't really make a proper determination.

Mr. Mosher?

Mr. MOSHER. I think it should be recognized that the laser, the whole concept is so new—it's only 2 years old, and it's so exciting, so revolutionary that this is almost every minute or every second someone new in this field may be popping up with new ideas and new uses and I suspect from day to day to provide an inventory or catalog who is working on what, would be almost an impossibility.

I think it is good if we knew it, but I can see the difficulty.

Mr. KARTH. I think at the time we make our determination, if we can have as up-to-date information as is possible; and I assume just by virtue of the Executive order, that a very comprehensive study has been made. I recognize, as the gentleman from Ohio does, that things have a habit of changing from day to day and may be changing day to day in the field of researching the laser; all the more reason, I think, why the subcommittee might be interested in knowing just how much work is being done. If so much work is being done that this technology is changing every day almost every minute, as the gentleman from Ohio indicates it might be, then it seems to me we have almost got a full-time job just keeping track of the changes. Might be well worth our time to retrieve and catalog and then disseminate the information to our people who are vitally interested in this area.

Mr. MORRIS. Mr. Chairman, could I interrupt?

Is the chairman suggesting by that remark, we establish a center for this purpose?

Mr. KARTH. Well, I'm not suggesting anything except that I be better informed.

Mr. RANDALL. The chairman has suggested for the purpose of the committee, as I understand this question, we attempt to catalog for use those others who are doing work in this field so we can maybe look at that. Isn't that true?

Mr. KARTH. Let me just say this, if I may. I would like to call the attention of Dr. Kelley and the subcommittee members to the scientific research study that the U.S. Senate made in 1961. Now this isn't really ancient history, but I suppose the problem has probably become magnified, rather than lessened since that time.

The Senate committee on October 4, 1961, had this to say about the electronics industry research program.

They said:

> One-tenth of federally supported electronic research and development may consist of unwitting needless duplication of effort. The waste may add up to $200 million out of $2 billion currently expended for this type of work.

This is $200 million annually out of $2 billion annually, the subcommittee reported.

> The reason for the waste—

they stated—

is poor Federal management on tens of thousands of projects. Electronic research and development as supported by the Department of Defense and the National Aeronautics and Space Administration is so vast and complex no one really knows who is now doing what, where, and how, in experiments.

The report says:

> Some of the work may already have been successfully performed elsewhere, but may not have been described yet in reports or published in technical journals. Still other experiments may have yielded negative results elsewhere but may not have been written up and may thus "disappear" only to be finally duplicated later on.
>
> The results of the situation—

the chairman stated—

> are—
>
> 1. Programs crucial to the Nation's security do not attain their highest and promptest yield.
> 2. Extra financial burdens are levied on the Nation's taxpayers, and
> 3. Byproducts from federally sponsored research and development do not become available as promptly as they might become available for our civilian economy.
>
> The subcommittee singled out information, electronics in view of the crucial importance of this "dynamics" research and development to national security and to rising standards of living.
>
> Electronics represents about one-fourth of all defense support of research and development.

This is the kind of report issued by the Senate committee just a year and a half ago. This report was the reason for stimulating my curiosity as to what are we doing in the field of retrieval, retrieving this vast amount of research information that is going on, as the gentleman from Ohio says every minute of the day.

How can we possibly keep track of this unless we have a substantially large staff apparently doing nothing but this?

People who are not necessarily working with industry, just on their problems, but just retrieving this information and then getting it back to those people who do work for NASA in the various centers and who have some responsibility on specific programs to the Defense Department, to the other Government agencies, and laboratories, and to all of industry so that each researcher can take advantage of what somebody else has done. This would probably advance the state of the art much more rapidly than if we build 40 laboratories, but don't do a proper job on retrieval and dissemination.

This is my very honest and sincere concern, Doctor, and I would like to have you address yourself to this problem.

Dr. KELLEY. Yes, sir, I will.

I have read the report. I have it right in front of me and I am familiar with the problem it addressed itself to at that time which was the number of or proliferation of reports an agency such as ASTIA—Armed Services Technical Information Agency—was one Agency set up to coordinate these and make sure they get to the proper hands on time.

Now since, and I believe it was in progress at the time this report was issued but certainly since that time, NASA has instituted an information retrieval service or rapid access to its reports, contract reports, and I'm sure this is coordinated with the DOD system.

I think the NACA system for the reports they had written, I was not a member of the NACA, but a user of their reports, has been one of the best documentation systems in this country.

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However, in addition to information retrieval which is essentially how to catalog, classify, and disseminate the vast number of reports that are written, I believe you have to have a group that can digest the reports and evaluate their contents and, in fact, by coordination, association, and reputation, work with the people from other agencies, universities, contractors, and more readily and more quickly exploit the ideas.

In other words, this addresses itself——

Mr. KARTH. I am in agreement with you up to that point, Doctor. I'm telling you that you have a real friend.

I have been complaining about it for years, ever since I have been in Congress.

Dr. KELLEY. We feel in addition to a documentation classification service, we need in-house competence to be able to evaluate the results of ourselves and others, and the best way to do this—I heard some discussion in the committee last week on it—we feel the best way to do this is with people who are getting their fingers dirty, if you will, who understand the real live problems.

If I may return for 1 second to the laser situation, I would hope any electronics company worth its salt which hoped to stay in the forefront of the military space electronics business, was thinking and working on lasers.

One of our problems—on lasers, that is part of electronics—one of our problems, is to evaluate the good ones from the bad ones.

Mr. KARTH. Are we making those evaluations now, Doctor?

Dr. KELLEY. We have to develop our own in-house competence to evaluate the results of others and also make known our requirements to the engineering companies in terms that they can understand.

Mr. KARTH. Doctor, you find a real sympathetic ear here on what you said up to this point but I hope I can find a sympathetic ear, too, when I say that I think we should take first steps first.

I think we have got to first determine what is being done in this country and I think you probably agree with me we really don't know what's being done in all of these areas you so eloquently discussed and showed us beautiful slides on. We really don't know everything that's being done in these other areas, and I'm not talking about up-to-the-minute-type knowledge.

Dr. KELLEY. Whatever knowledge—I don't know what you mean. I don't understand the question.

Mr. KARTH. I say, we really don't know what's going on in this country in all of the areas that you showed us slides on, in the field of electronics.

We really don't know what's going on in all of these areas, all over this United States of America in Government laboratories as well as privately owned laboratories and private industry.

We just don't know what's going on, and I said I wasn't going to say "up to the last minute" either. We are way behind in retrieving all of the information on all of the research effort that's being made in this Nation, are we not?

Dr. KELLEY. I would hope that is not the case.

Mr. KARTH. What is your opinion, Doctor?

Dr. KELLEY. My personal opinion, with the large, lively, and capable electronics industry in the United States; whatever they are doing, if they hope to find a market for it, they make it known to the customer.

In this case it happens to be the Government.

That is part of the 40 contacts a day I was discussing.

We don't know up to date, every minute, what is going on in every backroom in every company, but everything they think is applicable to our missions I am sure they call it to our attention.

Mr. KARTH. Do you really, honestly, think, Doctor, that you are familiar with all of the electronics research that goes on in this country in all these specific areas you mentioned today and many more we should be interested in?

Do you honestly and truly believe that?

Dr. KELLEY. I don't believe I, myself, am, specifically, no.

I couldn't catalog the business.

Mr. KARTH. Do you think NASA is?

Dr. KELLEY. To what is pertinent to our business, I think we are pretty much on top of the state of the art; however, I think we see many more problems in the future that we have to solve.

But I think we are pretty much on top of the state of the art and this is very largely due to the activities themselves.

Mr. KARTH. Are you the Dr. Albert Kelley who headed up the Ranger program study?

Dr. KELLEY. I am.

Mr. KARTH. Now, for some reason or other, this document is still classified secret and I shall not invade that secrecy, but I wonder if you could tell us, at least in those areas that are not secret, what you found and as a result of it what your major recommendations were in the Ranger program?

What were our major problem areas?

What were your major recommendations for getting this program going and making it a success?

Mr. MORRIS. Mr. Chairman.

Mr. KARTH. Mr. Morris.

Mr. MORRIS. In order to get the question—and we want you to be very brief, Dr. Kelley, I don't want to put you in an embarrassing position now, to any information that is secret, confidential, or classified and you feel that you would have to divulge that in answering the question.

We don't want to embarrass you.

Is that correct, Mr. Chairman?

Mr. KARTH. I'm sure he understands that.

Mr. MORRIS. If you want the question put in a different manner we'll put the question in a different manner, or if you don't think you can answer the question without divulging things you should not, I think the committee would understand.

Mr. RANDALL. I join the gentleman from New Mexico on that. In another committee we had the same instance in which the witness had problems.

Mr. KARTH. I'm sure you understand that. We don't want to go into anything that is confidential.

Dr. KELLEY. To go into detail would require a classification discussion.

We looked at the Ranger program as a whole, and there are secret and valid secret classification items woven throughout the whole program. However, I can make a generalized observation right here, if I may, which would not invade the security domain and if we wanted to

discuss any security measures, maybe I could at the pleasure of the chairman in an executive session.

Mr. KARTH. Fine.

Dr. KELLEY. But you must look at the whole Ranger program in terms of what we were trying to do when we were trying to do it.

We were shooting for the Moon and we were trying to accomplish something that hadn't been done before.

Ranger is one of the most difficult missions that we set out to accomplish; with an Atlas launch; Agena first burn followed by a coast down the South Atlantic almost to the tip of South Africa; second burn; escape; release of the capsule; orientation of the capsule to the Sun; orientation to the Earth; midcourse maneuver and then coming up to the Moon; a reverse maneuver to orient the spacecraft to land; separation of a capsule; crashing of the capsule into the Moon while it's taking TV pictures and then the capsule itself bouncing around and surviving—we hope.

Very, very, frankly, we pushed the state of the art in that case and it was the electronic state of the art.

As you know, all the failures in the Ranger problem were of an electronic nature, in one way or another

Mr. KARTH. I think when you say "in one way or another," I guess you could attribute almost any difficulty we have in this country to electricity or something that's connected with a switch.

Most of our fires are caused by faulty circuits, let's eliminate electricity, then we won't have any more houses burning down.

This we can honestly and fairly say, Doctor, because this is true. You can do almost anything with statistics and can almost make it say anything you want to tell.

Because of this we want just one more big inhouse laboratory. This is really what you are saying, aren't you?

Dr. KELLEY. No, I wasn't relating it to the lab.

I was stating the facts in the Ranger report which I understand is in the hands of the committee.

Mr. KARTH. I really want to get into this in executive hearing. I don't want to take a chance of violating this secrecy but nothing in here would demonstrate to me you had any electronics—the big problem in our continuous failure to make a satisfactory Ranger shot was an electronic shot.

Mr. MOSHER. I don't think you really stated the purpose of your line of questioning here.

Do I understand it is all directed to a skepticism on your part concerning the validity of the proposal for a new electronics laboratory in the Boston area?

Mr. KARTH. I don't think there is any question but that's what Dr. Kelley is here for. This is the budget request and this is part of the reason for his appearance today.

Mr. MOSHER. This is the significance of all his questioning in the last half hour as it relates to this?

Mr. KARTH. I would say a portion of it is.

Mr. MOSHER. Yes.

Mr. KARTH. I had in mind the doctor was doing a real good job here and I want to congratulate you, Dr. Kelley, attempting to convince this subcommittee you are in need of the budget request that is before this committee for consideration.

I think you are doing a very good job, and I class you along with some of those other able Government people who have appeared before this committee.

Let me ask you this question, Doctor. Has this electronic research center ever been proposed to the Bureau of the Budget?

Dr. KELLEY. You mean in past years?

Mr. KARTH. Prior to 1964.

Dr. KELLEY. No, it was not.

In fact, there was no electronics organization, as such, in NASA until November of 1961 when our office was formed and we realized that we had to do something about the future of the agency in electronics. While we are in the electronics business throughout our projects, as you saw in the slides, in fact to a large extent, there was no organizational implementation and when the agency reorganized, November 1, 1961, as you are aware, included along with the major reorganization for the Office of Manned Spaceflight was a reorganization of the Office of Advanced Research and Technology including recognition of the importance of electronics by establishment of our Office.

Mr. KARTH. You are not saying you just became aware of this problem last year, are you?

Dr. KELLEY. No; not at all. The agency was aware of the problem, as I understand, even when it was being formed. This was something that was lacking.

Mr. KARTH. I see.

Dr. KELLEY. We were directed shortly after we were formed; that is, our office, to come up with a plan to implement NASA's long-range requirements in the area of space electronics and guidance.

In other words there was recognition, and this was well over a year ago, there was recognition, formally, of the fact we were going to have to grow in electronics and in guidance-research capability.

We had to investigate and study the implementation of this growth.

Mr. KARTH. We have been growing in this area, haven't we, Doctor?

Dr. KELLEY. I hope we continue to grow more.

Mr. KARTH. But the question is, We have been, haven't we?

Dr. KELLEY. We have been growing, gradually, yes, sir.

Mr. KARTH. I'm sorry for having interrupted you before you completed your testimony.

Have you completed it?

Dr. KELLEY. No, sir. I have about 5 more minutes.

Mr. KARTH. All right, maybe we could complete your testimony today and then get the questions tomorrow.

Dr. KELLEY. We were on the subject of lasers.

Could I have the next slide, please (fig. 116, p. 1954)?

Mr. KARTH. I think that's what started the question. Go ahead, Doctor. I'm sorry.

Dr. KELLEY. One of the first experiments now in space, using lasers will be the S–66 satellite which we will launch later this year which will have many corner reflectors on it.

A corner reflector is a device which, when illuminated with a beam, reflects the beam right back to you regardless what angle you are looking at the reflector. We are doing reflection and tracking experiments.

One of the facets of this, since it is a tracking instrument, is that we don't have to use any equipment on the satellite.

Anyone with a good laser on the ground could participate.

We have asked, or made available, the means for international cooperation. One of the people in my office attended a major symposium in Paris about a month ago where there was quite an interest in tracking the S–66 with lasers that people have in Europe as well as this country.

Some of the things we have to learn—How does the atmosphere affect a laser?

What are the tracking and range accuracies?

One of the more interesting aspects is relativity. Dr. Einstein is beginning to get into the picture. Always in these equations we use a term involving the proportional velocity with respect to the velocity of light, a percent, but the velocity has never been high enough to bother us and we just ignored the term.

Now, with the satellite going by at some 18,000 miles an hour, we have to begin to think about relativity.

One of the things we are concerned about is the proof of relativity. In this case, if, in fact, Dr. Einstein was correct.

Will the light be reflected right back to you; as I said a corner reflector normally operates, or would it be disturbed slightly, which would be an Einstein relativistic effect, and one of the purposes of the experiment.

The next one (fig. 213).

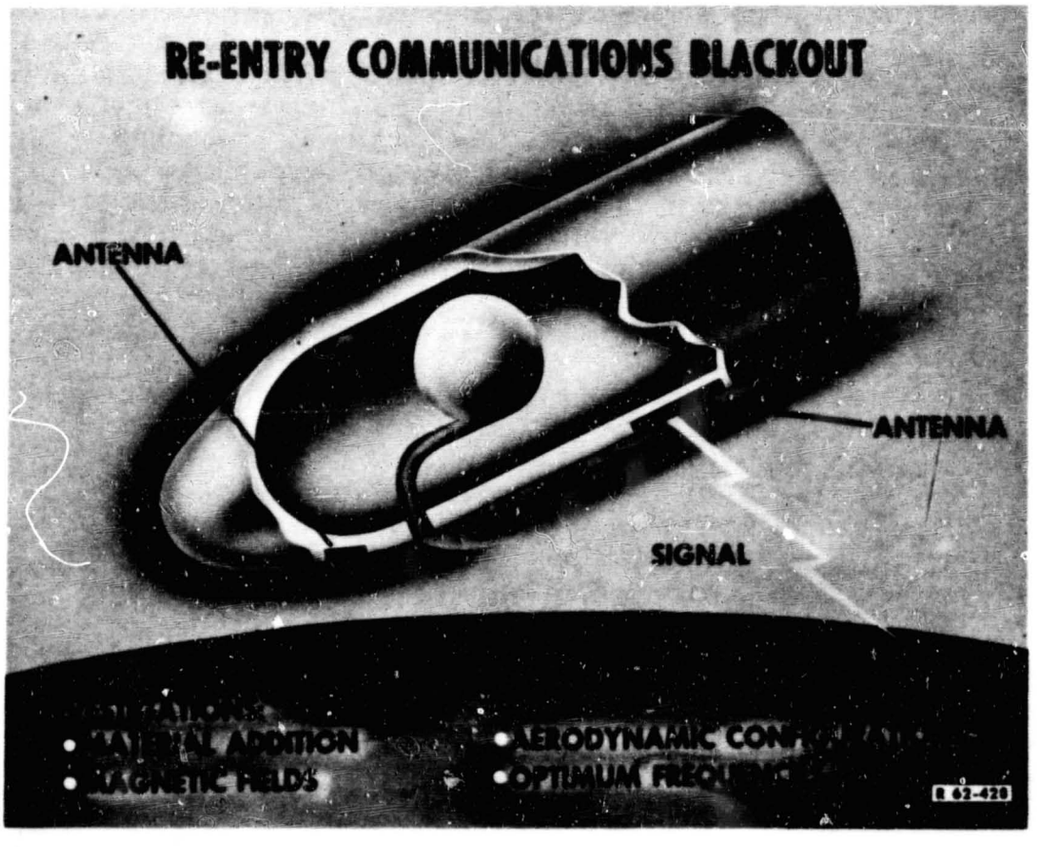

FIGURE 213

Now, reentry communications, blackout problem is well known. John Glenn and Carpenter and Wally Schirra all experienced blackout up to 3 or 4 minutes, and this is caused by reentry, heating up the air as you enter the atmosphere which actually causes it to ionize. That is, the electrons separate from the rest of the atoms. You have positive ions and negatively charged electrons and these tend to form an electric shield around the spacecraft and just makes it impossible, with our present technology, to communicate.

This communication during reentry can get very, very important; particularly, if you are going through some of this manned reentry control as I showed with the heart-shaped cardioid.

I showed this slide to the Subcommittee on Advanced Science and Technology last year to show what we were doing and what we were investigating.

We were investigating materials additions including water and ablative materials, aerodynamic configurations, and then the whole frequency spectrum

You can see here an example of material addition, the antenna where the transmissions don't get through.

If we add a material like water, an antenna where the water has cooled farther back, on the spacecraft, where the water has cooled down the ionization, then transmission can get through.

We have recently had some reason for optimism in wind-tunnel tests at Langley Field with water addition.

If I could have the next slide (fig. 214).

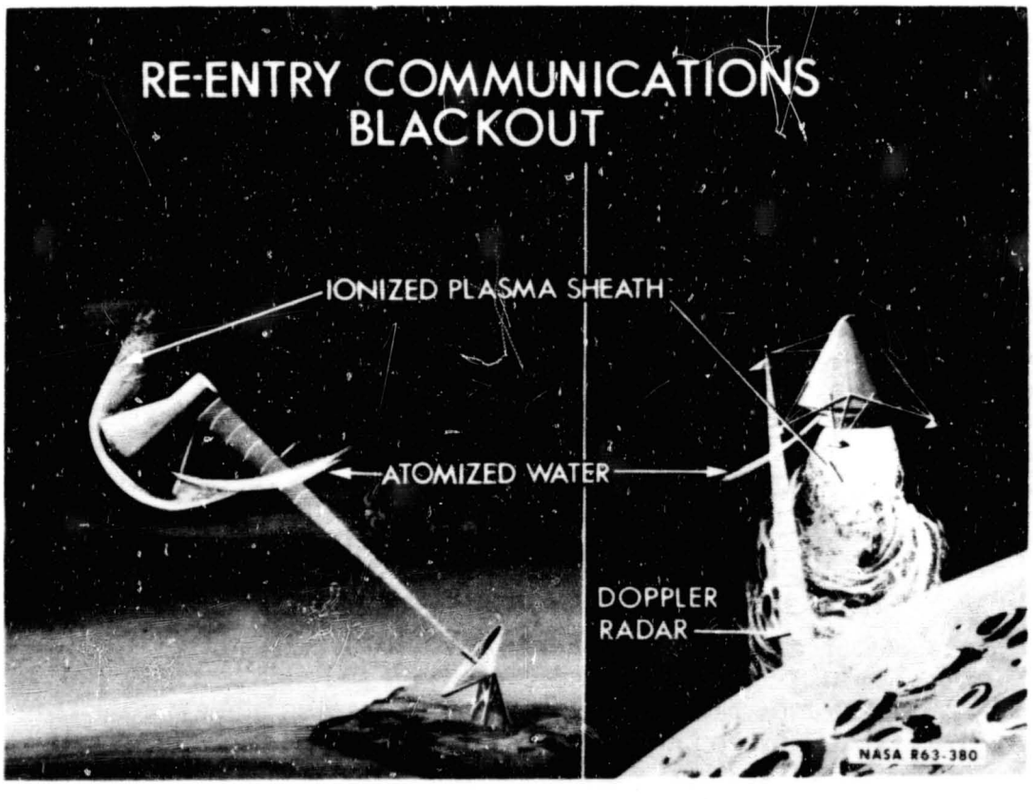

FIGURE 214

We have shown it is possible that we can read through or transmit through the communications blackout by cooling down the ionized gases in the vicinity of the antenna and here you have an example in an illustration of what this might look like where the astronauts, for example, every time he wanted to talk, would squirt water into the ionized stream and cool it down and then he can get his transmissions through.

Incidentally, we have the same problem in rocket exhaust. For example, if we have a spacecraft coming down to the surface of the Moon with a radar altimeter, the rocket exhaust gases again interfere with the transmission and cause the same type of communications blackout.

Next one, please (fig. 215).

COMPONENT TECHNOLOGY OBJECTIVES

- COMPATABILITY WITH SPACE ENVIRONMENT
- RELIABILITY
- STANDARDIZATION
- QUALIFICATION
- RECIPROCITY WITH FLIGHT PROJECTS
- EXPLOITATION OF ADVANCED TECHNIQUES

FIGURE 215

One of our areas is component technology. That is, How do we get the right pieces, the right parts for the job? These are the objectives or requirements of our component technology program.

We have to have compatibility with the space environment and I mentioned earlier, when I started, what some of the particular problems of the space environment were and the reliability factor, I've already mentioned.

We have standardization requirements. That is the only way we can get reliability, really, is to use the same parts over and over again

under different conditions and different vehicles and build up a history of experience.

The word now is "commonality."

Mr. KARTH. How do you achieve this?

Dr. KELLEY. You just don't go on the open market and buy parts. You have to qualify them. You have to qualify them to certain standards, specifications, that are compatible with the space environment.

Incidentally, as we learn more and more about the space environment, the standardizations themselves change, because we don't want to build equipment for last year's space environment if we know this year's space environment is different.

So, we have to be very close to the people who make the components, if we are going to get payoffs in this field.

This is involved with reciprocity with flight projects. That is we have to have a quick information channel on this space environment, what we learn out of our projects, back to the component-technology development so we can again get early exploitation of advanced techniques and then have them in turn feed back to the next series of spacecraft or vehicles.

Next one, please (fig. 113, p. 1951).

Just an example of some of our requirements in the areas we are pursuing, is the radiation resistant device. I think most of you are familiar, as an example, with Telstar and why it got a little sick in flight, because of the radiation environment. The conventional—to the right—semiconductor device transistor is a semiconductor device that has a molecular crystal lattice structure inside of it, as you see by the cutaway and a proton—there's lots of them in the radiation fields—can destroy the lattice structure and this makes the device cease to operate the way it was designed.

We are looking very intensively at thin-film devices. By their natures, by the very materials involved, we hope to make them resistant to radiation; but the fact that they are thinner, there is less chance of collision—also for the proton getting through, less chance of disturbance or, in fact, if it goes through and hits something it leaves only a small hole which is now not any good instead of destroying the whole structure of the device as is the case at the right where the whole device doesn't operate any more.

Now, the NASA and the other components—the NACA and other components from which the NASA was created, possessed a rich heritage of capabilities which enabled us to easily effect the transition to space exploration.

Although these naturally included some elements of electronics research competence, this area was represented by a relatively small cumulative effort diffused throughout the agency.

At the same time the space exploration task, in the future focused a very large long-range emphasis on electronics. This is the reason why nearly 2 years ago NASA management began studying this responsibility and its associated organization implementation.

This led to the organization of the electronics and control directorate, which is my office, in the Office of Advanced Research and Technology, reporting to Dr. Bisplinghoff, and our task was to formulate and pursue a research program in the electronics disciplines which would enable the NASA to fulfill its mission under the Space Act of 1958.

Now, a constant and continuing review of the problems of electronics and associated disciplines has gone on since that time.

The need for more reliable electronics equipment is one of our most famous problems. I have already discussed it. This results from one simple fact that we—and I referred to it briefly in the Ranger discussion—we are forced by the pace of space exploration to use and operate electronic components which were not designed for the space environment. The problem begs for solution even as the performance demands on electronics continue to increase, due to the severity of the hostile space environment.

Much of the large, active and capable electronics industry is turning to the NASA for research direction and support of their space-oriented activities. While NASA can take up part of the support role by providing funds, proper and effective agency direction can come only from a nucleus of experienced and knowledgeable engineers and scientists—just as direction in other disciplines comes from other NASA laboratory centers.

Suffice to say, NASA simply must have qualified people on its staff who are well informed on space missions and their related electronic systems performance requirements, able to identify the problem areas, and competent to evaluate the research results of others. They must also exercise leadership in a favorable environment.

As a result of our review and study on the implementation of electronics responsibilities for future space missions, in our fiscal year 1964 budget, we have already discussed today, we are requesting congressional approval for additional funding for $5 million land acquisition, design engineering services to establish a new Electronics Research Center to be located in the Greater Boston area.

Our long-range plans call for an installation buildup over a 6- to 7-year period yielding a staff of approximately 2,000 personnel total, of whom 600 to 700 would be professionals and a plant value of approximately $50 million.

Now, the rate of Center growth will be gradual and represents, we feel, an investment in the future of space flight, analogous to the investment made in the older research centers many years ago which is paying off so handsomely today.

This rate of growth together with upgrading of Center personnel by continued graduate education after they are on board, is expected to allow us to meet our staffing requirement with little or no impact on electronic or scientific manpower during this projected growth period.

The NASA considered many potential sites throughout the country for location of the Electronics Research Center. On balance, the overall university-industrial strength and capability in electronics and guidance research in the Greater Boston area resulted in its selection as the location for the Center.

This area, noted for its past and current heavy concentration on electronics research, both in industry and universities, provides a compatible, stimulating environment for growth of NASA capabilities in this important area of technology.

The Center will have the principal function of conducting and directing research and component technique investigations in the related fields of communications, data processing, guidance, instrumentation, and control. It will be staffed and equipped to perform original work and to work closely with industries and universities with common interests.

As you are aware, currently, we are spending approximately 90 percent of our funds out-of-house.

The Center will serve to focus the increasing NASA out-of-house efforts in the burgeoning area of electronics technology; and most important of all, it will provide a easy path for the early exploitation of advanced techniques or developments for space flight, whatever their source.

Thank you, Mr. Chairman.

Mr. KARTH. Thank you very much, Dr. Kelley. I see that our time has expired for the day.

I want to thank you very much for your very able presentation.

I'm sure the other committee members enjoyed it as much as I did and if there are no questions——

Mr. RANDALL. Just one, Mr. Chairman, in relation to charts or slides which you showed as the record is completed would you identify them, because some were displayed which were not attached and they are, certainly, not in the order of your context, if you could do that.

Dr. BISPLINGHOFF. Mr. Chairman, both Mr. Zimmerman and Dr. Kelley's verbal presentation was somewhat different than what they submitted for the record and——

Mr. KARTH. Thank you very much, Doctor, for bringing it to my attention.

Since we have already established the principle of having these put in the record, if there are no objections to that procedure, it will be so ordered.

Hearing nothing, both Mr. Zimmerman's and Dr. Kelley's prepared statements will be inserted in the record.

Dr. Kelley, the committee will be adjourned until 10:00 o'clock tomorrow morning.

(Whereupon at 12:15 p.m. the subcommittee was adjourned until 10 a.m. April 3, 1963.)

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APPENDIX A

INDUSTRIAL AND GOVERNMENTAL ELECTRONICS RESEARCH CAPABILITIES IN THE UNITED STATES

The following listings cover industrial and Federal governmental research laboratories and the areas of electronics and related subjects in which these laboratories have capabilities. Although many of these companies also conduct development, testing and evaluation in the electronics field, all companies listed have a research capability of a greater or lesser degree. Companies having primarily a development or production capability, and no research capability, are not listed. Only those Government laboratories primarily conducting a research operation are listed.[1] Further evaluation of the capabilities of these laboratories is dependent upon a knowledge of the professional personnel and the tasks and projects currently being undertaken.

INDUSTRIAL LABORATORIES HAVING CAPABILITIES IN ELECTRONICS AND RELATED DISCIPLINES

The laboratories shown in the following listing have a research capability in one or more areas of electronics and its associated disciplines. All laboratories shown have 25 or more personnel. This listing is based on the professional knowledge of the staff of the Directorate of Electronics and Control, Office of Advanced Research and Technology, on available Government documents, and on trade publications available to the staff working in the field.

A further listing of all small business concerns interested in performing research and development is contained in "Research and Development, List of Small Concerns Interested in Performing Research and Development," 609 pages, Small Business Administration, November 1961. This listing of 2,877 companies is indexed, showing individual firms, areas of capabilities, and number of scientists and/or engineers. A copy is submitted as an appendix to this material.

INDUSTRIAL RESEARCH LISTING

ACF Industries, Inc., New York, N.Y.:

ACF Electronics Division, Electro-Physics Laboratories, Bladensburg, Md.: Research capabilities in ionospheric propagation, HF communications, solid state techniques.

Electronics Division, Riverdale, Md.: Research capabilities in analog computers, digital devices, visual displays, automation, simulation and training, test and checkout.

Electronics Division, Paramus, N.J.: Research capabilities in infrared detection, data processing, industrial controls, microwave and communications equipment, television and display systems.

A.R.F. Products, Inc., River Forest, Ill.: Research capabilities in range instrumentation, major components for automated electronic checkout systems, laboratory test equipment, FM-signal generators and deviation meters, electronic remote control equipment, special electronic components, communications equipment and navigational aids.

A.R. & T. Electronics, Inc., Little Rock, Ark.: Research capabilities in radio frequencies and electronic, mechanical, and photoelectric devices.

Acton Laboratories, Inc., Acton, Mass.: Research capabilities in electronic instruments and space instrumentation.

[1] Definitions of "research" and "development" are based on the National Science Foundation's definitions:
Research is "systematic, intensive study directed toward fuller scientific knowledge of the subject studied. Such study covers both basic and applied research."
Development is "the systematic use of scientific knowledge directed toward the production of useful materials, devices, systems, or methods including design and development of prototypes and processes. It excludes quality control or routine product testing."
Test and Evaluation are categories used by the Department of Defense covering the processes in which objects developed are tested and evaluated to determine whether they meet the design requirements.

Adelphi College, Adelphi Research Center, Inc., Garden City, N.Y.: Research capabilities in instrumentation, solid state physics (ferroelectrical materials), electronic computation, applied mathematics.

Aero Design & Engineering Co., Bethany, Okla.: Research capabilities in aircraft and air science.

Aero Geo Astro Corp., Alexandria, Va.: Research capabilities in advanced radar, payload instrumentation, high temperature problems, dielectric measurements, microwave propagation.

Aero Service Corp., Philadelphia, Pa.: Research capabilities in analog and digital computers and devices, servomechanisms.

Aeronca Manufacturing Co., Middletown, Ohio: Research capabilities in instrumentation and telemetry, environmental testing.

Aerospace Division, Baltimore, Md.: Research capabilities in electronics, aerospace.

Aerovox Corp., New Bedford, Mass.: Research capabilities in capacitors, dielectrics, insulation, electrochemistry, component parts.

Hi-Q Division, Olean, N.Y.: Research capabilities in ceramics, dielectrics, capacitors, insulation, measurements.

Airborne Accessories Corp., Hillside, N.J.: Research capabilities in electromechanical components, automatic control systems, electrical rotating machinery.

Aircraft Armaments, Inc., Cockeysville, Md.: Research capabilities in electronic systems and components, classical physics, servomechanisms, controls.

Airpax Electronics, Inc., Fort Lauderdale, Fla.: Research capabilities in electronic amplifiers, electrical contact materials, magnetic circuits.

Alford, Andrew, Consulting Engineers, Boston, Mass.: Research capabilities in antennas, air navigation aids, wave propagation.

Allen-Bradley Co., Milwaukee, Wis.: Research capabilities in electrical arcs and contacts, solid state devices, fixed and variable resistors, ceramic capacitors, magnetic materials, semiconductors, resins.

Allied Record Manufacturing Co., Hollywood, Calif.: Research capabilities in development of manufacturing techniques for radar antenna and structural components.

Allied Research Associates, Inc., Boston, Mass.: Research capabilities in electronics and instrumentation, flight control and industrial control systems, and aircraft stability.

Allis, Louis, Co., Milwaukee, Wis.: Research capabilities in development of electric motors and generators, electrical and electronic control equipment, and insulation systems.

Allis-Chalmers Manufacturing Co., Milwaukee, Wis.: Research capabilities in applications of physics, electricity, and processing.

Alloyd Corp., Cambridge, Mass.: Research capabilities in electron beam processes; zone refining, welding, evaporation, melting; dimensional stability; and ultra-pure metals.

American Bosch Arma Corp., Springfield, Mass.:

American Bosch Division, Springfield, Mass.: Research capabilities in generators; voltage regulators, magentos; coils; vibrators; distributors, and condensers.

Arma Division, Garden City, N.Y.: Research capabilities in electronics, electromagnetics, computing equipment, gyroscopic equipment, and servo systems.

American Electronic Laboratories, Inc., Philadelphia, Pa.: Research capabilities in electronics: antennas, electromedical instrumentation, electrical noise, and microwaves.

American Enka Corp., Enka, N.C.: Wm. Brand-Rex Division, Concord, Mass.: Research capabilities in dielectric materials.

American Institute for Research, Pittsburgh, Pa.: Research capabilities in engineering psychology, systems and operations analysis, and measurement and evaluation.

American Institute of Engineering and Technology, Chicago, Ill.: Research capabilities in electronics and physics.

American Machine & Foundry Co., New York, N.Y.:

Central Research Laboratory, Samford, Conn.: Research capabilities in physical sciences and mathematics, particularly: solid state physics, and operations research.

Mechanics Research Division, Niles, Ill.: Research capabilities in engineering mathematics, automation, and automatic controls.

Research and Development Division, Advance Development Laboratory, Buffalo, N.Y.: Research capabilities in automatic mechanisms.

Research and Development Division, Mechanical Development Laboratory, Springdale, Conn.: Research capabilities in electromechanical devices.

Potter & Brumfield, Princeton, Ind.: Research capabilities in electromagnetic relays.

American Metal Climax, Inc., New York, N.Y.: AMCO Research & Development, Inc., Carteret, N.J.: Research capabilities in production and testing of semiconductors.

American Meter Co., Inc., Philadelphia, Pa.: Research capabilities in instruments for fluid measurement and control.

American Optical Co., Southbridge, Mass.:

Southbridge Group, Research Department: Research capabilities in geometrical and physical optics; optical and electronic instruments; vision, and thin films.

Instrument Group, Instrument Division, Buffalo, N.Y.: Research capabilities in electronic instrumentation; and special-purpose optical instrumentation.

Instrument Group, J. W. Fecker Division, Pittsburgh, Pa.: Research capabilities in gyroscope testing equipment, and optical instruments.

American Radiator & Standard Sanitary Corp., New York, N.Y.: Advanced Technology Laboratories, Mountain View, Calif.: Research capabilities in space-vehicle attitude control, data monitoring and display, temperature instrumentation, and electromechanical controls.

American Research & Manufacturing Corp., Rockville, Md.: Research capabilities in electronics.

American Telephone & Telegraph Co., New York, N.Y.:

Bell Telephone Laboratories, Inc., New York, N.Y.; Murray Hill, Whippany, Holmdel, and Chester, N.J.: Research capabilities in physics, mathematics, acoustics, high vacuum and solid state physics, electronics, magnetism; telephone transmission, including speech and hearing; transmission of telephone and television currents by radio; recording and reproducing of sound; switching and control of telephone circuits, including electromechanical, electronic, and other structures; electrical contacts employed in switching; new designs; application of the mathematical theory of probability to switching problems. Development and engineering activities: Switches, relays, condensers, coils, electron tubes, semiconductor devices, required in switching and transmission systems for telecommunication; service performance and improvement of designs; development and application of standards of quality for communication apparatus and systems; electrical communication systems combining communication apparatus and circuits, power equipment, and other equipment and electrical circuits essential to the control, switching, and supervision of communication circuits; transmission studies and development based on field and laboratory work, insuring adequate volume, intelligibility, and freedom from noise and other disturbing effects; current design.

Western Electric Company, Inc., New York, N.Y.; Princeton, N.J.: Research capabilities in systems and data processing; material and processes; semiconductors, traveling wave tubes, microwave tubes, and ferrite switches; automation techniques in assembly wiring and cable forming; capacitors, resistors, wiring; ferrite manufacturing; electronic control circuits; electronic devices for testing; computerized data processing; semiconductors and special-purpose electron tubes; automatic manufacturing facilities for microwave equipment; manufacturing techniques for ferrites, printed wiring, plating, and tantalum capacitors; guidance systems, components, gyros, apparatus, waveguides, relays, carbon deposited resistors, and radars.

Amperex Electronic Corp., Hicksville, N.Y.: Research capabilities in electronics, microwaves, and radiation detection.

Ampex Corp., Redwood City, Calif.: Research capabilities in magnetics, electron optics, and ferrites.

Amphenol-Borg Electronics Corp., Broadview, Ill.: Research capabilities in dielectric materials; radio-frequency cables, transmission lines, and connectors; RV, FM, and communications antennas; radar and radio components.

Andersen Laboratories, Inc., West Hartford, Conn.: Research capabilities in electronics.

Andrea Radio Corp., Long Island City, N.Y.: Research capabilities in electronics, television equipment, and special electronic devices.

Andrew Corp., Orland Park, Ill.: Research capabilities in antennas and transmission lines.

Anton Electronic Laboratories, Inc., Brooklyn, N.Y.: Anton-Imco Electronics Corp., New York, N.Y.: Research capabilities in instrumentation, and gas discharge tubes.

Applied Electronics Laboratories, Manhattan Beach, Calif.: Research capabilities in electronic instruments and computers; and medical instruments.

Applied Physics Corp., Monrovia, Calif.: Research capabilities in instruments for absorption spectroscopy, raman spectroscopy; refraction and polarization, electrometers, calorimeters.

Applied Psychology Corp., Arlington, Va.: Research capabilities in human engineering, systems analysis, and operations research.

Applied Radiation Corp., Walnut Creek, Calif.: Research capabilities in microwaves, including kystron tube development.

Applied Research Laboratories of Florida, Inc., Miami Springs, Fla.: Research capabilities in environmental testing, actual and simulated; and infrared spectrography.

Arizona, University of, Tucson, Ariz.: Numerical Analysis Laboratory: Research capabilities in numerical analysis, operations research, programing digital computers, information retrieval.

Armour Research Foundation of Illinois Institute of Technology, Chicago, Ill.: Research capabilities in physics.

Arnold Engineering Co., Marengo, Ill.: Research capabilities in magnetic materials; various types of high permeability alloys in solid and powder form, ceramics, including barium ferrite permanent magnets and barium titanate piezoelectric transducers.

Arnoux Corp., Los Angeles, Calif.: Research capabilities in telemetry, instrumentation, solid-state power converters, and magnetometers.

Astra, Inc., Raleigh, N.C.: Research capabilities in advanced theoretical analyses, space technology, and controls and computers.

Atlantic Research Corp., Alexandria, Va.: Research capabilities in electronics, communications, and optics.

U.S. Flare Division, Saugus, Calif.: Research capabilities in infrared radiation.

Auerbach Electronics Corp., Philadelphia, Pa.: Research capabilities in digital data processing and computation, digital communications systems, control, custom test equipment, systems engineering, and automation.

Austin Co., East Cleveland, Ohio: Austin Electronics, New York, N.Y.: Research capabilities in automatic controls; data recording and processing, gauging and measurement; automation.

Automatic Electric Laboratories, Inc., Northlake, Ill.: Research capabilities in communications systems; control systems; electromagnetic mechanical and electronic devices; and instruments.

Automatic Switch Co., Florham Park, N.J.: Research capabilities in electromagnetical control equipment.

Automation Industries, Inc., Manhattan Beach, Calif:

Automation Instruments, Inc., Boulder, Colo: Research capabilities in instrumentation piezoelectric transducers; and magnetic field instrumentation.

Magnetics Division, Boulder, Colo.: Research capabilities in microwave components.

Datran Division, Manhattan Beach, Calif.: Research capabilities in general instrumentation; strain gaging; digital recording systems; variable inductance pressure transducers; sub-carrier oscillators; servo converters.

Ultrasonics Division, Paramount, Calif.: Research capabilities in electronics.

Autometric Corp., New York, N.Y.: Research capabilities in electronics, specialized mechanical and optical equipment, color television, special purpose analog and digital computers.

Avco Corp., New York, N.Y.:

Avco-Everett Research Laboratory, Everett, Mass.: Research capabilities in high temperature gas dynamics, magnetohydrodynamics, thermodynamics; chemical physics, particularly dissociation and recombination of molecules, atoms, and ions in upper atmosphere.

Avco-Research and Advanced Development Division, Wilmington, Mass.: Research capabilities in space technology, materials, structures engineering, and medical science technology.

Crosley Division, Cincinnati, Ohio: Research capabilities in communications, radar, electronics, electronic ground support, infrared radiation,

radiation, air traffic control, electronic data transmission, and other basic electronics.

Bailey Meter Co., Cleveland, Ohio: Research capabilities in measurement, control data handling, and computing.

Baird-Atomic, Inc., Cambridge, Mass.: Research capabilities in optical and electronic systems; narrow band optical filters, transistor circuitry, specialized optical instrumentation, and crystal optics.

Baldwin-Lima. Hamilton Corp., Philadelphia, Pa.:

Electronics & Instrumentation Division, Waltham, Mass.: Research capabilities in electronics.

Loewy-Hydropress Division, New York, N.Y.: Research capabilities in electronic controls.

Loewy Construction Co., Inc., New York, N.Y.: Electromechanical and electronic controls.

Baldwin Piano Co., Cincinnati ,Ohio: A.R. & T. Electronics, Ind., Little Rock, Ark: Research capabilities in digital encoders, crystal development, special electronic devices.

Ball Brothers Research Corp., Boulder, Colo.: Research capabilities in electronics, servomechanisms, optics; balloon, rocket, and satellite instrumentation.

Barden Corp., Danbury, Conn.: Research capabilities in instrumentation.

Barkley & Dexter Laboratories, Inc., Fitchburg, Mass.: Research capabilities in instrumentation; communications; electronics; and optics.

Milligal Geoscience Laboratory: Research capabilities in gravity instrumentation system.

Barnes & Reinecke, Inc., Chicago, Ill.: Research capabilities in electronic guidance systems.

Barnes Engineering Co., Stamford, Conn.: Research capabilities in infrared components, instruments, and systems, including radiometers, thermistor IR detectors, IR scanners and trackers, IR sources, and radiation standards.

Bart Laboratories & Design, Inc., Newark, N.J.: Research capabilities in electrochemical devices in regard to light, sound, pressure, motion, and temperature; solid state semiconductors; wave guide manufacture.

Basic & Experimental Physics, Falmouth, Mass.: Research capabilities in operations research, numerical analysis, solid-state physics, electronics, cryogenics, communication theory, communications systems; and space environments.

Basic Products Corp., Milwaukee, Wis.: Sola Electric Co., Cicero, Ill.: Research capabilities in constant voltage a.c. and d.c. power supply; transformers for special uses.

Baso Inc., Milwaukee, Wis.: Research capabilities in thermoelectric generators.

Battelle Memorial Institute, Columbus, Ohio: Research capabilities in computer, electrical, human, reliability, and systems engineering; applied mathematics; electronics; information processing; instrumentation; operations research; semiconductors and solid-state devices.

Bausch & Lomb Optical Co., Rochester, N.Y.: Research capabilities in thin films, diffraction gratings, photography refractometry, colorimetry, polarimetry, and human vision; spectroscopy in visible, infrared, and ultraviolet spectra; electronics.

Bay State Research, Inc., Cambridge, Mass.: Research capabilities in crystal technology, precision electromechanical systems and control, and operations research.

Beckman Instruments, Inc., Fullerton, Calif.:

Berkeley Division, Richmond, Calif.: Research capabilities in high-speed counting and timing devices; analog computers.

Helipot Division, Fullerton, Calif.: Research capabilities in high temperature material for potentiometer elements; cermet composition; precision winding equipment; potentiometer linearity; expanded scale voltmeters, and ammeters; miniature synchros, resolvers, and motors; delay line techniques.

Scientific and Process Instruments Division, Fullerton, Calif.: Research capabilities in near infrared; far ultraviolet; gas chromatography, analytical; oxygen measurement and detection in closed and open environments; infrared spectroscopy, including high-temperature gases or fuels; CO^2 measurement in closed and open environments; instrumentation, including automatic data handling and processing combined with sensing elements.

Special Projects Division, Fullerton, Calif.: Research capabilities in components, instruments and systems for analysis, measurement, counting and control.

Systems Division, Anaheim, Calif.: Research capabilities in low-level multiplexing; advanced data handling techniques; digital circuitry; system

design, solid state or vacuum tube, including compilers; telemetry, data reduction systems; amplifiers, low-level d.c.; rapid-speed, solid-state counting equipment; conversion, digital to analog, analog to digital.

Los Angeles Computation Center, Los Angeles, Calif.: Research capabilities in development and application of analog simulation techniques.

Bell & Gossett Co., Morton Grove, Ill.: Dualex Division, Morton Grove, Ill.: Research capabilities in electronic communication systems, control systems, telemetering.

Bell & Howell Co., Chicago, Ill.: Research capabilities in optics.

Bell Helicopter Corp., Fort Worth, Tex.: Research capabilities in electronic devices to provide all-weather helicopter flight capabilities.

Belock Instrument Corp., College Point, N.Y.: Research capabilities in analog computers, radar simulators, transistorization and miniaturization.

Bendix Corp., Detroit, Mich.:

Bendix Products Division, South Bend, Ind.: Research capabilities in support equipment, guidance and discriminating equipment.

Bendix Radio Division, Towson, Md.: Research capabilities in steerable array radar, advanced communication systems, secure communications, molecular electronics, computer and data handling techniques, collision avoidance.

Bendix Systems Division, Ann Arbor, Mich.: Research capabilities in data processing, display, communications, guidance and control, radar, nucleonics, infrared radiation, acoustics, instrumentation, and support equipment.

Cincinnati Division, Cincinnati, Ohio: Research capabilities in development and design of scientific, nuclear, and industrial instruments.

Eclipse-Pioneer Division, Teterboro, N.J.: Research capabilities in automatic flight control systems, airborne digital computers, flight and navigational computers, gyros and reference systems, radar antenna equipment, cockpit instrumentation, components, support equipment.

Friez Instrument Division, Towson, Md.: Research capabilities in low-light-level closed circuit television.

Lakeshore Division, St. Joseph, Mich.: Research capabilities in servomechanisms, and miscellaneous controls.

Bendix-Mishawaka Division, Mishawaka, Ind.: Research capabilities in guidance and electromechanical systems, electronics, systems analysis, and controls.

Montrose Division, South Montrose, Pa.: Research capabilities in aircraft instrumentation, synchros, dynamotors, and d.c. motors.

Pioneer-Central Division, Davenport, Iowa: Research capabilities in cyrogenics, liquid measuring and sensing, test equipment and ground support equipment.

Red Bank Division, Eatontown, N.J.: Research capabilities in a.c. and d.c. power generating equipment for aircraft and missiles; inverters, converters, and regulators for aircraft and mobile equipment; microwave, gas, and receiving tubes and semiconductor devices.

Research Laboratories Division, Southfield, Mich.: Research capabilities in electronic, and electromechanical systems and controls; analog and gidital computers, microwave systems and components, electron tubes, solid state physics and instrumentation, and acoustics.

Scintilla Division, Sidney, N.Y.: Research capabilities in electrical connectors, ceramics; capacitors, cables and harnesses for communication equipment and test equipment.

York Division, York, Pa.: Research capabilities in electronics: subminiaturization, automatic test and control equipment.

Benson-Lehner Corp., Santa Monica, Calif.: Research capabilities in information processing, applied cybernetics; data banking; energy metamorphic physics; data reduction devices; and data display devices.

Documentation, Inc., Washington, D.C.: Research capabilities in the logic, mathematics, techniques, systems, and machines for data input, processing, retrieval, and use.

Bjorksten Research Laboratories, Madison, Wis.: Research capabilities in electronics and microwave physics.

Blanche, Ernest E., & Associates, Inc., Kensington, Md.: Research capabilities in mathematics, statistics, data processing computer design.

Blaw-Knox Co., Pittsburgh, Pa.: Blaw-Knox Equipment Division, Pittsburgh, Pa.: Research capabilities in antennas, radio telescopes.

Block Associates, Inc., Cambridge, Mass.: Research capabilities in physical optics, infrared spectroradiometry.

Boeing Airplane Co., Seattle, Wash.:

Boeing Scientific Research Laboratories: Research capabilities in solid state physics and infrared.

Aero-space Division, Avionics Section Laboratories, antennas and radomes: Research capabilities in development and design of all types of antennas for aircraft, including small aperture antennas (communication and navigation types) and large-aperture radar arrays (scanning and fixed); high-temperature solid dielectric materials; antenna breakdown and performance when immersed in a plasma.

Avionics Section Laboratories, automatic controls: Research capabilities in automatic flight controls.

Avionics Section Laboratories, computers, displays, and data processors: Research capabilities in data processors, digital and analog computers, displays.

Avionics Section Laboratories, Measurement & Inertial Technology Laboratories: Research capabilities in inertial navigation components, enviornmental instrumentation.

Avionics Section Laboratories, Radar Laboratory: Research capabilities in development and testing of radar systems and test equipment and of radio interference measurement and shielding techniques.

Space Medicine Laboratories: Research capabilities in miniaturized bio-instruments.

Systems Engineering Laboratories: Research capabilities in guidance and navigation, communications, and data-processing systems.

Transport Division, Renton, Wash., Electro-Dynamics Staff Laboratories: Research capabilities in acoustics, electricity, electronics, flight controls, solid state physics, optics and infrared, flight instruments, antennas, data processing.

Transport Division, Engineering, Computing, and Analysis Staff: Research capabilities in systems and operations research, mathematics, physics, numerical analysis, systems, and digital computing.

Boeing Flight Center, Seattle, Wash.: Research capabilities in design and development of airborne instrumentation systems, development of flight test data processing and reduction systems and methods.

Wichita Division, Wichita, Kans., Electrical and Electronics Section: Research capabilities in acoustics, antennas and propagation, communications, and solid state physics.

Wichita Division, Flight Test Section: Research capabilities in methods and systems of instrumentation applicable to new aircraft testing.

Bolt, Beranek, & Newman, Inc., Cambridge, Mass.: Research capabilities in applied physics, engineering, psychology, acoustics, instrumentation.

Booz-Allen Applied Research, Inc., Glenview, Ill.: Research capabilities in operations research, mathematics, reliability and statistics, electronics, instrumentation, physics and engineering.

Borg-Warner Corp., Chicago, Ill.:

Borg-Warner Controls, Santa Ana, Calif.: Research capabilities in RF instrumentation, transducers, magnetic tape recorders, data-processing equipment.

Pesco Products Division, Bedford, Ohio: Research capabilities in cryogenic pumps and associated equipment; power supplies (electric); static inverters; and unconventional power supplies.

Weston Hydraulics, Ltd., Van Nuys, Calif.: Research capabilities in valves and servomechanisms for aircraft and space applications.

Bowser, Inc., Fort Wayne, Ind., National Scientific Laboratories, Inc., Washington, D.C.: Research capabilities in electronics, communications.

Bristol Co., Waterbury, Conn.: Research capabilities in instruments; measurement, control, indication, and recording of temperature, pressure, flow, humidity, liquid level, electrical values, chemical content, and viscosity; telemetering means for remote indication, recording, and control; aircraft control instruments.

Broadview Research Co., Burlingame, Calif.: Research capabilities in data systems analysis, scientific computing, computer simulation, operations research, logistics, information storage and retrieval, control systems technology, numerical analysis, programing services; photogrammetry, geodesy, aerotriangulation, infrared and radar.

Brobeck, William M., & Associates, Oakland, Calif.: Research capabilities in quality control instrumentation, data processing development; scientific instrumentation.

Brooks Research, Inc., Rochester, N.Y.: Research capabilities in self-programing, automatic test equipment; computer programing; large-scale magnetic amplifier; special magnetic field design; high-speed storage systems and feasibility studies.

Brown, Dayton T., Inc., Long Island, N.Y.: Research capabilities in environmental tests of aeronautical, electronic, electromechanical applications; instrument calibration and standards.

Bulova Research & Development Laboratories, Inc., Woodside, N.Y.: Research capabilities in safety and arming, pressure-sensing, and infrared devices, subminiature electronic components.

Burnell & Co., Inc., Pelham Manor, N.Y.: Research capabilities in audio filters, telemetering; missile, communications, constant delay, subminiature, and piezoelectric delay networds and toroids; variable inductors.

Burroughs Corp., Detroit, Mich; Paoli, Pa.: Research capabilities in data processing equipment; electronic devices; and communications systems.

CG Electronics Corp., Albuquerque, N. Mex.: Research capabilities in digital and computing electronics, antennas, and telemetry design.

CTS Corp., Elkhart, Ind.: Research capabilities in variable resistors; semiconductors, development of designs, and testing to determine operating characteristics; electronic components.

California Eastern Aviation, Inc., Chicago, Ill.: Research capabilities in digital systems data collection, data reduction; airborne electronics; X-ray; nuclear energy.

Capehart Corp., Richmond Hill, N.Y.: Research capabilities in electronic instruments and measurement techniques; communications devices; radar and ECM techniques and equipment; interference reduction techniques.

Century Geophysical Corp., Tulsa, Okla.: Research capabilities in solid state electronics, instruments.

Cessna Aircraft Co., Wichita, Kans: Aircraft Radio Corp., Boonton, N.J.: Research capabilities in applications of electromagnetic wave propagation phenomena: application of solid state devices; properties of materials used in radio communication and navigation equipment; circuit and component development.

Clevite Corp., Cleveland, Ohio: Clevite Transistor Products, Waltham, Mass.: Research capabilities in semiconductor devices.

Clifton Precision Products Co., Inc., Clifton Heights, Pa.: Research capabilities in production engineering; aircraft electromagnetic instruments, airborne analog computer components, servomotors and servomechanism systems.

Cohu Electronics, Inc., San Diego, Calif.: Kin Tel Division, San Diego, Calif.: Research capabilities in low level d.c. amplifier development; analog to digital converters; closed circuit television; a.c. and d.c. calibration devices.

Coleman Engineering Co., Inc., Torrance, Calif.: Research capabilities in IR systems; electronic systems.

Collins Radio Co., Cedar Rapids, Iowa: Research capabilities in radio communications equipment for aviation, amateur, broadcasting, and general communications services; navigational aids, radar and fire-control equipment; UHF and microwave communications; missile electronics; propagation studies; radio astronomy; servomechanisms; flight control, space communications and navigation systems.

Columbia Broadcasting System, New York, N.Y.:

CBS Laboratories Stamford, Conn.: Research capabilities in solid state physics, including semiconductor devices; vacuum physics; recording systems (audio, data, video); magnetics; acoustics; data display and character generators; optics.

CBS Electronics, Danvers, Mass.: Research capabilities in microelectronic, semiconductor devices, thermionic tubes, special cathode ray devices.

CompuDyne Corp., Hatboro, Pa.: Research capabilities in feedback controls-systems and instrumentation; electronic, electromechanical, and electrohydraulic; pressure, level, and weight transducers.

Computer Control Co., Inc., Framingham, Mass.:

Eastern Division, Framingham, Mass.: Research capabilities in special purpose digital systems, digital modules, coincident current memories.

Western Division, Los Angeles, Calif.: Research capabilities in special purpose digital systems, digital modules, coincident current memories.

Computer Instruments Corp., Hempstead, N.Y.: Research capabilities in electronic components, electromechanical computation and control, solid state devices, extreme environments reliability, conductive film techniques, conductive plastics.

Consolidated Diesel Electric Corp., Stamford, Conn., Consolidated Avionics Corp., Long Island, N.Y.: Research capabilities in data processing, automation, space technology.

Consolidated Electrodynamics Corp., Pasadena, Calif., Central Research Division, Pasadena, California.: Research capabilities in solid state devices, magnetic tape recording, transducers for measuring vibration strain and pressure, mass spectrometry, chromatography, electrochemistry, electronics.

Datalab Division, Pasadena, Calif.: Research capabilities in digital data handling equipment; magnetic tape recording.

Datatape Division, Pasadena, Calif.: Research capabilities in advanced analog and digital magnetic record/reproduce systems, magnetic head development, magnetic tape and accessories.

Emi Division, Pasadena, Calif.: Research capabilities in development of analog data recording instruments, electronic signal conditioning equipment, military electrical connectors, transistorized portable test instruments.

Continental Oil Co., Ponca City, Okla.: Research and Development Department, Research Services Division: Research capabilities in automation, electronics, separations, mass spectrometry, molecular spectroscopy.

Cornell Aeronautical Laboratory, Inc., Buffalo, N.Y.: Research capabilities in electronics, flight testing, instrumentation.

Cornell-Dubilier Electric Corp., Norwood, Mass.: Research capabilities in dielectrics and insulating materials, solid state, semiconductor devices, magnetics, and high voltage.

Cubic Corp., San Diego, Calif.: Research capabilities in electronic distance and angle measuring, spatial geodesy, missile and satellite tracking.

Cutler-Hammer, Inc., Milwaukee, Wis.: Airborne Instruments Laboratory, Long Island, N.Y.: Research capabilities in electronics, including data handling, receiving and reconnaissance devices, microwave equipment, antennas, medical electronics, radar, navigation and traffic control devices, industrial control and gaging.

Dallons Laboratories, Inc., Los Angeles, Calif.: Research capabilities in medical electronics, solid state devices, and space technology.

Daven Co., Livingston, N.J.: Research capabilities in precision wire-wound resistors; molding and encapsulating material; development of high-speed rotary switches, test equipment, and special types of attenuators and potentiometers.

Daystrom, Inc., Murray Hill, N.J.:

Corporate Central Research Laboratory, West Caldwell, N.J.: Research capabilities in electronic measurements, semiconductors, and data and control systems.

Control Systems Division, La Jolla, Calif.: Research capabilities in automatic control systems based on digital and analog computers.

Weston Instruments Division, Newark Laboratory, Newark, N.J.: Research capabilities in electrical indicating and measuring instruments.

Military Electronics Division, Archbald, Pa.: Research capabilities in electromechanical devices and systems for control and data display, training simulators, and digital computer systems.

Pacific Division, Los Angeles, Calif.: Research capabilities in free and rate gyros, precision motion transducers, potentiometers, and instrumentation systems.

Transicoil Division, Worcester, Pa.: Research capabilities in instrument servosystems and components.

Decker Corp., Bala Cynwyd, Pa.: Research capabilities in communication and transmission of data by modulated light, measurement of mass flow of liquid and gas, special instrumentation problems, and measurement and control systems.

Del Mar Engineering Laboratories, Los Angeles, Calif.: Research capabilities in training systems, microwave (radar) techniques in combination with optical film techniques in measurement of distance, remote control devices (radio controlled), infrared simulation, pyrophoric fuels, blood flow measurement in intact veins, flight sequence and operation timers, d.c. servomotors, and high beta transistors.

Designers for Industry, Inc., Cleveland, Ohio: Research capabilities in electronics, mechanical engineering, fluid engineering, and controls and instrumentation.

Development Engineering Corp., Washington, D.C.: Research capabilities in communications systems design, antenna design, propagation, and substrata communications.

Devenco, Inc., New York, N.Y.: Research capabilities in electronics (all frequencies), including radar, communications, and servomechanisms; theory of correlation techniques, optimum filters, basic communication systems, and infrared.

Dewey Corp., G. C., New York, N.Y.: Research capabilities in electronics, design and development of radars, digital computers, specialized recording, data handling and conversion systems.

Dictograph Products, Inc., Jamaica, N.Y.: Research capabilities in acoustics, transducers and audiometry, electronic circuits for communication devices, magnetic field and field distribution in closed magnetic circuits and in free space radiation.

Djordjevic Engineering Co., Chicago, Ill.:

Research Division,Chicago, Ill.: Research capabilities in semiconductors, solid state physics, digital and analog computers, plasma, electromagnetic radiation, antenna, microwave, instrumentation, automatic control devices and systems, ultraregulated power supplies, and electronics.

Djeco Division, Chicago, Ill.: Research capabilities in semiconductors, solid state physics, digital and analog computers, plasma, electromagnetic radiation, antenna, microwave, instrumentation, automatic control devices and systems, ultraregulated power supplies, and electronics.

Dorne & Margolin, Inc., Westbury, N.Y.; Research capabilities in microwave antennas and circuits.

Dorsett Laboratories, Inc., Norman, Okla.: Research capabilities in electronics and optics.

Douglas Aircraft Co., Inc., Santa Monica, Calif.:

Testing Division. Santa Monica Plant, Santa Monica, Calif.

Aerophysics Laboratory & Development Testing, El Segundo Plant, El Segundo, Calif.

Development Test, Tulsa, Okla.

Research capabilities in aircraft, space, and related systems and components; acoustics and vibration, automatic controls, data processing and computing, materials and process, normal and extreme environment, nuclear and isotope applications, structures and metallurgy, and thermodynamics and heat transfer.

DuMont, Allen B., Laboratories, Inc., Clifton, NJ.: Research capabilities in electronic tube cathode ray oscilloscopes; industrial television, and electronic instrumentation.

Dunn Engineering Associates, Inc., Cambridge, Mass.: Research capabilities in equipment and systems in the electronics and microwave fields, radar and guidance, industrial control, and specialized test equipment.

Dyna-Empire, Inc., Garden City, N.Y.: Research capabilities in electroacoustics.

Dynamics Corp. of America, New York, N.Y.:

Radio Engineering Laboratories, Long Island City, N.Y.: Research capabilities in point-to-point FM communications, wide band tropospheric scatter and line-of-sight transmission systems, single sideband point-to-point communication systems.

Reeves Instrument Corp., Garden City, Long Island, N.Y.: Research capabilities in space guidance and control, range instrumentation radar systems, electronic computing systems, servomechanisms, automatic control systems, gyroscopes, accelerometers, and resolvers.

Dynatronics, Inc., Orlando, Fla.: Research capabilities in antennae and antenna systems, and digital electronic circuitry.

Eder Engineering Co., Inc., Milwaukee, Wis.: Research capabilities in electronic and electromechanical test equipment.

Edgerton, Germeshausen & Grier, Inc., Boston, Mass.: Research capabilities in hydrogen thyratron and rectifier; electric flash; and spark gap.

Edo Corp., College Point, N.Y.: Research capabilities in electronics.

Eitel-McCullough, Inc., San Carlos, Calif.: Research capabilities in electron tubes, high-power klystrons, traveling-wave tubes, reflex klystrons, voltage-tunable magnetrons, negative-gride tubes; electron and plasma physics.

Electric Autolite Co., Toledo, Ohio:

Battery Engineering Laboratory, Toledo, Ohio: Research capabilities in lead-acid storage batteries; electrochemical power sources systems; nickel-cadmium, silver-zinc; and electrical circuitry in battery application.

Electrical Products Group, Toledo Engineering, Toledo, Ohio: Research capabilities in alternators, starting motors, and drive clutches; generators

(d.c), traction motors, centrifugal governors, solenoids, relays and controls, distributors, condensers, ignitors, transistorized ignition regulators, transistorized regulators, high- and low-voltage ignition systems.

General Products Group, Port Huron Engineering Laboratory, Port Huron, Mich.: Research capabilities in cable design, materials evaluation for wire and cable, new wire and cable construction; ignition coils and electronic ignition systems, instruments and gauges; wire and cable for electronic and electrical application.

Spark Plug Division, Ceramics Laboratory, Fostoria, Ohio: Research capabilities in nuclear control material, and neutron poisoned ceramics; high temperature insulation, metalizing ceramics, electronic applications, semiconductors; ceramic micro-wave absorbers; and glass-to-metal seals.

Electric Storage Battery Co., Philadelphia, Pa.: Carl F. Norberg Research Center, Yardley, Pa.: Research capabilities in new and improved electrochemical systems and related areas; designing new and improved batteries for industrial and military applications.

Electrical Testing Laboratories, Inc., New York, N.Y.: Research capabilities in illuminating engineering, light source photometry, light transmitting and diffusing media; wire and cable; insulating materials, plastics; air filtering media, air conditioning; and radiometry and spectrophotometry.

Electro-Mechanical Research, Inc., Sarasota, Fla.: ASCOP Division, Princeton, N.J.: Research capabilities in electronics, data processing, communications, and instrumentation.

Electro-Mechanics Co., Austin, Tex.: Research capabilities in radiofrequency measurements and interference analysis, and magnetic measurements.

Electronic Communications, Inc., St. Petersburg, Fla.: Research capabilities in electronic systems; microwave and millimeter wave techniques, including ferrites; antennas and infrared devices.

Electronic Engineering Co. of California, Santa Ana, Calif.: Research capabilities in electronic circuits, data processing systems and precision timing equipment.

Electronic Measurements Co., Inc., Eatontown, N.J.: Research capabilities in regulated d.c. power supplies, tube-type and transistorized; precision calibrated power supplies, d.c. amplifiers, test and measurement instruments, a.c. voltage regulators.

Electronic Research Associates, Inc., Cedar Grove, N.J.: Research capabilities in transistor components, circuitry, instrumentation, and new products; new measurement processes; and sonics and ultrasonics.

Electronic Specialty Co., Los Angeles, Calif.:

ESCO Group, Los Angeles 39, Calif.: Research capabilities in electronic components and systems for space vehicles, aircraft and missiles; antenna systems and components; and shock and vibration resistant control relays.

Systems Laboratories Division, Los Angeles, Calif.: Research capabilities in space systems, aeronautics, mechanics, electronics, missile systems, automatic control, and computer systems.

Technicraft Division, Thomaston, Conn.: Research capabilities in microwave components and transmission (rigid and flexible); precision microwave measuring techniques.

Electronic Systems Development Corp., Ventura, Calif.: Research capabilities in special purpose digital and analog computers; solid state commutators and other solid state electronic devices, including amplifiers, power supplies, frequency to d.c. voltage converters, power switches and digital modules; liquid rocket engine control malfunction protection systems, other instrumentation and control systems.

Electronic Tube Corp., Philadelphia, Pa.: Research capabilities in cathode ray tubes, circuits, oscilloscopes; chemistry, mathematics.

Electronics Associates, Inc., Long Branch, N.J.: Research capabilities in analog computers, datalogging E.D.P., X–Y plotters, D–A and A–d converters.

Princeton Computation Center, Princeton, N.J.: Research capabilities in communications, system optimization; continuous data processing via analog computing techniques.

Electronics Corp. of America, Cambridge, Mass.: Research capabilities in photoelectric and other industrial controls, and photoconductors.

Electro-Optical Systems, Inc., Pasadena, Calif.: Research capabilities in advanced propulsion (ion, plasma); energy and advanced power sources; heat rejection in space; guidance, homing, control, and communications (pulsed optical techniques); phenomenological electronics; multifunctional microminiaturization; space defense systems.

Electro-Pulse, Inc., Culver City, Calif.: Research capabilities in data handling systems, pulse generation and timing, modulation systems, industrial control, automatic test systems, radar systems.

Electro-Voice, Inc., Buchanan, Mich.: Research capabilities in acoustics, electronics, and allied fields.

Elgin National Watch Co., Elgin, Ill.: Miniature devices in electronics, electrochemistry, solid state physics, and associated fields.

Elgin Micronics Division, Elgin, Ill.: Research capabilities in electromechanical timing instruments; electronics.

Elgin Micronics—West Coast, Chatsworth, Calif.: Research capabilities in miniature electromechanical devices.

Emerson Radio & Phonograph Corp., Jersey City, N.J.: Emerson Research Laboratories, Division of Emertron, Inc., Silver Spring, Md.: Research capabilities in airborne electronic systems, beacons, trainers and simulators, navigational aids, altimeters, recorders, weather and electronic reconnaissance, test equipment, and communications.

Empire Devices, Inc., Amsterdan, N.Y.: Research capabilities in communications and RF interference and field intensity measuring equipment, microwave components, radar interference blankers, special power supplies.

Engleman & Co., Inc., Washington, D.C.: Research capabilities in electromagnetic radiation, information storage and retrieval, communications, and electronics.

Erie Resistor Corp., Erie, Pa.: Research capabilities in electronic components and modules; ceramic dielectrics; organic coatings; semiconductors; electronic circuitry; digital electronic instruments: and electromechanical assemblies.

Executone, Inc., New York, N.Y.: Adams Laboratories, Inc., Long Island City, N.Y.: Research capabilities in electronics, particularly audiocommunication and signaling.

FXR, Inc., Woodside, N.Y.: Research capabilities in microwave test equipment; electronic instrumentation; radar components and subsystems; high power pulse modulators; and high-voltage power supplies.

Fairbanks, Morse & Co., Chicago, Ill.: Research capabilities in electronics, electrical machinery.

Fairchild Camera & Instrument Corp., Long Island, N.Y.:

Defense Products Research & Engineering Department, Long Island, N.Y.: Research capabilities in systems and subsystems; test instrumentation; cameras and processing equipment; tactical ground support equipment; reconnaissance, satellites; data gathering, processing and transmission; radar optics and nucleonics; testing of entire systems in the environment of extremely high altitudes and subject to satellite operating conditions.

Graphic Division, Long Island, N.Y.: Research capabilities in photoelectric engraving equipment; punched tape analog computers; color computers; electro-optical rectifiers; and electromagnetic transducers.

Fairchild Controls Corp., Components Division, Hicksville, N.Y.: Research capabilities in precision electromechanical components and sensing devices.

Fairchild Semiconductor Corp., Mountain View, Calif.: Research capabilities in semiconductor devices.

Fairchild Stratos Corp., Hagerstown, Md.:

Fairchild Aircraft & Missiles Division, Hagerstown, Md.: Research capabilities in antennas and avionics.

Astrionics Division, Wyandanch, N.Y.: Research capabilities in electronic devices and systems.

Fansteel Metallurgical Corp., North Chicago, Ill.: Research capabilities in W, Mo, Ta, Cb, and their alloys; special nonferrous alloys; powder metallurgy of rare refractory metals; wet and solid electrolytic capacitors; electrolytic rectifiers; silicon rectifiers; electrical contacts and their applications; and rare-metal and hard carbides.

Farrington Manufacturing Co., Needham Heights, Mass.: Intelligent Machines Research Division, Alexandria, Va.: Research capabilities in character recognition, optical scanning techniques, pattern interpretation, data processing systems, and computer logic and circuitry.

Federal Manufacturing & Engineering Corp., Garden City, N.Y.: Research capabilities in electronic circuitry; tracking cameras; medical electronics; and environmental testing.

Federal Scientific Corp., New York, N.Y.: Research capabilities in coherent radar systems and subsystems, special computer accessories, radar simulation techniques and equipment, special high resolution filters, highly phase-stable amplifiers and frequency multipliers, and acoustics.

Filtron Co., Inc., Flushing, Long Island, N.Y.: Research capabilities in radio frequency interference measurement, analysis, and control; RF interference filters; special application capacitors; and pulse packages and delay lines.

Flame Research, Inc., Pittsburgh, Pa.: Research capabilities in infrared radiation; visible and infrared optics; system analysis; and analog and digital computers.

Flite Tronics Inc., Burbank, Calif.: Research capabilities in electronics and electricity.

Fluke, John, Manufacturing Co., Inc., Seattle, Wash.: Research capabilities in differential a.c. and d.c. voltmeters: high voltage, precision calibrated and general purpose power supplies; electronic wattmeters; voltage dividers.

Ford Motor Co., Dearborn, Mich.:

Engineering & Research Laboratory, Dearborn, Mich.: Research capabilities in acoustics, cryogenics, paramagnetic and nuclear resonance, thermoelectricity; optical materials, devices, and systems; radiation effects, electrochemistry, physical electronics, electronic structures, gas discharge phenomena, microwave phenomena, electromechanical servomechanisms, control systems, semiconductor devices, instrumentation.

Aeronutronic Division, Newport Beach, Calif.: Research capabilities in computer products and systems; satellite range instrumentation equipment; products and systems applicable to space vehicles, travel, and communications; and atomic, molecular, and atmospheric physics.

Franklin Institute of the State of Pennsylvania, Philadelphia, Pa.: Research capabilities in electromechanics, electronics, magnetics and semiconductors, nuclear systems and power and control systems.

Frederick Research Corp., Wheaton, Md.: Research capabilities in measurements predictions and suppression of radio frequency interference, development and evaluation of communications equipment systems, reliability and quality control, microwave systems engineering and component design, experiment design, test equipment evaluation, and management.

Freed Transformer Co., Inc., Brooklyn, N.Y.: Research capabilities in transformers, reactors, magnetic amplifiers, toroid inductors, filters, laboratory test equipment.

Friden, Inc., San Leandro, Calif.: Research capabilities in integrated data processing machines.

G-M Laboratories, Inc., Chicago, Ill.: Research capabilities in components for servosystems; electrical and photographic products; electrical instruments.

GPE Controls, Chicago, Ill.: Research capabilities in automatic control systems, electronics, and measuring instrumentation.

Gabriel Co., Cleveland, Ohio: Gabriel Electronics Division, Millis, Mass.: Research capabilities in antenna electronics; prototype high-frequency communications and radar antenna systems, including drive mechanisms, controls, and related transmission line circuitry for fixed station, vehicular, marine, and airborne applications.

General Applied Science Laboratories, Inc., Westbury, Long Island, N.Y.: Research capabilities in electronics and related fields of aero and space technology.

General Atronics Corp., Bala-Cynwyd, Pa.: Research capabilities in electronics, signal and information handling; and automated learning.

General Cable Corp., New York, N.Y.: Research capabilities in electric wires and cables, including new designs; properties of conductors, of dielectrics, and of protective covering materials.

General Communication Co., Boston, Mass.: Research capabilities in microwave measurement techniques and test equipment.

General Devices, Inc., Princeton, N.J.: Research capabilities in telemetry, data reduction, and thermoelectricity.

General Dynamics Corp., New York, N.Y.:

General Atomic Division, San Diego, Calif.: Research capabilities in solid state physics and radiochemistry.

Convair, San Diego, Calif.: Research capabilities in electromagnetic propagation, electronic systems, and solid state physics.

Electric Boat, Groton, Conn.. Research capabilities in sound and vibration, operations research, engineering psychology, simulation techniques, and systems analysis.

Stromberg-Carlson, Rochester, N.Y.: Research capabilities in air navigation, hydroacoustics, human communications, coding, logic circuits, semiconductors, magnetic materials, dielectric materials, defect solid state, signal propagation and detection, data processing, storage, readout, and display;

speech analysis and bandwidth compression; underwater acoustics; and air acoustics.

General Electric Co., Schenectady, N.Y.:

Research Laboratory, Schenectady, N.Y.: Research capabilities in physics, mathematics, and engineering in such areas as: plasma physics; physical, solid state, and high-frequency electronics; information systems.

General Engineering Laboratory, Schenectady, N.Y.: Research capabilities in acoustics, arc and circuit interruption, bearings, computing circuits and systems, electronics, electron optics, energy conversion, high frequency, high voltage, information processing, magnetics, mathematical methods, materials engineering, microwaves, stress analysis, superconductivity, thermal systems, and vacuum systems.

Component Products Division, Laboratory Operation, Fort Wayne, Ind.: Research capabilities in small motors, generators, relays, dry-type transformers, ballasts, and related electrical components.

Computer Laboratory, Palo Alto, Calif.: Research capabilities in circuit devices and systems; logic research and synthesis; computer peripheral device research and development.

Advanced Projects and Laboratories Operation, Erie, Pa.: Research capabilities in electromagnetics; organic and inorganic insulating materials; insulation systems; and equipment development.

Electronics Laboratory, Syracuse, N.Y.: Research capabilities in electronics and related fields involving materials, devices, techniques, equipment, and systems.

Measurements Laboratory, West Lynn, Mass.: Research capabilities in photoconductive and photovoltaic materials for photometric measurements; thermoelectric and resistance materials for high-temperature measurements; electronic sensors; solid state amplifiers; magnetic modulators; analog recorders; and indicators and control systems.

Materials and Processes Laboratory, Erie, Pa.: Research capabilities in physics (data reduction, solid state devices, electrical phenomena); mathematics (matrixes, computer techniques—analog and digital); and metallurgy (conductor materials, magnetic materials).

Advanced Engineering and Laboratory Subsection, Medium A. C. Motor & Generator Department, Schenectady, N.Y.: Research capabilities in electromagnetics; dielectric and insulation theory; instrumentation and measurements; and materials evaluation.

Space Sciences Laboratory, Philadelphia, Pa.: Research capabilities in physics and dynamics of partially ionized gases; plasma dynamics, guidance, communications and detection, orbits and trajectories; and extra-atmospheric vehicles.

Microwave Laboratory, Palo Alto, Calif.: Research capabilities in new microwave tube types and related microwave components, including focusing devices, cathodes, attenuators, couplers, slow-wave structures, duplexers, and microwave filters.

Laboratory Operation, Switchgear & Control Division, Philadelphia, Pa.: Research capabilities in initiating, controlling, and interrupting the flow of electric power; materials and processes engineering in electrical, insulation, and fields associated with switchgear and control equipment and devices.

Materials & Processes Laboratory, Bridgeport, Conn.: Research capabilities in properties of polymers, with particular reference to their use in wire and cable products.

General Instrument Corp., F. W. Sickles Division, Chicopee, Mass.: Research capabilities in inductors, radio frequency tuning assemblies; cathode ray deflection units; variable condensers; rod antennas; FM tuners; magnetic amplifiers; transistor power supplies; audio, supersonic, and RF filters; toroids; and delay lines.

General Kinetics, Inc., Arlington, Va.: Research capabilities in engineering, mathematics, physics, digital computers, magnetic recording.

General Laboratory Associates, Inc., Norwich, N.Y.: Research capabilities in ceramics, semiconductors, cold cathode rectifiers, spark gaps, capacitors, and transformers. A radio interference laboratory is maintained.

General Mills, Inc., Minneapolis, Minn.:

Central Research Laboratories, Minneapolis, Minn.

Mechanical Division Research Department, Minneapolis, Minn.

Larro Research Farm, Indianola, Iowa:

Research capabilities in solid state and electron physics; surface chemistry; radiation physics; meteorology; servomehcanisms; fine particle

technology; analog and digital computers; microwave technology; and stress analysis.

Magnaflux Corp., Chicago, Ill.: Research capabilities in nondestructive testing; magnetic particle, penetrant, electronic, and ultrasonic.

General Motors Corp., Detroit, Mich.:

General Motors Technical Center, Warren, Mich.: Research capabilities in physics of metals; semiconductors; solid state electronics; isotope development and applications; rational mechanics; and operations research simplified computer programing.

Allison Division, Indianapolis, Ind.: Research capabilities in aircraft gas turbines, power shafting, and remote reduction gearboxes; heavy-duty transmissions for off-the-road vehicles, buses, trucks, and marine and industrial applications; and precision sleeve-type bearings.

Aeroproducts Operations, Dayton, Ohio: Research capabilities in electronic and hydraulic control systems; hydraulic and electric and pneumatic actuator systems; hydraulic servo control valves; emergency ram-air generators and pumps; ram-air drive systems; and auxiliary power systems.

Delco Applicance Division, Rochester, N.Y.: Research capabilities in magnetics, thermoelectric devices, electromagnetic devices, and electronics.

Delco Products Division, Dayton, Ohio: Research capabilities in electrical and electronic products.

Delco Radio Division, Kokomo, Ind.: Research capabilities in two-way communication radios, including loudspeakers, automatic tuners, and printed circuits; electronic and other vehicular heater and air conditioner controls; static inverters and converters; analog and servo electronics; digital computers and components; transistors and rectifiers, particularly power type; solar cells; and thermoelectric devices.

General Precision, Inc., New York, N.Y.:

GPL Division, Pleasantville, N.Y.

Kearfott Division, Little Falls and Clifton, N.J.; Cambridge, Mass.; and Van Nuys, Calif.

Librascope Division, Glendale, Burbank, and Sunnyvale, Calif.

Link Division, Binghamton, N.Y.; Palo Alto, Calif.; and Dayton, Ohio: Research capabilities in airborne and shipboard electronics; computer techniques; simulation techniques; advance navigation and guidance-in-space technology; general industrial and military electronics; high precision instruments and system and human engineering.

General Radio Co., West Concord, Mass.: Research capabilities in electrical and electronic measurement techniques, acoustic measurements, frequency standardization, stroboscopy.

General Railway Signal Co., Rochester, N.Y.: Research capabilities in devices and systems for air traffic control, tower-center coordination and interlocking, and high-speed checked communication systems.

General Time Corp., New York, N.Y.:

Central Research Laboratory, New York, N.Y.

Chicago Laboratory, Chicago, Ill.

Research capabilities in time systems, programing, data processing; motors, rotary solenoids; and other electronic and electromechanical devices.

Genesys Corp., Los Angeles, Calif.: Research capabilities in digital computer circuits, memory development magnetic material, display and human engineering.

Genisco, Inc., Los Angeles, Calif.: Genistron, Inc., Los Angeles 45, Calif.: Research capabilities in instrumentation, guidance, radio interference, filter, ground support, test equipment, environmental inertial guidance packages and gyros.

Geophysical Research Corp., Tulsa, Okla.: Research capabilities in geophysical instruments and methods.

Geophysics Corp. of America, Boston, Mass.: Research capabilities in geoastrophysics group—geophysics and astrophysics; atmospheric chemistry; plasma, radiation, atomic, molecular, planetary, and high temperature physics; electronic, mathematic, ultra high vacuum magneto-hydrodynamics; and gas electrodynamics.

Geotechnical Corp., Dallas, Tex.: Research capabilities in data detection, transmission, handling, and reduction; electrical engineering; development an manufacture of electromechanical instruments and systems.

Gibbs Manufacturing & Research Corp., Janesville, Wis.: Research capabilities in electronic and electric musical instruments, acoustics, electromechanical assemblies.

Globe Industries, Inc., Electronic Division, Belleville, N.J.: Research capabilities in radio communication and radar techniques, and transistor applications.

Globe Union, Inc., Milwaukee, Wis.:

Battery Division: Research capabilities in batteries and other electrochemical power sources.

Centralab Division: Research capabilities in resistoring and metallizing on plastics and ceramics; ceramic dielectrics and insulators; and insulating coatings.

Good-All Electric Manufacturing Co., Ogallala, Nebr.: Research capabilities in capacitors (tubular, disc, electrolytic); controlled power supplies; transistorized testing equipment for special purposes; microwave, beam tube focusing electromagnets; and foil-type transformers.

Goodyear Aircraft Corp., Akron, Ohio: Research capabilities in astronautics—systems, material and electronic applications, including guidance; support equipment; and special devices. Aerodynamics and electronics—fluid mechanics; thermodynamics of jet propulsion; heat pumps; linear and nonlinear analog computers; electronic navigational systems; autopilots; high-resolution and airborne radar; simulators and training devices; special instruments and devices for structural and flight tests; specialized assemblies, such as structural and mechanical components of large radar antenna systems and towers; and ground support equipment.

Graflex, Inc., Rochester, N.Y.: Research capabilities in electronic equipment.

Gray Research & Development Co., Hartford, Conn.: Research capabilities in audio recording and reproducing systems; television, video, and radio frequency techniques; radio frequency altimeter development; electromechanical devices.

Grumman Aircraft Engineering Corp., Bethpage, N.Y.: Research capabilities in instrumentation and avionic systems as related to boats, aircraft, missiles, and space vehicles.

Guardian Electric Manufacturing Co., Chicago, Ill.: Research capabilities in electromechanics.

Gulton Industries, Inc., Metuchen, N.J.: Research capabilities in medical electronic instrumentation; solid state transducers and devices; applied information theory; ultrasonics; and technical ceramics.

Hammarlund Manufacturing Co., Inc., New York, N.Y.: Research capabilities in radio and wire remote supervisory controls; telemetering; radio communication receivers and transmitters; variable radio capacitors.

Harris-Intertype Corp., Cleveland, Ohio:

Gates Radio Division, Quiucy, Ill.: Research capabilities in AM-FM-TV broadcast transmitters and controls; automatic studio equipment; single sideband radio transmitters and receivers; magnetic tape recording equipment; and audio and video instruments and controls.

PRD Electronics Division, Brooklyn, N.Y.: Research capabilities in microwave instruments, test equipment, and power sources; electronic instruments and test equipment; and cryogenic masers.

Harvard University, Littauer Statistical Laboratory, Cambridge, Mass.: Research capabilities in statistical programing and computing.

Harvey-Wells Electronics, Inc., Southbridge, Mass.: Research capabilities in high speed (5–10 mc.) solid state digital logic; nuclear magnetic resonance instrumentation; high precision electromagnets; high speed (10 mc.) digital counters; and scalers.

Hazeltine Corp., Little Neck, N.Y.:

Hazeltine Research Corp., Plainview, N.Y. and Chicago, Ill.

Wheeler Laboratories, Inc., Great Neck, N.Y.

Hazeltine Technical Development Center, Indianapolis, Ind.,

Research capabilities in space guidance and navigation communication systems; microwave components; signal processing; solid state devices; antennas; microminiaturization; and advanced radar systems.

Hermes Electronics Co., Cambridge, Mass.: Research capabilities in crystal filters, electronic computer, and digital systems, frequency standards, design of communications systems utilizing microwave techniques and scatter-propagation theory, including antenna design; physics and design of complementary laboratory equipment.

Hewlett-Packard Co., Palo Alto, Calif.: Research capabilities in development of electronic instruments; solid state devices, photoconductor and vacuum electronics, and ferrite applications.

F. L. Moseley Co., Pasadena, Calif.: Research capabilities in instrumentation and development of electronic measuring devices.

High Voltage Engineering Corp., Burlington, Mass.: Goodrich-High Voltage Astronautics, Burlington, Mass.: Research capabilities in high-voltage electrostatic particle accelerators; microwave linear accelerators and associated apparatus for use in supervoltage X-ray therapy, industrial radiography, and nuclear physics research; radiation chemistry; radiobiology; electron beam sterilization; applied neutron and charged-particle studies; custom equipment components, including acceleration tubes, magnets, stabilized power supplies and magnetic beam deflection systems, charged-particle beam-focusing systems, high vacuum equipment, ion sources, and special electronic apparatus and controls; and ion propulsion devices.

Hill Electronics, Inc., Mechanicsburg, Pa.: Research capabilities in frequency standards and devices, especially low to audio frequency quartz crystals; ultraprecise oscillators, ultra low-frequency crystal filters; specialized components required in these areas; and piezo-electric effect and applications.

Hoffman Electronics Corp., Los Angeles, Calif.:

Hoffman Science Center, Santa Barbara, Calif.: Research capabilities in solid state materials, principally semiconductors information theory and data processing systems analysis.

Consumer Products Division, Los Angeles, Calif.: Research capabilities in television, radio, stereophonic high fidelity.

Military Products Division, Los Angeles, Calif.: Research capabilities in navigation, communications, radar, instruments, and systems.

Semiconductor Division, El Monte, Calif.: Research capabilities in semiconductors.

Hogan Faximile Corp., New York, N.Y.: Research capabilities in special record communication equipment; recording instruments; data plotters; electronic analyzers.

Hoover Electronics Co., Timonium, Md.: Research capabilities in transistorized circuitry and telemetering methods.

Horizons, Inc., Cleveland, Ohio: Research capabilities in physics—solid state, ferroelectrics, piezoelectrics, conductors and insulators, electro-optical photography, photoconductive materials, transistors and rectifiers, electronics, phosphorescence and fluorescence.

Howard Industries, Inc., Racine, Wis.: Research capabilities in servomechanisms; dynamotors; hysteresis motors; and handcrank and gasoline-driven generators.

Howe Sound Co., New York, N.Y.: Sperry Products Co., Danbury Conn.: Research capabilities in instruments for nondestructive testing, ultrasonic testing of engineering materials for internal flaws, and ultrasonic instruments for thickness gaging; hydraulic remote controls and electronic motor overload controls.

Hughes Aircraft Co., Culver City, Calif.:

Engineering Division: Research capabilities in airborne control systems; antenna development; infrared search and track systems; radar satellite surveillance systems; and space vehicles.

Communication Division, Engineering Laboratory, Los Angeles, Calif.: Research capbailities in space communications problems, wave propagation, communications applications of various detection techniques, miniaturization and microminiaturization techniques.

Ground Systems Group, Engineering Laboratories, Fullerton, Calif.: Research capabilities in complex electronic systems; systems analysis and planning; mechanical, electromechanical, and circuits design; breadboarding; product engineering; laboratory and field testing of systems comprised of advanced radars, digital computers, and special displays.

Hughes Research Laboratories, Malibu, Calif.: Research capabilities in new concepts in atomic and molecular physics, electron tubes, semiconductors, and solid state materials; magnetics; chemical physics; radiowave propagation, underwater propagation, exotic inertial guidance techniques, systems techniques, maser systems, electronic scanning techniques, pictoral displays; statistical communications, network theory, feedback theory, and electronic displays; and information processing.

Microwave Tube Division, Los Angeles, Calif.: Research capabilities in high- and low-power microwave tubes.

Santa Barbara Research Center, Santa Barbara, Calif.: Research capabilities in infrared photoconductive detectors, infrared optical techniques, precision electromechanical devices.

Semiconductor Laboratories, Newport Beach, Calif.: Research capabilities in solid state physics and semiconductor materials and devices.

Tucson Engineering Laboratory, Tucson, Ariz.: Research capabilities in radar and infrared guidance, electronics, electromechanical and hydraulic controls, and electrical powerplants.

Vacuum Tube Products Division, Oceanside, Calif.: Research capabilities in storage, high vacuum, vacuum, and gas-filled tubes.

I–T–E Circuit Breaker Co., Philadelphia, Pa.:
Greensburg Division, Greensburg, Pa.
Kelan Power Circuit Breaker Division, Los Angeles, Calif.
Victor Insulators Division, Victor, N.Y.
Bulldog Electric Products Division, Detroit, Mich.
Special Products Division, Philadelphia, Pa.
Chase-Shawmut Co., Newburyport, Mass.

Research capabilities in development of circuit breakers and interrupting devices, including products in the switchgear and transformer fields in voltages up to 600 kilovolts; and materials including insulation, waveguide, and radio frequency devices.

Ideal Electric & Manufacturing Co., Mansfield, Ohio: Research capabilities in electric motors and generators.

Industrial Technological Associates, Inc., Cleveland, Ohio: Research capabilities in special electronic instrumentation and controls.

Industro Transistor Corp., Long Island City, N.Y.: Research capabilities in semiconductors.

Infrared Industries, Inc., Waltham, Mass.: Research capabilities in infrared photoconductors and interference filters.

Infrared Standards Laboratory, Riverside, Calif.: Research capabilities in infrared physics; instrumentation; and semiconductors.

Institute for Defense Analyses, Washington, D.C.: Weapons Systems Evaluation Division; Advanced Research Projects Division; and Communications Research Division, Princeton, N.J.: Research capabilities in operations and systems analysis; solid propellants, materials; and communications.

International Business Machines Corp., New York, N.Y.:
IBM Research, Yorktown Heights, N.Y.
Data Systems Division, White Plains, N.Y.
General Products Division, White Plains, N.Y.
Advanced Systems Development Division, Yorktown Heights, N.Y.
Federal Systems Division, Systems Development Center, Rockville, Md.:

Research capabilities in administrative systems, air traffic control, communications, and navigation; data processing systems, machines, and components (commercial, military, and scientific); dynamic systems simulation, electrical and mechanical engineering, experimental machines research, guidance and control systems, human factors engineering, hydraulics and hydrodynamics, image processing, industrial process control systems, intelligence systems, mathematics, metallurgy, oceanographic systems studies of underwater sound propagation, beam formation, and signal correlation; and operations research, physics, reliability techniques.

International Resistance Co., Philadelphia, Pa.: Research capabilities in electrical resistors, rectifiers, capacitors, printed circuits, fluorocarbon plastics, ceramics, glasses, semiconductors, metal evaporation surface film, synthetic resins, and polymers; rheology; colloid chemistry.

International Telephone & Telegraph Corp., New York, N.Y.: ITT Laboratories, Nutley, N.J.; Ft. Wayne, Ind.; San Fernando and Palo Alto, Calif.: Research capabilities in systems and equipment for advanced radio and wire communication and electronic and allied arts, including space systems and satellite communications, radar direction finders, radio aids to aerial navigation, specialized television data handling displays, tubes (microwave, power, image, etc.), storage tubes, telephone and data switching systems, microwave systems, guidance, data processing, computer systems, automation systems, dielectric and semiconductors, materials, and cables.

Iron Fireman Manufacturing Co., Portland, Oreg.: Research capabilities in electromechanics.

Itek Corp., Waltham, Mass.: Research capabilities in optics; information handling; human factors; and electronics.

Vidya, Inc., Palo Alto, Calif.: Research capabilities in Aero, thermo, and gas dynamics; physics; electronics; and computation and programing.

JFD Electronics Corp., Brooklyn, N.Y.: Research capabilities in electronic components and circuitry.

Jack & Heintz, Inc., Cleveland, Ohio: Research capabilities in aircraft and missile accessories, ground support equipment; a.c. and d.c. generators and systems, controls, motors, starters, actuators, inverters; and special commercial applications.

Jansky & Bailey, Washington, D.C.: Research capabilities in electronic engineering, specializing in communication.

Jay Laboratories, Andover, Mass.: Research capabilities in electronic analog computers, transistors; nucleonics, and physics.

Jennings Radio Manufacturing Corp., San Jose, Calif.: Research capabilities in electrical characteristics in high vacuum, vacuum components for RF capabilities, use of vacuum components as coaxial relays.

Jerrold Electronics Corp., Philadelphia, Pa.: Research capabilities in wide-band RF amplifiers and converters between 1 and 1,000 mc., sweep frequency generators, closed circuit television systems.

Johns Hopkins University, Applied Physics Laboratory, Silver Spring, Md.: Research capabilities in guided missile and satellite electronics (integrated weapons systems, airborne guidance and control, ground radars, data processing, telemetry), electronic, microwave, solid state, physics.

Johnson Service Co., Milwaukee, Wis.: Research capabilities in development of control mechanisms; feedback control analysis.

Kaiser Industries Corp., Oakland, Calif.:

Kaiser Aluminum & Chemical Corp., Oakland, Calif.: Research capabilities in aluminum metallurgy; production, fabrication, and utilization of aluminum and alloys; alumina, hydrated aluminas, dolomite, and magnesium oxide products; refractories.

Kaiser Electronics Corp., Toledo, Ohio: Research capabilities in electronic test equipment of the Go/No-Go type; flight-recording techniques; printed circuit techniques; electronic circuits; electromechanical techniques.

Kettering, Charles F., Foundation, Yellow Springs, Ohio: Research capabilities in solar energy utilization.

Kidde, Walter, & Co., Inc., Belleville, N.J.: Research capabilities in specialized electronic development, including precision speed control, transistorized power supplies, and static switching devices; electrical and mechanical devices for detecting heat and smoke.

Kip Electronics Corp., Stamford, Conn.: Research capabilities in special purpose electron tubes.

Knights, James, Co., Sandwich, Ill.: Research capabilities in quartz crystals, filters, and crystal oscillators; transistorized oscillators; component ovens; frequency standards.

Laboratory for Electronics, Inc., Boston, Mass.: Research capabilities in electronic aids to navigation: Airborne doppler navigators, doppler inertial navigators, precision altimeters, electronic survey and distance measuring equipment, ground control radars, aircraft landing aids, moving target indicators. Analog and digital computers: Operational digital techniques, navigational computers, machine tool controls, aircraft power system controls, data processing systems. Microwave techniques: Dielectric lens, printed circuit r.f. components, stable oscillators. Electronic instruments: Stalos, stalo testers, doppler test sets. Components: Ultrasonic delay lines, magnetic circuits, high lens for drum storage, thin film research, data display, automatic reading techniques. Theoretical studies: Communication theory, antenna design, wave propagation, ferromagnetic research.

Lear, Inc., Santa Monica, Calif.: Solid State Physics Laboratory, Los Angeles, Calif.: Research capabilities in electron microscopy and X-ray diffraction; emission spectrography; crystal growing and purification; vacuum deposition.

Leeds & Northrup Co., Philadelphia, Pa.: Research & DevelopmentC enter, North Wales, Pa.: Research capabilities in systems and apparatus, primarily electrical, for precise measurements, recording, and control, principally in the fields of heat, electricity, magnetism, heat treatment of metals, composition of gases, chemical analysis, and fluid flow.

Leesona Corp., Providence, R.I.: Research capabilities in machine design, textile engineering, and fibers.

Patterson Moos Research Division, Jamaica, N.Y.: Research capabilities in fuel cells, infrared, nucleonics, timers, radioisotope applications, nuclear batteries, semiconductors, solid state, special-purpose instrumentation, radar, fuses, mines, guided missile components, and weapons systems evaluation and development.

Lehigh Design Co., Inc., Newark, N.J.: Research capabilities in electronic techniques.

Levinthal Electronic Products, Inc., Palo Alto, Calif.: Research capabilities in high-power modulators, transmitters, power supplies, scintillation crystals.

Linfield Research Institute, McMinnville, Oreg.: Research capabilities in electronics (field emission).

Link-Belt Co., Chicago, Ill.: Physical Research and Testing Laboratory, Indianapolis, Ind.: Research capabilities in solid state physics (properties of metals and alloys); electronic instrumentation and control; electron microscopy, X-ray diffraction with special reference to solid state properties of metals and products.

Lionel Corp., Irvington, N.J.: Research capabilities in electrical and electromechanical circuits, communication equipment mechanisms.

Little, Arthur D., Inc., Cambridge, Mass.: Research capabilities in physics, engineering, and cryogenics.

Litton Industries, Inc., Beverly Hills, Calif.:

Research and Analysis Department, Woodland Hills, Calif.: Research capabilities in control systems, digital computers, instrumentation; materials (electronics), medical electronics, nuclear testing, reconnaissance and electronic warfare systems, astronautical (aeronautical) guidance systems, molectronics, bionics, displays.

Maryland Division, College Park, Md.: Research capabilities in magnetohydrodynamics, and electronics.

Western Geophysical Co. of America, Los Angeles, Calif.: Research capabilities in electronic instrumentation, seismograph systems, data reduction techniques.

Westrex Corp., New York, N.Y.: Research capabilities in facsimile communications, data and timing recorders, recording papers, frequency standards.

Lockheed Aircraft Corp., Burbank, Calif.:

Missiles & Space Division, Research Branch, Palo Alto, Calif.: Research capabilities in electronics: telecommunications, computers, electromagnetics, solid state physics, instrumentation, power systems. Advanced systems: spacecraft and missile systems.

Georgia Division, Marietta, Ga.: Research capabilities in engineering, antenna; materials and solid state sciences in radiation environment; energy sources, conversion, and utilization.

Lockheed Electronics Co., Plainfield, N.J.: Research capabilities in electronics, radar, sonar; fire control; systems and operation analysis; human factors.

Lombard Corp., Youngstown, Ohio: Research capabilities in electronic problems.

Lorain Products Corp., Lorain, Ohio: Research capabilities in electrical equipment using saturable magnetic cores and transistors for frequency changers, regulators, control applications, battery chargers, and magnetic amplifiers; selenium rectifier cells.

Loral Electronics Corp., New York, N.Y.: Research capabilities in microwaves, transistor circuitry, analog computations, optical display devices.

Lowell Technological Institute Research Foundation, Lowell, Mass.: Research capabilities in electronics.

Lynch Communication Systems, Inc., San Francisco, Calif.: Research capabilities in carrier frequency and multiplex equipment; electric wave filters; remote control and supervisory control equipment using solid state components.

MTD Research and Developent Corp., Timonium, Md.: Research capabilities in electronic engineering for space vehicles; guidance systems engineering; microwave; test instruments; simulators; communications; automation and special devices.

Magnavox Co., Fort Wayne, Ind.: Research capabilities in data systems and collection (information storage and retrieval) and communications.

Magnetics, Inc., Butler, Pa.: Research capabilities in magnetic materials: components, amplifiers, and devices.

Maico Electronics, Inc., Minneapolis, Minn.: Product Research and Development, Minneapolis, Minn.: Research capabilities in electroacoustics, digital display systems, peripheral and general electronics equipment, detection systems, radiation and solid state physics applications, nagnetics, and medical electronics.

Mallory, P. R., & Co., Inc., Indianapolis, Ind.: Research capabilities in electrical properties of metals and alloys; electronic and electrical components, semiconductor devices, electronic assemblies, electrical control devices, ferroelectric ceramic devices, and electrical storage devices.

Malt & Ness, Inc., Buffalo, N.Y.: Research capabilities in electronic systems and data processing systems.

Manning, Maxwell & Moore, Inc., Stratford, Conn.: Research capabilities in electronics as applied to pressure and temperature control on transmission, involving d.c. amplification and electromechanical transducing.

Manson Laboratories, Inc., Stamford, Conn.: Research capabilities in communications and frequency control.

Martin Marietta Corp., Baltimore, Md.:

Baltimore Division, Electronics Laboratory, Baltimore, Md.: Research capabilities in synthesis of solid state equivalents of electronic circuits; electronic cryogenics related to superconductive gyro, bolometer, and digital circuits; infrared detector materials; semiconducting compounds as applied to thermoelectricity; optical correlation filter design; transister circuits.

Denver Division, Electronics Research Laboratory, Denver, Colo.: Research capabilities in guidance, control, and communications systems for space vehicles.

Orlando Division, Engineering Research Laboratory, Orlando, Fla.: Research capabilities in solid state physics (semiconductors); molecular and atomic microwave devices; thin film electrical properties (inorganic); inertial phenomena applicable to guidance of missiles.

Orlando Division, Microwave Laboratory, Orlando, Fla.: Research capabilities in microwave components; antennas, including low noise amplifiers, harmonic generators, ferrite circulators, and strip lines.

Orlando Division, Standards Laboratory, Orlando, Fla.: Research capabilities in measurement of radio frequency; power, attenuation, frequency.

Mast Development Co., Inc., Davenport, Iowa: Research capabilities in photo-optical, data display, equipment; simulators and trainers; digital display counters.

Materials Research Corp., Yonkers, N.Y.: Research capabilities in electronic materials.

Maxson, W. L., Corp., New York, N.Y.: Research capabilities in radar systems; fixed antennas; computing devices and adaption kits; navigation equipments, components and instruments.

McDonnell Aircraft Corp., St. Louis, Mo.:

Research Division: Research capabilities in electronics and solid state physics.

Airplane Engineering Division: Research capabilities in systems and components, including aircraft, manned spacecraft, and electronics.

Missile Engineering Division: Research capabilities in systems, unmanned spacecraft and components, including electronic guidance and control systems, and propulsion systems.

McGraw-Edison Co., Chicago, Ill.:

Thomas A. Edison Research Laboratory, West Orange, N.J.: Research capabilities in solid state physics, electromechanical instruments and apparatus, semiconductors, electronics, thermoelectricity, insulation, electrical apparatus, electrical breakdown of gases.

Thomas A. Edison Industries, Instrument Division, West Orange, N.J.: Research capabilities in ultraviolet sensing and thermodelay devices, telemonitoring systems, and temperature and pressure transducers.

Thomas A. Edison Industries, Voicewriter Division, West Orange, N.J.: Research capabilities in dictation systems and instruments; recording processes.

McMillan Co., Ipswich, Mass.: Research capabilities in generation, conduction, radiation optics, absorption, and control of electrical and electromagnetic energy.

Melabs, Inc., Palo Alto, Calif.: Research capabilities in communications equipment, microwave solid state materials, ferrite and garnet microwave products, maser and solid state amplifiers.

Menlo Research Laboratory, East Palo Alto, Calif.: Research capabilities in satellite systems, subsystems, and components; telemetry, electronic control systems, miniature and subminiature electronic devices; radiation detection instruments.

Micamold Electronics Manufacturing Corp., Newark, N.J.: Research capabilities in tantalum, film, paper, natural and reconstituted mica, and electrolytic capacitors; RF interference filters and suppression capacitors; pulse-forming networks.

Microwave Associates, Inc., Burlington, Mass.: Research capabilities in gas discharge, solid state physics, vacuum tubes, electromagnetic theory, microwave circuitry.

Microwave Development Laboratories, Inc., Wellesley, Mass.: Research capabilities in microwave theory, all phases; components, including hybrids, mixers, duplexers, phase shifters, filters, ferrites, power dividers, and directional couplers; instruments, including signal generators and paramagnetic amplifiers.

Midwest Research Institute, Kansas City, Mo.: Research capabilities in mathematics; electrical engineering; physics.

Midwestern Instruments, Tulsa, Okla.: Research capabilities in servomechanism components, recording oscillographs, and galvanometers; electromechanical precision instruments: telemetering ground station equipment, instrumentation and audio tape recorders, magnetic heads, and memory drums.

Miehle-Goss-Dexter, Inc., Chicago, Ill.: The De Florez Co., Inc., Englewood Cliffs, N.J.: Research capabilities in mechanical, electronic, and optical devices.

Millen, James, Manufacturing Co., Inc., Malden, Mass.: Research capabilities in electronics, including radar.

Mine Safety Appliances Co., Pittsburgh, Pa.: Technical Products Division, John T. Ryan Memorial Laboratory, Pittsburgh, Pa.: Research capabilities in instruments for determining explosive or poisonous gases, dusts, and mists; process stream analyzers for gases, liquids, and powders; instrumentation for space capsule atmosphere control; sound and noise measurement and control; exhaust gases, and other fluids.

Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.:

Honeywell Research Center, Hopkins, Minn.: Research capabilities in servomechanisms analysis; electronic, magnetic, pneumatic, and thermostatic devices; heat transfer, humidity measurements; semiconductors, transducers, electric contact phenomena; instrumentation for atomic energy; hermetic sealing; radioisotoped; metallurgy, ceramics, primary sensors, electrochemistry, gaseous electronics, infrared.

Military Products Group Research Department, Minneapolis, Minn.: Research capabilities in automatic controls, systems techniques, human factors, inertial sensors, operational computation instrumentation, and optics.

Industrial Products Group, Brown Instruments Division, Philadelphia, Pa.: Research capabilities in measurement and control of process variables such as flow, pressure, temperature, and liquid level; industrial data handling and computation.

Heiland Division, Denver, Colo.: Research capabilities in infrared, recording techniques, gaseous electronics, and transducers.

Minnesota Mining & Manufacturing Co., St. Paul, Minn.: Research capabilities in pressure sensitive and sound recording tapes; electrical products.

Missouri Research Laboratories, Inc., St. Louis, Mo.: Research capabilities in electronic test equipment.

Monogram Precision Industries, Inc., Culver City, Calif.:

Lewis & Kaufman: Research capabilities in electron tubes (microwave and transmitting); long-life cathodes.

Cascade Research, Los Angeles, Calif.: Research capabilities in products employing the gyromagnetic resonance phenomenon in ferrite materials at microwave frequencies, such as unidirectional transmission lines, amplitude modulators, and duplexers; switches.

Motorola, Inc., Chicago, Ill.:

Riverside Research Laboratory, Riverside, Calif.: Research capabilities in guidance, radar navigation, instrumentation.

Chicago Military Electronics Center, Chicago, Ill.: Research capabilities in communications, radar, data processing and display, digital communications; underwater electronics; filters and crystals.

Western Military Electronics Center, Scottsdale, Ariz.: Research capabilities in special communications and navigation systems equipment, airborne radar; beacons and transponders; guidance and control systems.

Narda Microwave Corp., Mineola, N.Y.: Research capabilities in microwave transmission devices, waveguides, coaxial and strip lines, ferrite devices, electronic instruments, high-frequency transmitters.

National Aeronautical Corp., Fort Washington, Pa.: Research capabilities in radio communication and navigation devices for aircraft.

National Cash Register Co., Dayton, Ohio: Research capabilities in electrical, electronic, mechanical, and metallurgical problems in the field of business machines.

Electronics Division, Hawthorne, Calif.: Research capabilities in digital data processing systems.

National Research Corp., Cambridge, Mass.: Research capabilities in high vacuum equipment.

National Video Corp., Chicago, Ill.: Research capabilities in cathode-ray tubes, electrostatic and magnetic fields, phosphorescent materials, thermionic cathodes, vacuum, techniques, and vacuum metallizing.

Non-Linear Systems, Inc., Del Mar, Calif.: Research capabilities in electronic instruments, digital voltmeters, analog-to-digital converters, data logging systems.

North American Aviation, Inc., Los Angeles, Calif.: Autonetics Division, Downey, Calif.: Research capabilities in inertial navigation; armament and flight control; computers and data systems.

Columbus Division, Columbus, Ohio: Research capabilities in aerodynamics, thermodynamics, electronics, electromechanics, hydromechanics, flight test, instrumentation.

Missile Division, Downey, Calif.: Research capabilities in space mechanics, gas dynamics, geological sciences, applied physics, astronomical sciences, life sciences.

Los Angeles Division, Engineering Laboratory, Los Angeles, Calif.: Research capabilities in aeronautics, thermodynamics, hydraulics, electronics, acoustics, mechanics, and cryogenics.

Los Angeles Division, Atomics International, Canoga Park, Calif.: Research capabilities in nuclear instrumentation.

North American Philips Co., Inc., New York, N.Y.: Research capabilities in semiconductors and solid state physics, microwaves, X-rays, crystallography, magnetics, thermionics, cryogenics, radiation detection.

North Electric Co., Galion, Ohio: Research capabilities in electronic switching techniques and transmission systems; industrial and remote control systems.

Northrop Corp., Beverly Hills, Calif.:

Norair Laboratories, Hawthorne, Calif.: Research capabilities in astronautics, aircraft, bioastronautics, aerodynamics, nuclear, technology, materials, electronic systems, space propulsion, space physics, plasma dynamics, electromechanical systems, and environments.

Nortronics, Electronic Systems and Equipment, Hawthorne, Calif.: Research capabilities in systems, equipment, and components for space electronics and other fields of electronics; computers; systems for inertial and astronertial guidance, flight safety and control, space guidance and defense; optical radiation and infrared systems.

Nortronics, Systems Support Department, Anaheim, Calif.: Research capabilities in automatic electronic test systems, infrared pyrotechnics, internal and external ballistics, optics, and photogrammetry.

Nuclear-Chicago Corp., Des Plaines, Ill.: Research capabilities in design and development of electronic instruments for detection of radioactivity, application of instruments in fields of medicine, life sciences, and research and industrial process control.

Nuclear Corp. of America, Denville, N.J.:

Central Electronic Manufactures Division: Research capabilities in electron tubes, solid state physics, microwaves.

Instrument and Research Division: Research capabilities in effects of radiation on matter, nuclear instruments.

Nuclear Materials & Equipment Corp., Apollo, Pa.: Research capabilities in analytical and quality control techniques; chemistry and metallurgy of new and advanced high-temperature thermal shock-resistant metals, ceramics, and cermets.

Offner Electronics Inc., Schiller Park, Ill.: Research capabilities in industrial and medical instrumentation.

Ohio Crankshaft Co., Cleveland, Ohio: Research capabilities in induction heating.

Ohio Steel Foundry Co., Lima, Ohio: Springfield Works, Springfield, Ohio: Research capabilities in spectrographic analysis, radiography.

Ohmite Manufacturing Co., Skokie, Ill.: Research capabilities in resistors, rheostats, switches, relays, tantalum capacitors, variable transformers, germanium diodes, electrical controls, new electronic components.

Oklahoma, University of, Research Institute, Norman, Okla.: Research capabilities in electrical and aeronautical engineering.

Olin Mathieson Chemical Corp., New York, N.Y.: Metals Division, New York, N.Y.: Research capabilities in physical testing, physics, electronic instrumentation.

Operations Research, Inc., Silver Spring, Md.: Research capabilities in systems analysis; research and development program analysis; industrial engineering; information theory; sonar, radar, solid state infrared, and space technology; systems management; communications; life sciences.

Owens-Illinois Glass Co., Toledo, Ohio:

Owens-Illinois Technical Center, Toledo, Ohio: Research capabilities in high temperatures, physical chemistry of melts and surfaces, solid state physics, and polymers.

Kimble Glass Co., Toledo, Ohio: Research capabilities in glass items for electrical, electronics, and nuclear industries, including insulators, diode and capillary tubing for power and X-ray and other radiation bulbs, various other types of glasses, transmitting, low-expansion, high-temperature, and nuclear-resistant.

Pacific Gas & Electric Co., San Francisco, Calif.: Research capabilities in electrical and other measurement techniques.

Pacific Optical Corp., Inglewood, Calif.: Research capabilities in high resolution photographic lenses and optical systems; aspheric surfaces; fiber-optics.

Pacific Scientific Co., San Francisco, Calif.: Research capabilities in guidance, control, and measurement instruments.

Pacific Semiconductors, Inc., Culver City, Calif.: Research capabilities in surface effects, and solid state diffusion, primarily of silicon; development of semiconductor devices, EI. transistors.

Packard Bell Electronics, Los Angeles, Calif.: Research capabilities in IFF (identification, friend or foe), electronic support equipment, communications, computers, instrumentation, high-temperature components, infrared applications.

Page Communications Engineers, Inc., Washington, D.C.: Research capabilities in telecommunications, antennas, and propagation.

Pan American Petroleum Corp., Tulsa, Okla.: Research capabilities in geophysical instruments and equipment; electronic instruments applicable to production of oil and gas.

Panellit, Inc., Skokie, Ill.: Research capabilities in data-reduction systems, electrical instruments, scanning and computing systems; automatic control dynamics.

Pan-Fax, Inc., Santa Barbara, Calif.: Research capabilities in telephoto, facsimilie, and communications equipment.

Panoramic Radio Products, Inc., Mount Vernon, N.Y.: Research capabilities in spectrum analyzers; telemetering and specialized test equipment.

Parr Instrument Co., Moline, Ill.: Research capabilities in laboratory instruments and apparatus for measuring heats of combustion and chemical reactions at elevated pressures and temperatures.

Parsons, Ralph M., Co., Los Angeles, Calif.: Research capabilities in systems engineering, telemetry, miss-distance indicators, precision electronic timing systems, precision delay lines; radar augmenters and beacons; equipment for CW, phase, and pulse tracting radar; velocimeters; design, construction, and instrumentation of technical facilities.

Peer, Inc., Benton Harbor, Mich.: Research capabilities in electronics, especially control equipment and radio transmitters and receivers; resistance welding equipment and high-current low-voltage apparatus; rectifiers and semiconductors.

Penta Laboratories, Inc., Santa Barbara, Calif.: Research capabilities in power-transmitting, traveling-wave, inert-gas-filled, and special-purpose (switching, photoelectric, photosensitive) electron tubes; materials, techniques, and designs of electron tubes; prototypes of equipment using developed tubes.

Perkin-Elmer Corp., Norwalk, Conn.: Research capabilities in instrument development, special optics and electrooptical systems, application of infrared analytical techniques to laboratory and process plant problems.

Perkin Engineering Corp., El Segundo, Calif.: Research capabilities in design and development of a.c. and d.c. static voltage regulators; magnetic amplifiers.

Philbrick, George A., Researches, Inc., Boston, Mass.: Research capabilities in electric and electronic analog computing techniques and their applications.

Philco Corp., Philadelphia, Pa.:

Philco Research Division: Research capabilities in electronics, thermoelectricity, physics; solid state and vacuum physics and devices; electronic circuits and components; electronic, mechanical, and thermodynamic systems and equipment.

Sierra Electronic Corp., Menlo Park, Calif.: Research capabilities in communications in the radio frequencies; specialized test equipment; specialized transmitting systems for VLF, VHF, UHF, and microwaves.

Phoenix Precision Instrument Co., Inc., Philadelphia, Pa.: Research capabilities in optical, mechanical, hydraulic, and electronic devices; monochromatic sources and photometric detector systems.

Photogrammetry, Inc., Silver Spring, Md.: Research capabilities in measurement and analysis of photography, development of photogrammetric instru-

mentation; mathematical analysis of moving and fixed points in space by analytical photogrammetry.

Pickard & Burns, Inc., Needham Heights, Mass.: Research capabilities in electronics—aids to navigation, communications, and radar (VLF through the millimeter region).

Pittsburgh, University of, Computation and Data Processing Center, Pittsburgh, Pa.: Research capabilities in digital computation.

Plasmadyne Corp., Santa Ana, Calif.: Research capabilities in reentry simulation; magneto- and electrogasynamics; low desnity plasma generation and containment, microwave generation, collison cross sections and transport phenomena; upper atmosphere physics.

Polarad Electronics Corp., Long Island City, N.Y.: Research capabilities in microwave systems, electronic instrumentation, microwave vacuum tubes and components, scientific instrumentation.

Polaroid Corp., Cambridge, Mass.: Research capabilities in one-step, three-diamensional, and color photography; color vision; polarized light; absorption of light; physics and crystallography, especially as related to phenomena involving radiation; spectroscopy; electronics.

Premier Instrument Corp., New York, N.Y.: Research capabilities in microwave components and systems for radar, link systems, and satellite tracking.

Prudential Industries, Inc., Philadelphia, Pa.: Research capabilities in electronic test and measurement equipment for semiconductor industry; general laboratory test devices.

Quantum, Inc., Wallingford, Conn.: Research capabilities in chemistry; design and engineering; surface science; radiation and radioisotopes; rubber and plastics; infrared and vapor phase chromatography; industrial applications of electronic computers.

R S Electronics Corp., Palo Alto, Calif.: Research capabilities in electronics—IF–RF amplifiers, receivers, radar, and associated types of equipment.

Radiation Counter Laboratories, Inc., Skokie, Ill.: Research capabilites in nucleonics and digital computers.

Radiation, Inc., Melbourne, Fla.: Research capabilities in telemetering, records ing, radio frequency, wave propagation and reflection, astrionics, specialized test and data handling equipment.

Radiation Instrument Development Laboratory, Inc., Chicago, Ill.: Research capabilities in nuclear spectrometry; electronic instrumentation for the study and analysis of radioactivity.

Radio Corp. of America, New York, N.Y.:

RCA Laboratories, David Sarnoff Research Center, Princeton, NJ.: Research capabilities in physics, chemistry, electrical, and mechanical engineering, metallurgy, optics, acoustics, mathematics; phenomena, devices, circuits, and systems.

Astro-Electronic Products: Research capabilities in space vehicles and associated equipment; data handling equipment.

Defense Electronic Products: Research capabilities in radar, airborne systems, electronics and controls, and surface communications.

Home Instruments: Research capabilities in AM, FM receivers, television receivers, and associated circuits.

Industrial Electronic Products: Research capabilities in electronic data processing equipment and systems; broadcast, television, closed circuit, film recording, high-power, mobile communications, microwave, and scientific instruments.

National Broadcasting Co.: Research capabilities in specialized television and radio broadcasting equipment.

Record Division: Research capabilities in electroforming, rheology, record compund, and magnetic tape formulation, disk and magnetic tape recording, special tools for molding records and coating magnetic tape.

Semiconductor and Materials Division: Research capabilities in semiconductor devices: germanium, silicon, and compounds. Materials: Magnetic memory devices and assemblies; compound semiconductor crystals, micromudules, and other packaged circuits.

RCA Service Co.: Research capabilities in field support engineering, test equipment, test range operation, and instrumentation.

Electron Tube Divislon: Research capabilities in receiving tubes, microwave tubes and devices, kinescopes; small, medium, large, and super power tubes; phototubes and image tubes; camera, oscillograph, and storage tubes.

Rand Development Corp., Cleveland, Ohio: Research capabilities in electronics, chemistry, mechanics, metallurgy, biology, and plastics.

Raymond Engineering Laboratory, Inc., Middletown, Conn.: Research capabilities in electromechanics.

Raytheon Co., Waltham Mass.: Research capabilities in semiconductor materials and devices; ferromagnetic, high-temperature, and ferroelectric materials; microwave signal generation, amplification and control, plastics, luminescence, metallurgy, and ceramics.

Airborne Equipment Operations, Sudbury, Mass.: Research capabilities in airborne radars for search (surveillance), fire control, and navigation (doppler navigators, altimeters), and microwave heat exchangers for manned or unmanned airborne vehicles; associated ground-based equipment.

Receiving Tube Division, General Engineering Department, Quincy, Mass. Research capabilities in receiving tubes and tube processes.

Missile Systems Division, Bedford, Mass.: Research capabilities in guidance systems and subsystems; radar, computer, guidance, and control systems; space systems and subsystems.

Microwave and Power Tube Division, Spencer Laboratory, Burlington, Mass.: Research capabilities in microwave power tubes—magnetrons, O- and M-type backward wave oscillators, amplitrons, stabilotrons, klystrons, traveling wave tubes, and infrared detectors.

Equipment Division, Santa Barbara Operations, Santa Barbara, Calif.: Research capabilities in electronic reconnaissance; microwaves; infrared reconnaissance, communications, and optics.

Engineering Department, Semiconductor Division, Newton, Mass.: Research capabilities in semiconductor materials and devices, and applications.

Commercial Apparatus & Systems Division, Waltham, Mass.: Research capabilities in industrial and commercial applications of microwaves; magnetics, including power supplies and modulators; electronics and systems; industrial components and systems; marine radar, and communications.

Surface Radar & Navigation, Operations Engineering, Wayland, Mass.: Research capabilities in radar systems development, navigation and flight control equipment, special displays.

Machlett Laboratories, Inc., Springdale, Conn.: Research capabilities in large electron tubes—X-ray, power, photosensitive, and storage.

Sorensen & Co., Inc., South Norwalk, Conn.: Research capabilities in electronic power supplies.

Reed Research, Inc., Washington, D.C.: Research capabilities in application of optics, development of microminiaturization of electronic and electrical circuit components.

Reliance Electric & Engineering Co., Cleveland, Ohio: Research capabilities in electric motors and generators, electromechanical and electronic motor control and drive systems, gear reducers and electric brakes, electronic systems, electrical insulation system development, special system applications.

Republic Aviation Corp., Farmingdale, Long Island, N.Y.: Research capabilities in design and development of advanced airborne systems; space systems, space communications; power transmission and navigation and guidance systems for aircraft, and spacecraft.

Scientific Research: Research capabilities in nuclear physics electron physics, electrical systems, solid state physics, guidance and control, mechanics, electric analogs, mathematics, plasma dynamics, fluid dynamics, aerodynamics, viscoelastic effects, space physics, and astronautics.

Missile Systesm Division, Long Island, N.Y.: Research capabilities in airborne systems, power transmission, and communications.

Republic Steel Corp., Pasadena, Calif.: Research capabilities in applied electronics.

Rese Engineering, Inc., Philadelphia, Pa.: Research capabilities in high-speed transistor switching.

Research-Cottrell, Inc., Bound Brook, N.J.: Research capabilities in electrophysics.

Research, Inc., Minneapolis, Minn.: Research capabilities in electronics, mechanics, and aeronautics.

Rheem Semiconductor Corp., Mountain View, Calif.: Research capabilities in semiconductor materials and devices; diodes and transistors.

Rixon Electronics, Inc., Silver Spring, Md.: Research capabilities in electronics and special communications equipment.

Roanwell Corp., New York, N.Y.: Research capabilities in electroacoustical equipment, and electronics.

Robertshaw-Fulton Controls Co., Richmond, Va.: Research capabilities in automatic precision temperature and pressure control devices, and control systems.

Ryan Aeronautical Co., San Diego, Calif.: Research capabilities in electronic systems and electromechanical components.

Ryan Electronics, San Diego, Calif.: Research capabilities in doppler radar navigational systems.

Sadtler, Samuel P., & Son, Inc., Philadelphia, Pa.: Research capabilities in infrared and ultraviolet spectroscopy and their applications; and components.

Sanborn Co., Waltham, Mass.: Research capabilities in measuring and recording equipment, including direct writing and photographic recorders, amplifiers, transducers, and associated equipment.

Sangamo Electric Co., Springfield, Ill.: Research capabilities in watt-hour and thermal electric meters; timeswitches; capacitors; sonic electronic gear; instruments and specialty transformers; synchros and precision motors.

Scientific-Atlanta, Inc., Atlanta, Ga.: Research capabilities in electronics, electrical engineering, physics, antenna measurements.

Scope, Inc., Fairfax, Va.: Research capabilities in cognitive computers, electronic speech analyzing and processing, electrical-optical devices, microwave systems design and development, and applications of abstract algebra.

Servo Corp. of America, Hicksville, N.Y.: Research capabilities in radio spectrum, infrared, solid state materials, servo control, infrared glass and transmitting materials.

Servomechanisms, Inc., Research Division, Goleta, Calif.: Research capabilities in materials and techniques; advanced systems and circuits; thermoelectrics and microminiaturization.

Shall Cross Manufacturing Co., Selma, N.C.: Research capabilities in development of electronic components and instruments and delay lines.

Siegler Corp., Olympic Radio & TV Division, Long Island City, N.Y.: Research capabilities in precision time standards; communication; and navigation.

Simpson Electric Co., Chicago, Ill.: Research capabilities in electrical indicating panel instruments and precision instrument standards, control relays, and electronic test instruments.

Singer Manufacturing Co., New York, N.Y.: Research capabilities in industrial and domestic sewing machines and related electrical apparatus.

HRB-Singer, Inc., State College, Pa.: Research capabilities in electronics, data processing, electromechanical instruments and devices, infrared developments, microwave systems, and nuclear and solid state physics.

Smith, A. O., Corp., Milwaukee, Wis.: Research capabilities in electric and electronic equipment; application of emission, absorption, infrared and X-ray diffraction.

Smith-Corona Marchant, Inc., Syracuse, N.Y.:

Data Processing Systems Division, Oakland, Calif.: Research capabilities in data processing and handling; high-speed printing; digital arithmetic apparatus; computer peripheral equipment.

Kleinschmidt Division, Deerfield, Ill.: Research capabilities in teleprinting communication equipment.

Smyth Research Associates, San Diego, Calif.: Research capabilities in radio wave propagation; tropospheric and ionospheric physics; and special instrumentation.

Southern Research Institute, Birmingham, Ala.: Research capabilities in electrical engineering: instrumentation, and instrument development.

Southwest Research Institute, San Antonio, Tex.: Research capabilities in electronics and electrical engineering; and physics.

Space Technology Laboratories, Inc., Los Angeles, Calif.: Research capabilities in aeromechanics, electromechanics, guidance, telecommunications, advanced fields of theoretical, experimental, and solid state physics, engineering, plasma physics; advanced system analysis and design for missile and space systems; and experimental mathematics.

Sparton Corp., Jackson, Mich.: Research capabilities in electronics.

Specialty Electronics Development Corp., Soysset, N.Y.: Research capabilities in miniaturization, electronic test and communications equipment.

Speer Carbon Co., St. Marys, Pa.: Research capabilities in electronic components such as fixed carbon resistors, metal film type resistors, coil forms (iron and insulated), ceramic capacitors, modular type component assemblies, and wound coils.

Speidel Corp., Providence, R.I.: Research capabilities in space, instrumentation; inertial sensing magnetohydrodynamic gyros; solid state pulse and delay devices; and pressure sensing devices.

Sperry Rand Corp., New York, N.Y.:

Remington Rand Group, New York, N.Y.: Research capabilities in solid state and surface physics, computer logic, high-speed digital circuitry, and information retrieval.

Sperry Gyroscope Co., Great Neck, N.Y.: Research capabilities in satellite and space vehicle instrumentation and control; infrared and optical devices, passive microwave electronic equipment, microwave electronic tubes and active solid state microwave devices, solid state physics, and electronics.

Sperry Electronic Tube Division, Gainesville, Fla.: Research capabilities in high power klystrons, traveling wave tubes, and related microwave devices.

Sperry Microwave Electronics Co., Clearwater, Fla.: Research capabilities in microwave antennas, transmission lines, circuit components and systems, test equipment and instruments, and solid state electromagnetic components.

Sperry Phoenix Co., Phoenix, Ariz.: Research capabilities in navigation, control, and communications.

Sperry Piedmont Co., Charlottesville, Va.: Research capabilities in navigation, control, and communications.

Sperry Utah Engineering Laboratory, Salt Lake City, Utah: Research capabilities in guidance and control equipment, and infrared scanners.

Vickers, Inc., Electric Products Division, St. Louis, Mo.: Research capabilities in control equipment and servomechanisms, rectifiers, and magnetic amplifiers.

Ford Instrument Co., Long Island City, N.Y.: Research capabilities in space navigation, digital techniques, telemetry, and radar.

Sprague Electric Co., North Adams, Mass.: Research capabilities in electrolytic, electrostatic, and ceramic capacitors; precision and power resistors; electrical networks; printed circuits; noise suppression filters; magnetic devices and functional circuit subassemblies; ceramic-coated wire, semiconductor devices; and piezoelectric transducers.

Square D Co., Electric Controller & Manufacturing Division, Cleveland, Ohio: Research capabilities in development of control systems including solid state rectifiers, magnetic amplifiers, and logic techniques.

Stanford Research Institute, Menlo Park, Calif.: Research capabilities in electronic devices and systems, including computer, video, and central systems; electromagnetic radiation, including electromagnetics, communication, propagation, and radar meteorology.

Stewart-Warner Corp., Chicago, Ill.: Alemite and Instrument Division, Research capabilities in apparatus and devices concerned with electronics and instrumentation.

Electronics Division, Chicago, Ill.: Research capabilities in communication, navigation, data processing, automation and display systems; solid state components; information and communication theory; and microwave devices.

Stoddart Aircraft Radio Co., Hollywood, Calif.: Research capabilities in equipment for measurement and analysis of electromagnetic interference for 0.3 cps to 100 Kmc.

Sylvania Electric Products Inc., New York, N.Y.: Research capabilities in physics, electronics; data processing, microwave and solid state physics; semiconductors, communications; and information theory.

System Development Corp., Santa Monica, Calif.: Human Factors Laboratory: Research capabilities in data processing.

Systems Research Laboratories, Dayton, Ohio: Research capabilities in thin films, high-temperature studies, and electronic fundamentals.

Tally Register Corp., Seattle, Wash.: Research capabilities in solid state circuitry; and gaseous conduction (thyratron) circuitry.

Technical Operations, Inc., Burlington, Mass.: Research capabilities in computer applications and technology; electronics; and theoretical physics.

Technitrol Engineering Co., Philadelphia, Pa.: Research capabilities in pulse transformers; delay lines; data processing equipment and digital computers.

Tektronix, Inc., Portland, Oreg.: Research capabilities in electron devices; cathode ray tubes: electron emission; luminescence and semiconductor devices.

Telechrome Manufacturing Corp., Amityville, N.Y.: Research capabilities in communications techniques, video tape recording, and data handling.

Telectro Industries Corp., Long Island City, N.Y.: Research capabilities in magnetic tape recording equipment for audio, video, and data acquisition applications.

Teleregister Corp., Stamford, Conn.: Research capabilities in on-line electronic computers, and digital data systems.

Telex, Inc., St. Paul, Minn.: Research capabilities in solid state circuitry, data processing, and magnetics.

ten Bosch, M., Inc., Pleasantville, N.Y.: Research capabilities in gyroscopes and stabilizing systems, automatic control systems, computers, and inertial navigation.

Texas Instruments, Inc., Dallas, Tex.: Research capabilities in semiconductors, devices and components, electronics systems, and energy conversion.

Apparatus Division, Dallas, Tex.: Research capabilities in electronics and electromechanical and optical systems.

Industrial Products Group, Houston, Tex.: Research capabilities in instrumentation, automation, and electronic systems.

Semiconductor Components Division, Dallas, Tex.: Research capabilities in semiconductor materials and devices, and other electronic components.

Textron, Inc., Providence, R.I.:

California Technical Industries, Belmont, Calif.: Research capabilities in automatic test equipment for the electronics industry, communications, radar, sonar, infrared detection systems, and microwave.

Dalmo Victor Co., Belmont, Calif.: Research capabilities in airborne radar and ground based antennas.

Thompson, John I., & Co., Washington, D.C.: Research capabilities in electronics, electromechanics, and computer techniques.

Thompson Ramo Wooldridge, Inc., Cleveland, Ohio: Electronics Laboratory Research capabilities in FM video telemetry systems, microwave and waveguide, coaxial, and antenna lobing switches, amplifiers, and advanced electronic detection systems.

Tracerlab, Inc., Waltham, Mass.: Research capabilities in electronic instrumentation.

Transitron Electronic Corp., Wakefield, Mass.: Research capabilities in high-frequency transistors, alloy diffusion techniques in semiconductors, crystals, SiC junctions and SiC active devices, high-efficiency silicon solar cells, silicon power transistors and high-power rectifiers, development of radiation-resistant diodes, silicon carbide devices, microminiaturization, thermoelectric materials and devices.

Trionics Corp., Madison, Wis.: Research capabilities in electronics and applied physics, electronic devices and instrumentation, automatic control, microwave systems, solid state and molecular electronics.

Tung-Sol Electric, Inc., Newark, N.J.: Research capabilities in vacuum tubes, self-sustaining cathodes and devices, semiconductors, and crystal perfection.

Chatham Electronics Division, Livingston, N.J.: Research capabilities in tubes, hydrogen thyratron, gas regulator and reference, and electromechanical circuitry.

Underwood Corp., New York, N.Y.: Research capabilities in electronic data handling, data processing systems and equipment.

Canoga Division, Van Nuys, Calif.: Research capabilities in electronics, including microwaves, electromechanical mechanisms.

Union Carbide Corp., New York, N.Y.: Parma Research Laboratory, Parma, Ohio: Research capabilities in solid-state physics, chemical physics, and physical chemistry.

United Aircraft Corp., Hartford, Conn.: Research capabilities in plasma, particle, and solid state physics; electromagnetics, and digital and analog computational operations.

Norden Division, Stamford, Conn.: Research capabilities in radar, television, guidance and control systems, analog-digital converters, snychros, resolvers.

United States Steel Corp., Pittsburgh, Pa.: Edgar C. Bain Laboratory for Fundamental Research, Monroeville, Pa.: Research capabilities in solid state physics, instrumentation, and techniques.

Van Norman Industries, Inc., New York, N.Y.: Electronics Division, Manchester, N.H.: Research capabilities in test and communications equipment, meters, control systems.

Varian Associates, Palo Alto, Calif.:

Central Research Laboratory, Palo Alto, Calif.: Research capabilities in solid state and plasma physics, gaseous and microwave electronics.

Instrument Research Laboratory, Palo Alto, Calif.: Research capabilities, in space physics.

Tube Division, Palo Alto, Calif.: Research capabilities in microwave tubes.

Bomac Laboratories, Inc., Beverly, Mass.: Research capabilities in microwave electronic tubes and devices.

S-F-D Laboratories, Inc., Union, N.J.: Research capabilities in microwave electronics, electron tubes.

Varo Manufacturing Co., Inc., Garland, Tex.: Research capabilities in microwave power (other than radar), microcircuitry, vapor deposition of circuits, power conversion, electronic controls.

Victoreen Instrument Co., Cleveland, Ohio: Jordan Electronics, Alhambra, Calif.: Research capabilities in semiconductor circuitry.

Vitro Corp. of America, New York, N.Y.: Nems-Clarke Co., Silver Spring, Md.: Research capabilities in equipment in the field of communications and special electronic instruments.

Vocaline Co. of America, Inc., Old Saybrook, Conn.: Research capabilities in communications in frequencies up to 890 megacycles, and radar.

Warwick Manufacturing Corp., Chicago, Ill.: Research capabilities in modular approaches, solid state applications, miniaturization, new modulation and reception systems.

Washington Technological Associates, Rockville, Md.: Research capabilities in electrical/electronic automation and test equipment, and space systems.

Waste King Corp., Technical Products Division, Los Angeles, Calif.: Research capabilities in electronics; instrumentation; and electromechanical.

Waterman Products Co., Inc., Philadelphia, Pa.: Research capabilities in oscilloscopes and allied equipment; cathode-ray and special electron tubes.

Wells-Gardner Electronics Corp., Chicago, Ill.: Research capabilities in design and development of television and radio receivers; electronic controls for remote use.

Western Union Telegraph Co., Inc., New York, N.Y.: Research capabilities in communications systems.

Westinghouse Air Brake Co., Pittsburgh, Pa.: Melpar, Inc., Falls Church, Va.: Research capabilities in electronics.

Westinghouse Electric Corp., Pittsburgh, Pa.: Research capabilities in physics, semiconductors, thermoelectric materials, cryogenics, nuclear physics, solid state electronics, servomechanisms, electron optics, television, magentism, X-rays, radar, mechanics of materials, and physical electronics.

Electronic Tube Division, Elmira, N.Y.: Research capabilities in vacuum tubes.

Semiconductor Department, Baltimore, Md.: Research capabilities in semiconductor materials, devices, and circuits.

Defense Products Group, Air Arm Division, Baltimore, Md.: Research capabilities in airborne and spaceborne electronic systems; guidance, detection, control, navigation, computation, radar, and infrared.

Electronics Division, Baltimore, Md.: Research capabilities in electronic apparatus including radar, communications, navigation, computers, and missile control.

General Products Group, Aircraft Equipment Department Laboratory, Lima, Ohio: Research capabilities in aerospace electrical systems (generators, controls, motors).

Wheeler Laboratories, Inc., Great Neck, N.Y.: Research capabilities in radio and electronics; communications, radar, microwave antennas, and waveguide components.

Winder Aircraft Corp. of Florida, Dunnellon, Fla.: Research capabilities in electronics.

Zenith Radio Corp., Chicago, Ill.: Research capabilities in vacuum tubes; electromechanical transducers; thermoelectric, ferroelectric, and ferrielectric materials.

Rauland Corp., Chicago, Ill.: Research capabilities in development of special purpose cathoderay tubes, photosurfaces for image converters, high resolution tubes, solid state devices.

Zenith Radio Research Corp.: Menlo Park, Calif.: Research capabilities in microwave tubes, flash X-ray tubes and modulators.

SUPPLEMENTARY LISTING

ARINC Research Corp., Washington, D.C.: Research capabilities in physics, engineering reliability in airborne equipment, electronics.

Academy for Interscience Methodology, Chicago, Ill.: Research capabilities in computing devices.

Adcole Corp., Cambridge, Mass.: Research capabilities in electronics, instrumentation.

Adcom, Inc., Cambridge, Mass.: Research capabilities in advanced communications, modulation and detection theory, information theory, high accuracy tracking, advanced digital transmission techniques.

Advanced Computer Products, Los Angeles, Calif.: Research capabilities in computing devices.

Advanced Development Laboratories, Nashua, N.H.: Research capabilities in microwave antenna techniques, and optical data processors.

Advanced Information Systems Co., Los Angeles, Calif.: Research capabilities in computing devices.

Aerial Measuring Laboratory, Evanston, Ill.: Research capabilities in solid state research, transducer development.

Aerospace Controls Corp., Santa Monica, Calif.: Research capabilities in guidance and navigation, and electronics.

Aerospace Research, Inc., Newton, Mass.: Research capabilities in communication sciences, radio propagation.

Airtechnology Corp., Cambridge, Mass.: Research capabilities in physics, electronics.

Alpha Microelectronics Co., Silver Spring, Md.: Research capabilities in computing devices.

Amelco, Inc., Los Angeles, Calif.: Research capabilities in digital techniques, advanced communications systems, microwave, inertial navigation, instrumentation.

Aries Corp., Minneapolis, Minn.: Research capabilities in computing devices.

Artisan Industries, Inc., Waltham, Mass.: Research capabilities in data acquisition, film processors.

Astro-Space Laboratories, Inc., Huntsville, Ala.: Research capabilities in inertial components and systems.

Astrosystems International, Inc., Caldwell, N.J.: Research capabilities in tracking and telemetry.

Avco Corp., New York, N.Y.: Avco-Tulsa, Tulsa, Okla.: Research capabilities in inertial and optical guidance components and systems.

Babcock Electronics Corp., Costa Mesa, Calif.: Research capabilities in radio communications and command guidance systems.

Bay State Electronics Corp., Boston, Mass.: Research capabilities in instrumentation design, signal generators, and signal analysis equipment.

Bell Aerosystems Co., Buffalo, N.Y.: Research capabilities in inertial components and systems.

Bowles Engineering Corp., Silver Spring, Md.: Research capabilities in computing devices.

Breeze Corp., Inc., Union, N.J.: Research capabilities in electronics, optics, and inertial systems.

Budd Electronics, Inc., Long Island City, N.Y.: Research capabilities in data processing digital techniques.

Cambridge Thermionic Corp., Cambridge, Mass.: Research capabilities in digital circuitry, miniature electronic packaging, and microminiature coils.

CEIR, Arlington, Va.: Research capabilities in computing devices.

Central Hadley Corp., Pomona, Calif.: Research capabilities in fluid control devices.

Coast Centerless Grinding Co., Los Angeles, Calif.: Research capabilities in guidance bearings and guidance components.

Comcor, Inc., Denver, Colo.: Research capabilities in computing devices.

Computer Sciences Corp., Palos Verdes, Calif.: Research capabilities in computing devices.

Comress, Inc., Washington, D.C.: Research capabilities in computing devices.

Computronics, Inc., Fort Lee, N.J.: Research capabilities in computing devices.

Conductron Corp., Ann Arbor, Mich.: Research capabilities in computing devices.

Consolidated Systems Corp., Monrovia, Calif.: Research capabilities in spectrometers, ionization cells, instruments, computing devices.

Control Data Corp., Minneapolis, Minn.: Research capabilities in guidance and control systems and components.

Control Science Corp., Alexandria, Va.: Research capabilities in development of solid-state instrumentation techniques.

Control Technology, Inc., Long Beach, Calif.: Research capabilities in guidance and navigation systems and components.

Controls for Radiation, Inc., Cambridge, Mass.: Research capabilities in radiation detectors, solid-state devices, upper atmosphere geophysics.

Data-Control Systems, Inc., Washington, D.C.: Research capabilities in computing devices.

Defense Electronics, Inc., Rockville, Md.: Research capabilities in tracking and data acquisition components and techniques.

Dynamics Research Corp., Stoneham, Mass.: Research capabilities in electromagnetic and electro-optics.

Electrada Corp., Culver City, Calif.: Research capabilities in computing devices.

Electroforms, Inc., Gardena, Calif.: Research capabilities in electroforming techniques.

Electro-Logic Corp., Los Angeles, Calif.: Research capabilities in computing devices.

Electro-Optical Systems, Pasadena, Calif.: Research capabilities in thin-film, microelectronics, imaging devices, radiation-resistant devices.

Electronic Controls, Inc., Stamford, Conn.: Research capabilities in electronic control systems.

Emerson Electronic Manufacturing Co., St. Louis, Mo.: Research capabilities in digital adaptive control systems.

EPSCO, Inc., Cambridge, Mass.: Research capabilities in communication sciences, pulse-code modulation, telemetry, instrumentation.

Exotech, Inc., Alexandria, Va.: Research capabilities in development of infrared sensing techniques.

Farrand Optical Co., New York, N.Y.: Research capabilities in optical and electronic instruments, electron optics; automation.

Federal Scientific Corp., New York, N.Y.: Research capabilities in biomedical instrumentation and computing devices.

Ferrotec, Inc., Newton, Mass.: Research capabilities in ferrite devices.

Garret Corp., Los Angeles, Calif.: Airesearch Division: Research capabilities in vacuum technology, development of cryogenic systems.

General Electronic Laboratories, Inc., Cambridge, Mass.: Research capabilities in communications, electronics.

General Motors Corp., Detroit, Mich.: AC Spark Plug Division, Wakefield, Mass.: Research capabilities in inertial navigation, advanced inertial sensors, inertial sensor elements, inertial navigation systems.

General Precision Equipment Corp., Tarrytown, N.Y.: Toledo Division, Toledo, Ohio: Research capabilities in solar indication simulation and effects.

Giannini Controls Corp., Pasadena, Calif.: Systems Division, Duarte, Calif.: Research capabilities in hypervelocity, plasma, solid state and semiconductor physics; optical and dielectric spectroscopy.

Hallicrafters Co., Chicago, Ill.: Research capabilities in coherent light communications, plasma, microwave.

Honig Laboratories, Brooklyn, N.Y.: Research capabilities in biomedical instrumentation.

Hollander Associates, Fullerton, Calif.: Research capabilities in computing devices.

Howard Research Corp., Arlington, Va.: Research capabilities in electronic modules.

Hyelectronics Corp., Burlington, Mass.: Research capabilities in computing devices.

INDATACON, Sudbury, Mass.: Research capabilities in operation analysis.

IRCO Corp., New York, N.Y.: Research capabilities in development of optical membranes and sensors.

Incabloc Corp., New York, N.Y.: Research capabilities in computing devices.

Industrial Nucleonics, Columbus, Ohio: Research capabilities in development of measuring methods using nuclear radiation techniques.

Isomet Corp., Palisades Park, N.J.: Research capabilities in computing devices.

Kaman Nuclear, Colorado Springs, Colo.: Research capabilities in neutron activation, nuclear instrumentation, analytical studies.

Kearfott Semiconductor Corp., West Newton, Mass.: Research capabilities in solid state discrete devices, microcircuits, advanced miniature components and instrumentation.

Knight, Ewen, Corp., East Natich, Mass.: Research capabilities in high resolution radar systems, telemetering tracking systems.

Kollmorgen Corp., Northampton, Mass.: Research capabilities in optical systems, spectrometer development, pyrometers, ultraviolet systems.

Kulite Tungsten Co., Ridgefield, N.J.: Research capabilities in gyroscope components.

Ling-Temco-Vought Corp., Dallas, Tex.: Research capabilities in autopilots, experimental instrumentation, electronics, guidance, materials, special computers, antennas, and operations analysis.

Longines-Wittnauer Watch Co., Inc., New York, N.Y.: Research capabilities in instruments, timing devices, microelectronics.

Magnetic Controls Co., Minneapolis, Minn.: Research capabilities in digital and analog data processing equipment.

Malaker Laboratories, Inc., Highbridge, N.J.: Research capabilities in cryogenic cooling, instruments.

Martin-Marietta Corp., Baltimore, Md.: Research Institute for Advanced Studies, Baltimore, Md.: Research capabilities in mathematical analyses, advanced advanced theoretical investigations.

Maser Optics, Inc., Boston, Mass.: Trident Division: Research capabilities in laser, solid and gas state devices, optics.

Maurer, J. A., Inc., Long Island City, N.Y.: Research capabilities in photographic equipment.

Mechtron Corp., Orlando, Fla.: Research capabilities in inertial systems and components.

Melpar, Inc., Arlington, Va.: Research capabilities in computer systems, artificial intelligence, plasma research.

Applied Science Division, Watertown, Mass.: Research capabilities in pattern recognition, advanced instrumentation, communications theory, physics.

Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.:

Boston Division, Boston, Mass.: Research capabilities in electrical engineering, physics, magnetics, electro-optical processes, and mathematical analysis.

Electronic Data Processing Division, Wellesley Hills, Mass.: Research capabilities in physics, mechanical engineering, electrical engineering, metallurgy.

MITHRAS, Inc., Boston, Mass.: Research capabilities in radar, optics.

Modal Systems, Inc., La Jolla, Calif.: Research capabilities in computer devices.

Monitor Systems, Inc., Fort Washington, Pa.: Research capabilities in computing devices.

Northrop Corp., Beverly Hills, Calif.: Precision Products Department, Norwood, Mass.: Research capabilities in gyroscope and accelerometer research, specialized electrical circuitry, precision test equipment.

Orbit Industries, Inc., Vienna, Va.: Research capabilities in electronics.

Oster Avionic, Racine, Wis.: Research capabilities in instrumentation, servosystems, computing systems.

Pacific Infrared Systems Co., Tarzana, Calif.: Research capabilities in IR, optics, electronics.

Parametrics, Waltham, Mass.: Research capabilities in plasma research.

Pennsylvania Research Associates, Inc., Philadelphia, Pa.: Research capabilities in advanced research in optical instrumentation, solid state devices, computers.

Portable Electric Tools, Inc., Geneva, Ill.: Research capabilities in electronic circuitry.

Quantatron, Santa Monica, Calif.: Research capabilities in optical masers (lasers).

Radio Corp. of America, New York, N.Y.:

Aerospace Communications and Controls Division, Burlington, Mass.: Research capabilities in electronics and electro-optical research.

Memory Products Operation, Needham Heights, Mass.: Research capabilities in memory products, ferrites, cryogenics, permalloyed thin films.

Renner, Inc., Bethesda, Md.: Research capabilities in inertial components and systems.

Research Triangle Institute, Durham, N.C.: Research capabilities in solid-state electronics devices.

Resources Research, Inc., Alexandria, Va.: Research capabilities in biological instrumentation.

Rosemont Engineering Co., Minneapolis, Minn.: Research capabilities in airdata, temperature and pressure sensors, cryogenic applications.

Sanders Associates, Inc., Nashua, N.H.: Research capabilities in electronics, microwave techniques, physics, quantum electronics, lasers.

Advanced Systems Laboratories, Burlington, Mass.: Research capabilities in radar, phased arrays, space communications.

Scott Aviation Corp., Lancaster, N.Y.: Research capabilities in pneumatic control devices.

Sensor Dynamics, Ann Arbor, Mich.: Research capabilities in optics, data processing techniques.

Shure Brothers, Evanston, Ill.: Research capabilities in biomedical and acoustic instrumentation.

Signetics Corp., Sunnyvale, Calif.: Research capabilities in integrated microcircuitry.

Simmonds Precision Products, Tarrytown, N.Y.: Research capabilities in measuring devices for cryogenic applications.

Spacelabs, Inc., Van Nuys, Calif.: Research capabilities in development of biomedical instrumentation.

Space Sciences, Inc., Natick, Mass.: Research capabilities in plasma propulsion, satellite instrumentation, control systems, and devices.

Spectra Physics, Inc., Mountain View, Calif.: Research capabilities in optical masers (lasers).

Sperry Rand Corp., New York, N.Y.: Sperry Rand Research Center, Sudbury, Mass.: Research capabilities in solid-state and plasma physics, communication sciences, atmospheric physics.

Stearns Rogers Corp., Denver, Colo.: Research capabilities in space vehicle simulator systems.

Strand Engineering Co., Ann Arbor, Mich.: Research capabilities in electronic devices.

Sylvania Electronic Products, Inc., New York, N.Y.:

Electronic Systems Division, Waltham, Mass.: Research capabilities in information processing, communications, radio physics, space techniques, aerospace sciences.

Semiconductor Division, Woburn, Mass.: Research capabilities in physics, electrical engineering.

Systems Technology, Inc., Inglewood, Calif.: Research capabilities in automatic flight control systems, manned flight control.

TRG, Syosset, Long Island, N.Y.: Research capabilities in masers, physics, optical masers (lasers).

Tasker Instruments Corp., Van Nuys, Calif.: Research capabilities in hybrid digital-analog systems, tracking and positioning determination, displays, computers, space systems, radars, countermeasures.

Texas Research & Electronics Corp., Dallas, Tex.: Research capabilities in development of solid-state and electrolytic sensing devices.

Trans-Sonics, Inc., Burlington, Mass.: Research capabilities in physics, electrical engineering.

Trident Engineering Associates, Inc., Annapolis, Md.: Research capabilities in guidance systems.

Ultrasonic Industries, Plainview, Long Island, N.Y.: Research capabilities in sound equipment.

United Industries Corp., New York, N.Y.: Aircraft Armaments, Inc., Cockeysville, Md.: Research capabilities in spacecraft motion simulators.

VEDA, Inc., Ann Arbor, Mich.: Research capabilities in systems analyses.

Vector Manufacturing Co., Trevose, Pa.: Research capabilities in computing devices.

Wells Industries Corp., North Hollywood, Calif.: Research capabilities in electronic devices.

Winzen Research, Inc., Minneapolis, Minn.: Research capabilities in human support systems.

Wolf Research & Development Corp., West Concord, Mass.: Research capabilities in digital computers.

Government Laboratories Having Significant Capabilities in Electronics and Related Disciplines

The Government laboratories and affiliated private organizations shown in the following listing have a significant research and development capability in electronics and related disciplines. Although most of these laboratories also perform development, test, and evaluation functions, they are distinguished from other Government laboratories by having a significant research capability in electronics. Personnel figures shown are for fiscal year 1961.

DEPARTMENT OF COMMERCE, NATIONAL BUREAU OF STANDARDS

Scientific activities

The scientific activities encompassed by the Bureau are, in descending order of concentration, scientific research and development with emphasis on research, scientific and technical information, scientific testing and standardization, and scientific data collection.

The subdivisions of the Bureau report directly to the Director and Deputy Director or are under the supervision of the Director of Boulder Laboratories or the Associate Director (administrative). Those subdivisions performing scientific activities under the supervisions of the Director of the Boulder Laboratories are the Divisions of Cryogenic Engineering, Radio Standards, Ionosphere Research and Propagation, Radio Propagation Engineering, Radio Systems, and Upper Atmosphere and Space Physics.

Radio propagation

Radio propagation activities include research on the physical phenomena of the troposphere and of the the upper atmosphere, radio propagation characteristics, propagation and antenna systems, and new propagation techniques. The programs are carried out in four technical divisions of the Bureau's Boulder Laboratories as well as several smaller groups under the Office of the Director of Boulder Laboratories. These activities comprise the Central Radio Propagation Laboratory, which serves as the central agency of the Government for collecting, analyzing, and disseminating information on the propagation of radio waves at all frequencies along the surface of the Earth, in the atmosphere, and in space. The Laboratory performs scientific studies looking toward new techniques for the efficient use and conservation of the radio spectrum. It exchanges data with other countries to advance the knowledge of radio propagation and interference phenomena and provides the liaison required to carry out international responsibilities and agreements. The use of the title Central Radio Propagation Laboratory serves administrative convenience and assures continuity in national and international scientific activities. It avoids confusion, for example, when used in international agreements and conferences.

The Ionosphere Research and Propagation Division acts as the primary agency for the conduct and coordination of basic research on the propagation of radio waves as affected by the ionosphere and on the special factors which give rise to large departures from normal behavior. It conducts basic research on the nature of the media through which these radio waves are transmitted and the interaction of radio waves with the media and prepares predictions of radio wave propagation and warnings and disturbances. The Division acts as a central repository for data, reports, and information in the field of ionospheric radio wave propagation; it maintains a staff of experts on the characteristics of the ionosphere and on radio wave propagation in the ionosphere for consultation when needed by other Government agencies and industry.

The Radio Propagation Engineering Division conducts research on the basic characteristics of radio propagation with the ultimate object of improving the utilization of the radio spectrum. The Division performs research on new experimental techniques for the measurement of the basic characteristics of radio propagation and studies the lower atmosphere particularly those characteristics affecting propagations through the troposphere. It measures radio noise in a worldwide network of stations at all frequencies throughout the radio spectrum; it provides consultative services on problems relating to propagation.

The Radio Systems Division conducts research in long-distance radio transmission for communication, navigation, time-synchronization, detection and positioning, and carries out electromagnetic wave propagation studies for ionospheric ground wave and line-of-sight paths to define the utility, limintations, and disturbances of the transmission channel. The Division studies antenna principles, communication theory, and modulation and navigation techniques to improve the reliability and efficiency of radio spectrum utilization, and devices standards and methods of measurement in radio systems. It provides consultative and advisory service as required by other Government, commercial, and scientific activities.

The Upper Atmosphere and Space Physics Division undertakes basic and applied research in the physical and dynamic properties of the Earth's upper atmosphere and the interplanetary medium, including studies of the interactions of electromagnetic and corpuscular radiation with both media and the influence of the Sun upon these media. It makes comparative studies of the Earth's atmosphere and the atmospheres of other planets, and conducts laboratory investigations of ionized gases and atmospheric constituents, with particular reference to solar and planetary atmospheres and the interplanetary medium.

Physics and electronics

Activities in physics and electronics include work in the fields of optics, meteorology, heat, rheology, atomic and electron physics, radiation physics, instrumentation, electricity, and electronics. Research and development are involved in support of standards and measurement of light, color, length, heat, mass, volume, viscosity, ionizing radiation, atomic constants, electricity magnetism, and electronic phenomena. The development and application of digital and analog computer and control systems are included.

The Electricity Division is responsible for the establishment, maintenance, and dissemination of units and standards for measurements in electricity and magnetism and determination of fundamental constants of nature. The Division performs basic research in the nature of dielectric and magnetic matter, calibrates standards and precision instruments for industry and Government laboratories, furnishes consultative service to Government agencies, devises new types of electrical apparatus and makes technical information in these fields available to the public.

DEPARTMENT OF DEFENSE, FIELD STATIONS AND INSTALLATIONS

Department of the Army

Harry Diamond Laboratories.—These laboratories at Washington, D.C., conduct research and development in the physical sciences and engineering directed toward meeting military characteristics for fuzes and related items; provide consulting and liaison services in connection with development, production, and use of items developed in laboratories; fabricates models and prototypes of items under development at the laboratories; and performs developmental testing, including destructive testing of protypes. Total personnel, 1,440.

U.S. Army Electronic Proving Ground.—The U.S. Army Electronic Proving Ground, Ft. Huachuca, Ariz., carries out combat development, tests, and evaluation in all fields of interest to the Signal Corps. It performs a limited amount of research and development in micrometeorology and other minor fields, and provides operational meteorological support to other Signal and Army research, development, test, and evaluation activities, except the White Sands Missile Range. It includes the Army Electronic Environmental Test Facility. Total personnel, 3,000.

U.S. Army Signal Research and Development Agency and Laboratory.—The U.S. Army Signal Research and Development Agency and Laboratory, Fort Monmouth, N.J., among its other activities, conducts continuing research in all fields of physical science leading to the development of new techniques and the design and improvement of communications, radar, electronic countermeasures, automatic data processing, radiological, meteorological, photographic, drones, and solid-state devices. The Laboratory, the major element of the Agency, is the primary agency of the Chief Signal Officer for research and development in nearly all fields of interest to the Signal Corps. Total personnel, 3,800.

Department of the Navy

U.S. Naval Research Laboratory.—The U.S. Naval Research Laboratory, Washington, D.C., conducts a broad program of research and development which includes most areas of the physical sciences of interest to the Naval Establishment. The program is designed to meet the needs for equipment and materials to increase the combat effectiveness of the Navy. The Laboratory also conducts fundamental research and experimentation in anticipation of future requirements, conducts research and development for and provides scientific and consultive services to the materials bureaus of the Navy, Army, Air Force, and other governmental agencies. Total personnel, 3,260.

U.S. Navy Electronics Laboratory.—This Laboratory at Point Loma, San Diego, Calif., conducts research, development, and testing in electronics and related fields of engineering and science, including radio, radar, sonar, electronic countermeasures, oceanography, and instrumentation for and analysis of environmental weapons effect and human factors; it provides consultative service and sea test facilities as authorized for the fleet, Navy contractors, and other agencies of the Department of Defense. Total personnel, 1,334.

Department of the Air Force

Aeronautical Systems Division.—This Division at Wright-Patterson Air Force Base, Ohio, is responsible for the development and acquisition of assigned aeronautical systems and aerospace systems and for conduct of an aggressive research

and development program in intelligence techniques, equipments, and systems. A wide field of scientific investigations is carried out by the Division's laboratories in such fields as materials application, metals and ceramics, nonmetallic materials, physics, flight control, flight dynamics, flight accessories, propulsion, communications electronic technology, navigation and guidance, reconnaissance, life-support systems, biomedicine, personnel, and behavioral sciences. The research and development activities of the Aeronautical Systems Division encompass the majority of scientific disciplines; examples of this work include studies on the formulation and fabrication of rubber and plastics compounds and materials, static tests on electronic equipment, and tests on characteristics of ceramics.

Major Division programs include the B–70, a chemically powered strategic bomber; an air-launched ballistic missile; fire control system for a long-range interceptor; tactical air-to-surface missile; tactical fighter; cargo transport system; vertical-takeoff-landing utility transport; operations support involving 7 technical areas to develop hardware in support of existing equipment, a responsibility shared with the Electronic Systems Division; DYNA-SOAR, a manned hypersonic glider; ASAPP, aerospace advanced propulsion program; X–15, rocket-powered, manned aircraft with extra-high-speed, high-altitude capability; PLUTO, a nuclear rocket; LFC, laminar flow control; and a lightweight turbojet. It also shares responsibility with the Deputy Commander, for Aerospace Systems, the Office of Aerospace Research, and the Electronic Systems Division for applied research in 29 technical areas in support of efforts to adapt the results of basic research to use by the Air Force. The Aeronautical Systems Division, the Electronic Systems Division, and the Deputy Commander for Aerospace Systems also share responsibility for 14 projects in support of all test instrumentation requirements. Total personnel, 9,265.

Electronic Systems Division.—This Division at L. G. Hanscom Field, Bedford, Mass., manages the design, development, and implementation of ground communications and electronics environment required for weapon and forces control, called the command and control or L systems. The Division has management responsibility for all design and implementing phases of Air Force ground electronic systems from concept to checkout, including advanced conceptual planning, applied research and development, design, procurement, production, installation, test, and evaluation. Its main scientific responsibilities, capabilities, and activities, cover communications, electronics, data acquisition, processing, transmission, and display.

Major programs of the Electronic Systems Division include: AWCS, air weapons control system; NORAD COC, North American Air Defense Combat Operations Center; TRACALS, traffic control and landing system; weather observation and forecasting system; intelligence data handling system; SACCS, Strategic Air Command control system; electromagnetic intelligence collecting system; air communications system; and SPADATS, space detection and tracking system. The Division also shares responsibility with the Aeronautics Systems Division, the Deputy Commander for Aerospace Systems, and the Office of Aerospace Research for 29 technical areas of applied research in support of efforts to adapt the results of basic research to use by the Air Force.

The nonprofit MITRE Corporation, established in 1958, is a direct assistant to the Division to provide analytical planning, technical guidance and supervision and intersystem engineering. During the last fiscal year MITRE received $22,844,000 from the Department of Defense. The Corporation has a close working relationship with the Massachusetts Institute of Technology and is directed by leaders from industry, universities, public utilities, and large law firms.

The Division also works closely with the Air Force Cambridge Research Laboratories of the Office of Aerospace Research and Massachusetts Institute of Technology's Lincoln Laboratory, receiving direct and indirect support from their basic research activities and in many instances participating jointly with them in special studies and in certain applied research projects. The Division's work is closely related to the communications and electronic research and development programs of the National Aeronautics and Space Administration, Federal Aviation Agency, National Security Agency, Advanced Research Projects Agency, Defense Communications Agency, Navy, Army, and other agencies within the Air Force. Total personnel, 4,199.

Rome Air Development Center.—This Center, located at Griffis Air Force Base, N.Y., is a major supporting agency and subcommand of the Research and Technological Division of the Air Force Systems Command. The Center provides the Air Force with contract management and in-house capabilities in the areas of global communications, missile tracking and guidance, intelligence and recon-

naissance techniques, electronic warfare, long-range early warning systems, and other large military electronic developments. Current efforts emphasize acquisition, processing, transmission and display of data from command and control elements. Major development contracts for hardware products in these areas are managed by RADC personnel. Total personnel, 1,572.

U.S. Air Force Cambridge Research Laboratories.—The Air Force Cambridge Research Laboratories at Hanscom Field, Bedford, Mass., conduct and sponsor basic and applied research in electronics and geophysics, the program combining a substantial intramural research effort with a large contractual program. The Laboratories have two Directorates. The Electronics Research Directorate operates seven Laboratories: Computer and Mathematical Sciences, Electronic Materials Sciences, Electromagnetic Radiation, Propagation Sciences, Communication Sciences, Control Sciences, and Astrosurveillance Sciences. Eight Laboratories are under control of the Geophysics Research Directorate: Aerophysics, Atmospheric Circulations, Meteorological Development, Photochemistry, Terrestrial Sciences, Ionospheric Physics, Thermal Radiation, and Research Instrumentation. The Geophysics Research Directorate also operates the Sacramento Peak Observatory near Alamogordo, N. Mex. Total personnel, 1,042.

FEDERAL AVIATION AGENCY

Scientific activities

The Service is responsible for the conduct, planning, and administration of a research and development program to accomplish inservice improvements with currently available equipment; systematic application of existing technology to meet increased air traffic load, while maintaining requirements for increased safety and expeditious traffic handling; and long-range development of new equipment and concepts to meet requriements of the future. The Service also operates and provides plant support for the National Aviation Facilities Experimental Center at Atlantic City, N.J.

Applied research is conducted in atmospheric and solid earth sciences, engineering in the area of air traffic control systems, and social science with regard to airport systems research. Most research and development is performed contractually with industrial firms, a small amount by private institutions and State agencies. All test and experimentation is performed by Federal employees at the National Aviation Facilities Experimental Center, Atlantic City, N.J. The Service does not support research and development programs of foreign governments; however, for the blind landing experimental unit landing system, considerable testing and evaluation is programed in the immediate future; a complete installation of the unit's British landing system is being made ready for testing at the National Aviation Facilities Experimental Center.

FIELD STATIONS AND INSTALLATIONS

National Aviation Facilities Experimental Center

This Center, at Alantic City, N.J., is operated entirely by the Service and houses its divisions.

The Test and Experimentation Division is responsible for conducting comprehensive engineering and operational tests, and evaluation of systems, equipment, and procedures proposed or intended for use in the national system of aviation facilities. The character of work conducted falls into the categories of simulated tests and tests conducted under actual flight conditions.

The Research Division predicts future air traffic needs to permit systems analysis and timely development of new and improved equipment and procedures; analyzes currently used air traffic control and other aviation support systems and measures their effectiveness; conducts research in air traffic control and other technical aviation support subjects; performs studies and research in known aviation safety problem areas; determines feasibility of using applicable scientific principles, new equipment, or advances in technology to improve efficiency and safety in aircraft operations; and conducts human factors research. Work involves the supervision of contractors performing applied research and conduct of laboratory work by Government personnel. Total personnel, 1,061.

1964 NASA AUTHORIZATION

WEDNESDAY, APRIL 3, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SPACE SCIENCES
AND ADVANCED RESEARCH AND TECHNOLOGY,
Washington, D.C.

The subcommittee met, pursuant to adjournment, at 10 a.m., in room 304, Old House Office Building, Hon. Joseph E. Karth (chairman of the subcommittee) presiding.

FURTHER STATEMENT OF DR. ALBERT J. KELLEY, DIRECTOR, ELECTRONICS AND CONTROL, OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY, NASA

Mr. KARTH. The committee will be in order. Dr. Kelley, yesterday when we adjourned, I believe we adjourned on the conclusion of your prepared testimony and so if there is anything you would like to add at this time, please proceed. If not, perhaps there are questions in the minds of the subcommittee members they would like to ask at this point.

Dr. KELLEY. I have nothing to add.

Mr. KARTH. If Doctor Bisplinghoff has something to add at this point, he may proceed.

Dr. BISPLINGHOFF. I have nothing to add.

Mr. KARTH. Doctor Kelley, yesterday I interrupted you, briefly, to discuss the Ranger program. We didn't make much progress because of the classification of the document, but inasmuch as you were the chairman of the study group, I wonder if you and I couldn't agree, and certainly there's no reason why this should be secret information, a substantial portion of the total number of reasons for failure of the Ranger program really lies with management. I recognize that there may be a conglomeration of reasons.

Couldn't we agree to that?

Dr. KELLEY. I don't know what definition of "management" that you are using, Mr. Karth.

Mr. KARTH. I'll use it as broadly as you used the term "electronics."

Dr. KELLEY. It was pointed out by the Ranger board that in building or designing and constructing these vehicles that we have to pay very, very close attention to quality control.

That is, we can't just give the job to the individual engineer, although he may be the best in the world, and say, "Will you, at a certain time, deliver a product that will work?"

We all have blinders on, if you will. That's why people take examinations in school to check up on what they are doing. Even the smartest student has to take an exam and in the management sense there was not enough checking up on the individual engineer, the individual participant, in terms of quality control, in terms of electronic and other standards, throughout the particular vehicle.

Mr. KARTH. Well, where was this lack of checking up? Where did we find it—in JPL, in NASA, some of the subordinate contractors that worked under other contractors?

Can you be specific, or was it just general in nature?

Dr. KELLEY. For this particular project, JPL had the project responsibility so the problem was focused there.

Now, we also learned some factors on how much we should try to manufacture in-house and I think you are well aware that we have—"we," that is NASA and JPL, have taken on an industrial contractor to continue the production of the Ranger spacecraft. This was in accordance with the recommendations of the board that we not try to continue a production-line operation in-house.

This is something that is more amenable to the industrial complex. However, Ranger had taken on slightly different complexion from the time it started, to the time the Ranger board convened.

Ranger was originally a five-shot project and now, as you know, we are thinking in terms of expanding it up to 16, perhaps 20 shots; but as far as the management——

Mr. KARTH. Well, this could be because the first five failed, I suppose.

This is one of the reasons, I suppose, why we are expanding the program. It is a reasonably good reason, in my opinion, in view of the program's importance.

The first number you anticipated, if this necessarily fails, it seems to me you would have to expand the program.

Dr. KELLEY. We'd still like to get the information on the Moon that the Ranger was supposed to deliver for us.

Mr. KARTH. Yes.

Who did the electronics work on Ranger, Dr. Kelley?

Dr. KELLEY. Well, there was a combination, there were many contractors involved.

JPL did some of the work in-house.

The contracting ranged all the way from major subsystems which Aeroneutronics and Nortronics, for example, did; to bit and piece operations, constructing module boards, which various small companies around, for example, the Pasadena area did.

So there were many, many people involved, including JPL, doing some of their own in-house manufacturing, many companies and many groups who contributed to the operation.

Mr. KARTH. Who is the major manufacturer of electronic components?

Dr. KELLEY. I don't know the exact figure.

It would probably be either Aeroneutronics or Nortronics. They were the two major subcontractors. Now, however, there were many, many components supplied to JPL which they, in turn, had built into module boards by smaller contractors or which they built into module boards themselves.

So, if you would say who was the largest single electronics contractor in dollar volume, I really don't know.

Mr. KARTH. Well, I understood that a major portion of the electronic equipment produced for Ranger out-of-house, was done by Nortronics. This is a division of Northrop Aviation; isn't it?

Dr. KELLEY. Yes, sir; that is a division.

Mr. KARTH. Does this sound reasonable to you? Does it sound correct?

Dr. KELLEY. A "major proportion," I don't know whether it was the most. Aeroneutronics and Nortronics, those contractors were the two principal subcontractors through JPL, but JPL themselves acted as a systems or prime contractor on the whole Ranger program and brought all the pieces together; assembled them in-house, and tested them in-house.

Mr. KARTH. I understood that the assignment of the work done out of house has pretty much been to Northrop. Is that correct?

Dr. KELLEY. As I understand it, they are now the contractor, that is the systems contractor which we, on the Ranger board, recommended. We didn't recommend them specifically, but we recommended a systems contract be taken on to do a specific task and, as I understand it, Northrop has been selected as that contractor.

Mr. KARTH. Is this contract a bid-type contract or is it negotiated or what?

Dr. KELLEY. I am not familiar with it, Mr. Karth.

I have not maintained close contact with the Ranger program since we concluded our operations.

Mr. KARTH. I see.

Doctor, this research center that you spoke of yesterday, and which is in the budget for $5 million; after it has grown to its 2,000-personnel capacity, that you spoke of yesterday as a probability; what would you estimate its annual cost of operation to be?

Dr. KELLEY. Its annual cost of operation based on our present estimates per man, would be on the order of $28 to $30 million. This is 2,000 people.

Mr. KARTH. Now, there's some speculation that this 2,000 could very easily, and in all probability would, grow to about 5,000, if this should be approved. What do you think it would grow to? We would like to have some kind of assurance backed up by your word in the record that this thing would not become a gigantic installation, well beyond our powers of reasoning today, while we discuss a 2,000-man limitation?

Dr. KELLEY. I can tell you what we did. It was our recommendation that the agency needed approximately 2,000 additional people to carry on its electronics research and this was projected through 1970. In 1970 the facilities for the people would be compatible at the 2,000 level.

Now we see this as sufficient to meet the needs of the space program as we can project them to 1970.

Mr. KARTH. So if this were authorized up to 1970, you feel that this 2,000 personnel estimate is a very accurate one; that is, a maximum of 2,000?

Dr. KELLEY. Well, I am assuming that we continue the space effort along the same lines and at the effort that we are right now.

I couldn't predict whether there might be some reason to accelerate in the future.

Our planning right now says approximately 2,000 people.

Mr. KARTH. Your planning last year was, in effect, that you didn't need such a laboratory though.

Can you give this committee any assurance that this research laboratory would, in all probability, not expand beyond 2,000 personnel by 1970?

Dr. KELLEY. It's very difficult for me to predict between now and 1970 what the future of the space program will be, or what the future of the country will be. I can only assure you that our planning shows that 2,000 people meet the needs of the agency as we can see them to 1970, based on the best prediction I can make right now—2,000 people, yes.

Mr. KARTH. We have electronics research people working in the NASA research organization now, Dr. Kelley?

Dr. KELLEY. Yes, we do.

Mr. KARTH. How many?

Dr. KELLEY. We have a total of 391 professionals scattered throughout the agency.

Mr. KARTH. 391 people; does this fit your broad interpretation of electronics or is it a rather narrow interpretation as we were talking about interpretations yesterday?

Dr. KELLEY. This fits the interpretation as I described in the beginning of my discussion yesterday and my interpretation in the budget documents under "Electronics systems."

Mr. KARTH. Which includes those people who fix wires to terminals and things like that?

Dr. KELLEY. No, it does not.

Mr. KARTH. Includes research people, period.

Dr. KELLEY. Working on research and advanced technology, that is correct.

In the projects, of course, there are electricians and electrical engineers.

I am talking about the people working on research.

Mr. KARTH. These are not included in the 391.

Is that correct?

Dr. KELLEY. That is correct.

These are research and advanced technology.

Mr. KARTH. Failures that might have occurred in our space missions, up to this time, that could be attributed, for example, to an electrician, would you call this an electronic failure?

Dr. KELLEY. You mean an electrician making a mistake——

Mr. KARTH. Yes.

Dr. KELLEY (continuing). On the wiring or something?

Mr. KARTH. Yes.

Dr. KELLEY. If it occurs on a module board, electronic in nature, we would call it electronic. If it occurred in a wiring harness, we would call it electrical.

Mr. KARTH. How do you make the distinction between those two types on the basis of your statement yesterday—all inclusive or separate?

Dr. KELLEY. We are concerned, I guess, if I have to say it in a few words, in the electronic systems, with information systems. That is the devices that handle, process, and generate information at low-level signals, as I mentioned yesterday—the brains.

Mr. KARTH. We are talking about 90 percent of the failures occurring in the field of electronics as a very, very broad interpretation

and possibly this includes even those errors that an electrician might make in whatever workload he may have in connection with the program, is that correct?

Dr. KELLEY. No, I was referring to electronic systems devices.

Now, if an electrician makes a mistake in an electronic system we account that as a failure on an electronic system.

Mr. KARTH. Let's talk about the electrical engineer.

What if it's a mistake an electrical engineer made?

Let's talk about mistakes, which, I guess, involves poor management in most cases. And this involves poor quality control, which, I guess, involves a good many things other than research.

So, could you, for the benefit of this committee, give any accurate estimate as to what these failures amount to, in terms of percentages, in the area where we've had inadequate research, as opposed to where we have had inadequate management?

Dr. KELLEY. You are talking about, I believe, the straight reliability failures or the mistakes or "goofs" versus the fact that a component was misused or wasn't available to do the job.

I don't have a specific breakdown.

Mr. KARTH. I'm thinking of the case where quality control wasn't good enough.

The item was improperly built because the specifications were inaccurate, or substandard, because the quality control techniques were substandard; so it became an inferior piece.

Dr. KELLEY. You can't divorce these two, really.

Mr. KARTH. I know these things are difficult to divorce. I was wondering if there is any possibility that you can do it.

Dr. KELLEY. The reason you can't divorce it, really, is because the quality control and the specifications are part of the environment you are in and depend on how much you know about the environment. You just can't get parts by writing specifications. You have to do research to get the parts.

There are component failures. That is, the component just failed—catastrophic failures, we call them. And there are failures due to the fact we didn't, in the space environment, know how to use a particular component which was delivered to us, although it was a good component; there is a history of this in the Ranger program, for example.

Mr. KARTH. Doctor, how many real professional people do you expect to employ out of this 2,000, for the Research Center?

Dr. KELLEY. 600 to 700 would be professionals.

Mr. KARTH. 600 to 700. They would be on equal terms, professionally, with the 400 we now have?

Dr. KELLEY. Approximately the same level of distribution.

Mr. KARTH. So you are saying that what we should do is slightly more than double our research personnel. Is that what you are saying?

Dr. KELLEY. That is correct.

Mr. KARTH. Where are these 391 we now have?

Where are they located, Doctor?

Dr. KELLEY. They are throughout the agency.

Would you like me to tell you where they are?

Mr. KARTH. Yes, sir; I certainly would, for the record.

Dr. KELLEY. I have some notes here. Here we are.

There are 147 at Langley Research Center, 68 at Ames Research Center, 35 at Lewis, 20 at Flight, 40 at Goddard, 3 at Manned Spacecraft Center, 52 at Marshall, 26 at Jet Propulsion Laboratory—and I think that adds up to 391.

Mr. DOWNING. Would the Chairman yield for 1 minute, for one question?

Mr. KARTH. Yes. Mr. Downing?

Mr. DOWNING. Would the effect of this research laboratory mean you would take these boys from these places and from the universities and concentrate them in this particular research center?

Dr. KELLEY. No, sir; our intention is to leave the work at the existing centers largely as it is; this is an additional buildup of capability within the agency.

Now, I'm sure there will be some fluxing or redistribution of people who may want to go to one or another, but we would plan the approximate distribution to remain about the same at the existing centers and the 600 to 700 would be over and above these.

Mr. DOWNING. It wouldn't take anything away from the universities and the present centers which are now engaged in this work?

Dr. KELLEY. No, sir; not at all.

Mr. KARTH. If the gentleman would yield.

I think he should separate the two areas of professional personnel of universities apart from the centers.

Would you care to do that?

Mr. DOWNING. Yes, indeed, would you do that, Dr. Kelley?

Dr. KELLEY. I don't understand the question.

Mr. KARTH. His question was: Would we take anyone away from the universities and other centers. Your answer was "No."

Do you mean you wouldn't draw on the university talent to staff your research center?

Dr. KELLEY. I can't say there wouldn't be some university people who would join the center. This has been a prevalent fact throughout the past few years.

Mr. KARTH. Your "no" answer refers to the 391 located at the centers.

Dr. KELLEY. That is correct.

It's not an absolute "no." There may be individuals who will move about throughout the agency and there may be individuals at universities who come to NASA and vice versa.

Mr. KARTH. But the additional 600 professional people would be drawn from universities and from industry, would they not?

Dr. KELLEY. Well, our plan——

Mr. KARTH. Where else do you get them, Doctor?

Dr. KELLEY. I see 600 to 700 professionals by approximately 1969 and with the buildings to be completed by 1970, which means that we have a little leadtime on the personnel so we don't have empty buildings, we have people to move into the buildings. The 600 to 700 represents a gradual growth over a 6- to 7-year period. Now, these are people who will come from many sources.

Some will come from within the agency. Some will come from universities. Some will come from industry and a substantial number, we hope, will be younger graduates from the universities who will have an opportunity to work on what we think is the new, exciting, field of space electronics and at the same time continue to upgrade their graduate education.

This has been the history of the NACA where many of the senior people in NACA, now in the NASA, came to the agency right out of college with bachelor degrees and continued working in the laboratory, continued their graduate education along with their work; in fact, many of them went to industry from the agency.

But this has been the history of growth of the agency and we call it homegrowing our own.

We don't expect this to cause a serious impact on the manpower as we see it through the next several years; that is, on the scientific manpower.

Mr. KARTH. If a substantial portion of your recruitment is going to come from the universities and then you propose to give them more education, postgraduate level education, the question immediately arises in my mind: How effective is your laboratory going to be, until after 1968, 1969, or 1970?

Dr. KELLEY. Well, people from the university, in the context in which I was using the term, are people just graduated from the universities who are looking for employment.

Mr. KARTH. Yes.

Dr. KELLEY. Now, this Center is to be established for the long haul. We have been trying to make this clear in our discussions that it is a gradual buildup.

It is for the future of the space program. There will be some impact on Apollo and other immediate programs, just like any one of our agency programs have an impact on one another; but this is for the long-range future of space exploration, to establish our long-range electronic posture for the future, but we expect it to make a contribution as it grows.

We don't expect these people all to be in school all the time. These will be part-time courses; and this has been a very satisfactory arrangement where somebody can be going to school part time and then working on a real problem in the laboratory.

Then, I think, the schooling means more to him and he can combine, in fact, his thesis work with some of his laboratory work.

Mr. KARTH. Now, Dr. Kelley, I'm sure you are more familiar with the electronics field than I am. We have a lot of people working in it. I think it is very desirable.

Maybe this is one of the reasons there are a lot of people working in it.

I understand that NASA's recruitment job, in all the disciplines, becomes more and more complex, and more difficult every year, does it not?

Dr. KELLEY. I don't know that for a fact.

I think you have to balance the agency's requirement versus the available pool of manpower at any time to see how difficult it is. I think we have been successful in attracting a good number of high caliber people.

Mr. KARTH. I don't think there is any doubt about it. The fact of the matter is I am not only well pleased, but somewhat amazed at the very high caliber of the people who have appeared before this committee.

I say this in all honesty and sincerity. I really mean it, and this includes you and Dr. Bisplinghoff, incidentally.

When I suggested that maybe the agency was having recruiting difficulties, I was basing my assumption on money, I guess, more than anything else.

Last year it cost us $380,000 to recruit people. This year, NASA is asking for nearly half a million; so, I assume that the job is becoming more difficult. If it isn't, we ought to take a look at the budget, and I assume that our recruiting problem, in the event that the Congress should authorize the Boston Research Laboratory, would be quite a problem.

Dr. KELLEY. I believe we are talking about two different problems.

There has been a rapid expansion of the agency within the last couple of years, particularly in an attempt to get people on board to do an immediate job, Apollo.

That is where our emphasis has been within the agency, and of course, we do have other programs including advanced research and technology.

Now, the Center is designed for the long-range future and the slope of the buildup of personnel, the rate of acquisition will be quite gradual; we have always planned it to be quite different than the buildup that we have undertaken over the past 2 or 3 years and I don't see that this would have a serious effect of manpower in the United States, scientific and engineering manpower.

In fact, one of the reasons for our desire—for the desirability of locating near a university complex was this very factor, that we could attract good people and, as I said, "home grow" them and let them continue their graduate education in the right environment.

Mr. KARTH. Doctor, don't you see quite a problem, though, in the approach that you are suggesting?

It seems to me that with Government pay schedules being what they are, in an industry where talented people are in great demand, that we may find ourselves in a situation where we have spent vast sums of money training people who have just come from the universities, and then lose them to industry which will be willing to pay them twice or three times as much as we can legally pay them.

Have you considered that possibility?

Dr. KELLEY. Yes, we considered that.

Mr. KARTH. I am very glad that you did.

I want you to tell me how we are going to retain them.

Dr. KELLEY. I don't think the problem is peculiar to the Electronic Research Center.

I think it is a problem throughout the Government with scientific and engineering manpower, and I think that the Government in many cases offers responsibilities and challenges and so forth, that, perhaps, are not in industry.

I don't know what the magic is, but we, in the Government, have been able to attract some pretty good people.

Mr. KARTH. I think this is true, Dr. Kelley.

Where people can clearly identify themselves or associate themselves with an important program, this is true. I am not so sure it is true when you get in a laboratory.

I can say we have some very able people in the OART, the Office of Space Sciences, in the various offices of NASA; but they are interested in specific programs, in the main.

The manned lunar landing program, for example; I am sure we have some very able people here, but they are really interested in this program.

It's not a matter of them going to a laboratory in the morning. They are directors. They are top technical people, highly professional, and they are interested in the program.

I just wonder if this would also be true when we talk about a research laboratory. There are reports that suggest Government research laboratories do not do the best job, really, because they cannot retain the best people.

After all, when you talk about the very top-caliber people you need to advance the state of the art, you are talking about a unique talent that is possessed by a very, very small percentage of the people who are eminent in that field, perhaps only 1 percent of the people in the field.

So, you are talking about the cream of the crop.

I'd like to have you just address yourself to this for a minute, if you will.

Dr. BISPLINGHOFF. I would like to say a word about that if I may, sir.

Mr. KARTH. Dr. Bisplinghoff, yes.

Dr. BISPLINGHOFF. I have been with NASA for 8 months and research has been my life's work and I have been very much pleased and surprised by the talent that we find in our own research centers, the kind of research talent you were just talking about.

I'm not sure I can explain it fully. If you are in a university it's very hard to get good research equipment. This is one of the biggest shortcomings a university researcher has.

He just can't get the kind of capital equipment in many cases he needs to do good research. There are, of course, many exceptions to this; but this is a difficult problem.

Mr. KARTH. Yes.

Dr. BISPLINGHOFF. If he goes into industry, there are a lot of deadlines to meet, a lot of "fire drills" and he oftentimes has to go from one thing to another.

This is especially true in the aerospace industries.

Mr. KARTH. What you are saying is that in industry he is pushed much more rapidly?

Dr. BISPLINGHOFF. He is pushed much more rapidly, yes.

In our own centers, we have, I think, the opportunity to have much better equipment than can be gotten in universities and he doesn't have the constant problem of meeting the "fire drills" that are often put on him in the industry.

Mr. KARTH. That doesn't mean he works 2 hours a day instead of 8?

Dr. BISPLINGHOFF. No, sir.

Mr. KARTH. I just wanted to make sure.

Dr. BISPLINGHOFF. I think our history will show us many of the really fundamental contributions have been made by NASA rather than the industry. I can state so, myself.

The field I worked in was the field of flutter. Here, in spite of a fair amount of effort in industry and the universities, the biggest contribution was made at the Langley Laboratory by Dr. Theodorsen and his staff, and it's my very firm belief after looking at the history

of our centers and their ability to keep people, keep very competent people in research, we are going to be able to do the very same thing with the Research Center.

Mr. MOSHER. Mr. Chairman.

Mr. KARTH. Mr. MOSHER?

Mr. MOSHER. Can we have a translation of the term "fire drills"? What do you mean by that?

Dr. BISPLINGHOFF. By "fire drills" I mean, perhaps in order to satisfy the claims that a salesman might make about a product, that the researcher has to, maybe, work night and day to justify these claims or he may have to—just the business of making proposals which research people are getting into more and more every day—he may have to spend a great deal of his time on writing proposals to send to the Government.

Mr. MOSHER. You mean the industrial salesmen make claims and then the researchers try to write them up?

Dr. BISPLINGHOFF. Yes, sir, this is a very common practice.

Good research has to be done with a certain element of leisure. Actually, research is very hard work, you have to keep at it day and night. It's always turning over in your mind. You can't be pushed in a lot of subsidiary directions and make good progress in the direction of research you are working on.

Mr. KARTH. Am I to understand, Doctor, that when you do research in industry you are always having "fire drills" and things of this nature that just don't allow you to do real good research?

Dr. BISPLINGHOFF. In aerospace industries, this is true.

Mr. KARTH. How about in the electronics industry?

Dr. BISPLINGHOFF. There may be organizations like the Bell Laboratories where things are different.

Mr. KARTH. Well there may be—as a matter of fact, there are, aren't there, Doctor?

Dr. BISPLINGHOFF. Yes, sir.

Mr. KARTH. And they do very good research?

Dr. BISPLINGHOFF. That is true.

Mr. KARTH. Very good research centers in private industries. Is this true?

Dr. BISPLINGHOFF. That is true.

Mr. KARTH. Mr. Randall?

Mr. RANDALL. Back on the "fire drill". Did you have any part in the review of the results of the "fire drill" on the LEM for instance, regarding the different advantages of the demonstration by these researchers between Grumman and Northrop or any of the others, North American?

Dr. BISPLINGHOFF. I am not acquainted with that.

Mr. RANDALL. You had no part in that?

Dr. BISPLINGHOFF. No.

Mr. RANDALL. I'd like to observe, maybe these "fire drills" have an advantage. They evidently impressed someone along the line as to the result and the division between two different projects. Isn't that true?

Dr. BISPLINGHOFF. I'm talking about more fundamental research than this. This is a proposal to build a piece of hardware for a mission. I'm talking about more fundamental research than this.

Mr. RANDALL. You said oftentimes the researcher had to meet a salesman's claim, oftentimes had to meet proposals. As I understand,

there were two or three proposals. In some cases five, in the case of the LEM. Someone must put on good "fire drills".

Dr. BISPLINGHOFF. I am talking about proposals for more fundamental research.

Mr. RANDALL. You are not talking about the "fire drills" related to proposals for specifications?

Dr. BISPLINGHOFF. Right.

Mr. KARTH. Doctor, in the case of your research, specially where the research is designed to have a direct application to future programs, it seems to me that although you may do research and your research may result in the ultimate in a particular area, that when you are talking about very complicated programs where many things have got to be taken into consideration, you can't use the technology, that is the ultimate technology, that you developed as a result of your research because it has to be coordinated with all of the other problems that also must go into the program.

Dr. BISPLINGHOFF. Yes.

Mr. KARTH. So, in many cases the "what makes the grass green" type research really does not apply, because someplace along the line it has to be diluted just a little bit, otherwise, it can't be integrated in the program.

Isn't this true?

Dr. BISPLINGHOFF. This is true and this is one of the problems of the research director. You can make a great deal of progress on one part of the system and very little progress on the other.

You have got to slow down your effort here, and speed it up over here.

Mr. KARTH. Let's say, for example, that Dr. Kelley came up with a beautiful gyroscope, foolproof, but it weighed 10 tons. This is what I'm talking about when I say that the perfect piece that's been developed as a result of research may not fit into the program.

Dr. BISPLINGHOFF. The early inertial gyros that had the accuracy to guide our missiles weighed many hundreds of pounds and we managed by very hard work to get down to a few pounds; so you must start with a monstrosity to begin with.

Mr. KARTH. As a matter of fact, there's one school of thought, Doctor, that indeed has some substance to their argument, and which says that we have gone overboard in this direction. They say we should be talking about utilizing more of our talents to develop greater thrust engines and not try to get so sophisticated by miniaturization or microminiaturization, because they claim that it is in these areas where our failures occur. I'm not saying I agree with the argument; but I want to make sure the record shows there are two schools of thought.

One argument is that as a result of or intensive research to microminiaturize, we have actually caused some of our own problems.

They say, on the other hand, that the Soviets haven't done a good job in this area; they haven't made an effort to become overly sophisticated, if I may use that designation.

Dr. BISPLINGHOFF. Yes.

Mr. KARTH. And, therefore, they have not suffered from this whole question of unreliability quite as much as we have.

Dr. BISPLINGHOFF. I think this is a very, very important argument.

I think we have to balance these two things as well as we can in our research effort.

Mr. KARTH. Yes, sir, and this is what happens, I guess.

Dr. Kelley, I wonder if you could tell me what is the scope of the research performed by the 147 people at Langley, the 68 people who work at Ames, the 35 people who work at Lewis, and so on.

Could you, for the record, tell us what the scope of their electronics research is?

Dr. KELLEY. Yes, I'd be glad to.

We have a diffusion of talent throughout the agency and Langley and Marshall are the only ones who have some people working across the board in the things we call "electronic systems." Langley has people working on guidance components; thay have a control systems effort, a large part of which is manned flight control. Then people in communications and tracking data acquisition systems and some people in data handling and processing and then a fairly large number in instrumentation.

You note the number of people at Langley is larger than the number of any at any other Centers; 147 out of 391.

There is a reason for this. For example, the reentry blackout communications project, RAM, is at Langley and the horizon project is at Langley. Langley is used largely, in fact as almost our sole electronic test flight agency for packages that we want to put up to specifically test phenomena, light communications, blackout or like Scanner project, all using Wallops Station as the launch area. So, there are a large number of people throughout the activity at Langley working on these flight projects and we would continue to use them as our experimental electronic flight test operation.

Mr. KARTH. Do you have some of these people at Marshall, Doctor—people who work in simulations, tracking, communications, and control systems effort?

Dr. KELLEY. Yes, we have, and the number is quite a bit smaller.

Mr. KARTH. Yes. I understand.

Dr. KELLEY. In fact, the number is 52 in all, of which 35 are in guidance and the others are relatively small research efforts which we have stimulated and encouraged to be undertaken, to be accomplished at Marshall.

We feel that some of the research should be done in close association with the project as well as, for example at the Electronics Research Center.

Mr. KARTH. Do you feel we are deficient? I'm talking about NASA.

Do you feel that NASA is deficient in their work effort in the guidance control systems efforts, communications, applications, and tracking?

Dr. KELLEY. The total communications, electronics systems area. Absolutely.

Mr. KARTH. So you would be doing some of this work at the Electronic Center also.

Dr. KELLEY. Yes. This is, we consider, a minimal effort and woefully inadequate to meet our future needs.

Mr. KARTH. How many people, Doctor, would you say of the 600, would be doing this kind of research?

Dr. KELLEY. This kind of research?

Well, there's different orientations on research.

The 600 to 700 people will be working on guidance systems, control systems, communications, and so forth, which will complement what is going on now.

For example, control systems; I mentioned manned flight systems, a substantial effort at Langley, and there's a substantial effort at Ames with some reentry simulators and an effort at Flight Research Center especially with the X–15.

We would not attempt to duplicate that at the new Center.

We would not attempt to build manned flight control simulators.

We would do some additional automatic control work which is necessary to continue to pursue the mission of the agency.

Similarly at Langley in communication, tracking, and data acquisition, the 19 in communications and 13 in data acquisition; Langley is the ideal place for them. For example, I mentioned the RAM project, reentry communications. The work they have been doing so far has been associated with wind tunnels, blast air over the model and get it to ionize and then you can test this water addition phenomena I mentioned. Then we go out to Wallops and flight-test it. We actually have a flight-test program as you can see in the budget.

This is complementary. It would not be done at the new Center.

The new Center would tie in, would do additional research—for example, in communications and tracking and data acquisition—additional component technology and subsystems work we feel is absolutely necessary.

The type of work we are not carrying on right now.

Mr. KARTH. I'm afraid you confuse by what you said, rather than what you haven't said.

You haven't really planned well enough yet to ascertain in your own mind how many people you need to complement the people who work at Langley and Marshall in these disciplines that you've mentioned. Right?

Dr. KELLEY. No, I didn't say that, Mr. Karth.

I said the numbers would remain approximately stable at the existing centers.

Mr. KARTH. Yes, sir. My question was, how many people of the 600 or 700 professional research people like the 147 at Langley does your plan call for to work at the new Boston Center on guidance, control systems, communications, applications, and other problems?

Dr. KELLEY. This is a phasing problem and tied into how we would plan to build the facilities.

It is a fluctuating distribution throughout the period of time, 7 years.

Mr. KARTH. Your answer is then, that you haven't really determined how many of the 600 would be complementing the work of the 200 now doing this type of work. Is that right?

Dr. KELLEY. All of them would be complementing the work.

Dr. BISPLINGHOFF. This is in guidance and control, I believe.

Dr. KELLEY. In guidance and control?

Mr. KARTH. Whatever you are doing at Langley and Marshall.

Dr. KELLEY. Yes.

Mr. KARTH. Maybe we should run through the whole list First, Doctor, what are the 68 doing at Ames?

Dr. KELLEY. It will take me a minute to bring it out.

Mr. MOSHER. Mr. Chairman.

Mr. KARTH. Mr. Mosher.

Mr. MOSHER. It may be a fact that there aren't absolute categories of work here. Among these research people, there may not be a group of 50 doing just tracking work, as distinguished between another 50 doing another type of work.

I am sure their research must be integrated. You use the word "complementary." It probably fluctuates month to month or year to year, depending on the direction the research goes.

Mr. KARTH. I think this is probably true, but I do expect it to be well managed and well organized, regardless of what the phase of the research might be.

Dr. KELLEY. I can give you an exact number as we planned it for fiscal year 1964.

I don't have a number for 1965 with me.

We have planned that. But the exact number—and we've broken it down in terms of electronics and control—the first two items on your list, "Guidance systems and control systems," we call that "control" and the last four, "electronics."

In fiscal year 1964, 68 personnel in guidance and control and 92 in the other 4 categories at the new center.

Mr. KARTH. And we don't have any idea what the additional people would be doing in these areas?

You just can't say at this time.

Dr. KELLEY. Well, these are the exact areas they'd be working in. It would be dependent how the state-of-the-art changes.

In fact, there is definite crossover with some of these people and how they spend their time. These are equivalent professional man-years. This doesn't mean a man, say the number 13 at Ames, works only on control. It means there are an equivalent 13 man-years working on control systems. People are working on other things, too.

In other words, these are not bodies. These are equivalent professional man-years.

Mr. KARTH. The only question that comes to mind, and I'm not going to pursue this, is whether or not these people aren't also going through some "fire drills."

I thought they were given all the time they needed to give themselves to a particular effort and just stay with it. This was the testimony I understood and that's why I must disagree with my colleague, Mr. Mosher.

I was assuming this was done in our laboratories because it was a point that was made when I asked the question: Isn't the research good in privately owned laboratories?

Mr. RANDALL. At Marshall, I have some slight knowledge. I was down there a day—and what is your top man in your electronics there?

Dr. KELLEY. Dr. Hauessermann is the Director of the Astrionics Division.

Mr. RANDALL. Dr. Hauessermann, distinguished by the saber mark. He is one of the Von Braun team.

Dr. KELLEY. He is one of the Von Braun team.

Mr. RANDALL. I'd like to submit on this particular date the emphasis seemed to be on a particular thing; working leisurely and not in any "fire drill" respect on perfecting the source of solar energy. That was the project that particular day.

Also another project was going on, on gyroscope perfection.

Those were the two going on that day in the Electronics Division at Marshall.

Dr. KELLEY. This is the Astrionics Division.

Mr. RANDALL. The Astrionics Division, that's what it's called.

That's under your direction, isn't it?

Dr. KELLEY. No, it is not. The Astrionics Division serves the total center, the largest portion of which is development effort for Saturn and a small portion of which is advanced research and technology which comes under our direction.

Mr. KARTH. What is the research and technology personnel doing at Ames?

I realize, as my colleague said, we probably haven't nailed all of these down and said, this is your problem, don't deviate.

With some semblance of order, however, can you tell me what they do? What is their particular forte?

Dr. KELLEY. We have 35 in guidance systems.

Thirty-five equivalent man years in guidance systems and Ames has done considerable effort in guidance systems over the past several years and will continue to do so.

A large part of their effort, for example, is in flight trajectory analysis analysing some of the flight paths shown on the slide yesterday or flight mechanics, as we call it.

We also have experimental work there with the "dog on the leash" concept.

Here we went into theoretical navigation—branched off from the theoretical to the "dog on the leash" concept and into some of the particular hardware.

They are developing the "dog on the leash" concept.

We also have some guidance simulators at Ames where we actually have a cabin sitting on an air bearing in a darkened room with simulated sun, stars, and moon. Looking out the window, the "ground" astronauts can take sights and see how well they can take them and how well they operate for several days at a time. One of the interesting facets of this, which we didn't think of in an aircraft, is how much the movement around the cockpit during the taking of star sights affects the actual movement of the ship. Because, if this thing is sitting on an air bearing or in space with no gravity or air then just our motion around the ship can disturb it.

Does it disturb it enough so it upsets the whole navigation sight and the whole guidance problem?

The control people, of which there are 13, are largely working on some manned flight control work, primarily manned reentry.

I think some of the most significant work in reentry in this country has come out of Ames Research Center; both the flight mechanics and some simulators that they are operating.

Mr. KARTH. So you do have these people broken down into categories—35 in guidance, 13 in control at Ames?

Dr. KELLEY. Yes, sir.

In fact, this all comes out of our managing accounting system, which is a form of task accounting where we locate, instantaneously, any research going on throughout the agency, and that's what these numbers came from.

We have one man-year in data processing which goes along with some of the guidance and control simulation effort. We find several of our old NACA research centers with effort in instrumentation, a lot of which we would like to allow to continue because people who are close to the problem in many cases in instrumentation, have a better feel for the need of the instrument and can give us something unique in addition to pure instrument technique research and that's why, you see for example, a heavy loading at Langley in instrumentation people.

This is instrumentation for the flight systems that I mentioned, launched out of Wallops and instrumentation for the wind tunnels to support the research projects that are conducted in the wind tunnels.

Mr. KARTH. How about Lewis?

Dr. KELLEY. Lewis has 26 data handling and processing people and 9 instrumentation people. We are doing some interesting work at Lewis in processing and handling engineering data on a rapid basis so that the engineer can have access to it and use it. Rather than do it in the old tedious way, perhaps we can do it in an automatic fashion.

And again—the instrumentation people are there because of their close association with some of the nuclear and chemical propulsion work going on.

Mr. KARTH. How about Goddard?

Dr. KELLEY. Goddard in control systems has people doing work on specific requirements for specific work for satellites which is the Goddard primary mission.

I mentioned some of the gravity gradient and magnetic field type of work. There is a small effort going on there.

Some communications, tracking, and data acquisition work is being done with some minimal work in components and techniques.

There are 10 people there in data handling and processing. They have a close association with the problem that I mentioned of 140 miles of tape a day, and there is some small effort in instrumentation.

Mr. KARTH. What is the annual cost of our present electronics research, Dr. Kelley?

Dr. KELLEY. This last year the R. & D. costs—that is largely out-of-house, was $20.7 million, approximately; and the in-house costs, that is personnel costs, operations, installations, were $44 million.

Mr. KARTH. I'm sorry, would you restate those two figures?

Dr. KELLEY. The R. & D. costs—these are largely out-of-house, were $20.7 million, approximately, and the in-house costs were—I beg your pardon, I gave you an incorrect number, approximately $23 million. I would like to correct the record on that. The number is approximately $23 million in-house.

The total is approximately $44 million—total program.

This is this fiscal year.

Mr. KARTH. So in-house, electronics research, was slightly greater than out-of-house?

Dr. KELLEY. That is correct.

Mr. KARTH. For fiscal 1963?

Dr. KELLEY. Fiscal 1963. That is right.

Mr. MOSHER. Mr. Chairman, may I interject a question here?

Mr. KARTH. Mr. Mosher.

Mr. MOSHER. Dr. Kelley's testimony in the last few minutes has seemed to me to emphasize the value of distributing these people

around at the various centers where other work is being done and the value of proximity to other work.

Is there any contradiction in this policy? Is there any contradiction in deciding to put the additional 600 people in Boston where, I believe, they would be a long way from all these other centers?

Dr. KELLEY. There is no contradiction.

We feel a certain number of researchers should stay in the existing centers and we don't think it would be proper if we pulled all of them out to go into a new center, should one be established.

However, we think for the long-range position for the future, the additional things we have to do, the new problems we see, the things we face; we think this can be most effectively managed and organized in a central research center and we see 2,000 people additional needed over and above what we have now. We faced the question ourselves whether we should diffuse these throughout the agency or whether we should try to put them together in a first team, if you will, where they are in a favorable environment.

We think the two complement each other.

The new center, should there be one established, services the rest of the agency. You will notice that there is a scattering of capabilities throughout the agency. In fact, it's rather a hodgepodge right now and we are getting—trying to do our best to get the work done where we can get it done—utilizing the capability that grew up throughout the history of the agency.

Mr. MOSHER. Has your previous testimony established why you choose to put the concentration of new effort in the Boston area, rather than, say, at Langley where you probably would have room?

Dr. KELLEY. Yes, sir. We faced this whole problem.

I might start from the beginning.

Mr. MOSHER. The chairman may not want this line of questioning at this point.

Would you prefer to wait?

Mr. KARTH. I think the gentleman must use his own judgment. I don't have any preference as to the line of questioning.

I would say that it is the chairman's opinion we determine this thing strictly on the basis of whether we need it, and not on the basis of where it should be located.

Mr. MOSHER. Well, the question of location seems to me to be important.

Mr. KARTH. If you think so, why don't you pursue it?

Mr. MOSHER. Well, I am involved in this Cherry Blossom Princess business, and I have to leave in a few minutes. So why not get down to the nub of one question on the mind of everybody? Since I am a member of the minority party, it necessarily has to be on our mind. I refer to the nature of certain promises made by the Democratic candidate for the Senate in last year's campaign in Massachusetts; this tends to make the minority party members suspicious of any new installations which are suddenly placed in Massachusetts; and, therefore, to satisfy this curiosity of the minority members, I'd like to ask something about the process by which the location was determined.

Who determined the location of the proposed center? Who made the recommendation that the center be located in the Boston area?

Dr. KELLEY. As in all these——

Mr. KARTH. Before the doctor answers this—and I certainly hope you will address yourself to the question—I'd just like to say for the record, on behalf of the Democratic members, that whatever speculation there is in that area probably emanates from the gentleman's side of the aisle and I, personally, feel it's completely baseless. Now, Doctor——

Mr. MOSHER. Well, I think it's curiosity that has to be satisfied.

Dr. KELLEY. Yes, sir. About a year ago, I was directed, in my present capacity, to come up with a plan to implement NASA's future required growth in electronics and it was known that we were going to have to grow. How much and how we managed it, was not quite clear at that time.

We proceeded in three steps: What are the future projections of the agency? What are the electronic requirements? What are the electronic research requirements to meet our electronic project flight requirements?

We came up, first, with the recommendation that there be approximately 2,000 people added to the NASA staff.

And then the next question was how do you implement this? We told the Associate Administrator at that time, and this was somewhat less than a year ago, slightly less than a year ago; we were going to study three alternatives and we were looking to form what we called a critical mass which once we started it would be capable of standing on its two feet and growing so that we wouldn't have to keep pushing it.

We told him the alternatives we would look at would be a diffused approach or establishing at several centers this growth of personnel—diffusing it throughout the centers, existing centers; putting a satellite subcenter at an existing center, and the Langley Research Center was the one considered which you mentioned; then finally a new center.

We looked into each one of these three alternatives and we came to the conclusion—my recommendation was, the first alternative didn't establish a critical mass. It diffused the situation and made it worse than it was and we couldn't get a first team together.

The second approach at Langley, and Langley did a study for us, indicated they would have to expand the center to an inefficient size for research—2,000 or more people, approximately, with additional facilities, all of which could not be located onsite. It would dilute the primary effort of the Langley Research Center which has been aeronautical research and some associated electronics flight experimentation.

Then, finally, we looked at the alternative of a new center and my clear-cut unequivocal recommendation was, this was the way we should go, for a new center, and put it in the right environment.

Now then, the last subject that was discussed——

Mr. KARTH. Doctor, may I interrupt you there, please?

Did you find any other people in NASA disagreeing with you?

Dr. KELLEY. I suppose there wouldn't be 100-percent agreement on anything you tried to do.

Mr. KARTH. So, your answer is "Yes, there were people who disagreed; you should go the center route"?

Dr. KELLEY. I would certainly suspect there would be some people who disagree.

Mr. KARTH. Were there? You say you suspect. You undoubtedly know.

Was there disagreement with your theory?

Dr. KELLEY. Yes, there was some disagreement.

And then, the final decision was, where should you place such a center.

So, I was just trying to review for Mr. Mosher the process we went through in determining this.

Mr. MOSHER. To use your phrase, was it your "clear-cut unequivocal recommendation" that it be placed in the Boston area?

Dr. KELLEY. My recommendatiou was clear that I thought that this was the best place to put it in the United States for electronic research, and I still feel that way.

Mr. MOSHER. Then I judge you are assuring the committee, therefore, that there was no political motivation here at all?

Dr. KELLEY. There was none, to my knowledge, and Mr. Webb has a letter to Senator Williams of Delaware which, I think, is on the record of the committee which states this in very clear terms.

Mr. MOSHER. So that the proposal that this large and very important center be built in the Boston area, made very soon after last year's election, was only a fortuitous circumstance, so far as the Senator from Massachusetts was concerned, and he played no part, his influence played no part, in this decision?

Dr. KELLEY. So far as I am concerned, that is absolutely the case and my recommendation was based on the technical factors involved as to how we could upgrade the technology of the agency over the long haul.

Mr. MOSHER. Mr. Chairman, I think it's good to have this testimony in the record.

Dr. KELLEY. Incidentally, my recommendation for the center was made early in the fall of 1962, which Mr. Webb made clear in a letter to Chairman Miller.

Mr. KARTH. Doctor, when did NASA go before the Bureau of the Budget and make this recommendation for the Bureau?

Dr. KELLEY. I don't know exactly when discussions were held with the Bureau. I did not participate.

Mr. KARTH. I wonder if you would furnish that for the record.

Dr. KELLEY. As to when the discussions began with the Budget?

Mr. KARTH. On this center, yes.

(The information requested is as follows:)

DISCUSSIONS WITH THE BUREAU OF THE BUDGET

In the process of presenting NASA's fiscal year 1964 budget to the President for approval, the Administrator of NASA initially discussed the proposed Electronics Research Center and the suggested Boston location in mid-October 1962. It was decided at that time that the proposed Center would be handled discretely within the executive department until a reasonable time had elapsed after the November elections in order to obviate the impact this proposal might have had. The NASA Administrator reviewed the proposed Center with the Director of the Bureau of the Budget in the first half of December 1962 during detailed discussions of the total NASA budget. These discussions included the requirement for the Center, the role of the Center within and without the agency, the proposed location, and other details. After review of proposals for the national budget, taking into consideration the recommendations of the Director of the Bureau of the Budget and agency heads, the President included the proposed Center in the fiscal year 1964 budget sent to Congress.

Mr. MORRIS. Mr. Chairman.

Along the same lines my good friend from Ohio was expressing a moment ago, I'm reasonably certain that the candidate for the Senate in Boston was very similar to all candidates for public office in all parts of the country.

Most of us are not exactly modest when we speak of what we can do for the country and, in particular, what we can do for our own area when we face the people of our State.

I'm reasonably sure that the Democratic candidate for the Senate from Massachusetts was not being modest, either, and I think that this should be something that should also appear in the record. There will possibly be other projects in other parts of the country that public officeholders will not be reluctant to take some of the credit for, in case they are successful.

But, by and large, I think most projects are placed where it will be in the national interest, even though some of us like to think that we have something to do with getting them.

That's all I have to say on that, Mr. Chairman.

Mr. KARTH. I wouldn't question the gentleman on some of the points he has made. I understand that both candidates for the U.S. Senate, in the recent election in Massachusetts, were making some very elaborate promises.

Mr. MORRIS. Mr. Chairman, shouldn't we say, just a modest influence to the people.

Dr. WEAVER. Mr. Chairman, I might say, the Republican Members of Congress have been modest by necessity.

I would like to ask the question, too: What made the Boston area more desirable to NASA in contrast to, say, Los Angeles, Pittsburgh, or some others? I wonder if you would just give us a brief rundown on this.

Dr. KELLEY. I'd be glad to, Dr. Weaver.

I think you realize we were looking for electronic research competence and we were looking for a "hothouse environment" for our little "orchid" we were trying to grow. There are many factors that one considers: transportation; available residential communities; civil engineering; criteria such as water, heat, and power which you might find in most metropolitan communities.

But the principal reason was the industrial and university electronic research complex in the area and this has some origins before, and very largely during World War II—the Radiation Lab at MIT and the Instrumentation Lab at MIT, and some of the Harvard laboratories, the Cruft Laboratory——

Mr. RANDALL. What laboratory?

Dr. KELLEY. Cruft, C-R-U-F-T; together with the training environment that was set up there during World War II.

The great military radar schools, all these were complementary.

The industry complex sprung from this university environment and the two were very complementary.

Now, this is the type of environment.

Mr. KARTH. Would the gentleman yield at this moment?

Dr. WEAVER. Yes.

Mr. KARTH. Doctor, may I ask you a question?

Do you really think this is good to have heavy concentrations of a particular industry in one geographic location as opposed to a little

spreading around of this capability so that the whole Nation can benefit?

Dr. KELLEY. I think from my standpoint, considering the job we have to do, to build our electronic technological capability; I think this is good. This is the way to do it.

Mr. KARTH. Are you saying we can't build our technological capability unless we do have heavy concentrations?

Dr. KELLEY. No; I did not say that, Mr. Karth.

I said this is the best way to do it.

Now, there are other socioeconomic factors that others might want to throw in, who are more expert in this field than I am, but to do the job I feel we have to do, from where I stand, I feel that this is the best environment.

Mr. KARTH. Well, Doctor Kelley, I am not an expert on this; but I'm sure that I have read someplace that about 90 percent of the electronics work that's done on the east coast is on a line drawn from New York State down through New Jersey and across, right through Washington, D.C.

Now, this leaves, I think, about 6 or 7 percent in the Massachusetts area.

I'm not sure that you are right in either instance.

Dr. KELLEY. I think I should get back to the emphasis on the words "research and advanced technology."

Yes—and we are well aware of the concentration or distribution of the electronics industry throughout the United States; but the electronics research environment particularly so-called military electronics, has had a heavy concentration in the Boston area and I think this is represented by the number of companies who have established plants in that area, to be in that particular environment.

Mr. KARTH. Well, then your point is, there is a concentration of the electronics industry in that area as opposed to any other area in the east coast; your point is there is a concentration of Government-owned research laboratories in the area. Is that right?

Dr. KELLEY. No, not at all. There are some Government research laboratories.

Mr. KARTH. I thought that's what you said.

Dr. KELLEY. These are industrial companies who have placed research laboratories in the Boston area.

For example, Sperry Rand has their research division in the Boston area.

A–C Spark Plug, electronics division of General Motors, has their research division in the Boston area.

Minneapolis-Honeywell has their Boston laboratory, one of their research divisions, in the Boston area together with their electronic data processing division and there are many, many more and the reason is that they want there a group, in addition to their production facilities, who are in a concentrated electronics research environment.

Now, the statement about a belt, New Jersey through New York, on dollar volume is quite true; but this is largely a production base and a large part of it is consumer products which I tried to point out yesterday, are somewhat different from the products we have to build.

Mr. KARTH. Now, let's take the west coast.

Doesn't California produce substantially more in the way of electronics research and consumer item products than any other State in the Union?

Dr. KELLEY. The total State, perhaps more than any other State, but I'm sure we all realize that the State is broken down into various metropolitan areas. I think, primarily, the San Francisco-Oakland area versus the Los Angeles.

Mr. KARTH. No question about it.

So, your point is, the best possible route to follow is not only to have your heavy concentrations of a particular research program in a given State, but even in a given municipality.

Right? All put together in one neat, little package?

Dr. KELLEY. That is the best place as we see it. The most efficient place to grow such a research center.

Mr. KARTH. Doctor, just let me ask you another question.

Could it not be detrimental to other electronic firms who do not have research facilities in the Boston area such as those that you mentioned, Sperry Rand, Minneapolis Honeywell, et cetera, et cetera—for those companies to benefit as a result of it, then I assume other companies suffer as a result of this. Isn't this right?

Dr. KELLEY. We look on this, Mr. Karth, as a National Space Electronics Center and I'd say our principal reason is to be near the universities just as these research divisions of these various companies were placed there, primarily to be close to the universities.

Mr. KARTH. There are a great many universities in higher education complexes, really, in this Nation, that have quite a reputation for doing research work in the electronics field, don't they?

Dr. KELLEY. Yes, sir.

Mr. KARTH. You feel MIT and what was the other one——

Dr. KELLEY. MIT and Harvard.

Mr. KARTH (continuing). Are the best?

Dr. KELLEY. I think historically, they have proven the best.

Mr. KARTH. How much Federal money has gone to MIT in fiscal year 1961, 1962, and 1963?

What I'm trying to say—Well, you just give me the answer to that question and I'll say what I have in mind, I guess.

How much Federal money went into MIT in those 3 fiscal years, if you have those figures? If you don't, I wonder if you'd furnish them for the record.

Dr. KELLEY. No, I don't have those figures.

I do have the Department of Defense research and development figures that went into universities and out of 300—this is research, development, test, and evaluation contracts with universities from the Department of Defense——

(The information referred to is as follows:)

FEDERAL FUNDS FOR MASSACHUSETTS INSTITUTE OF TECHNOLOGY

The Massachusetts Institute of Technology and its affiliated defense laboratories receive Federal funds in the following amounts:

	Fiscal year 1961	Fiscal year 1962	Fiscal year 1963 estimate
Research on campus	$18,093,548	$21,506,384	$27,500,000
Facilities		2,756,500	3,700,000
Defense laboratories [1]	56,637,000	66,472,438	79,100,000
Total	74,730,548	90,735,322	110,300,000

[1] Affiliated defense laboratories having a high percentage of personnel with no MIT faculty status include the Lincoln Laboratories, the instrumentation laboratory, and the naval operations and evaluation group.

Mr. KARTH. This a dollar amount?

Dr. KELLEY. This is the dollar amount. It's not broken down by universities, but it's broken down by States.

Out of $326 million in fiscal year 1961: $119 million of it went to Massachusetts and the rest was distributed; 38 to California, 45 to Maryland, 25 to New York, "All others category," 33; and in addition there are some smaller ones.

Mr. KARTH. What you are saying is that this capability has been built up by taxpayers' contributions all over the Nation, and those that have, apparently, get more.

This is your philosophy? Is this right?

Dr. KELLEY. I don't know how you say a capability built up. These are research, development, test, and evaluation contracts.

Mr. KARTH. $1 million in a fiscal year certainly would build a capability, Doctor; wouldn't you say so? Wouldn't you think this would help make it one of the largest research organizations in the Nation, if it be that?

Dr. KELLEY. I would think the Department of Defense felt it was a good area to put some research in, also.

Mr. KARTH. I am not asking you that. I am asking you the question to further identify your philosophy for the record.

Dr. KELLEY. If there is a capability there, I think that's where we should put our contracts.

Mr. KARTH. Doesn't this conflict with Administrator Webb's philosophy?

I heard him say on several occasions that what we have got to do is divest our heavy concentrations and try to allow the whole country to benefit as opposed to very small narrow geographic areas.

How do we square these two theories with top-level management?

Dr. KELLEY. These are completely consistent.

There is another part of the program called "Training grants" and "Facilities grants"; this is our "seed money," if you will, in the universities, to establish centers of competence and learning throughout the country. The agency's method on this is to stimulate the universities, and I mentioned in the Boston area how that started, and then you began to stimulate the rest of the growth, the intellectual growth and the industrial growth; but we do have a planned program of building up centers of university competence throughout the country.

Now, that is over and above our pure R. & D. type grants.

Mr. KARTH. Oh, yes, absolutely.

Thirty minutes ago, you told me you were going to hire these people at the research center. I assume this good number of people from the universities are the people we are going to train as a result of the Ten Square program.

You have heard of the Ten Square program?

Dr. KELLEY. That is correct.

Mr. KARTH. And its oncoming programs.

What you are saying, the taxpayers and other people around the Nation who have been benefited momentarily by the Ten Square program are going to lose whatever benefits they received when these people are hired by NASA to work in the research center on the east coast?

I think this is a pretty normal deduction for one to make: if you are going to do what you say you are going to do, and that's to hire these people from these universities; especially those who have taken graduate training, and those who haven't, if you hire them, you are going to give it to them.

This is really a followon, Doctor, I must say.

Dr. KELLEY. We don't see these 600 to 700 over a 7-year period, having a great impact on the Ten Square program.

Mr. KARTH. Let me ask you this. How many people are going to be trained in the Ten Square program in the next 5 years?

Dr. KELLEY. I don't know. I had the understanding the numbers were in the thousands.

I thought it was something—4,000 doctors, something like that.

Mr. KARTH. Over how long a time?

Dr. KELLEY. Over the next 4 or 5 years.

Mr. KARTH. It might have expanded over that period of time. I don't know.

The Ten Square program, as it originally started, was a hundred—10 times 10—10 doctors to be trained at 10 different universities.

Dr. KELLEY. That has expanded quite a bit, to my knowledge.

Mr. KARTH. It must have expanded considerably, if it's going to be 4,000 or 5,000.

I know it has expanded, Doctor. I didn't know it had expanded that much.

I might say here, for the record, that I think this is a good program. But if the effect of it is going to be as I thought you stated earlier, that these people will be hired away from almost every geographic area in the country to concentrate their talents in one geographic area, then I doubt if this is good. I would question the wisdom of that.

Dr. KELLEY. Well, I would hope this would be a national space electronics center.

Incidentally, I have for the record, the numbers out of our book on these training grants, if I might read them.

Mr. KARTH. Why don't you just submit them for the record, Doctor?

(List of training and faculty grants.)

PREDOCTORAL TRAINING GRANTS

NASA is providing predoctoral training grants to the following 88 colleges and universities for the academic year 1963–64. The grants will go to approximately 800 predoctoral trainees who have chosen a graduate study research program that is space oriented. Those colleges that are asterisked received training grants for the academic year 1962–63. Also listed are those colleges and universities that have received grants to date from NASA for facilities to be used in connection with their training grants.

In the fiscal year 1964 budget, NASA has requested that 1,250 predoctoral training grants be established. This would bring the total number of trainees to 2,150 by the 1964–65 academic year. The goal that NASA has established is that of training 4,000 graduate students, in 150 qualified universities, which would yield an annual output of approximately 1,000 Ph. D.'s in science and engineering. Present plans call for the attainment of this goal in the academic year 1966–67.

COLLEGES AND UNIVERSITIES RECEIVING NASA TRAINING GRANTS

Alabama, University of, University, Ala.
Arizona State University, Tempe, Ariz.
Arizona, University of, Tucson, Ariz.
Arkansas, University of, Fayetteville, Ark.
Auburn University, Auburn, Ala.
Brooklyn, Polytechnic Institute of, Brooklyn, N.Y.
California Institute of Technology, Pasadena, Calif.
*California, University of, at Los Los Angeles, Calif.
Carnegie Institute of Technology, Pittsburgh, Pa.
Case Institute of Technology, Cleveland, Ohio.
Catholic University of America, Washington, D.C.
*Chicago, University of, Chicago, Ill.
Cincinnati, University of, Cincinnati, Ohio.
Clemson College, Clemson, S.C.
Colorado, University of, Boulder, Colo.
Colorado State University, Fort Collins, Colo.
Columbia University, New York, N.Y.
Connecticut, University of, Storrs, Conn.
Cornell University, Ithaca, N.Y.
Delaware, University of, Newark, Del.
Denver, University of, Denver, Colo.
Duke University, Durham, N.C.
Florida State University, Tallahassee, Fla.
Florida, University of, Gainesville, Fla.
George Washington University, Washington, D.C.
*Georgia Institute of Technology, Atlanta, Ga.
Houston, University of, Houston, Tex.
Illinois Institute of Technology, Chicago, Ill.
Illinois, University of, Urbana, Ill.
Indiana University, Bloomington, Ind.
*Iowa, State University of, Iowa City, Iowa.
Iowa State University, Ames, Iowa.
Johns Hopkins University, Baltimore, Md.
Kansas State University, Manhattan, Kans
Kansas, University of, Lawrence, Kans.
Kent State University, Kent, Ohio.
Lehigh University, Bethlehem, Pa.
Louisiana State University, Baton Rouge, La.
*Maryland, University of, College Park, Md.
Massachusetts Institute of Technology, Cambridge, Mass.
Michigan State University, East Lansing, Mich.
*Michigan, University of, Ann Arbor, Mich.
*Minnesota, University of, Minneapolis, Minn.
Missouri, University of, Columbia, Mo.
Missouri School of Mines and Metallurgy, Rolla, Mo.
Nevada, University of, Reno, Nev.
New Mexico, University of, Albuquerque, N. Mex.
New York University, New York, N.Y.
North Carolina State College, Raleigh, N.C.
North Carolina, University of, Chapel Hill, N.C.
Northeastern University, Boston, Mass.
Nortwestern University, Evanston and Chicago, Ill.
Notre Dame, University of, Notre Dame, Ind.
Ohio State University, Columbus, Ohio.
Oklahoma State University, Stillwater, Okla.

Oklahoma, University of, Norman, Okla.
Oregon State College, Corvallis, Oreg.
Pennsylvania State University, University Park, Pa.
Pennsylvania, University of, Philadelphia, Pa.
Pittsburgh, University of, Pittsburgh, Pa.
Princeton University, Princeton, N.J.
Purdue University, Lafayette, Ind.
*Rensselaer Polytechnic Institute, Troy, N.Y.
Rhode Island, University of, Kingston, R.I.
*Rice University, Houston, Tex.
Rochester, University of, Rochester, N.Y.
St. Louis University, St. Louis, Mo.
Southern California, University of, Los Angeles, Calif.
Stanford University, Stanford, Calif.
Stevens Institute of Technology, Hoboken, N.J.
Syracuse University, Syracuse, N.Y.
Tennessee, University of, Knoxville, Tenn.
*Texas, Agricultural & Mechanical College of, College Station, Tex.
Texas Technological College, Lubbock, Tex.
Texas, University of, Austin, Tex.
Tulane University, New Orleans, La.
Utah State University, Logan, Utah.
Utah, University of, Salt Lake City, Utah.
Vanderbilt University, Nashville, Tenn.
Vermont, University of, Burlington, Vt.
Virginia Polytechnic Institute, Blacksburg, Va.
Virginia, University of, Charlottesville, Va.
Washington University, St. Louis, Mo.
Washington, University of, Seattle, Wash.
West Virginia University, Morgantown, W. Va.
Western Reserve University, Cleveland, Ohio.
Wisconsin, University of, Madison, Wis.
Yale University, New Haven, Conn.

COLLEGES AND UNIVERSITIES RECEIVING NASA FACILITY GRANTS

Fiscal year 1962:
Rensselaer Polytechnic Institute, Troy, N.Y.
Stanford University, Stanford, Calif.
University of Chicago, Chicago, Ill.
State University of Iowa, Iowa City, Iowa.
University of California, Berkeley, Calif.
Fiscal year 1963:
Harvard University, Cambridge, Mass.
University of Minnesota, Minneapolis, Minn.

Dr. KELLEY. It is 4,000 in 150 universities yielding output of 1,000 Ph. D.'s and scientists per year.

Mr. KARTH. Per year?

Dr. KELLEY. 4,000 graduate students. I'm not sure this represents any one time or the output per year.

It does represent the total output per year, 1,000 Ph. D.'s.

Mr. RANDALL. If the chairman would yield. I just wanted to verify what the witness said in connection with these numbers.

I am not familiar with the Ten Square program. That is purely NASA?

Dr. KELLEY. Yes, sir.

Mr. RANDALL. That could easily total 4,000.

Mr. KARTH. I thought the doctor was speaking only of NASA's program.

Dr. KELLEY. This only NASA's program.

Mr. RANDALL. Then there's a great many more than that.

Mr. KARTH. Dr. Weaver?

Dr. WEAVER. Dr. Kelley, because of the political suspicion and also the curiosity about the site of Boston, if the chairman is willing, I wonder if the committee could have a listing of the areas you re-

viewed and your basic evaluation of the areas that led to your selection of Boston.

I am talking about areas such as Los Angeles, Pittsburgh, Philadelphia, Chicago—whatever areas you reviewed as potential sites for this research center and what your evaluation was of them, before you made your personal selection on this matter. I wonder if you could do that for us, if the chairman is agreeable.

Mr. KARTH. I think it is a very good suggestion.

Dr. KELLEY. I will consult the Administrator and see what we can get in the records.

Mr. KARTH. Well, let me ask this question. Did you make a review?

Dr. KELLEY. We considered the electronic capability throughout the country.

Now, the principal areas of concentration are on the west coast, the Midwest, the Chicago, Milwaukee, Minneapolis axis, and the Northeast from Philadelphia up to Boston. Those are the considerable areas of concentration and we considered those.

Mr. KARTH. Whatever review you made, let me request that you put it in the record.

(The information requested is as follows:)

Soon after making his recommendation in September 1962 that the NASA establish an Electronics Research Center, Dr. Kelley was asked where he would propose establishing such a laboratory. In discussing potential locations at that time, Dr. Kelley recommended the location of such a center in the Boston area primarily because of the presence of outstanding university and industry electronics research capabilities there. In response to the request of the Subcommittee on Space Sciences of the House Committee on Science and Astronautics, Dr. Kelley has prepared the following evaluation showing the factors which he took into account in making his recommendation. This evaluation covers those metropolitan areas which Dr. Kelley considered as most compatible locations for the proposed Center. While various other areas were given consideration, the areas discussed were considered to best provide an electronics research-oriented environment in both the university and industrial sectors of the community. It is important to note that any relative factors cited in this evaluation concern only the relationships of these areas to one another. Each area discussed contains, within itself, significant industrial and university capability in the areas of interest.

NEW YORK

The Metropolitan New York area should be able to provide ready availability of utilities and services, including electric power and communications links. Institutions of prominence in graduate engineering and physics include Columbia University; City College, New York; New York University; and Polytechnic Institute of Brooklyn. Universities in the area have in the past concentrated the greater percentage of their curriculums on undergraduate education in these fields, but the number of graduate degrees awarded each year is high and increased emphasis is being placed on graduate curriculums. The engineering and scientific population is relatively large in number and relatively low as a percentage of total population. Consideration must be given to the fact that many of these professionals are employed at various corporate headquarters offices in downtown Manhattan. The number of professional and technical workers as a percentage of total work force is about in the median of the areas considered. A large electronics industry abounds in the metropolitan area and surrounding communities such as Long Island. Possessing extensive research capability, this industry, proportionally, is largely oriented toward consumer and military development and production. A high percentage of the electronic industry consists of small electronics producers or vendors concentrating on product lines of electronic parts or supplies. Housing is available in desirable communities. Adequate transportation is available for local and long-distance travel. Widespread high density land use may affect the availability of land close to institutions of higher education as well as to the industrial community with allied research interests. NASA maintains an active scientific facility in Manhattan, the Institute for Space Studies.

NORTHERN NEW JERSEY

The northern New Jersey metropolitan area should be able to provide ready availability of utilities and services, including electric power and communications links. Institutions of prominence in graduate engineering and physics are Steven Institute of Technology and Newark College of Engineering. Each of these institutions has a significant percentage of its effort in graduate education and each began recently to grant degrees at the doctorate level. The engineering population is approximately in the median in number and relatively large as a percentage of total population while the scientific population is relatively low on both counts. The number of professional and technical workers as a percentage of total work force is approximately in the median. A large electronics industry is present in the area and surrounding communities. Increased research activity has taken place in the local electronics industry in recent years, but this industry is primarily characterized by heavy orientation toward consumer and military production. Probably the most outstanding private electronics research laboratory complex in the country, the Bell Telephone Laboratory, is located in this area. Housing is available in desirable communities and adequate transportation is available for local and long-distance travel. High-density land use may affect the availability of land within reasonable commuting distance from the institutions of higher learning. The Army maintains its Electronics Research and Development Laboratory at Fort Monmouth, south of the metropolitan area.

LOS ANGELES-LONG BEACH

The Metropolitan Los Angeles area should be able to provide ready availability of utilities and services, including power and communications links. Institutions of prominence in graduate engineering and physics include California Institute of Technology; the University of California, Los Angeles; and the University of Southern California. These universities place a heavy emphasis on their graduate engineering and physics curriculums. The engineering and scientific population is very large both in number and percentage of total population. The number of professional and technical workers as a percentage of total work force is also relatively large. A large electronics industry is present in the area. With extensive orientation toward engineering and development associated with aerospace products, the local electronics industry is well known for its research capability in a highly developed research environment. Housing is available in desirable communities. Adequate transportation is available for local and long-distance travel. Widespread separation between activities would affect site location within reasonable commuting time from all of the engineering universities and from the allied industrial community. NASA maintains a technical facility in Pasadena at the Jet Propulsion Laboratory, California Institute of Technology.

CHICAGO

The Metropolitan Chicago area should be able to provide ready availability of utilities and services, including electric power and communications links. Institutions of prominence in graduate engineering and physics include Illinois Institute of Technology, Northwestern University, and the University of Chicago. These universities maintain a balance between undergraduate and graduate education emphasis in the technical fields of interest. The engineering and scientific population is relatively large in number and relatively small in terms of percentage of total population. The latter situation also applies to the number of professional and technical workers as a percentage of total work force. A large electronics industry is present in the area. This industry has concentrated largely on consumer and military production and is not considered, in general, to be research oriented with industrial electronics research activity relatively low in terms of percentage of local electronics plant activity. Housing is available in desirable communities and adequate transportation is available for local and long-distance travel. High-density land use and relative locations may affect the availability of land within reasonable commuting time from more than one of the local institutions of higher learning.

PHILADELPHIA

The Metropolitan Philadelphia area should be able to provide ready availability of utilities and services, including electric power and communications links. Institutions of prominence in graduate engineering and physics include Drexel Institute of Technology, Temple University, and the University of Pennsylvania.

These institutions maintain a balance between undergraduate and graduate curriculums in the technical fields of interest with greater focusing of graduate effort at the second-degree level rather than at the doctorage. The engineering and scientific population is approximately in the median in number as well as in percentage of total population. The number of professional and technical workers as a percentage of total work force is approximately in the median of the areas considered. A large electronics industry is present in the area and adjacent communities including Camden, N.J. While this industry has been largely oriented toward consumer and military production, increased research activity has taken place in recent years, particularly in the suburban Philadelphia area. Housing is available in desirable communities and adequate transportation is available for local and long-distance travel. High-density land use prevails but the relative locations of the local institutions of higher learning and the industrial community should make possible site location within reasonable commuting time from all elements. The Navy maintains a technical facility, the Airborne Electrical and Electronics Laboratory, at the Naval Air Development Center, Johnsville, just outside Philadelphia.

SAN FRANCISCO BAY AREA

The Metropolitan San Francisco Bay area should be able to provide ready availability of utilities and services, including electric power and communications links. Institutions of prominence in graduate engineering and physics include the University of California, Berkeley; and Stanford University. Both institutions maintain strong graduate curriculums through the doctorate level. The engineering and scientific population is approximately in the median in number and relatively large in terms of percentage of total population. The number of professional and technical workers as a percentage of total work force is relatively large among the areas considered. A significantly large and growing electronics industry is present in the area. The growth is characterized by heavy emphasis on electronics research, particularly in the Palo Alto-San Jose area, which has already become one of the most important centers of electronics research in the country. Housing is available in desirable communities and adequate transportation is available for local and long-distance travel. Adequate land should be available. Relative geographical location affects site placement within reasonable commuting time from more than one of the two prominent institutions of higher learning. NASA maintains a technical facility at the Ames Research Center, Mountain View.

BOSTON

The Metropolitan Boston area should be able to provide ready availability of utilities and services, including electric power and communications links. Institutions of prominence in graduate engineering and physics include Harvard, MIT and Northeastern University. While, in general, balance is maintained between undergraduate and graduate curriculums, heavy emphasis is placed on graduate research. As a result, this area produces the greatest number of graduate degrees in engineering and physics, including the engineering doctorate level. The engineering and scientific population, which includes the largest area membership in the National Academy of Sciences, is approximately in the median in number and relatively large in terms of percentage of total population, particularly in the scientific portion of the spectrum. The number of professional and technical workers as a percentage of total work force is relatively large among the areas considered. A large electronics industry is present, ranking as the largest industry in the area. The area is well known for its concentration on electronics research in terms of the university and the industrial research laboratories. The industry complex is characterized by the significant number of electronics research laboratories maintained by large companies whose principal corporate plants are located elsewhere. Housing is available in desirable residential communities and adequate transportation is available for local and long-distance travel. Adequate land should be available for site location within reasonable commuting time from institutions of higher learning and the industrial community. The Air Force maintains two technical facilities at Hanscom Air Force Base, Bedford—the Electronic Systems Division (system development and integration), and the Cambridge Research Laboratories.

ST. LOUIS

The Metropolitan St. Louis area should be able to provide ready availability of utilities and services, including electric power and communications links. Institutions of prominence in graduate engineering and physics are St. Louis University and Washington University. These institutions maintain a balance between undergraduate and graduate curriculums in the technical fields of interest. Among the areas considered, the number of engineers and scientists is relatively small in number and as a percentage of total population, which is also the case with the number of professional and technical workers as a percentage of total work force. A moderate size growing electronics industry is present in the area, which is characterized by specific examples of excellence in research and development (NASA's second largest prime contractor is located here). Housing is available in desirable communities and adequate transportation is available for local and long-distance travel. Adequate land should be available within reasonable commuting time from the institutions of higher learning and the industrial community.

MINNEAPOLIS-ST. PAUL

The Metropolitan Minneapolis-St. Paul area should be able to provide ready availability of utilities and services, including electric power and communications links. The University of Minnesota is prominent in graduate engineering and physics with a reaonable distribution between undergraduate and graduate students. The number of engineers and scientists is relatively small in number and about in the median in percentage of population. The number of professional and technical workers as a percentage of total work force is relatively large among the areas considered. A moderate-size electronics industry is present within the area. This industry is characterized by specific examples of excellence (i.e., the headquarters of NASA'S largest guidance contractor is located here) and as a whole has a significant research as well as production and development character. Housing is available in desirable communities and adequate transportation is available for local and long-distance travel. Adequate land should be available within reasonable commuting time from the university and the industrial community.

Mr. CHENOWETH. Mr. Chairman, I just wanted to make one observation—and ask one question.

I think you realize, Dr. Kelley, now there are certain implications whether they are justified or otherwise, in this Boston selection.

Now you don't want to tell this committee that there is some unusual, unsurmountable features connected with the Boston selection that you couldn't find anywhere else?

Is there an advantage so marked, so pronounced, that you were just led immediately to Boston without any reflection on any other place in this country?

You don't want to tell this committee that Boston is the only place that you could build this installation and, if for some reason Boston wasn't available, you'd have to pass it altogether.

Aren't there some other locations just about as good as Boston, maybe some better in some respects, as the chairman tried to point out?

We shouldn't put everything in one area.

What about Atlanta? We have plenty of locations there, and it might be a little more secure there.

I think other agencies have recognized that. Instead of putting everything on the seacoast, maybe it would be better putting some back in the interior. Might not be quite as accessible, if something should happen.

What do you think of that?

I am not accusing you of any political connivance of any kind.

I have full faith in your statement.

However, there is this implication Dr. Weaver mentioned. I think everyone—not just the minority party—but the minute you mention

Boston, there are some implications, political implications, involved. Whether they are deserved or not.

Dr. KELLEY. I certainly didn't want to leave the impression that this is the only place such a center could be placed.

I think from my standpoint, from the standpoint of the job we have to do in the agency, particularly in electronic research, I think this is the superior area in the United States.

Now, there are other factors that were discussed that if someone wants to take into account, socioeconomic factors. I don't feel qualified to speak on them; but from a purely scientific technological standpoint this is the superior area.

Mr. CHENOWETH. You realize there are other elements that enter into this, in addition to the technological, isn't that true?

It's not just a technological decision. You have other factors, economic factors and geographical factors that have to be considered; is that right—or no?

Dr. KELLEY. In many of these decisions there are many factors that enter into them besides purely technical, I'm sure. My selection was based on the technical.

Mr. CHENOWETH. Your main objective is to get this installation?

Dr. KELLEY. Absolutely.

Mr. CHENOWETH. You say you need it and must have it. The location, wouldn't that be of secondary importance?

The main thing is, you need the installation.

Dr. KELLEY. I wouldn't say the location is of secondary importance. There are varying degrees of advantage for certain locations. I mentioned the orchid in a hothouse. Perhaps we wouldn't try to grow an orchid in the desert for we might have to build a hothouse to go along with it. This might be very expensive.

There are varying degrees of satisfaction, you might say, varying degrees to which an area might be satisfactory in meeting our requirements and I don't know where you draw the line.

Mr. CHENOWETH. Could you do your work just about as well if it were located in some other State and accomplish about the same results, same objective?

Mr. KARTH. Other areas in the countries, I think, are not quite as destitute as the orchid in the desert. I hesitate to let this implication be in the record. I know this is not a fact.

Dr. KELLEY. I didn't understand.

Mr. KARTH. I say, other geographic locations in this Nation are not quite as destitute in the electronic research field as the orchid in the desert analogy you drew.

Dr. KELLEY. There is a clear distribution throughout the country and I think you find it pretty well concentrated and there are areas where there is not——

Mr. KARTH. But there are other locations where there are heavy concentrations of the electronic industry, almost as heavily concentrated as Boston. Some might be more heavily concentrated. I don't know because I haven't made a personal survey. I do know that there are heavy concentrations in other geographic areas of the Nation.

Mr. CHENOWETH. I think it is desirable, Doctor, to have these spread out—not concentrated in one immediate area, and I was trying to get your direct answer to a question, whether or not, if you

had this installation, wouldn't it be just as advantageous to have it located, say, in Colorado as it would Boston, as an example?

You will have your installation. You will have the same men there doing the same work. You will get the same results, same advantage.

We have fast transportation in this country today. It doesn't take long to go from one State to another, to another part of the country. We are not isolated anywhere you are these days.

Dr. KELLEY. The very close university association is very, very important to us, universities of preeminence in this particular field, so that we can have our researchers, as I said, upgrading their education, working with the university people as consultants.

The advantage in the past, from close association with the industrial complex, have been the rapid exploitation of the ideas out of the university laboratory into operation and this is what we are trying to do in the space program. So, the university association is quite important.

Mr. CHENOWETH. Well, you have universities other places, too, don't you, Doctor—maybe not quite the same degree of perfection you have in Boston, but very close to it, I would think, some of these universities. They could be developed and expanded.

Dr. KELLEY. There are many, many, other universities of excellence throughout the United States.

Mr. CHENOWETH. Mr. Chairman, I don't want to pursue it further. I think there are other elements involved and I don't want to recognize any political implication here at all. I'm sure Mr. Mosher didn't intend to inject it and I know I don't, nor does Dr. Weaver.

Whenever you hear the word "Boston," immediately some suspicion arises just as it has in moving other installations. I think some important installation out of New York moved to Boston—been there many, many, years.

Dr. WEAVER. Internal Revenue.

Mr. CHENOWETH. I don't know whether that's because they want to be closer to the universities or not.

Mr. STAEBLER. Mr. Chairman, in the few minutes remaining, may we ask a few questions about the Russian shot, yesterday?

Mr. KARTH. Let me just ask if either of the two witnesses feel they would like to give us a rundown on the most recent space effort.

Dr. BISPLINGHOFF. I must say my knowledge is limited to what I've seen in the paper this morning.

Mr. KARTH. Dr. Kelley, how about it?

Dr. KELLEY. The same way. Rumors in the paper would make it look similar to the Ranger Mission we have. That is all I could say.

Mr. KARTH. Does the gentleman wish to pursue it under these conditions?

Mr. STAEBLER. Just a little bit, because of the similarity to Ranger and the fact we have been pursuing Ranger in this very gathering. When then do we anticipate our next Ranger shot will be made?

Dr. KELLEY. I don't have that date, Mr. Staebler and I don't know if its been definitely established. As you know, as a result of the Ranger board of inquiry it went through quite a lot of review and testing. I don't know the schedules. We have already shot three to the Moon and two prior to that were test shots.

Mr. STAEBLER. The size of the Russian load was said to be something in the neighborhood of 3,000 pounds. What was the size of our last instrumented load?

Dr. KELLEY. The Ranger runs about 700 to 750 pounds, depending on the phase of the Moon and the trajectory, but it's around that order—700 to 750.

Mr. STAEBLER. Does the fact that the Russians are following this course suggest that they are doing a similar set of probes, similar to the Ranger?

I ask the question because we were discussing earlier the possibility of the Russians taking a shortcut and not securing the information that we are endeavoring to secure through the series of Ranger shots.

Dr. KELLEY. Well, every indication in the newspapers, this morning is that this has a mission similar to Ranger's mission, but I don't think we can really tell until they get up near the Moon, whether they want to orbit or actually land.

Dr. BISPLINGHOFF. The Russians aren't explicit about this. I would suspect, myself, whether it is a flyby, an orbit, or a soft landing, will be something that we don't learn until it happens and then they will say they planned it that way.

I doubt whether they are going to announce ahead of time which one of these it will be.

We are just going to have to wait and see.

Mr. STAEBLER. The move, in any event, confirms the desirability of our Ranger program, but does it throw any light on the combination of the Ranger and the orbiting observatory program?

Dr. KELLEY. I am not sure the association of the orbiting observatory program with Ranger—are you talking about the Surveyor, Mr. Staebler?

Mr. STAEBLER. Yes.

Dr. KELLEY. We still need information about the Moon as soon as possible.

Now, what program we use to get it, I don't think we are qualified to say at this point in time from our position in the organization, but the sooner we can get some information, the better, and the Ranger program is continuing to be pursued as far as I know, with Surveyor to follow on later.

Mr. KARTH. Would the gentlemen yield at that point?

Mr. STAEBLER. Surely.

Mr. KARTH. Doctor, I wonder if you could give us your opinion then as to how many programs we should pursue to get information on the lunar surface and surrounding conditions—radiation, gravitation, and so on.

Dr. KELLEY. We are pursuing two unmanned programs, right now, Ranger and Surveyor, and it is a question of how fast you need the information and what kind of information you will get.

Mr. KARTH. Isn't there a logistics program in the manned lunar flight program as well as the Ranger and Surveyor?

Dr. KELLEY. I believe this is an Apollo follow-on or part of the extension of Apollo—Apollo defined right now as being the program to first land a man on the Moon, and then there is a logistics vehicle, I believe, which is part of this program.

Mr. KARTH. This is after the manned lunar landing?

Dr. KELLEY. I'm not sure whether it lands just before or just after, but it's part and parcel of the Apollo program, as I understand it.

Mr. KARTH. The question was how many programs should we pursue? How many do you think we should have?

Dr. KELLEY. I think the Ranger and Surveyor are sufficiently different in time scale and mission, they both give us the time coverage we need. They are both supplementary.

Ranger exists to get early information and to land a package on the Moon.

Mr. KARTH. Doctor, you headed up a study group on this. When do you think we should shoot Rangers again to give us the information we need?

Dr. KELLEY. I have not kept track of the information on the results of the recommendation of the board of inquiry, I don't know.

Mr. KARTH. If it should be that the Ranger program and the Surveyor program are entering into the approximate same timetable, would you suggest we abandon one for the other and put all our strength and resources and manpower and money into one?

Dr. KELLEY. I think we have to be very, very careful that we don't try to jump on another bandwagon, just because the existing bandwagon doesn't look so good.

Surveyor may tend to look more attractive if it's in the same time scale——

Mr. KARTH. Doctor, I don't mean jumping on another bandwagon. Earlier, you were talking about concentrating our electronic research. I am talking about concentrating our efforts, our abilities, on one program, rather than allowing our abilities to be diffused in several directions. This is my question.

Dr. KELLEY. I think you would have to look, Mr. Chairman, at the uncertainties in either one of the programs at a particular point in time. In other words, you might say they are overlapping, but one might give you potentially more reliability and have less pitfalls than the other program, more proven, perhaps.

Mr. KARTH. You think we might need two electronics research laboratories to give us this kind of capability in electronics?

Dr. KELLEY. No.

Mr. KARTH. You think one is enough?

Dr. KELLEY. One is enough.

Mr. KARTH. OK.

Doctor, I think we are going to have to adjourn and we hope you could come back tomorrow at 10 o'clock.

Mr. Randall?

Mr. RANDALL. Inasmuch as I won't be able to be here tomorrow because of another committee meeting, if you can supply it for the record—you mentioned a letter of the Administrator to John Williams of Delaware, I think it was.

(The information requested is as follows:)

MARCH 21, 1963.

Hon. JOHN J. WILLIAMS,
U.S. Senate, Washington, D.C.

DEAR SENATOR WILLIAMS: Thank you for your letter of January 29. You are correct in your understanding that decisions on questions of location of projects such as the proposed Electronics Research Center in Massachusetts are based on a careful evaluation by responsible officials and employees of this agency.

I am sure you have noted that requests for authorization for the Center to be located in Boston and for the initial increment of funds were included together in the 1964 budget. In most such cases, Congress is requested to authorize the facility, and after action by the Congress, site-location procedures are instituted to determine the best site. In this case, our planning was moving very

rapidly. We were entering a phase when the electronics components of our most important spacecraft needed the close collaboration between about 600 scientists and engineers, supported by about 1,400 technicians and other administrative personnel, grouped in such a center. Therefore the President and I decided that the entire matter should be put before the Congress in the budget. The result is that in this case Congress has before it in the same budget a request for authorization of the construction of the Center, its location in Boston, and a request for the initial increment of funds.

No Members of Congress influenced the decision to locate this Center in Boston, and indeed the matter was so closely held, in accordance with budgetary procedures relating to the President's budget, that I would be very surprised if any Member of Congress knew about the matter until it was discussed in the press briefings the day before the budget went to Congress.

As you know, frequently following such advance press briefings newspapermen ask Members of Congress for their views on specific items for release and publication simultaneously with the publication of the budget. Therefore in this case, after the press briefing and with the knowledge that the press was bound not to release any information prior to the release date of the budget, we did notify the Massachusetts Senators and Speaker McCormack of the fact that this item was included in the President's budget so that they would not be surprised at any inquiries addressed to them by the newsmen. I am convinced that this was the first time they knew about it.

Enclosed is a discussion of the background and planning for the NASA Electronics Research Center.

Sincerely yours,

JAMES E. WEBB, *Administrator.*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, WASHINGTON, D.C.—PROPOSED ELECTRONICS RESEARCH CENTER, FEBRUARY 15, 1963, ELECTRONICS RESEARCH TASK GROUP

BACKGROUND

The National Aeronautics and Space Administration has been conducting studies concerned with present electronics and associated physics capabilities within the organization for over a year. These studies, designed to assess NASA's capabilities in the light of present and future aeronautics and space needs, were conducted principally by NASA's Office of Advanced Research and Technology (OART), and were the first major effort in assessing NASA's electronics capabilities since the establishment of the agency in 1958.

It is significant that these studies were conducted after NASA had access to results from an appreciable number of space flights: 10 in 1961 and 14 in 1962, compared with 5 in 1960 and 5 in 1959. These flights pointed up certain areas, particularly electronics and related physics, in which NASA needed to increase its capabilities.

In addition to the talents available to NASA in the aeronautical and propulsion sciences from the research centers of the predecessor agency, the National Advisory Committee for Aeronautics (NACA), NASA also integrated the talents of the Development Operations Division of the Army Ballistic Missiles Agency at Huntsville, Ala., under Dr. Werhner von Braun, the Vanguard team of the Naval Research Laboratory, and (under contract) the Jet Propulsion Laboratory of the California Institute of Technology. These groups endowed NASA with a first-rate capability in the aeronautical and the propulsion fields, but did not provide the broad base of electronics and related physics skills necessary to meet future requirements in the space field.

The studies conducted led to the conclusion that NASA requires substantial increase in its capabilities in electronics and related physics disciplines in order to provide adequate support for its future space efforts. The review clearly indicated that the successes of NASA's space efforts to date have been based on existing electronics technology, inherited from other fields, and that more advanced space efforts would require a growth of electronics research and technology specifically directed toward space needs and applications. The major role of electronics components, technology, and instrumentation in all space endeavors makes it necessary to broaden the base of NASA space electronics research as rapidly as possible.

SELECTION OF METHOD

Analysis by NASA indicated several potential methods of accomplishing the required buildup of electronics research capability:

(*a*) Establish and electronic systems research and development group at several of NASA's existing centers;

(*b*) Establish a fairly large electronics research subcenter at an existing NASA center;

(*c*) Establish a new NASA center having the necessary facilities;

(*d*) Utilize the electronics talents existing at some other Government laboratory; and

(*e*) Establish a non-Government laboratory as an affiliate of a major university or foundation.

All alternatives were estimated to require about the same personnel and facility resources when finally in operation.

The first method would not provide the concentration of personnel nor the extensive facilities needed for effective and economical conduct of electronics research. The second method would double the size of any existing center, posing difficulties in management, and requiring a site expansion.

The third method of establishing a new NASA center specifically planned for research in electronics and the related physics disciplines, appeared to have clear advantages. Concentration of research talent, absence of conflicing development missions or research efforts in other fields, and availablility of comprehensive research facilities specifically tailored for electronics research would all contribute to creation of a potent capability in electronics research as rapidly as possible.

The fourth method would pose many of the same problems as establishment of a subcenter at an existing NASA center, and would also involve the host laboratory in NASA programs that would dilute its efforts toward its own agency programs.

The fifth alternative was considered to be impractical because of the required size of the laboratory, the necessity of incorporating experienced NASA personnel into the new laboratory, and the requirement that the laboratory provide guidance and coordination in electronics throughout NASA.

CRITERIA FOR SELECTION OF LOCATION

As the next step in planning an electronics research augmentation, NASA developed certain location criteria. Two major objectives in the creation of the new Center are achievement of a research and advanced technology capability in space electronics and related disciplines as efficiently as possible, and staffing by top caliber scientists and engineers. In view of these considerations, the following primary criteria were used in evaluating and recommending Center locations to NASA top management.

(*a*) *Ready availability of adequate utilities and services, including power, water, communications, and sanitary facilities.*—The growth of Center staff complement together with the operation of projected specialized facilities will require substantial support from the surrounding community in terms of facilities and services. Of particular importance are a reliable, adequately shielded electric power system and versatile communications links for voice and data transmission, including tie-in to computers in other geographic locations.

(*b*) *Proximity to institutions of higher scientific and engineering education.*—In order to remain in the forefront of technology, members of the Center staff must be afforded the opportunity and be encouraged to continue their education, particularly graduate studies. Hence, proximity and easy access to established, recognized academic facilities are necessary. In addition, university proximity will provide opportunity for extramural interchange of ideas as well as a source of technical consultants to advise the Center staff.

(*c*) *Proximity to an industrial community having allied technical interests that are research oriented.*—The mutuality of professional interests associated with an industrial research complex will serve to challenge and cross-fertilize individual efforts. Furthermore, the technological atmosphere engendered by seminars conferences, and professional society activities will contribute to proliferation of knowledge and quickening of research applications.

(*d*) *Available housing in desirable communities.*—This criterion implies many factors related to family welfare and education, which manifest themselves in housing, recreation, climate, schools, and colleges. These factors will play an important role in the recruitment of top grade personnel, the most critical element in determining future accomplishments of the Center.

(e) *Adequate current and planned transportation for local and long-distance travel.*—There must be free access locally in terms of good roads and mass transportation. In addition, excellent long-distance air and rail facilities must be available with frequent schedules in order that Center personnel can maintain, on a reciprocal basis, the essential personal contact required with other NASA centers, other Government laboratories, universities, and industries throughout the country.

(f) *Availability of adequate land conveniently located and not in conflict with existing metropolitan planning.*—There must be suitable land located conveniently both for Center personnel and for individuals having business with the Center, which does not conflict with metropolitan plans being developed for the area.

LOCATION SELECTION

The NASA considered many potential areas throughout the country for location of its Electronics Research Center. Areas in the Northeast, Midwest, and West, with specific electronic competence satisfied the selection criteria to one degree or another. On balance, the overall university-industrial strength and capability in electronics and guidance research in the Greater Boston area resulted in its selection as the best location for the Center. This area, noted for its past and current heavy concentration on electronics and related physics research, both in industry and universities, provides a compatible, stimulating environment for regenerative growth of NASA electronics capabilities at the Electronics Research Center.

After carefully considering NASA's present programs and future plans and the recommendations as to location, the agency management decided to recommend in its fiscal year 1964 budget the establishment of an Electronics Research Center in the Greater Boston area. The President submitted this recommendation to the 88th Congress in his budget for fiscal year 1964.

FURTHER PREPARATION AND PLANS

NASA has requested authorization of, and appropriations for, 250 personnel for an Electronics Research Center in fiscal year 1964. Also requested were $5 million for acquisition of land, site development, and planning for facilities, and $3.5 million for personnel costs and operation of the installation. Personnel would be located in temporary quarters in the Greater Boston area until permanent facilities are ready for occupancy. Current plans for the Center foresee a growth to about 2,000 people and $50 million worth of facilities.

As an interim step in planning this augmentation of NASA's electronics research capability, prior to congressional decision on the recommended budget, NASA has established an Electronics Research Task Group under the direction of the Office of Advanced Research and Technology. This group is composed of personnel located both at headquarters in Washington and at the northeastern office in Cambridge, Mass. It is carrying out the planning of technical programs, and planning for specific site location, site preparation, and facilities that is required should Congress decide to approve NASA's proposal. The Electronics Research Task Group is administratively housed and supported by NASA's northeastern office. The Electronics Research Task Group and the northeastern office staffs will work closely together in conducting the necessary planning drawing in the northeastern office's familiarity and relations with the local universities, industry, and community.

FURTHER INFORMATION CONCERNING THE PROPOSED ELECTRONICS RESEARCH CENTER

NASA will cover in detail, during congressional authorization and appropriations hearings this spring, the plans for the proposed Electronics Research Center and the factors that have led to its recommended formation. Current information on the Electronics Research Center will be available in Washington in the office of Dr. Albert J. Kelley, NASA Electronics Research Task Group (Dudley 2-7355), and in the Boston area from the office of Mr. Franklyn Phillips, Director, NASA northeastern office, 30 Memorial Drive, Cambridge, Mass. (491-1500).

I'd like to know something about that and what it is.

Then you were unable to give us the total amount of moneys NASA had spent for anything under the jurisdiction of this committee, whatever our legislative oversight might have been. You mentioned

R. & D. for the Defense Department or MIT and Harvard, and at least this member would like you to give us those figures as soon as you can for the record by NASA or anything this specific committee has oversight of.

Dr. KELLEY. In advanced research and technology; the area we are talking about now.

Mr. RANDALL. The area we are talking about.

Mr. MORRIS. Would the gentleman yield for unanimous consent? Why not other universities also? Maybe we ought to spend a little money at the University of Michigan, University of Minnesota; I'd even drop a nickel out in New Mexico.

Mr. RANDALL. Or the University of Kansas.

Mr. KARTH. Does Dr. Kelley understand the request?

Dr. KELLEY. I think this is fairly straightforwarded, we have documentation.

Mr. KARTH. Would you provide that for the record Doctor? We would appreciate that immensely.

(The information requested is as follows:)

RESEARCH GRANTS AND CONTRACTS

The Office of Grants and Research Contracts, NASA, has obligated the following amounts for research grants and contracts in the fiscal years indicated below-

[In millions of dollars]

Obligations	Fiscal year 1961	Fiscal year 1962	Fiscal year 1963 (July 1–Dec. 31)
University	14.3	22.3	15.8
Nonprofit	2.4	6.7	5.2
Industry	7.2	3.7	.7
Government	2.6	6.1	1.5
Total	26.5	38.8	23.2

Included in this report is a complete list of NASA research grants and contracts initiated from July 1, 1962, through December 31, 1962. Grants and contracts awarded during fiscal years 1961–1962 are listed in the appendixes of previous NASA semiannual reports to Congress.

APPENDIX

RESEARCH GRANTS AND CONTRACTS

(Initiated from July 1, 1962 through December 31, 1962)

(Contracts have prefix NAS; Grants have prefix NsG; Transfer of Funds to Government Agencies have prefix R. Earlier Grants and Contracts are listed in appendices of previous NASA Semi-Annual Reports to Congress.

State and Grant or Contract No.	Organization and Purpose	Investigator	Amount
ALASKA			
NsG-201	**University of Alaska** Conduct a theoretical study of the ring current and geomagnetic field phenomena.	**Sydney Chapman**	35,000
ARIZONA			
NsG-161	**University of Arizona** Conduct selenodetic and physical studies of the lunar surface.	**Gerald P. Kuiper**	248,400
NASr-82	**University of Arizona** Construction of a 60-inch lunar and planetary telescope.	**G. P. Kuiper**	375,000
ARKANSAS			
NsG-153	**University of Arkansas** Basic experimental research leading to improved cold electron sources and new types of velocity filter mass spectrometers.	**M. K. Testerman**	30,434
CALIFORNIA			
NsG-93	**Stanford University** Large deflection buckling of thin shells.	**Nicholas J. Hoff**	59,957
NsG-101	**University of California (Berkeley)** Reflection spectra as a basis for studying extraterrestrial life.	**M. Calvin**	252,500
NsG-104	**University of California (Berkeley)** Detection and study of microorganisms in the upper atmospheres.	**Sanford S. Elberg**	33,000
NsG-274	**University of California (Berkeley)** Theoretical and experimental research concerning the effect of non-linear material properties on the stress distribution in thin sperical shells.	**E.P. Popov & J. Penzien**	31,500
NsG-285	**City of Hope Medical Center** An experimental investigation of the dietary requirements of man, particularly astronautics, with emphasis on water-soluble chemically-defined diets.	**Milton Winitz**	150,000

State and Grant or Contract No.	Organization and Purpose	Investigator	Amount
CALIFORNIA (Continued)			
NsG-289	**Institute for Medical Research (Cedars of Lebanon Hosp)** A study of measurement techniques for determining cardiac performance, including consideration of methods for vibrocardiogram interpretation, and of physiological stress effects on man.	**Clarence M. Agress**	174,009 15,925
NsG-296	**Stanford University** Joint support of Third International Symposium on X-ray Optics and X-ray Micronanalysis.	**A. H. Bowker**	5,896
NsG-299	**Stanford University** Theoretical research on electron energy in plasma thermionic diodes.	**Walter C. Scott**	47,000
NsG-303	**University of California (San Diego)** Experimental research on techniques for determination of magnetic properties of lunar and planetary materials.	**J.C. Belshe**	27,200
NsG-313	**University of California (Los Angeles)** Isotopic Chemistry of Meteorites, including Studies of Variation in isotopic abundances among discrete specimens	**George Wetherill**	72,430
NsG-314	**University of California (Los Angeles)** High pressure study of the solid phases of inert gases, with emphasis on applicability to the nature of extra-terrestrial bodies	**George Kennedy**	85,000
NsG-317	**University of California (San Diego)** Conduct study of the composition and structure of meteorites, including the use and refinement of x-ray microspectrometic and microdiffraction techniques.	**G. Arrhenius**	83,018
NsG-318	**University of California (San Diego)** Experimental research on x- and gamma-radiation at high altitudes, including design and use of balloon-borne instrumentation	**L. E. Peterson**	85,000
NsG-319	**University of California (San Diego)** Geochemistry of trace elements in meteorites	**G. G. Goles**	55,158
NsG-322	**University of California (San Diego)** An investigation of the cosmic abundances of the elements	**H. E. Suess**	66,242
NsG-323	**University of California (San Diego)** An investigation of inert gases and isotopic abundances in meteorites	**H. C. Urey**	73,054
NsG-329	**Stanford University** Radio propagation techniques for the study of planetary ionospheres and interplanetary medium	**O. K. Garriott**	81,000
NsG-(F)-2	**Stanford University** Biomedical instrumentation facilities	**Joshua Lederberg**	535,000
NsG-(F)-5	**University of California (Berkeley)** Space sciences research facilities	**Samuel Silver**	1,990,000
NASr-21(01)	**Rand Corporation** (a) Conduct studies of economic and international policy questions associated with communication satellites etc.; (b) conduct studies of the economic implications of meteorological satellites etc.		141,200
NASr-26	**University of California (Berkeley)** Conduct research on low energy cosmic radiation from the sun.	**K. A. Anderson**	32,000

State and Grant or Contract No.	Organization and Purpose	Investigator	Amount
CALIFORNIA (Continued)			
NASr-68	**Douglas Aircraft Company, Inc** Investigation of control-display problems occurring in the accelerative flight phases of high-performance vehicles.	A. A. Burrows	27,560
NASr-110	**Douglas Aircraft Company, Inc.** Wind tunnel investigation of turbulent boundary layer as noise related to design criteria for high-performance aircraft.	J. S Murphy	66,913 12,024
NASr-111	**Aerojet-General Corporation** Develop analytic methods for analyzing the aero-dynamic, static dynamic loads on large flexible-expansion-ratio nozzles during flow separation conditions	B. Mazelsky	66,026
NASr-114	**Norair (Div. of Northrop Corp.)** Research on the fundamental principles governing the characteristics of primary forms of ring articulated-arch variable-geometry structures	W. R. Hilker	56,109
NASr-116	**University of California (San Diego)** Conduct analytical, theoretical, and experimental studies of geomagnetically trapped particles.	Carl E. McIlwain	277,997
NASw-81	**California Institute of Technology** Investigation of the Moon with a lunar seismograph station.	H. Benioff	140,429
NASw-383	**Solid State Radiations, Inc.** Advanced development of semiconductor detectors.	S. S. Friedland	111,656
NASw-414	**Space Technology Laboratories, Inc.** A study of a space system for comet encounter		82,100
NASw-438	**Shell Development Company** Development of Analytical Techniques for Hydrocarbons in Mineral Aggregates		95,000
NASw-457	**North American Aviation, Inc.** Study on the sonic velocity and penetrability measurements of rock dust under vacuum conditions		48,931
NASw-468	**General Motors Corporation** Investigation of Space Radiator Protection		130,350
NASw-491	**Convair (Div of General Dynamics)** "Onset of Creep" Stress Measurement of Metallic Materials	R. H. Raring	61,350
NASw-493	**Corbin-Farnsworth, Inc.** Study and development of remote blood pressure measuring system.	Tom Corbin	47,400
NASw-495	**Hughes Research Laboratories** Technical studies of problems related to multiple-access satellite communication.	Samuel G. Lutz	68,046
NASw-504	**Space Technology Laboratories, Inc.** Study of buckling of shells under dynamic loads		96,419
NASw-514	**Electrochimica Corporation** Research and development of an electrolytic oxygen generator based on solid phosphorus pentoxide.	Bernard S. Baker	45,768
NAS5-1253	**General Atomic** Research on carbides as cathode for Thermionic Space reactors		98,500

State and Grant or Contract No.	Organization and Purpose	Investigator	Amount
COLORADO			
NsG-61	**University of Denver** The scavenging of tungsten and molybdenum with selected rare Earths. (Cont. NASw-8)	D. T. Kledt	12,500
NsG-78	**Colorado State University** I. Pathogen-free plants in a microcosm. II. Effects of high intensity light on plant growth.	R. Baker	44,743
NsG-92	**University Corporation for Atmospheric Research** Research and development of new techniques of observation of solar phenomena.	H. Zirin	75,000
NASw-448	**Martin Marietta Corporation** Determination of time to launch saturn vehicles		14,418
R-74	**U.S. National Bureau of Standards** Initiate studies of solar cosmic ray emission events, by ionospheric forward scatter observations in the Antarctic during the International Quiet Sun Year.	D. K. Bailey	25,000
CONNECTICUT			
NsG-1	**Yale University** Investigation of molecular beam frequency standards and atomic collision cross-sections.	V. W. Hughes	80,000
NsG-29	**Yale University** Research on problems of satellite and planetary motion.	Dirk Brouwer	342,500
NsG-163	**Yale University** Theoretical research in relativity, cosmology and the physics of stellar interiors.	Vernon W. Hughes	46,000
NsG-309	**University of Connecticut** Analytical and experimental research on methods of reducing the sensitivity of sampled data systems to parameter variations and disturbances	D. P. Lindsoff	26,390
NsG-312	**Yale University** Studies of the constitution of planetary interiors, and mathematical techniques for planetary modeling	R. Wildt	117,760
NASr-129	**The Connecticut Agricultural Experiment Station** Experimental investigation of the use of higher plants for the production of breathing oxygen in a closed ecology	P. E. Waggoner	28,704
NASw-512	**United Aircraft Corporation** A biological design study of man's capabilities for operation in space environments, with particular emphasis on a feasibility study of the extension of man's capabilities.	Richard J. Preston	96,210
NASw-542	**United Aircraft Corporation** Development of Stimulator Monitor and Monitor Systems.	W. A. Menzel	192,508

State and Grant or Contract No.	Organization and Purpose	Investigator	Amount
DISTRICT OF COLUMBIA			
NsG-87	**Smithsonian Institution** Optical satellite tracking program.	**Fred L. Whipple**	3,250,000
NsG-291	**Smithsonian Institution** Systematic in-flight photography and subsequent recovery of meteorites	**F. L. Whipple**	239,500
NASr-10	**Resources Research Inc.** Research on radioisotopic methods for detecting the presence and monitoring the metabolic radioisotopec activity of microorganisms on an extraterrestrial body, and design and build a prototype of the detection and monitoring apparatus.	**Gilbert V. Levin**	87,556
NASr-132	**American Institute of Biological Sciences** Conduct symposium on the minimum ecological systems for man	**Frank Fremont-Smith**	34,872
NASr-142	**National Science Teachers' Association** Develop and publish a series of six (6) paperback books which will be arranged to help the elementary school teachers enrich the science program	**R. H. Carlton**	21,275
R-24	**U.S. Navy-Naval Medical Research Lab.** Research on the diurnal periodicity of physiological functions and of performance level; including studies of the effects of removing, or of changing the period or the phase of, environmental time indicators.	**Karl E. Schaefer**	40,000
R-30	**U. S. National Bureau of Standards** Conduct research on the electron content, distribution and temporal variation in the ionosphere by means of scintillations and Faraday rotation of satellite.		147,000
R-45	**U. S. National Bureau of Standards** Conduct research on the physical properties of hydrogen; techniques for determining engineering data on cryogenic fields; materials and design principles for cryogenic systems and compilation of low temperature data from the literature.		425,000
R-48	**U. S. Navy - Office of Naval Research** Reimbursement for balloons, launching services and related expenses in connection with high altitude balloon measurements of the electron, low-energy proton, and alpha-particle spectrum of primary cosmic radiation. (Cont. of R-23)	**Wemsley**	50,000
R-66	**U.S. Dept of Interior (Geological Survey)** Conduct studies of the lunar surface, including lunar geologic mapping; cratering and crater impact mechanisms; chemical, physical and petrographic properties of material of possible lunar origin; and ranger and surveyer data reduction and interpretation.	**F. E. Senftle**	556,200
R-70	**U.S. Navy-Naval Research Laboratory** Conduct solar research from a solar-pointed Aerobee Rocket by the atmosphere and Astrophysics Division		60,000
R-72	**U. S. Navy - Office of Naval Research** Provide helium in conjunction with balloon flights to be conducted by General Mills under NASA Contract NASr-81		2,000

State and Grant or Contract No.	Organization and Purpose	Investigator	Amount
DISTRICT OF COLUMBIA (Continued)			
R-73	U. S. National Bureau of Standards Investigate the physical properties of light sources and detectors in the far ultra-violet and soft x-ray regions of the spectrum, and develop radiometric standards in the same spectral regions.	R. P. Madden	100,000
FLORIDA			
NsG-148	Florida State University Pheripheral mechanisms of human temperature sensitivity.	D. R. Kenshalo	45,294
NASr-126	University of South Florida Conduct development of specific space related teaching material, designed to serve as guides and supplements to classroom instructio	Charles Helvey	5,500
GEORGIA			
NsG-304	Georgia Institute of Technology Conduct theoretical and laboratory experimental research on chemical releases at high altitudes	Howard D. Edwards	93,550
HAWAII			
NsG-328	University of Hawaii Theoretical and experimental investigation of electron emission, conductivity and luminescence of selected solids under vacuum ultraviolet excitation.	Peng and Watanabe	95,000
ILLINOIS			
NsG-24	University of Illinois Investigation of the ionosphere using signals from Earth Satellites.	G. W. Swenson, Jr.	109,991
NsG-96	University of Chicago Theoretical investigation of further consequences of solar wind.	E. N. Parker	39,496
NsG-280	University of Illinois Theoretical research on the periodic motion and stability of a small mass under the gravitational attraction of two heavy bodies	J. H. Bartlett	48,916
NsG-333	University of Chicago Meteorological interpretation of satellite radiation data	T. Fujita	55,059
NsG-(F)-3	University of Chicago Space science research facilities	John Simpson	1,775,000
NASr-65(01)	Armour Research Foundation Conduct a theoretical and experimental study of the radiative properties of simulated Martian and Venusian atmospheres, and at the aerodynamic heating of space vehicles entering these atmospheres.	William O. Davies	63,589

State and Grant or Contract No.	Organization and Purpose	Investigator	Amount
ILLINOIS (Continued)			
NASr-65(02)	**Armour Research Foundation** Conduct studies of lunar soil mechanics, including the determination of static mechanical properties of simulated lunar soils under lunar-like environmental conditions	**Weil, Solig & Vey**	51,578
INDIANA			
NsG-301	**Purdue University** High precision spectroscopy with applications to the study of the atomic spectra of the carbon group and to the secondary standards in the vacuum ultraviolet and the development of computer methods of data analysis	**K. L. Andrew**	100,000
IOWA			
NsG-(F)-4	**State University of Iowa** Physics and astronomy research facilities	**James A. Van Allen**	610,000
KANSAS			
NsG-292	**Kansas State University** Gas chromatography techniques for the determination of dilute constituents of biological material, including consideration of material relevant to the ecology of astronauts	**Anthony Gawienowski**	103,858
NsG-298	**University of Kansas** Interdisciplinary studies in space science and technology	**John S. McNown**	100,000
NASr-124	**University of Kansas** Development of specific space related teaching material, designed to serve as guides and supplements to classroom instruction	**Clay Hobson**	1,650
NASw-461	**The Boeing Company** Jet Exhaust wake degradation investigation.	**J. Parkinson**	71,836
MAINE			
NsG-338	**University of Maine** Interdisciplinary studies in space-related science and technology	**T. H. Curry**	61,250
NASr-133	**Hebron Academy** Conduct development of space related materials designed to serve as guides and supplements to classroom instructions	**Gerald Twitchell**	4,000
NASr-134	**Gorham State Teachers College** Conduct development of specific space related teaching materials, designed to serve as guides and supplements to classroom instruction	**Morris Whitten**	2,750
MARYLAND			
NsG-189	**University of Maryland** Conduct behavioral research and experimental analysis of complex behavioral repertoires under full environmental control.	**J. D. Findley**	100,000
NsG-283	**University of Maryland** Techniques for extraterrestrial measurement of low energy charged particle fluxes in the interplanetary plasma	**T. D. Wilkerson**	18,179

State and Grant or Contract No.	Organization and Purpose	Investigator	Amount
MARYLAND (Continued)			
NASw-545	**ACF Industries, Inc.** To investigate, under controlled conditions, the comparative sensitivity of several commonly employed performance measures to the effects of strong motivating factors.	J. P. Mullin	73,135
R-71	**U.S. Naval Ordnance Laboratory** Conduct a drag and static and dynamic stability investigation of models of the Mariner B Shape A-1 and JPL Configuration V-1 at flight velocities from 13,000 feet per second to 18,000 feet per second, etc.		63,943
MASSACHUSETTS			
NsG-254	**Massachusetts Institute of Technology** Analytical and laboratory investigations to determine information on possible guidance, navigation, control system and instrumentation concepts and configurations for spacecraft having long term earth orbit lunar and planetary missions	C. S. Draper	100,000
NsG-262	**Harvard University** Interdisciplinary studies of the effects of high energy protons on biologic systems, including participation in the nationwide cooperative study on shielding materials as related to the Apollo Mission	Sweet & Preston	195,540
NsG-264	**Massachusetts Institute of Technology** An experimental investigation of the terrestrial atmosphere utilizing baloon-borne millimeter radiometers	Barrett, Graham, Ratuse	131,300
NsG-282	**Harvard University** Research on mineral constituents of meteorites	Clifford Frondel	65,865
NsG-310	**Northeastern University** Studies in magnetohydrodynamics to explain the structure of spiral galaxies	H. D. Greyber	34,956
NsG-(F)-6	**Harvard University** Biomedical research facilities	William H. Sweet	182,685
NASr-41	**National Research Corporation** Research on the effects of simulated space environments on the viability of microorganisms.	W. H. Keller	82,440
NASr-58	**Bolt, Beranek and Newman, Inc.** Conduct research directed toward the establishment of criteria for evaluating the subjective noisiness of aircraft sounds.		40,000
NASw-37	**Massachusetts Institute of Technology** Designing, constructing and testing a high-energy gamma ray detector capable of being carried in a satellite.	W. L. Kraushaar	50,000
NASw-389	**AVCO Corporation** Study of the Use of Fungal Luminescence as a Physiological Index		42,300
NASw-441	**Sylvania Electronics Systems** Study of the application and instrumentation of visual perception for space exploration		61,961
NASw-535	**Allied Research Associates, Inc.** Study of Biological Mechanisms in Instrumentation Development.	W. D. Green	69,227

State and Grant or Contract No.	Organization and Purpose	Investigator	Amount
MASSACHUSETTS (Continued)			
NASw-549	**Parametrics, Inc.** Experimental Determination of Transport Properties of High Temperature Gases.	**E. H. Carnevale**	39,479
NASw-500	**Geophysics Corporation of America** Proposed rocket measurements in the ionosphere during a solar eclipse.	**Leslie G. Smith**	281,794
W-11,054-B	**U. S. A. F. Cambridge Research Center** Experiment for orbiting solar observatory S-16a.	**L. Hogarth**	46,500
MICHIGAN			
NsG-181	**University of Michigan** Conduct research on space-probe techniques for possible measurements of electromagnetic phenomena.	**F. T. Haddock**	133,770
NASr-54(01)	**University of Michigan** Conduct research on the temperature, pressure, and density of the Earth's atmosphere by rocket probe techniques, including: a. Analysis of data from nine (9) IGY rocket flights. b. Collection and analysis of pitostatic pressure data from approximately six (6) rocket probe flights at altitudes between 40 and 140 kilometers. c. Collection and analysis of data from pressure gages and an electron temperature probe etc.	**L. H. Greco**	32,135
NASw-138	**University of Michigan** The development of rocket instrumentation commenced under Contract NASw-4 for the measurement of atmospheric pressure, density, temperature and composition in the altitude region 100-200 kilometers. Test instrumentation and synoptic version of system in rocket fired at Wallops Island.	**L. M. Jones**	180,000
NASw-490	**Conductron Corporation** A theoretical Investigation of the Use of Radar in the Study of the Moon and Planets.	**K. M. Siegel**	48,550
MINNESOTA			
NsG-79	**University of Minnesota** Closed ecological system studies. (Cont. of NASw-70)	**H. M. Tsuchiya**	215,280
NsG-281	**University of Minnesota** Analytic and experimental research in Space Physics, including balloon and rocket flight experiments	**J. R. Winckler & E. P Ney**	800,000
NsG-286	**University of Minnesota** Experimental research on mass spectrometric techniques for the study of planetary and upper atmosphere composition	**Alfred O. C. Nier**	223,990
NsG-327	**Mayo Association** Cine roentgenographic study of the heart and lungs of man during exposure to forward acceleration	**E. H. Wood**	153,156
NASr-148	**University of Minnesota** An administrative history of NASA, including documentation of changes in agency structures and related problems of operational decentralization and program integration.	**Short and Rosholt**	8,394
MISSOURI			
NsG-185	**Washington University (St. Louis)** A determination of some characteristics of high altitude primary cosmic radiation at low and/or southern latitudes.	**M. W. Friedlander**	36,000

State and Grant or Contract No.	Organization and Purpose	Investigator	Amount
MISSOURI (Continued)			
NASr-63(02)	**Midwest Research Institute** (a) Conduct studies on the influence of surface coatings on exo-electron emission during fatigue, (b) conduct studies on the physical configuration and electrical characteristics of test samples with associated equipment, (c) monitoring fatigue damage by the solid-state electron collection device.	J. C. Grosskreutz	42,125
NASr-63(04)	**Midwest Research Institute** Develop and apply a methodology for measuring the short- and long-term effects of increased participation in space technology on the economy of the states of Missouri, Oklahoma, Kansas, Arkansas, Iowa, and Nebraska; and analyze the technical capabilities of these states in determining the optimum direction of future economic effort.	M. H. Thornton	25,000
NEW JERSEY			
NsG-69	**Princeton University** The use of television techniques with telescopes above the atmosphere.	M. Schwarzschild	500,000
NsG-306	**Princeton University** Theoretical and experimental studies of the formation and stability of the magnetogasdynamic front in a pinch discharge	Jahn, Kunnen & Bernstein	55,926
NASw-449	**Thiokol Chemical Corporation** Investigation of an advanced high energy, space storable propellant system.		200,000
NEW MEXICO			
NASr-115	**The Lovelace Foundation for Med Ed. and Res.** Prepare a compilation of definitive current information in all areas of life science bearing on the bio-medical aspects of manned spacecraft operations	W. Randolph Lovelace II	243,920
NEW YORK			
NsG-162	**University of Rochester** Conduct investigation of the abundance of helium isotopes and other selected nuclei in low-energy primary cosmic radiation.	M. F. Kaplon	15,000
NsG-165	**Polytechnic Institute of Brooklyn** Conduct theoretical study of the forces acting on bodies in rarefied ionized environments.	Manlio Abele	22,300
NsG-177	**City College of New York** Conduct theoretical study of the interaction of two colliding plasmas with applications to astrophysics.	R. Mirman	1,500
NsG-197	**City College of New York** Theoretical investigations of particle orbits and radiation modification in gravitational fields, and high-density plasma oscillations.	Henry Semat	20,324
NsG-229	**Columbia University** Conduct a summer institute for space science, including the selection and support of fifty (50) outstanding undergraduate science-student attendees.	Arthur N. Strahler	34,531
NsG-290	**Rensselaer Polytechnic Institute** Studies of radiation damage to semi-conductors and thin metallic films by high-energy electron, proton, and neutron-gamma radiation	Corelli & Huntington	151,030
NsG-294	**Columbia University** Conduct materials research investigations using the field ion emission microscope	Eugene S. Machlin	100,000

State and Grant or Contract No.	Organization and Purpose	Investigator	Amount
NEW YORK (Continued)			
NsG-302	**Columbia University** Theoretical research investigations in Plasma Physics and Magnetogasdynamic	**Robert A. Gross**	35,000
NsG-307	**Columbia University** An interdisciplinary study of problems related to the space program	**David S. Smith**	36,380
NsG-308	**University of Rochester** Investigation of New Methods of Designing Multilayer Filters having Specified Transmission or Reflectance as a Function of Wavelength	**Philip W. Baumeister**	16,817
NsG-(F)-1	**Rensselaer Polytechnic Institute** Materials research facilities.	**Stephen E. Wiberley**	1,500,000
NASr-104	**Grumman Aircraft Engineering Corp.** Conduct theoretical and experimental investigation of high-engery molecular reflection from solid surfaces in the range of incident-particle energy	**Richard Omen**	55,000
NASr-119	**Cornell Aeronautical Laboratory, Inc.** Conduct a research program to determine the non-equilibrium flow field and the optical radiation around vehicles traveling at high altitudes and super-orbital speeds	**A. Hertzberg**	119,996
NASr-121	**Cornell Aeronautical Laboratory, Inc.** Conduct a research study to establish requirements for spaceborne detection, tracking and navigation systems suitable for use in future manned spacecraft having rendezvous and lunar landing missions	**Richard Taylor**	84,973
NASr-130	**Inst. of the Aerospace Sciences** Expansion of IAS to enable the Institute to provide a comprehensive coverage of world-wide published literature in the aerospace sciences.	**J. J. Glennon**	222,895
NASr-31	**Wilmot Castle Company** Perform research on sterilization of space-probe components by dry heat, irridiation, or other techniques.		13,617
NASw-384	**General Electric Company** Research and development on an electrostatic gyro system		274,596
NASw-459	**Excelco Developments, Inc.** Study and evaluation of fabrication methods necessary for production of large diameter 260 solid propellant booster		27,900
NASw-513	**Cutler-Hammer, Inc. (Airborne Instr. Lab.)** Studies for sounding planetary ionospheres in the Mariner Program.	**Roger C. Moore**	78,089
NASw-517	**Schwarz BioResearch, Inc** Research into the development of a superior diet for use in space nutrition.	**David R. Schwarz**	183,000
NASw-520	**Radiation Applications, Inc.** Water recovery study		142,560
NASw-541	**Grumman Aircraft Engineering Corp.** Statistical Study of Lunar Surface Information Requirements.	**G. F. Titterton**	18,167
NASw-550	**Wilmot Castle Company** Studies for sterilization of Space Probe Components.	**C. W. Bruch**	91,681
NAS3-2121	**Cornell Aeronautical Laboratory, Inc.** Study of Meteoroid Impact Processes		78,000

State and Grant or Contract No.	Organization and Purpose	Investigator	Amount
NORTH CAROLINA			
NASw-503	**Astra, Inc.** A preliminary parametric study of the Rankine steam cycle for space power operation systems.		34,908
OHIO			
NsG-36	**Case Institute of Technology** Investigation of the use of hybrid numerical circuits in closed-loop control systems.	H. W. Mergler	70,770
NsG-110	**Case Institute of Technology** Research to establish methods of systematic structural synthesis.	L. A. Schmit, Jr.	10,000
NsG-270	**Drexel Institute of Technology** Theoretical analysis of the stresses induced into the walls of a liquid filled propellant tank impacted and penetrated by a small hypervelocity particle, including prediction of impact conditions at which catastrophic failure of the tank wall will occur.	P. C. Chou	53,292
NsG-295	**Ohio State University** Biological effects of prolonged exposure of small mammals to closed gaseous environments low or free of nitrogen	E. P. Hiatt	120,000
NsG-315	**Xavier University** Support of a one week conference on the foundation of quantum mechanics	B. Podolsky	7,000
NASr-100(01)	**Battelle Memorial Institute** Conduct a mechanical cycling experimental research program to determine whether there is a significant problem in mechanical fatigue of possible supersonic transport materials due to long-time thermal instability	W. S. Hyler	53,000
NASr-141	**Ohio State University** Development of source book of guidance materials related to educational and vocational guidance in occupations involved in the exploration and use of space, including brochure and slides regarding same.	H. J. Peters	2,625
NASw-451	**North American Aviation, Inc.** Experimental research program on pilot performance during simulated low altitude-high speed flight.	Ben Sclahen	63,845
NASw-471	**Goodyear Aircraft Corporation** Study of methods of structurally evaluating expandable structures having potential space application		117,085
OKLAHOMA			
NsG-300	**Oklahoma City University** Interdisciplinary studies of the effects of the space enviroment on biological systems.		141,450
NASr-4	**Oklahoma State University** Development of a transistorized miniature 15-channel pulse-time telemeter transmitting set having performance characteristics comparable to the AN/DKT-7 telemeter equipment and compatibility with the AN/FKR-1 receiving equipment.	Herrington & Cooper	2,424
NASr-7	**Oklahoma State University** An analytical and limited experimental study of the mechanisms of impact, penetration and light emission for micrometeorites on an aluminum-coated photomultiplier.	F. C. Todd	56,208

State and Grant or Contract No.	Organization and Purpose	Investigator	Amount
OREGON			
[illegible]w-458	**Field Emission Corporation** Theoretical and experimental studies of the basic processes which contribute to Voltage breakdown under the general environmental conditions pertinent to ion propulsion systems.	**F. M. Charbonnier**	108,901
PENNSYLVANIA			
NsG-84	**Temple University** The production of hypervelocity particles of small size and to increase the sensitivity of micrometeorite detection techniques.	**J. Lloyd Behn**	37,814
NsG-287	**Haverford College** Research on wave functions and transition probabilities for light atoms and highly ionized ions	**Louis C. Green**	11,184
NsG-316	**University of Pennsylvania** Research in the conversion of various forms of energy by unconventional techniques	**M. Altman**	250,000
NsG-324	**Pennsylvania State University** Cellular biophysics: a study of the structure and function of living cells	**E. C. Pollard**	74,969
NsG-325	**University of Pennsylvania** Studies of the fundamental chemistry, properties, and behavior of fuel cells	**J. O'M. Bockris**	99,250
NASr-145	**The Franklin Institute** An investigation of the effect of nucleation of slip at the surface on the flow and fracture of beryllium	**K. U. Snowden**	73,500
NASw-470	**General Electric Company** Study of Relationship of Properties of Composite Materials to Properties of their Constituents.	**B. W. Rosen**	137,550
NASw-492	**SKF Industries, Inc.** Study of bearing lubricant endurance characteristics		144,937
NASw-511	**General Electric Company** Research study of Bio-Electrogenesis as an approach to waste management.	**John J. Konikoff**	256,196
TEXAS			
NsG-263	**University of Texas** Quantum mechanical calculations and studies on atomic systems of astrophysical interest	**Matsen & Scherr**	30,040
NASw-439	**Bell Helicopter Company** Research on utilization of part-task spatial orientation information in Dynamic Simulator.	**W. G. Matheny**	82,480
NASw-444	**Chance Vought Corp.** Elevated temperature material fatigue test program.	**J. E. Martin**	47,430
VIRGINIA			
NASw-543	**Exotech, Incorporated** Investigation of Precession Control and Orbit Maintenance Systems for Rotating Space Stations.	**William C. Cooley**	19,402
WISCONSIN			
NASr-139	**Astronautics Corp. of America** Stabilized platform for use with the X-15 ultraviolet experiments and related spare parts		150,441

State and Grant or Contract No.	Organization and Purpose	Investigator	Amount
WISCONSIN (Continued)			
NASr-143	**Astronautics Corp. of America** Field support personnel for stable platform equipment for the X-15 ultraviolet photography experiments		58,534
FOREIGN			
NsG-278	**Communication Research Institute of St. Thomas, V.I.** A study of the feasibility and methodology for establishing communication between man and other species.	John C. Lilly	80,700
NsG-288	**Manila Observatory** Daily optical monitoring of solar activity from Manila.	Richard A. Miller	90,000
NsG-297	**University of Manchester** Photographic observations of lunar surface from Japan.	Zdenek Kopal	25,374
NsG-305	**University of Munich** Investigation of atmospheric properties based upon evaluation of infrared radiation data obtained from TIROS satellites	F. Moller	12,750
NsG-320	**Dominion Observatory** Solar Flare Patrol: Observation of the Solar Chromosphere	V. Gaizauskas	29,000
NASr-127	**Inter American University of Puerto Rico** Development of specific space related teaching material, designed to serve as guides and supplements to classroom instruction.	Ismael Velez	2,750

I would like to say before we adjourn, that Congressman Bradford Morse, of Massachusetts, has asked that we insert in the record at this point a statement that he intended to make before the subcommittee this morning. Unfortunately he had to appear elsewhere this morning.

Mr. MORRIS. Is this statement going to be comingled with the statement of the Department or after the statement of the Department?

Mr. KARTH. He wanted to make the statement today and I don't think there is too much difference where it's inserted.

Mr. MORRIS. Sometimes a Member likes to have it first or last.

Mr. KARTH. Apparently he wanted it inserted at this point. If there are no objections it is so ordered.

(Statement of Congressman F. Bradford Morse follows:)

STATEMENT OF CONGRESSMAN F. BRADFORD MORSE BEFORE SUBCOMMITTEE NO. 3, HOUSE COMMITTEE ON SCIENCE AND ASTRONAUTICS

Mr. Chairman, I am delighted to have this opportunity to urge your subcommittee to support the National Aeronautics and Space Administration's request for funds to construct an electronics research center.

There is no doubt of the need for such a center. We cannot hope to keep up with the Soviet Union unless we give our space program the electronic tools it needs. This center will accomplish the research needed to do precisely that. It will develop electronic devices for both flight and on-the-ground projects in the areas of communications, instrumentation, data processing, tracking, flight control and guidance.

Obviously, this proposal is of extreme importance to this Nation's long range space research program and to our overall scientific effort.

America may never know the true story of the universe without this space research labcratory. The work that the center will accomplish will be essential in outer space. In the words of Raymond L. Bisplinghoff, Director of the Office of Advanced Research and Technology for NASA, "All the technology for guidance systems and communications to explore our solar system must be developed there."

The center's importance will be in the long-range efforts of our Nation to learn about other planets. It will involve fundamental research in electronic control systems, communications, and navigational procedures for deeper space missions.

The techniques developed at this laboratory will tell us whether we can send men on the longer space flights and determine, to a great degree, whether or not this Nation will win the race to the Moon.

The center will provide the National Aeronautics and Space Administration with one of the tools it needs successfully to participate in a competitive, worldwide space exploration effort.

Mr. KARTH. The committee will adjourn until 10 o'clock tomorrow morning. Thank you very much.

(Whereupon at 12:05 p.m. the subcommittee was adjourned until 10 a.m., Thursday, April 4, 1963.)

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1964 NASA AUTHORIZATION

THURSDAY, APRIL 4, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SPACE SCIENCES
AND ADVANCED RESEARCH AND TECHNOLOGY.
Washington, D.C.

The subcommittee met, pursuant to adjournment, at 10 a.m., in room 304, Old House Office Building, Hon. Joseph E. Karth (chairman of the subcommittee) presiding.

Mr. KARTH. The committee will be in order. Dr. Kelley, yesterday when we adjourned we had in mind asking a few more questions of you this morning; then we will hear from Mr. John Sloop who is here with Dr. Bisplinghoff.

At this time I will recognize the gentleman from New Mexico.

FURTHER STATEMENT OF DR. ALBERT J. KELLEY, DIRECTOR OF ELECTRONICS AND CONTROL, NASA

Mr. MORRIS. Doctor, referring to this Executive order which was issued during the previous administration and which, I believe, is still in effect; I believe they call it Executive Order 10521. It requires NASA to survey all existing Government structures prior to constructing new ones.

Was this done with regard to the Electronic Research Laboratory which is proposed in the budget?

Dr. KELLEY. There is a review procedure between, for example, the Department of Defense and NASA. I am not familiar with the exact interpretation but of course, we have the NASA–DOD Aeronautics and Astronautics Coordinating Board in that respect. The information is made known to the various agencies on an exchange basis. I do not know, specifically, what the procedure was in this case; but there is a constant yearly review of the particular facilities.

Now, in this case, I would like to point out, specifically, Mr. Morris, that we are asking for land acquisition. We are not asking for facilities or buildings this particular fiscal year.

Mr. MORRIS. Yes, Doctor, I understand that's the normal procedure and I don't find any fault in that. This is the way I'd go about something like this if I were to do it. You get the land first and you get the rest of it later on.

Mr. KARTH. Would the gentleman yield at this point?

Mr. MORRIS. This is the way you would like to do it.

Mr. KARTH. Well, I would merely say to Dr. Kelley, I think that the Executive order prohibits your acquisition of land until such time as a survey is made in accordance with that order.

This is a personal opinion, but I would assume this would be the force and effect of the Executive order.

Now, has the survey been made?

Dr. KELLEY. I did not mean to imply whether or not the Executive order was applicable in this case. I was merely pointing out that there would be—we would hope—facilities under this situation, which would be under constant review between the two agencies, DOD and NASA, for example. The review procedures going on between the NASA and the DOD are not a subject that falls in my domain.

For example, I have never been asked to comment, myself, on a particular DOD facility as to whether it would duplicate a NASA facility.

There is a review procedure, I understand, that I am aware of, between the two agencies.

Mr. MORRIS. Well, then you really don't know, Doctor, what procedure they carried out to implement this order for this particular installation?

Dr. KELLEY. I don't know the details. Discussion may even go on between Mr. Webb and Mr. McNamara and so forth on such matters.

Mr. MORRIS. I don't know whether I should put the question this way. Do you feel this order is applicable in this case?

Dr. KELLEY. Well, I feel the spirit of the order is applicable in any case. We certainly would not want to duplicate facilities between two agencies, between any agencies in the Government. That is, unnecessary duplication.

Some duplication is healthy and this, we would hope we would do, if it should happen, in a known fashion. But, certainly, the spirit would apply.

Mr. MORRIS. Now, you may not be familiar with a lot of these installations. For instance, do you know of the Naval Research Laboratory in Washington, D.C.?

Dr. KELLEY. Yes, sir; I am a member of the naval service.

Mr. MORRIS. I beg your pardon?

Dr. KELLEY. I am a member of the naval service.

Mr. MORRIS. Do you know what percentage of the effort at this installation is devoted to electronics research and development?

Dr. KELLEY. I know their approximate budget is a hundred million dollars and I know, for example, we have some work we are sponsoring at the Naval Research Laboratory.

I don't know the exact breakdown on a dollar basis, in electronics. However, we do have a close association with NRL as well as with other aspects of the Government who are working on electronics.

Mr. KARTH. Would the gentleman yield at this point?

Mr. MORRIS. I yield to my chairman, of course.

Mr. KARTH. Approximately how many employees do we have at the Naval Research Laboratory in Washington, Dr. Kelley?

Dr. KELLEY. I don't have the numbers in my head, but I could tell you what I have available, sir.

I can't remember all the numbers at the various installations.

Mr. KARTH. I understand that. Okay.

Dr. KELLEY. I think it's in terms of a few thousand. I am not sure.

Incidentally, as you are well aware, a significant portion of the Naval Research Laboratory was incorporated into the NASA when

it was first formed. This was the Project Vanguard group which became the nucleus for Goddard Space Flight Center.

I assure you, we are well aware of the capabilities of the Naval Research Lab.

Mr. KARTH. They are very capable, I agree.

Dr. KELLEY. They are a very able group and respected in the United States; yes.

Mr. MORRIS. Doctor, I am sure you are familiar, or know of the Navy Electronics Laboratory in San Diego, Calif.?

Dr. KELLEY. Yes, sir.

Mr. MORRIS. You are aware of the existence of the material lab in the New York Naval Shipyard in Brooklyn?

Dr. KELLEY. Yes, sir.

Mr. MORRIS. And that it does some research in electronics there?

Dr. KELLEY. Yes, sir.

Mr. MORRIS. It does do research and development with the Naval Research Lab in San Diego.

You also know, I am sure, of the Navy Underwater Sound Laboratory in New London, Conn.?

Dr. KELLEY. Yes, sir.

Mr. MORRIS. And that they do electronic research there?

Dr. KELLEY. Yes, sir.

Mr. MORRIS. The Naval Air Development Center at Johnsville, Pa.

Dr. KELLEY. Yes, sir.

Mr. MORRIS. And that they also devote a substantial portion of their efforts in electronics?

Dr. KELLEY. Yes.

Mr. MORRIS. The Naval Ordnance Laboratory at White Oak, Md., they also devote a considerable portion of their effort toward electronics?

Dr. KELLEY. Yes, sir.

Mr. MORRIS. The Naval Ordnance Laboratory at Corona, Calif.?

Dr. KELLEY. Yes, sir, we have some specific work out of my office with the Naval Ordnance Laboratory at Corona.

Mr. MORRIS. Is that a pretty good installation—pretty competent people out there?

Dr. KELLEY. Yes, they have been largely involved, in the past, in fusing, and electronic techniques associated with fusing, of explosive devices, particularly warheads.

They are doing some sensors which we, in fact, are sponsoring with them—infrared, particularly, I believe.

Mr. MORRIS. You are also, I am sure, familiar with the Naval Ordnance Test Station at China Lake, Calif., and their work there?

Dr. KELLEY. Yes, sir.

Mr. MORRIS. The Applied Physics Laboratory at Johns Hopkins University, Silver Spring, Md.?

Dr. KELLEY. Yes, sir, that is a lab of Johns Hopkins under contract to the Navy similar to the Jet Propulsion Lab contract with the NASA.

Mr. MORRIS. You are also aware, a good portion of their effort is devoted to electronics?

Dr. KELLEY. Yes, sir.

Mr. MORRIS. Now, are you familiar with the Army's installations?

Dr. KELLEY. Pretty much in general.

Could I add something, on the naval installations?

Mr. MORRIS. Yes, sir.

Dr. KELLEY. I don't know whether the committee was aware of the fact, but I am a commander on active duty in the U.S. Navy and an electronics specialist in the Navy as well as my job in NASA; so I hope I would know what is at the existing facilities.

Mr. MORRIS. You certainly have proven yourself capable and able, Doctor, and I want you to understand, and I'm sure you do because of the responsible position that you hold, that we are not trying to embarrass anyone.

We are trying to develop what existing facilities are available and what they do in order that we might, we hope, make an intelligent decision.

So far as I am personally concerned, Dr. Kelley, I have read very carefully, the report that you made on a recent panel that you conducted and I don't think that anyone could read this report and not have a great deal of admiration for the chairman of the panel and for all the members on the panel as well.

In the first place, it sometimes takes courage to write reports, and in the second place, it takes a lot of ability to find out the information that this panel apparently found out.

So, if we have left the impression that we are trying to be facetious, we certainly did not intend to.

Dr. KELLEY. I understood that. Thank you, sir.

Mr. MORRIS. It is possible that some of us are provincial at times, particularly when it gets close to parts of the country that are very dear to our hearts.

I have to admit that when we start thinking about New Mexico, I have some reservations as to whether I can be as unbiased as I can regarding some other places in the country.

Do you know of the installation at Fort Huachuca, Ariz.?

Dr. KELLEY. Yes, sir.

Mr. MORRIS. It is an Army installation?

Dr. KELLEY. Yes, sir.

Mr. MORRIS. You know of the existence of the White Sands Missile Range in New Mexico?

Dr. KELLEY. Yes, sir. In fact, NASA uses this quite a bit, as I am sure you are aware.

Mr. MORRIS. You also know of the electronic work they do there?

Dr. KELLEY. Yes, sir.

Mr. MORRIS. And also of the work that's being done at Fort Huachuca, Ariz.?

Dr. KELLEY. Yes, sir.

Mr. MORRIS. Under the sponsorship of the Army.

I'm sure you know that there are some other Army installations where Army research has been carried on in electronics?

Dr. KELLEY. Yes, sir.

Mr. MORRIS. Now, I'm not going to go down the list and ask you specifically on these.

I am going to ask unanimous consent, and the indulgence of the committee, that we place in the record, a list of installations of the Army, Navy, and the Air Force, that we have gotten information on, that do work in electronic research.

Mr. Chairman, I ask unanimous consent for this.
Mr. KARTH. I'm sure there would be no objection.
Hearing no objections. It is so ordered.
(The information requested for the record is as follows:)

U.S. ARMY ELECTRONICS RESEARCH AND DEVELOPMENT LABORATORY,
FORT MONMOUTH, N.J.

Plant facilities: The facilities of the physical plant provide more than 860,000 square feet of usable floorspace: hexagon area 429,619 square feet; Evans area, 348,021 square feet; test area, 29,761 square feet; supply area, 55,627 square feet. The hexagon and Evans areas consist of laboratory and office space supplemented by shop and supply service space. The hexagon construction permits 60- and 400-cycle electrical power, telephone, water, compressed air, gas, and other utilities to be placed in any 2-foot square anywhere in the building. The shops are equipped and staffed to perform any type of internal work required by the scientists and engineers.

Number of employees: 3,504.

Cost of current year in-house program, $28,800,000.

Description of special research facilities: In the test area are extensive high-temperature, humidity, and cold test facilities. A new humidity test chamber is under construction in the hexagon area; a new cold test facility will be added. When completed these facilities will meet all anticipated requirements for testing Army equipment.

A new, large-size White noise generator and an ionosphere chamber have just been installed in the Evans area where standard shock and vibration test equipment is also located.

A recently completed standards laboratory contains the latest calibration and test equipments, all of which have been coordinated with and approved by the National Bureau of Standards.

The Astro-Observation Center space receiving station at the Deal site is the most modern of its kind in this country. It is in operation 24 hours per day and has the largest known library of signals from outer space. This station has exceptional capabilities in respect to precision frequency measurements which are of critical importance in connection with the study and interpretation of radio propagation characteristics of the Earth's upper atmosphere.

Areas of major research effort:

1. Power sources research and development.
2. Basic research in physical sciences.
3. Basic research in earth sciences.
4. Electromagnetic phenomena applied research.
5. Electronic parts, research and development.
6. Electronics material, research and development.
7. Frequency control devices.
8. Thermionics devices, research and development.
9. Solid-state devices, research and development.
10. ADPS techniques applied research.
11. Meteorological investigations.
12. Communication techniques, research.
13. Radiofrequency compatibility research.
14. Target detectors techniques.
15. Supporting development for combat surveillance.
16. Command control center.
17. Intercontinental strategic communications.
18. Communications security equipments and techniques.
19. Tactical ADPS equipment.
20. Aerial combat surveillance equipment and systems.
21. Laser research.
22. Unmanned aerial surveillance systems.
23. Ground-based combat surveillance equipment and systems.
24. Nuclear surveillance devices.
25. Image interpretation and photographic equipments and systems.
26. Electronic warfare equipment and techniques.
27. Flight aids and instruments.
28. Navigation and air traffic regulation equipments.

U.S. ARMY ELECTRONICS RESEARCH AND DEVELOPMENT ACTIVITY, FORT HUACHUCA, ARIZ.

Plant facilities: This activity has the following facilities available:

1. Automatic data processing center; IBM 709 is a major item of equipment.
2. Standards and calibration laboratory.
3. Airborne television sensors laboratory.
4. Airborne photographic sensors laboratory.
5. Antennas test and evaluation tower.
6. Signal source suspension and control system.
7. Artillery bunkers; provide protection of personnel during experiments with EW jammers against actual and direct VT fuze fire.
8. Ground radar engineering laboratory.
9. Airborne radar engineering laboratory.
10. Drone engineering laboratory.
11. Antenna pattern measurement range.
12. Radar geometric fidelity facility.
13. Infrared laboratory.
14. Radiological sensors laboratory.

Number of employees: 644.

Cost of current year in-house program: $3,100,000.

Description of special research facilities:

1. Automatic data processing systems engineering facility includes mobile laboratory vans for data transmission capability tests.
2. Meteorological standards and calibration laboratory is equipped with test chambers and measurement standards for the calibration of temperature, pressure, humidity, and solar radiation sensors.
3. Meteoroligical research wind tunnel is located at Colorado State University and is especially designed for micrometeorological research. It has a test section which is 6 feet square in cross section and 80 feet long. Temperature, humidity, and wind speed are controllable and the temperature and roughness of the boundary surface can be adjusted for controlled experimentation with the boundary layer.
4. Computers for use in meteorological research including the following:
   (*a*) One Bendix G–15 digital computer.
   (*b*) One Pace 31–R analog computer with a special soil analog designed for use in simulating atmospheric energy balance at the Earth's surface.
5. Meteorological instrument test facility includes telemetering lines to an instrument recorder facility.
6. Electronics laboratory includes a microwave anechoic chamber. This chamber is 17 feet long by 15 feet wide by 11 feet high and is rated at 40 decibels absorption in all directions over a frequency range of 500 mc/s to 50 kmc/s.
7. Airborne sensor laboratory.
8. Nuclear laboratory and radiation calibration laboratory.

Areas of major research effort: Major in-house effort being accomplished includes:

1. The design, development, and engineering design test of automatic data processing systems.
2. Coordination of out-house basic research program in micrometeorology and integration of the research output into the development of mathematical models describing special conditions of the atmospheric boundary layers.
3. Provision of meteorological services to R.D. & T.E. test activities at 12 locations ranging from Alaska and Greenland to Panama and including 9 locations in the contiguous United States.
4. Special studies of the feasibility small-scale forecast techniques for use in the Army integrated meteorological system.
5. Research on weather forecast techniques based on atmosphere momentum principles.
6. Study of gamma ray intensity distributions in the vicinity of radioactive fallout fields.
7. Study of narrow-band techniques for frequency conversion to a new modulation system.

U.S. Army Security Agency

Test and evaluation facility, Fort Huachuca, Ariz.: The U.S. Army Security Agency's R.D.T. & E. facility at Fort Huachuca consists of three buildings providing a total of 17,710 square feet of floor space and two permanently assigned field test areas. Two of the buildings are modified barracks-type buildings which provide the administrative area and space for bench testing and area for storage of supplies and maintenance parts. The third building, used as a maintenance area and for storage of testing equipment, is a temporary building of approximately 1,800 square feet.

Number of employees: 79.

Cost of fiscal year 1963 in-house program: $450,000.

Computer facility: This facility will be used for testing computer techniques. It will be in operation as of March 25, 1963, at the following locations:

Vint Hill Farms Station, Warrenton, Va., 1,000 square feet.

Headquarters, U.S. Army Security Agency, Arlington, Va., 1,000 square feet.

Number of employees: 30.

Programed funding: $1,200,000 per annum.

Geodesy, Intelligence, and Mapping Research and Development Agency, Fort Belvoir, Va.

Facilities: The following facilities and equipment of the Geodesy, Intelligence, and Mapping Research and Development Agency are used for electronic research and development:

Continuous wave laser and auxiliary equipment, time and frequency standards; precise means for determining impedance, phase, frequency wavelengths, transistor and electron tube parameters; signal generators, zero to 10,000 megacycles, and receivers, 400 to 10,000 megacycles, oscilloscopes, various power supplies, and ohmmeters.

Number of employees: 9.

Cost of fiscal year 1963 in-house program: $60,000.

Scope of in-house effort:

1. Study application of lasers to mapping and geodesy, laser beam characteristics, modulation techniques, demodulation, noise problems, amplifiers, receivers, photo mixing, and optical heterodyning and laser transponder.

2. Study application of certain phenomena as Doppler effect, Zeeman effect, and Farady effect to geodesy. Interferometer studies connected with electronic angle measurement. R. & D. in connection with automatic mapping systems, design, building, and testing electronic circuits. Building vidicon scan system to test feasibility of electronically viewing a special type of photography. Transistor and vacuum tube amplifiers, logic circuits, counters, flying spot scanners, and photo multipliers are used in studies.

U.S. Army Electronics Research and Development Activity, White Sands Missile Range, N. Mex.

Plant facilities: Laboratory and engineering space, 54,511 square feet; shop, administrative, and assembly space, 22,503 square feet; storage space, 23,564 square feet.

Number of employees: 822.

Cost of current year in-house program: $9,100,000.

Description of special research facilities:

1. Satellite communications ground facility consists of a satellite communication ground station with UHF transmitter feeding a 28-foot parabolic antenna, a dual parametric receiver system, a 100-watt VHF, frequency modulation, transmitter, and a VHF dual diversity receiver system for satellite acquisition.

2. Micromodule laboratory is a complete micromodule design kit for designing, constructing, and encapsulating micromodule.

3. Radar laboratory facility (XN-3). This facility has been designed as a research and development tool for the instrumentation department. This facility includes a 3-megawatt AN/FPS-16-type radar, 2 analog computers with a total of 96 direct current amplifiers, 2 X-7 plotting boards, and various types of test equipment.

4. Electromagnetic environmental research facility. Used where free space conditions, or conditions having a controlled degree of ground or other

reflection, are needed for research in missile instrumentation, radio propagation, and related areas. Dynamic conditions are simulated using small missiles to carry test packages past associated equipment suspended above nonreflecting ground surfaces.

5. Electronic imaging research laboratory has the capability for research leading to the development of new and improved techniques and imaging equipment in the infrared, visible, and ultraviolet spectral region, primarily as applies to the military environment instrumentation and measurements mission.

6. Laser research laboratory. The electrochemical laboratory is capable of conducting research and development pertaining to the formulating of transformations and separations of successive operations required to prepare organic and inorganic electrophosphorescent materials for analysis and evaluation of efficiencies and spectral response measurements required for high-power continuous or pulsed radiant energy emission systems.

7. Instrumented meteorological towers:

(*a*) Tower I is a 225-foot triangular steel tower which is designed so that it can be extended to 400 feet. Ten booms supporting the instrumentation extend 9 feet out from the tower and are located at 6, 12, 22, 42, 62, 82, 102, 122, 162, and 202 feet above ground.

(*b*) Tower II is a 142-foot lightweight portable tower.

(*c*) Tower III is a 500-foot tower which has been designed for instrumentation at eight levels with Beckman & Whittey wind sensors.

8. Meteorological rocket facilities are available for preparing, launching, tracking, and collecting data from rockets such as Nike-Cajun, Nike-Apache, Asp, Arcas, Loki, Judi, Boosted Arcas, Metroc, and Hopi.

9. Meteorological instrumentation calibration facilities:

(*a*) A precision wind tunnel, with speed capability of 1 to 75 miles per hour, is available for calibration of wind instrumentation. The test section measures 4 feet in each dimension.

(*b*) Laboratory facilities are available for calibration of temperature, pressure, and humidity sensors.

10. Atmospheric propagation facilities are available for a determination of attenuation, absorption, and scattering of electromagnetic energy due to atmospheric constituents and contaminants under controlled conditions.

Area of major research effort:

1. Range instrumentation, research and development in the following areas:

(*a*) Radar instrumentation.
(*b*) Beacon development.
(*c*) Missile range contact and instrumentation communications.
(*d*) Telemetry systems.

2. Environmental sciences including:

(*a*) Atmospheric effects on missile activities.
(*b*) Operation of meteorological rocket network.
(*c*) Techniques for meteorological team services.
(*d*) Techniques for meteorological rocket network.

3. Missile electronic warfare covering investigations and studies covering long-range infrared detection, ionosphere radar research, and research for low-temperature application to IR detectors.

U.S. Army Electronic Proving Ground, Fort Huachuca, Ariz.

Facilities:

1. Automatic Data Processing Center consisting of IBM 709 computer and IBM 1401 computer.
2. Data reduction center.
3. Electronic EAM center.
4. Meteorological standards and calibration laboratory.
5. Airborne television sensors laboratory.
6. Airborne photographic sensors laboratory.
7. Antennae test and evaluation tower.
8. Signal source suspension and control system.
9. Two artillery bunkers utilized in test and evaluation of electronic experiments against actual and direct VT fuzes.
10. Heat range—east and west range.
11. Ground radar engineering laboratory.
12. Airborne radar engineering laboratory.

13. Drone engineering laboratory.
14. Radio frequency maintaining station.
15. Computers test facility.
16. Antenna pattern measurement range.
17. Radar geometric fidelity facility.
18. Decca navigation station.
19. Survey systems test facility (a terminal at Yuma and Fort Huachuca).
20. Telemetry facilities.
21. Radiofrequency facility.
22. Electromagnetic environmental test facility.
23. Spectra facility (425 electronic generators).
24. Infrared laboratory.
25. Radiological sensors laboratory.
26. Video raking and displaying facility (mobile).
27. Extensive technical libraries.
28. Pictorial-graphics facility.
29. Radar spoke.
30. Radar target indicating track.
31. Spatial resolution facility.
32. Ultrahigh computers station.
33. Avionics library.
34. R4D or C47 air plate laboratory.
35. Technical target complex.

Number of employees: 9,985.
Cost of current year program: $26,107,000.[1]

NAVY IN-HOUSE ELECTRONICS RESEARCH AND DEVELOPMENT FACILITIES

Naval Research Laboratory, Washington, D.C.—Conducts research and development in physical and related sciences toward new and improved materials, equipment, techniques, and systems. Effort is grouped into three major fields: electronics, materials, and nucleonics. Approximately 3,500 employees of which 1,200 are professional. Total funds, $68.4 million. About 50 percent of the total effort is devoted to electronics research and development.

Navy Electronics Laboratory, San Diego, Calif.—Conducts research, development, and tests in electronics and related fields of engineering and science, including radio, radar, sonar, and oceanography. Approximately 1,300 employees of which 750 are professional. Total funds, $26.6 million. About 90 percent of the total effort is devoted to electronics.

Material Laboratory, New York Naval Shipyard, Brooklyn.—Conducts research, development, analytical testing, evaluation, and standardization on various materials and equipme .t. Approximately 877 employees of which 393 are professional. Funds $15 million. About 25 percent of the total effort is devoted to research and development of electronic components.

Navy Underwater Sound Laboratory, New London, Conn.—Conducts research, development, system studies, and engineering evaluation in the fields of sonar, radio, radar, infrared, and related physical sciences. Approximately 778 employees of which 383 are professional. Funds, $14 million. About 50 percent of the total effort is in electronics.

Naval Air Development Center, Johnsville, Pa.—Conducts research, development, test, and evaluation of aircraft systems and equipment. Approximately 2,200 employees of which 565 are professional. Total funds, $28.8 million. About 40 percent of the total effort is in electronics.

Naval Ordnance Laboratory, White Oak, Md.—Conducts research, development, test, and evaluation of ordnance systems, components, and materials especially for missiles and underwater ordnance. Approximately 3,130 employees of which 1,090 are professional. Total funds, $47.1 million. About 25 percent of the total effort is in electronics.

Naval Ordnance Laboratory, Corona, Calif.—Conducts research, development, test, and evaluation of ordnance systems, components and materials especially for guided missiles and related electronics. Approximately 1,100 employees of which 462 are professional. Total funds, $24.4 million. About 75 percent of the total effort is in electronics.

[1] Includes contract to operate and maintain electromagnetic environmental and test facility, survey systems test facility, and common test facility.

Naval Ordnance Test Station, China Lake, Calif.—Conducts research, development, test, evaluation, and limited production of ordnance materials, components, and systems in the field of rockets, guided missiles, underwater ordnance, and aircraft fire control. Approximately 6,000 employees of which 1,230 are professional. Funds, $84.1 million. About 40 percent of the total effort is in electronics.

Applied Physics Laboratory, Johns Hopkins University, Silver Spring, Md.—This laboratory operated by Johns Hopkins University, has land mostly contractor owned and facilities mostly Government owned. It does research and development on surface-launched missiles and systems. Approximately 2,300 employees. Total funds, $41.5 million. About 75 percent of the total effort is in electronics.

AIR FORCE ACTIVITY AT L. G. HANSCOM FIELD, BEDFORD, MASS.

1. The principal activity at Hanscom is the Electronic Systems Division which is responsible for the acquisition of individual command and control systems for major commands having a need for such systems. At present there are 14 major command and control systems under development which involve detection, warning, data processing, display, communications, and weather systems.

2. The annual budget for ESD is slightly less than $1 billion. Of this, about 60 percent is expended for research, development, test, and evaluation of equipment for command and control L systems. It is expected that the ESD budget authorization over the next 5 years will undergo moderate growth, approximately 4- to 5-percent increase each year.

3. Also at Hanscom Field are the Air Force Cambridge Research Laboratories, a part of the Office of Aerospace Research, which, in addition to its independent research activity, devotes a portion of its mission to support of ESD by providing basic and applied research for command and control systems. Lincoln Laboratory, a MIT facility of specialized scientific competency, conducts basic research for command and control systems. Technical support is provided ESD by the Mitre Corp., a nonprofit organization. Its annual expenditures are on the order of $30 million. A facility of the Systems Development Corporation provides support to ESD in system design of computer programs. SDC is funded at an annual level of approximately $18 million.

4. The total work force of the Hanscom complex is in excess of 10,000 persons. Existing facilities were acquired for $68 million and approximately $5.5 million will be added during fiscal year 1964. The total annual payroll of the Hanscom complex approximates $71 million. In addition to the systems procurement already described, Hanscom Field local procurement amounts to approximately $15 million per year.

ESD PROJECTS—COMMAND AND CONTROL SYSTEMS

Command and control systems, often referred to as L systems because of their numerical and letter designations, are those major electronic systems used for collecting, transmitting, processing, and displaying information for command decisions and for control of forces, weapons, and aerospace vehicles.

412L—Air weapons control system: An oversea theater tactical air weapons control and warning system.

416L—SAGE air defense system: A semiautomatic area air weapons control and warning system including the backup interceptor control (BUIC) for detecting, identifying, tracking, and providing interceptor weapon direction against air-breathing threats to the United States and Canada.

425L—Norad Combat Operations Center: A system, hardened for sustained operations in the face of a nuclear attack, which collects, processes, and displays data to assist the commander in chief, North American Air Defense Command, in commanding and controlling his forces.

431L—Traffic control and landing system: A program for updating of the traffic control and landing systems at U.S. Air Force bases throughout the world.

433L—Weather observation and forecasting system: A global, semiautomatic electronic system for modernization of the Air Force Air Weather Service to provide high quality and timely weather observations, information, studies, advice and forecasts in support of military operations and command and control systems.

438L—Aerospace intelligence data system: A system for high-speed processing of worldwide intelligence data.

465L—Strategic Air Command control system: A system which collects, processes, and displays data to assist the commander in chief, Strategic Air Command, in commanding and controlling his forces.

466L—Electromagnetic intelligence system: A worldwide system for collecting intelligence by electromagnetic means and processing and transmitting it to users by high-speed electronic equipment and techniques.

473L—Headquarters, USAF, command and control system: A data processing and display system to assist Headquarters, USAF, in making command decisions.

474L—Ballistic missile early warning system: A system to provide early warning of a mass ballistic missile attack on the North American Continent from the north.

477L—Nuclear detection and reporting system: A system to provide the North American Air Defense Command and other military and civilian agencies with essential information on nuclear detonations occurring within the area of responsibility of the North American Air Defense Command.

480L—USAF aerospace communications complex: A program of support for the Air Force segment of the long-haul defense communications system and for the USAF ground/aerospace communications.

481L—Postattack command and control system: A system to enable the commander in chief, Strategic Air Command, to control his forces in the event that a nuclear attack destroys or seriously degrades his normal facilities.

482L—Emergency mission support system: A system which will provide air transportable air traffic control, communications, and navigational aid facilities in support of air operations where existing facilities are not available.

496L—Space track: A system for detecting, tracking, identifying, and cataloging orbiting objects.

Mr. MORRIS. Now, Doctor, yesterday, as I recalled, you made a statement and I thought it was a very fine statement.

Your position is a very responsible one in NASA and this is to get the best, the very best in electronics research and development in NASA, that's possible.

I believe that your statement was that the best way for you to do your job would be to have the electronics research at this propos d electronic center.

Dr. KELLEY. Yes, sir.

Mr. MORRIS. I am not telling you what you said. You know what you said better than I, but this is what I recall of what you said, and I think it is a fair statement, and I think that it's true.

It probably might be better for your position and for your agency, but there's another important thing; perhaps you think about this installation as I think about New Mexico.

What about the overall resources of the country?

What about the research in electronics, the contribution it would make to the overall effort of the country?

Now, do you think for the overall effort and advancement of the technology of our country, that it would be best to concentrate electronics research in one place?

Dr. KELLEY. I sincerely do, Mr. Morris.

If you mean for the overall benefit of the country, that part of this involves what is for the benefit of the space program and our national posture in space for the long-range future; I sincerely believe this is the best way to implement this particular technical requirement; yes, sir, the most efficient.

Mr. MORRIS. To have it concentrated in one place?

Dr. KELLEY. The most efficient in managing the required in-house and out-of-house growth that we have to have in this field.

Mr. MORRIS. Now, as I understand electronics research, it's the heart of a technical development in missile space and guidance and all the tremendous complex systems that we have?

Mr. KARTH. Could I interrupt the gentleman for just a minute? Chairman Miller has just entered the room.

Mr. Chairman, we welcome you to the subcommittee, sir.

Please be seated here with us.

Mr. MORRIS. If I understand it, electronic research is really the heart of the development of our space program, both military and peaceful use. Is that not correct?

Dr. KELLEY. I would not want to deprecate my professional colleagues in other technical fields.

Mr. MORRIS. If the question is in any way embarrassing, you certainly need not answer at all.

Dr. KELLEY. It's not embarrassing, Mr. Morris.

We think it is extremely important as an area and I think the dollar percentage we showed in our various flight projects indicates how important it is to us and also the reliability figures that I mentioned show the problems we face in this particular technical field.

I would prefer to call it the "brain, nerves, and senses" of the space vehicles and we consider it a very, very important part of the space technology.

Mr. MORRIS. I don't want to say it would be impossible.

It would be extremely difficult to carry on a program in space either for the military or for NASA, without any electronics?

Dr. KELLEY. It would be impossible.

Mr. MORRIS. Without the brains in the electronics industry?

Dr. KELLEY. Well, furthering the analogy to the human body; without a brain, nerves, and senses, we probably could survive but I don't think we would be much use. So, it is the information systems that we are talking about.

I think these are obviously quite important.

Mr. MORRIS. Well, you know whether or not NASA took into consideration the effect on our national security or our ability to advance the technology in space and also in any other technology that involves electronics; what would happen if we concentrated the electronics research in one area and the terrible catastrophe of nuclear war should happen and a near miss or a close explosion of, say, a 10-megaton warhead or an even larger one, which at least one other country has the ability to deliver by ballistic missiles, would do to us?

Dr. KELLEY. You mean the concentration of resources in one area which might be vulnerable to atomic attack?

Mr. MORRIS. I am speaking now about the electronics research. The decision has apparently been made to concentrate this research in one place, so far as your agency is concerned.

Dr. KELLEY. I do not know if that was taken into consideration, Mr. Morris, and I did not intend to give the impression yesterday. I hope I made it clear, we do not consider this the only area of electronics research competence in the United States. We consider it the best for our purposes.

Mr. MORRIS. You indicated very clearly. At least, I understood the record; Boston, the Midwest, and California—that there were

three places where you felt would make first-class areas for this installation.

I understood that.

Mr. Chairman, I don't have any more questions at the present time.

I commend you, Dr. Kelley, for your competence and your ability. They have certainly sent the "first team" in to handle this project.

Mr. KARTH. Mr. Chairman, are there any questions that you might have in mind which you'd like to ask at this time?

If so, we would be happy to hear them.

Chairman MILLER. Yes, I'd like to ask a few questions.

First of all, in the field of scientific electronic research, capabilities are not all centered at present in any one State or locality are they?

Dr. KELLEY. That is a true statement.

They are not located in any one State altogether.

Chairman MILLER. In other words, they are scattered, presently, among many universities, many industrial plants, that are widespread throughout the United States.

Are these in redundance? Are there too many of these to do the electronic research job that is required in the United States?

I am not talking of space now, but in all of its industrial activities and in breaking barriers in this new age of ours: Do you think there are too many of these electronic capabilities in the United States today?

Dr. KELLEY. You mean, are there too many companies in the business?

Chairman MILLER. Too many companies—too many universities—too many research institutes in this business today?

Dr. KELLEY. I believe this is a situation that kind of adjusts itself by supply and demand and I would rather say: look at the capability.

I think you find with the transient fluxing as we said the other day where you have a movement of people throughout companies, that you have to, when you are evaluating a company, look very carefully at the individuals who are doing the work because they might not be the same this year as they were last year. People move around in the business.

So, I think this being a free enterprise system, the situation tends to be self-adjusting.

Chairman MILLER. Well, I have in mind a computer center in California around a Stanford complex that I have been told—I wouldn't know one computer from another if it were brought in the door—that the strain on this center is very great. They do work for private industry. They do work for others, and they just haven't the capacity, they have to schedule their computers pretty carefully and run them overtime in order to meet the demands.

Do you know whether that's true, not only there but throughout the country; as far as the availability of electronic computers for research work is concerned?

Dr. KELLEY. I am not aware of the particular computer complex you are talking about, Mr. Miller, but I am aware of a general situation in the electronic business and the electronic industry and that is there is by no means an oversurplus of qualified personnel in this area and I think this is well recognized by various Government reports.

The Wiesner report being one of them. The NASA grant program being another recognition of the fact we do have to train more people, more engineers particularly, in the electronic and associated physics areas.

Chairman MILLER. This is a field that has a great potential, as I see it.

I think the demands are going to be more in the future than in the past.

Dr. KELLEY. I certainly agree with you, it has a great potential and I think the demands are going to be more stringent than we have imagined in the past or even up to now. I think the discussion I had with this subcommittee and some slides I presented indicated the fact that the situation is going to get a lot worse before it gets better, and this is, in fact, one of the reasons we have made this recognition and taken this step of recommending an Electronic Research Center because now after some experience in the space flight business we realize, fully, the problems of the space electronic environment and the demands that these put on the equipment. I must say they are much much more severe than we had even anticipated a few years ago.

Chairman MILLER. Mr. Chairman, I don't want to take up any more time going over work you have gone over, merely to satisfy my own curiosity. I will read the record. If I need more information, I know where to go get it.

Mr. KARTH. Thank you, Mr. Chairman.

Mr. Downing?

Mr. DOWNING. Dr. Kelley, aren't you an old Langley boy?

Dr. KELLEY. No, sir; I'm not.

Mr. DOWNING. You know, sir, we train them all in Hampton, Va., and send them up here to occupy these essential positions. Half the people here came from Langley.

Dr. KELLEY. I think there are a few distinguished Langley alumni throughout the organization, Mr. Downing.

Mr. DOWNING. I just want Mr. Miller to know that.

Chairman MILLER. He is very proud of the fact, and I am very proud of it with him.

I think if you scratched all these people and found out where they came from, I think you'd find along with Langley there were many parts of the country, many educational institutions, that go into making the great capacity we have in the United States, that is our greatest resource.

Mr. DOWNING. I agree with you, Mr. Chairman.

Dr. Kelley, I don't know how far this has been gone into, but this proposed Center in Massachusetts, is that a finalized decision, to place this Electronic Research Center in Boston?

Dr. KELLEY. It's a finalized recommendation to the Congress and so requesting their approval. It is our conclusion that this is the best way to proceed and to manage our future growth requirements and we so made a recommendation to Congress.

Mr. DOWNING. Yesterday, I asked you if it would drain away some of the research professors in the universities, and I believe your answer was no, and then subsequently you changed your mind and said that this would probably take some of the people that we have there at the universities around the country and place them in the Center.

Dr. KELLEY. I think there was an answer to two separate questions, Mr. Downing.

I would think that there would be some university people who would prefer to become associated with such a Center; not probably

a great number, but we would hope there would be some distinguished people from the universities.

Mr. DOWNING. You don't think this would drain our universities of their talent?

Dr. KELLEY. I don't think it would, any more than the rest of the NASA has. There are university people who already have come into the space agency. I wouldn't say in exceptionally large numbers, but I think this makes a good crossbreeding of the talent if we can get a few people like that.

Now, as far as the answer to the other question this was, I think, in reference to "home growing" some of our own graduate talent and in this specific instance I was referring to attracting people fresh out of universities, fresh graduates, and then giving them a chance to continue their graduate education in a university environment together with getting some of the facts of life in a real life laboratory which makes education more stimulating.

As you know, with particular reference to Langley; that has been the history of the NACA, where I think most of the distinguished Langley alumni came to NACA right out of college and continued their college education while working with the Government.

Mr. DOWNING. That was true with the old NACA.

Chairman MILLER. This is where the Department of Defense gets some of its people, particularly in the Air Force. All of the services bring young people in, particularly young officers, then send them to college to perfect their education, bringing them back into the service later. Isn't this their source of supply?

Dr. KELLEY. This is their source of supply.

In fact, I am an example of that particular system.

All my graduate education up through the doctorate degree as well as undergraduate education at the Naval Academy has been sponsored by the Government.

Chairman MILLER. This is what NASA is trying to do?

Dr. KELLEY. This is what NASA is trying to do in its own way.

Mr. DOWNING. Is this a budget item in fiscal year 1964, the research center?

Dr. KELLEY. In the research center category, we are requesting a total of $5 million under the C. of F. classification, $3 million of which is for land acquisition, and $2 million for design and engineering services.

Mr. KARTH. For what?

Dr. KELLEY. Design and engineering purposes.

Mr. DOWNING. How about construction?

Dr. KELLEY. We are not asking any facilities construction this year.

We would expect this to follow in fiscal year 1965.

Mr. DOWNING. $3 million for land acquisition.

How much land do you propose to acquire?

Dr. KELLEY. The proposal in the buget is for 1,000 acres. Now, this is approximately 1,000 acres.

Mr. KARTH. Would the gentleman yield at that point?

Mr. DOWNING. Yes, indeed, Mr. Chairman.

Mr. KARTH. There has been some change made on that, hasn't there, Doctor?

First, I understood they had in mind building a one-story type laboratory in the outskirts of Boston and then later on, and most recently, changing their minds to a high-rise type laboratory that is smaller in area but several stories.

I don't know whether or not there have been any ideas cemented in concrete, but which type of structure lends itself best for laboratory work?

Dr. KELLEY. We are looking at both alternatives and I have a press release in front of me, together with copies of letters that were sent to Chairman Miller, as well as Senator Anderson, concerning our intentions on this particular item.

Mr. KARTH. Have they been changed since the date of the press release?

Dr. KELLEY. They have not, sir.

Mr. KARTH. I'm sure that I haven't seen the press release. Did the press release indicate that you were going to build a several-story building or a large sprawled out one-story building?

Dr. KELLEY. This is one of the alternative concepts that we are considering. Our intention, when we submitted this item in the budget was to acquire a thousand acres of land. Since that time—and we have continued our study and review of this whole center concept—since that time we have decided also to look at an alternative concept which would involve a closer in site which would in turn go to higher rise.

Now, this is only an alternative consideration.

Mr. KARTH. Doctor, have you decided to look at some Government-owned land in the Boston area?

If you are looking around, it seems to me we might even save $3 million.

I understand there is a good deal of Government-owned land that General Services Administration would readily turn over to NASA.

Dr. KELLEY. I am sure that before our site selection procedure should be concluded, that we will consider the various Government sites and I can assure you we know what they are.

Mr. KARTH. Isn't it rather odd we wouldn't look at that first inasmuch as it wouldn't cost us any money?

Dr. KELLEY. We have taken them into preliminary consideration in asking for the budget figure we are asking for.

Mr. DOWNING. That is the question that naturally follows, Mr. Chairman, whether NASA has taken into consideration presently owned Government sites.

Mr. MOSHER. Would Mr. Downing yield?

Mr. DOWNING. Yes, indeed.

Mr. MOSHER. One question. I understood Doctor Kelley to say yesterday, Langley was seriously considered as a location for this center and rejected.

Is there land already available to the Government, sufficient land at Langley which would not have to be purchased?

Dr. KELLEY. Well, our decision in regard to Langley was based on several considerations, including the availability of land.

Mr. MOSHER. I understand.

Dr. KELLEY. One of the most important ones, as I mentioned yesterday, Mr. Mosher, was the fact that this would result in an increase in the laboratory of approximately 2,000 people which would

result in a research laboratory size which we considered inefficient from a management standpoint, from a management of research standpoint and would, as a result, cause the primary capabilities and responsibilities of Langley to be diluted. These have not been primarily electronics in the past.

Now, in looking at the Langley site, and I think we are all aware of the fact there is an Air Force base on the site with heavy electromagnetic radiation environment, and other factors; we came to the conclusion we'd have to go offsite.

Mr. MORRIS. The land might be available there but it wasn't suitable for these reasons you just mentioned.

Dr. KELLEY. The availability of land was one of our considerations, but there were several that enter into a consideration like this.

Mr. MOSHER. I knew Mr. Downing might be timid about asking this question.

Mr. DOWNING. Thank you very much. My colleague is sympathetic, and I appreciate it.

I did want to bring up why you didn't go to Langley, to be perfectly blunt about it.

Mr. KARTH. I might say, it's the first sign of timidity I have observed.

Dr. KELLEY. I might add something on this, Mr. Downing. In discussion of our capabilities yesterday throughout the agency, I pointed out there is an extensive flight test and supporting activity going on at Langley in the electronics field which is ideally located at Langley because of its association with the wind tunnels. We are doing some reentry blackout tests there together with the Wallop Station on the coast, where we can test these.

There will continue to be some electronics concentration at Langley.

Mr. DOWNING. You know the State of Virginia has been cooperative. They even started an educational complex in keeping with what Mr. Webb has stated and I think Mr. Webb has done a tremendous job.

We have all gotten education minded in this space field and we have a compact of universities there now, which, along with the State, NASA are cooperating to try to fulfill Mr. Webb's conditions.

I realize that in this space effort we are going to spend $20, $30, $40 billion and you should spread it through the country to stabilize the economy throughout the country and promote it; but I do think you ought to give careful consideration to the utilization of sites that you already have and facilities that you already have, regardless of whether it is Langley or California or wherever it may be.

Chairman MILLER. Mr. Chairman.

Mr. KARTH. Mr. Chairman.

Chairman MILLER. Would my good friend yield?

I am very glad that he made that last remark because I would like to point out Moffatt Field at which Ames Laboratory of NASA is located has practically been decommissioned. They keep one little squadron there and keep it in. Of course, I could offer this in California; but I'm very modest and I wouldn't want to be accused of being part of the State chamber of commerce.

Mr. KARTH. Mr. Chairman, don't feel too badly about it. I suppose I could overcome my timidity and mention the Minneapolis-St. Paul-Chicago, Midwest area.

Mr. DOWNING. That is my point.

Mr. KARTH. I certainly wouldn't want to do that.

For that reason I thought it would be necessary we confine our investigation as to whether we really need the Electronics Center first, and then, if we decide we need it, we can take a look at geography. If we don't need it, we save all this time on geographic speculation.

Chairman MILLER. I was going to say, I know there are some places in Ohio, and if I'm not mistaken, Indiana has a couple of vacant places that might be available.

We have to cover the waterfront in this.

Mr. RANDALL. Missouri, too.

Mr. KARTH. Don't forget Missouri and New Mexico.

Mr. MORRIS. Would the gentleman yield?

Chairman MILLER. I was going to say New Mexico. I was taking care of the West for Tom, see.

Mr. MORRIS. Mr. Chairman, this is why I felt rather reluctant about mentioning Fort Huachuca and White Sands, N. Mex. I felt very timid about doing it, but I felt it was my duty, sworn duty, to mention those facilities not getting into any quibble as to where it should be placed.

Mr. DOWNING. I don't want to get too far away from Langley, because that's where space was born and bred right there in Langley. We had all the astronauts down there. They were trained, and then they moved the whole project to Houston, Tex. But I haven't said too much about that.

Getting back to the meat of the situation; how much do you estimate the overall project in Boston to cost?

That is the building, acquisition of land, equipment that goes in, and so forth?

Dr. KELLEY. We estimate approximately $50 million plant value in facilities in addition to the $5 million we are asking this year.

Mr. DOWNING. You will have approximately 2,000 people there, and what do you expect that payroll to be?

Dr. KELLEY. I believe I gave the figure the other day.

Mr. DOWNING. You gave the figure, I believe, $28 million.

Dr. KELLEY. The $28 million, I should correct the record, includes both personnel salaries and operations of installations, and I believe—in fact, I could get the numbers for you right now, if you would like them for the record, on what the actual payroll would be.

Mr. KARTH. Doctor Kelley, would you please do that?

Dr. KELLEY. Yes, sir.

Chairman MILLER. This I would just like to say off the record.

(Off the record.)

Mr. KARTH. Mr. Chairman, could we get back on the record?

Chairman MILLER. Yes.

Mr. KARTH. Mr. Downing, you have the floor.

Mr. DOWNING. What will be the overall operating expense of the research center?

Dr. KELLEY. We estimate when we have 2,000 people aboard which would be 1968, 1969; and based on 1963 dollars and pay scales, that personnel costs would be approximately $19 million.

Mr. KARTH. Would the gentleman yield at that point?

Mr. DOWNING. Yes.

Mr. KARTH. I think your figures are awfully conservative, Doctor, although you are the one who made the estimates. I would just like

to call to your attention that experience is probably a better teacher, certainly better than conjecture, I think, though I'm sure you spent some time on the figures you developed.

I notice that in some of the Government laboratories that we now have where laboratories are involved in electronic research work, the annual cost of operation comes exceedingly high.

I don't mean this is an argument against the center, but I do think we should keep our figures as accurate as we can.

For example; Rome Air Development Center, there are some 1,600 people there. The cost of operation last year, research only, was $54 million.

Dr. KELLEY. I think we are not comparing the same thing, Mr. Karth.

I was giving you salary costs of the personnel. There is an operations of installation cost over and above that and then there would be an out-of-house R. & D. above that.

Mr. KARTH. I am sure the gentleman from Virginia is asking for total operation.

Mr. DOWNING. That is what I meant.

Dr. KELLEY. Yes, sir.

The personnel cost is, as I said, $19 million, and operations of installations cost would be approximately $9 million in addition.

Mr. RANDALL. Still a total of $28 million.

Dr. KELLEY. That's the total of $28 million.

Mr. RANDALL. No discrepancy there.

Mr. KARTH. If the gentleman would yield, I point out the Aeronautical Systems Division of Avionics Directorate employs, in round figures, 600 people—mostly highly professional people. Their "research only" payroll or cost of operation last year was $75 million.

This pretty generally follows the trend, but if this is your estimate, Doctor, we accept it for the record as you've stated it.

I think, however, that the committee must use their own discretion because we have on occasion been given estimates in the building of facilities and the staffing of facilities and so on and so forth, that in most instances I think have proven to be considerably lower than were originally anticipated.

If the gentleman would yield for just one more question.

Dr. KELLEY. Could I make a statement?

Mr. KARTH. Yes, sir. Please do.

Dr. KELLEY. The estimates I gave you are based on the averages we use in compiling the budget that's been submitted to the Congress. In other words, based on the figures we normally use per man-year, for 2,000 people it would come up to those figures. It is consistent with the way the agency has presented the rest of the laboratories.

Mr. KARTH. I think in estimating the cost of the entire laboratory, you have estimated it a little differently than estimating the cost of the overall program.

The only criteria I could use, Doctor, which incidentally is the reason I find myself in slight disagreement with you on the cost of operation—the criteria I have used has been what is it costing us to operate other laboratories of a similar nature; and the costs of operation of these laboratories which are similar in nature are considerably higher than what you've indicated the estimated cost of operation to be of this new Boston laboratory. This is all.

If the gentleman would yield just for one further question.

In answer to Mr. Downing's question you were talking about, whether or not this Electronics Research Center would decimate the university staffs, or have some adverse effect upon them; I suppose that this would be true to some extent and, indeed, it would be impossible for you to give us an accurate indication, until such time as you staff the Research Center, if it is built. Then you would know.

I think there would be another adverse effect on the university if you don't mind my saying so. Perhaps you would care to address yourself to this idea.

Today a good deal of this research that would be done at the research laboratory is being done in the university laboratories, so I assume that unless we are going to continue down the road with duplicate programs, that is extensive research universities, extensive research in private industry and extensive research in this laboratory if it were built; I assume that unless we are going to run down these triplicate roads, that somebody's going to lose something and I assume the universities would lose a good share of their basic researchers.

Would you care to address yourself to this?

Dr. KELLEY. I don't think so at all, Mr. Karth.

We would hope, in fact, the center would stimulate university research and help us identify the problems for the universities to work on.

Mr. KARTH. Doctor, are you saying the Government isn't really spending enough money in electronics research?

Let me just read some figures to you, all of which you may be familiar with, but I am sure the committee is not familiar with them, and I think they should get into the record. Then I'd like to have you, if you will, just address yourself to those figures. Referring to Government sponsored electronics research and development expenditures for just 1 fiscal year, 1960, which, incidentally, is the latest fiscal year figures I could get: The U.S. Army spent in Government laboratories that year, $70 million.

In industry, $335 million.

Universities and nonprofit institutions, $17 million; for a total U.S. Army expenditure in electronics research, $423 million.

The U.S. Navy spent $100 million in Government-owned laboratories.

In industry, $600 million.

Universities and nonprofit organizations, $32 million, for a total of $732 million.

The U.S. Air Force, $57 million in Government labs; $680 million outside; $37 million in universities; for a total of $774 million.

Well, going down the list, Doctor, the NBS, the FAA, the AEC, and NASA that year—NASA's expenditures, incidentally, was $25 million that year.

I find fiscal year 1960 Government-sponsored research in the field of electronics was $2,018,200,000.

I find, too, that the estimated national distribution of scientists, engineers, and technicians engaged in electronics work for the same year indicated that 180,472 of a total 229,680 were involved in work sponsored and paid for by the Government.

Some 79 percent of all of the scientists, engineers, and technicians engaged in electronics work, are working on jobs that are now being paid for by the Government.

What do we need? Eighty-five percent?

I mean, could you address yourself to this so this committee has a better understanding of how many more scientists and technicians and electronics engineers we have got to employ before we have enough?

Dr. KELLEY. Yes.

Mr. KARTH. Thank you. Please, Doctor.

Dr. KELLEY. I am familiar with the DOD figures, certainly that you've just mentioned. I would point out that I believe that they are under the research, development, test, and evaluation category under the DOD accounting system which includes test and evaluation through the hardware stage including project development which is a different subject matter than we are—or different category than we are talking about in our classification of advanced research and technology.

Mr. KARTH. Oh, it includes some development cost. No question about it.

When you talk about research, I guess you almost have to talk about research and development because I assume we will be doing some development work in the laboratory, too.

Dr. KELLEY. Some of the costs that will be comparable—some of our costs that would be comparable to the DOD costs in R.D.T. & E. are the type shown in the percentage breakdown I indicated on that graph with the percentage costs in electronics of the various projects; but I think the question that you wanted me to address myself to was how much more electronics do we need and I think we have to look at the requirements of each one of these agencies.

The Army has a battlefield mobile communications and battlefield surveillance requirement.

The Navy has quite an ASW problem which they still have to solve. I am quite familiar with that myself and I hope everyone in the Navy is working on it.

The Air Force have their own requirements, command, and control, as well as missiles and aircraft.

Incidentally, all three of the services operate in a countermeasure or jamming environment we don't normally expect to operate in. Their electronics are quite different in that respect.

We feel this effort we are addressing ourselves to, this new effort, is in the field of space electronics which is a new technology in which very little effort, we believe, very little effort to meet the future need, is being expended right now and certainly we have got to increase the effort if we are going to have a healthy space program for the long-range future. That is why we are proposing an increase in our electronic strength in-house as well as a budgetary increase, for example, this year in the R. & D. area so that we can get on a healthy footing in a new area of electronics.

I tried to point out within the last few days that electronics is really not electronics any more than a suit of clothes is a suit of clothes. They both have the same name but a suit of clothes may fit someone else somewhat differently.

So, we are in a custom-tailored business and our requirements are quite different than anything that has been developed for the earth-bound environment.

The DOD has been very active and intensive in the past few years in electronics. I think one of the significant steps taken in recent years was the so-called JANAF electronic tubes, joint Army-Navy-Air Force.

This was a line of components, electronic tubes, developed for military use, for the worldwide environment from the Equator to the poles and this has proven very, very successful and most people go to this component list if they want a component.

We don't have quite the same environment in space and we feel, for example, we will have to do the same thing in space as part of our responsibility.

Mr. KARTH. Doctor, you are not saying the Navy, nor the Army, nor the Air Force—you are not saying these three services are not doing any work on electronics research in their space programs, are you?

Dr. KELLEY. They are doing electronics research in space, but, as I understand the Space Act and NASA's responsibility, it is NASA's responsibility to pursue the advances in the technology and to be at the forefront of technology.

Mr. KARTH. I certainly agree.

This is the organic act. This is one of the things we try to impress on various agencies of the Government. If there is some real basic research to be done in the Government or by the Government, maybe we should start enforcing the organic act of 1958 that created NASA.

My question is, If this work is being done in other laboratories, then what do we do about it in NASA?

Do we just create the additional laboratory and go down the road also, or do we, some place along the line, convince these people perhaps they should stop the basic research and let NASA do it?

You see, this is the problem that I have, attempting to reconcile myself to the fact that we are not going to be going down three different roads all seeking to find a certain percentage of our total answer, will be the same.

So, how do we stop it at this stage of the game?

I agree, NASA has this responsibility.

Dr. KELLEY. We don't see that there is sufficient space electronics effort anywhere to meet the future needs of the space program. Certainly, the services will have some military missions in space and they should do some research to pursue their peculiar requirements in space.

Mr. KARTH. There is a good deal of disagreement on this, though.

Are you familiar with J. M. Bridges, Director of the Office of Electronics, Office of the Director of Defense Research and Engineering?

Dr. KELLEY. Yes.

Mr. KARTH. Let me just read some extracts from a speech that he made about a year ago on the occasion of a convention of engineers at the Institute of Radio Engineers in Los Angeles:

A recent survey—

These are extracts from his talk, and I understand his opinion is held in very high regard—

A recent survey, conducted jointly by my office and the Electronics Industries Association, revealed that approximately 150,000 scientists and engineers are engaged in electronic work in this country. Of this number, around 120,000, or

80 percent, are in Government-supported work, mainly for agencies of the Department of Defense.

This is the situation today. Now what about the future? In the next 5 or 6 years, the demand for electronic technical people in Defense research and engineering is expected to increase very substantially, perhaps to as much as 30 to 40 percent over what it is today. Added to this will be the demand for people to support the rapidly expanding space programs of the National Aeronautics and Space Administration * * *.

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* * * Along with the greater Government effort, there must be increased effort in industrial electronics, for this is just as important as our space and national security programs. The Nation's economic and social strength are too dependent—are also dependent—on electronics to drain all its resources into the Government. So, my guess is that based on our current level of productivity, the combined requirements for the period 1965 to 1967 will be for about 40 percent more engineers and scientists in electronics than will be available in this country.

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* * * We are going to be short 50,000 to 70,000 technical people in electronics * * *.

I have already briefly touched on the matter of engineer migration from one company to another, from one part of the country to another. The inevitable results of this situation are instability in the engineering profession and lower production. Unless he is already out of work, a man is unlikely to take a new job without bettering his financial condition, and this is normal. But when it is carried to an extreme, as it is today in the engineering field, the cost of the work progressively rises.

Now this is what Mr. Bridges had to say about this whole question of electronic research.

I wonder if you'd care to address yourself to the very pertinent points that he made?

Dr. KELLEY. As far as the shortage of engineers, if I could address myself to that as a first point; this is a well-recognized fact and we have to do something about it and I mentioned, as we have discussed in the last 2 days, the NASA grant program is one way to help the situation.

We consider the center with its university association, I mentioned how important we consider it; the university association has a couple of advantages.

It helps us train our own—"homegrow" our own, as I have said.

It also, within the Government organization, maintains this element of stability that this speech refers to. There is a definite element of instability in the electronic industry. I mentioned this earlier in this session this morning.

You go to a company and you find the same people were not there 2 years ago. Our problem is, How do we maintain a central core of knowledge and expertise in space electronics?

We feel it is done best by a competent, stable group and I think the stability of the Government research labs is well known. They are much, much, more stable than any industrial lab. I think this is one of the reasons we have Government labs.

Mr. KARTH. I am not sure of the stability, but I have read very interesting statements about the capability.

Dr. KELLEY. I think part of the capability, Mr. Karth, is due to the stability.

If you have, and the NACA has a longstanding history in this, if you get a team of people who are working together over a period of time, you get a much, much more efficient operation and much better results than if you have a transient operation with people moving in and out.

Mr. KARTH. I think I agree with you. Doctor, we can cite certain isolated examples of very capable teams and the fact that they've, if I may use the words "stuck together" for a long time.

I think, however, we have got to search far and wide, and then when we do we come up with very isolated instances of this kind. I think this is not general.

This is our problem, isn't it?

Dr. KELLEY. Yes, it is. The very reason as Jim Bridges cites in there, are pertinent to why we have proceeded along the approach that we have cited here today on the Electronics Research Center. We have to grow some new capability and we have to grow it in the right environment and it has to be a stable environment.

Mr. KARTH. I am very happy to have your views on it. I wonder if you'd address yourself to this point. Let me requote it so it is fresh in your mind:

> * * * Along with the greater Government effort, there must be increased effort in industrial electronics, for this is just as important as our space and national security programs. The Nation's economic and social strength are too dependent on electronics to drain all its resources into the Government.

That last sentence doesn't read well, but I can't help it. That's what it says.

Maybe we should just pay attention to the first one which indicates that his interest and concern is that the industrial electronics of the Nation is, indeed, very important and that by continuing to expand the Government electronics industry, if I may call it that, we disseminate this, you see, and this is not good for the overall economy. It's not good for the industry.

Dr. KELLEY. I am not clear what he means by that statement. When you read it, Mr. Karth, I interpreted he meant the industrial electronic industry which services industry rather than the Government as opposed to a Government electronic agency.

Mr. KARTH. He is talking about 80 percent, you see. His complaint is that 80 percent of the electronic engineers and the electronic experts in this country are now under contract directly or indirectly for the Federal Government.

He says if we continue to expand this type of program, he is seriously concerned about it.

At least, this is the way I interpret his remarks.

Dr. KELLEY. Well, I certainly hope—

Mr. KARTH. He says we should be doing less of this, rather than more of it. In other words, he is saying instead of building more laboratories, I guess, we shouldn't; and even instead of doing as much Government electronic research work as we are doing, maybe we shouldn't.

There are some people feel we have gone way overboard in this research. I don't happen to be one of them. I believe very strongly in research, but there are some people who feel we have gone overboard in electronic research.

This has been very popular, and the pendulum, you know, swings too far in one direction or the other, and today it has swung too far in that direction. This, I think, is what he is talking about.

I wonder if you would express yourself?

Dr. KELLEY. I think you pointed out the problem that we were faced with approximately 2 years ago and, specifically, the problem that was under study by our group well over the past year, and that is we now have an accelerated national space program; it is considered as part of our international posture.

Now, what do we do about the electronics to make this a healthy program? I admit we do have a problem on the number of people who are working for the Government, for any one of the services, or for NASA; but this is our attempt to solve that particular problem in terms of the research center.

I should say first of all with the growth of personnel that we require, which are put together or managed or implemented, in terms of a new research center that we definitely faced a problem on what do we do. I think it was more an effect than a cause. It was an effect.

Mr. KARTH. This subcommittee report that I quoted to you the other day said in very bold terms that approximately $200 million that year I think this was 1961——

Dr. KELLEY. This was 1961.

Mr. KARTH (continuing). Was wasted in their opinion out of a total expenditure of $2 billion in electronics research.

Now I have no way of ascertaining whether or not the Senate subcommittee made proper findings.

I suppose we could just say, "Let's completely ignore this report. Let's ignore the research that they have done on it. Let's ignore it because we'd like to build another laboratory."

This is a very comprehensive report. It's a couple of hundred pages long.

Dr. KELLEY. I have it right in front of me

Mr. KARTH. How many pages are involved in that?

Dr. KELLEY. There are several appendixes—292 pages. Comes up to 292 pages.

Mr. KARTH. Round figures 300 pages. This was under investigation a long time.

Dr. KELLEY. Yes sir.

Mr. KARTH. My real concern is we are not probably spending enough money in retrieval and dissemination of what we are already learning in research. This is my real concern.

I feel we could build five or six more laboratories and, certainly, benefit. There is just no question we could benefit some.

I think the real question, though, is, How much could we benefit? I mean, how much benefit could we get out of one, two, three, or five more laboratories as compared to the benefit we could get without any expenditure of that kind if we only did more in the field of retrieval of what we are now doing and then disseminating this information to everybody that's concerned? This is my very serious interest, Doctor.

Dr. KELLEY. There is one step in between the retrieval and the dissemination; and that is the translation of this information into the new technology.

How do you translate information that's already available, together with the new frontiers of space—translate this in terms of the engineering research that you have to do, that the Government has to direct, by contract and by application of funds?

How do you orient this and this is the step that—as I see it, is the responsibility of the in-house Government scientist?

One of his very important responsibilities.

Mr. KARTH. Isn't this what our in-house NASA electronics research people are today doing? They'd better be.

Dr. KELLEY. Yes, sir.

Mr. KARTH. I agree, Doctor.

You see, we have got to have some in-house capability. I couldn't agree with you more. I guess the question is, How much and what kind?

I feel very strongly that we've got to have highly capable people in the field of electronics working for NASA who can evaluate what's being done by industry and what's being done by the universities and what's being done by the other Government laboratories and then apply this to what we need. They should give very careful supervision, if you will, to the contracts that NASA has let to industry and to the universities and to other research laboratories. Make sure they are doing the right thing, if this is possible, or at least that they are doing something.

I doubt if we need another facility. Its personnel will be trying to get the same answers as these people are getting.

I think we have a lot of capability in this country and the question that bothers me, is: How many people are going down the same road today, all at the same time, attempting to arrive at the same conclusion that probably was already gone down last year and where the researchers met a dead end street?

This is my real serious concern, and I have not yet been able to reconcile myself to the fact we are not doing a tremendous amount of work in this area.

Mr. CHENOWETH. Mr. Chairman.

Mr. KARTH. Mr. Chenoweth.

Mr. CHENOWETH. I don't want to break your chain of thought. I have been tremendously interested in what you are saying. I certainly concur in your attitude.

I'd like to ask one question, if I could.

I attended a dinner of the American Electronics Industries Association and the statement was made the electronics industry is the fifth largest industry and will soon be the fourth largest industry in the United States.

Do I understand all the research is being done by the Government? They have achieved this phenomenal growth and no research is being done by the industry. What is that balance there? Are we able to take any advantage of the research and development grants of private industry?

Obviously it couldn't have achieved that growth and expansion without assuming 85 percent of the research and development has been by the Government and 15 percent was, in fact, by industry. This growth is extraordinary.

You feel this is a field for the Federal Government to preempt altogether, or should we leave a little for private industry?

I would like to have your observation on it, because the chairman opened up a very interesting question.

Just another question. What is involved in electronics? What does it encompass?

Dr. KELLEY. We call it electronics and control or electronics systems and when we say "electronics" we use the same definitions which have been used by activities like the Electronics Industries Association and this is really the equipment which involves the handling of information and intelligence and we call these things in terms of guidance, communications, in flight or transmitting it back to the ground, telling you which way is up, where you are going, what you are doing, what the information is, sending it back to the Earth, processing it in terms people can understand in a sort of digital language.

Mr. CHENOWETH. We could use a little of that in Congress to tell us where we are going.

Dr. KELLEY. There is a definition, in fact, in the report that Mr. Karth was just referring to and I don't know whether I can find it right now; but I think this says very succinctly the things I tried to say a few minutes ago. It does define the electronics business as essentially the handling of information and machine intelligence.

Mr. CHENOWETH. Comparably new industry; isn't it?

Dr. KELLEY. Oh, yes; the expansion of it, I think in the past few years—World War II—really kicked this thing off, radar and so forth; and the figure you had on the fifth largest industry is the way we understand it also, and in line as the fourth industry.

Mr. CHENOWETH. Doctor, you feel that the space effort has not kept pace and the electronics movement with private industry and other electronics development?

I'm not quite sure of your position?

Dr. KELLEY. Yes, sir; I think our reliability problem and record and the electronics part of it, is clear evidence of the fact we are not happy with the situation.

We have to do something about it.

Mr. CHENOWETH. What is it you are not happy about?

Dr. KELLEY. We are not happy with the electronic technology as applied to the space problem and this results from a very simple fact that the electronic technology, equipment we are using right now, is designed primarily for the environment here on Earth.

We have been using this equipment and if we are to progress in the future and get more reliable, longer life spacecraft for the planets and so forth, and get more regularity and get performance out of the equipment, too, we are going to have to improve.

Mr. CHENOWETH. Isn't private industry doing some of that, too?

Dr. KELLEY. Private industry is doing some of this. The 85-to-15 percent ratio you cited is an example.

Incidentally, I'd not like to think in the 85-to-15 percent ratio, that the numbers are mutually exclusive, that anything done in the military space electronics or Government electronics has no benefit in the industrial economics.

In fact, we think this is very important. This is the spinoff or technological fallout we talk about sometimes.

Chairman MILLER. Telstar is a good example.

Mr. CHENOWETH. You have some contracts for both private industry and NASA participation. Is that true in the development of electronics for the space efforts?

Dr. KELLEY. Most of our space electronic effort is with industry. As you know, 90 percent of every NASA dollar goes out of house.

So, most of the work is done in industry.

Mr. KARTH. Doctor, I'm not sure the gentleman from Colorado understood my statistics. Sometimes they are difficult to understand.

What I said, Mr. Chenoweth, was 80 percent of all the electronic work that's being done in this country is paid for by the Government. It's being done under Government contract.

Mr. CHENOWETH. It's not all for the benefit of the Government? It's for the private industries participating? I understand private industry is coming up with new inventions resulting in patents which will result in products advantageous for them as well as getting something going to help you in the space picture.

They want something going to be profitable to themselves, or the communities as well as to the Government.

Dr. KELLEY. Yes, sir.

Mr. CHENOWETH. So, it's a joint effort.

Dr. KELLEY. There are many, many examples of this. NASA and Mr. Webb, himself, is interested in this spinoff or technological fallout that can come from the NASA space program.

We have a group that is interested in the applications of the things we learn in space to the industrial economy, to use here in our day-to-day lives.

Mr. KARTH. Doctor, here's one area I don't think we are spending nearly enough money in.

If I recall correctly, and I may be in error by a million dollars or so; but, it seems to me that the last—during this fiscal year, fiscal year 1963, we appropriated $3 million to do this very thing you are talking about. That is, get this information back to industry so that we can more quickly get spinoffs into the industrial stream, the economic stream.

Probably we should be spending $50 million in that area, because I really don't think with the hundreds of millions of dollars of research and development that are going on for the Government in NASA and DOD, that $3 or $4 million could possibly get this information to the industry who are not participating in any of the Department of Defense or NASA work.

Seems to me we do a good deal of talking about getting this spinoff back into the economy for the benefit of the consumer and the general uplifting of the economy, but I don't really think we do it.

I know that this isn't your field, really.

Do you really think this is enough money?

Dr. KELLEY. I have no comment. This is not my area.

Mr. MOSHER. Mr. Chairman, if I remember correctly there was an announcement only within the last 2 weeks NASA was just getting around to this, really—had established an office under Dr. Simpson, just given him the responsibility.

Dr. KELLEY. This is a reorganization.

Dr. BISPLINGHOFF. May I interject, Mr. Mosher?

Mr. KARTH. Dr. Bisplinghoff?

Dr. BISPLINGHOFF. This particular responsibility had previously been under Mr. Stoller for some time and was transferred to Mr. Simpson's office. This was merely reorganization of the NASA offices.

Mr. MOSHER. Well, in line with the chairman's question, what is Mr. Simpson going to be given to work with, in terms of dollars and personnel?

Maybe you are not the right person to ask.

Dr. BISPLINGHOFF. I am not familiar with what his budget is going to be.

Mr. MOSHER. I think it is an important question you have raised, Mr. CHAIRMAN.

Mr. RANDALL. Mr. Chairman.

Mr. CHENOWETH. I have nothing further.

Thank you, Mr. Chairman. Thank you, Doctor.

Mr. RANDALL. This is just for clarification.

This is not so disheartening as it might seem. If you go over the figures read by our chairman—I want to say, I completely agree with his retrieval idea and dissemination. Maybe we don't have enough money.

As I understand the figures and the message from Mr. Bridges, we have $335 million in industry and $17 million in the universities.

Could you address yourself to the fact, isn't there some natural dissemination between industries? Don't they have your trade journals? Don't they know when something is going on?

I get big, thick, magazines each week in which there are publications.

Dr. KELLEY. Yes, sir, in addition to what the Government itself does, in addition to retrieval for example, by ASTIA, Armed Services Technical Information Agency, NASA has a documentation system which is cross-referenced with this, but this is by no means the only method of information dissemination.

We have trade journals, magazines, and the great professional societies in this country and they have frequent meetings with very high-class professional papers and this is extremely effective as a means of transmitting the information throughout the Government and industrial economy.

Both Government and industrial people appear, and university people as well appear in these symposia.

Mr. RANDALL. The comment of the gentleman from Colorado about the 85 per, of course, we never got up to the 85 percent at any time. It was 79 percent, but of that 79 percent, as you go through, you find a great part is in industry. It may be Government dollars, but it is industry.

Would you address yourself to that?

Dr. KELLEY. By far the greater proportion of our dollar, our dollar volume, 90 percent, goes to industry. Ninety percent of the dollars the Congress would appropriate to NASA, ends up in industry.

Mr. KARTH. Before we leave—the gentleman from Missouri wasn't here yesterday, so I wouldn't want to mislead him on electronic research for NASA.

Seems to me your testimony yesterday was, out of $43 million spent by NASA in electronic research during this fiscal year, that is fiscal year 1963, $20 million will be spent in-house and $23 million in industry.

Dr. KELLEY. No, sir; $15 million personnel costs. Eight million dollars is operations of installations—most of that goes out-of-house.

And then there is, as I said, $19 million was the number yesterday, that is——

Mr. KARTH. All I remembered were the totals and I have $20 million and $23 million someplace.

Dr. KELLEY. I rounded it off just now.

It is $20 million dollars spent in R. & D. funds on the actual engineering research.

Mr. KARTH. In-house?

Dr. KELLEY. Out-of-house.

Mr. KARTH. How much in-house?

Dr. KELLEY. $15 million personnel costs in-house.

Mr. RANDALL. You are probably not the right witness, but I think we should establish it, if you can address yourself to it, since it's been raised as, maybe, not an issue but a point of information.

These figures of the Department of Defense, actually the Army, most of that great bulk, is on the Nike-Zeus. Are you familiar with that?

Dr. KELLEY. Very familiar with the Nike-Zeus.

Mr. RANDALL. And this big, big expense in the Army is on that?

Dr. KELLEY. I don't know if it's specifically on that.

Mr. RANDALL. Related matters?

Dr. KELLEY. I would suspect, sir.

As I recognize this, these are "Research, development, test, and evaluation" appropriations.

Mr. RANDALL. Now, Doctor, the big item, as I understand it in the Navy, and I think you agree, it's ASW?

Dr. KELLEY. Absolutely, sir.

Mr. RANDALL. Of course, which we all agree is important.

And then, somewhere along the line, isn't there—if it is some element of basic research and electronics, can't you accomplish a retrieval, translation from that effort, so far as applied to space?

Dr. KELLEY. Yes, sir, we do. We have cross-correlation between the agencies on a continuous basis.

I might give you just a few examples.

Mr. RANDALL. I would hope it would go beyond cross-correlation.

Can't you actually use it?

Dr. KELLEY. We actually use it. In fact, in my area we have funds sponsoring, through specific DOD laboratories, R. & D. efforts.

Mr. RANDALL. And that is separate——

Dr. KELLEY. Where the capability exists we will try to seek it out and use it.

Mr. RANDALL. And that is a separate effort from this appropriation we are discussing, Mr. Stoll and the others?

That is a separate effort? That's your own?

Dr. KELLEY. That is right.

Mr. RANDALL. All right, Mr. Chairman.

Mr. KARTH. Mr. Mosher?

Mr. MOSHER. This morning's questioning began with Mr. Morris' reference to the Executive order which requires an agency such as NASA to thoroughly investigate the possibility of duplicate facilities with its requesting appropriations for a new facility and I think that under Mr. Morris' questioning we considered only the possibility of

the duplicaton in the DOD and you talked about the relationships between Mr. McNamara and Mr. Webb at the top level whereby they consider these matters.

I think, for the record, you should be asked whether in considering this facility proposed for Boston, whether you also considered the possibility of it duplicating any facilities available in other agencies, other than DOD.

I don't know which ones, Bureau of Standards perhaps. Specifically, was a study made to make sure there was no duplication there?

Dr. KELLEY. I can assure you, I considered all these facilities in making a recommendation, and I am familiar with the facilities.

Mr. MOSHER. Now, in the spirit of that order, do you also consider and make a real survey of what duplication there may be already available in private industry, industrial competence in this area, where, instead of building—buying all this land and building immense laboratory complex and hiring the 2,000 additional people; instead of doing that, you could employ the research facilities of industry which may be already available?

Would you consider that kind of study in the spirit of the Executive order?

Dr. KELLEY. This, I don't consider is necessary, in the spirit of the Executive order; but it's something we did anyway and I think you have got the question here as to how much in-house competence do you need and how much do you do with industry.

How much responsibility do you give the in-house group and how much do you give to industry?

One of the requirements I cited was a need in-house for a stable group who would be able to absorb all this knowledge and apply it in the space program and also—and there are various Government documents including reports of this committee on the need for in-house competence—to avoid conflict of interest, for example.

Mr. MOSHER. Would the reverse procedure work?

That is, is there research competence available in industrial laboratories, directing, of course from NASA. You could farm out these research projects?

Dr. KELLEY. I don't want to leave the impression that any laboratory which we might request or establish would preempt our efforts in industry at all.

In fact, we do use these industrial laboratories. We want to continue to use them and increase the effort. That is, in fact, one of the reasons why we want to increase in-house competence so we can effectively manage the out-of-house effort we want to increase; so we will definitely continue to use the industrial laboratories.

In fact—

Mr. MOSHER. Is it part of your philosophy that the long-term results of the work done in the new facility will actually spin off, produce a byproduct, whatever you call it, that the result of this research will stimulate the private industrial work?

Dr. KELLEY. We intend to work very closely with the universities and industry in such a lab. The lab itself would contract out-of-house a significant portion of the electronics advanced research and technology program and we consider this as a team effort between the

in-house group as represented at the center and industry and universities.

Mr. MOSHER. In other words, you have thoroughly considered the possibility of avoiding any unnecessary duplication of facilities that is available in private industry?

We are thinking in terms here of budget for the moment and we have got to assume this in terms of how the Federal money, the taxpayers' money, can best be spent.

Dr. KELLEY. These have properly been considered. In fact, as I mentioned, we would want to increase our usage of industrial facilities and try to stimulate some of the electronics industry into working on our space electronic problems.

We see the laboratory as an instrument to accomplish this.

Mr. MOSHER. Could I ask one other question?

I think you testified yesterday, in thinking of the location of this potential or proposed laboratory; you considered, among other places, Philadelphia, Milwaukee, the west coast, and so forth, and it was your considered and unequivocal decision the Boston area was the most advantageous location. Who did you make this recommendation to?

What is the chain by which this reaches the Budget Bureau?

Dr. KELLEY. It was my recommendation.

Mr. MOSHER. To whom?

Dr. KELLEY. To Dr. Bisplinghoff and Dr. Seamans.

Mr. MOSHER. How was this then transmitted to the White House or to the Bureau of the Budget?

Is it Dr. Seaman's final decision?

That is, where does the decision stop?

Where is the final decision as to location made?

Is it Dr. Seaman's decision or is it Mr. Webb's or whose?

Dr. KELLEY. In any such decisoin as this, a major source evaluation, the selection is Mr. Webb's.

Mr. MOSHER. You recommended the Boston location unequivocally; you didn't give three choices, as suitable to your standard?

Dr. KELLEY. I recommended this as the best one, sir.

Mr. MOSHER. When did you complete this study and make the recommendation, Dr. Kelley?

Dr. KELLEY. When did I complete the study and make the recommendation?

I think the exact date—I had discussions with Dr. Bisplinghoff. Maybe I can start back from the beginning further.

I think I mentioned yesterday on the record that this was one of some alternatives that I had told the associate administrator, well over a year ago, I was going to consider in response to his specific request I review the electronic capability and come up with a planned growth.

After we reviewed the procedure it was late in September I made a strong recommendation.

Mr. MOSHER. Late in September of 1962.

Dr. KELLEY. Last year; yes.

I made a strong recommendation to Doctor Bisplinghoff it was my conclusion that the best way to manage this in-house growth was with a new research center.

This was after the various steps I mentioned to you.

Mr. MOSHER. Chairman Miller referred, a few minutes ago, to the possible danger of redundancy of research capability around the country and I think you answered you had confidence in the supply and demand in the industry to take care of any redundancy. It doesn't exist now, and you would think future supply and demand would take care of that.

Did I interpret your statement correctly?

Dr. KELLEY. I feel the supply and demand takes care of the number of companies. Now, there is not a regulatory agency in the country to regulate the number throughout the country that I know of.

Mr. MOSHER. Are you expressing it as your own philosophy, and probably NASA's philosophy, you don't consider it part of your mission to manage or determine or direct the dispersal of electronic capability around the country?

This, you wouldn't consider part of it?

Dr. KELLEY. In terms of industry, no.

No, I consider this a free-enterprise system.

Mr. MOSHER. You think there is any threat of an unhealthy situation where, by locating your new facility in Boston—and I think the prime reason for your locating it, is the availability of competence in the industrial-university complex that's already there—do you see any threat of just compounding this competence to such an extent that it could become an unhealthy thing since competence is there now, you add competence to it, and that in turn adds further competence and, in effect, you are participating and you are weighting the scales in supply and demand, whether consciously or not, you are managing the dispersal as opposed to concentration of competence there?

Dr. KELLEY. Mr. Mosher, I'm not clear whether you are referring to the competence in industry or the competence at the center.

Mr. MOSHER. I am assuming that industry will follow.

You are locating there because university and industrial competence is there. Further industrial development will center there because of your new laboratory being there and that sort of thing—a "compounding of competence," if that means anything as a phrase.

Do you see this as an unhealthy possibility at all?

Dr. KELLEY. Well, not from——

Mr. MOSHER. Would you see it as a better policy, very consciously locating your laboratory of research someplace else in the expectation you would thereby encourage the establishment of a new center; of not draining away, necessarily from the Boston area, but establishing another healthy center which would be healthy in the long run?

Dr. KELLEY. I would look at this national center as a national electonics research and space center that would be working with the industry throughout the United States.

I don't know of the stimulation of the local economy.

I don't consider that in my province.

Mr. MOSHER. I wasn't talking about the local economy. I was just talking about qualified people in this field who like to work near and live near other qualified people.

Dr. KELLEY. I feel from where I sit, which might be a parochial technical viewpoint insofar as the electronics space program and getting it going in the best manner is concerned, I feel this is the best location in the United States.

Mr. KARTH. Doctor, where were you born and raised?

Dr. KELLEY. I was born and raised in the Boston, Mass., area, sir.

As you could probably tell by my accent—and I left over 20 years ago to to to the Naval Academy and have been in the Navy ever since.

Mr. KARTH. We all like to go home, Doctor.

Dr. KELLEY. I am in the Navy, sir.

Mr. MOSHER. Well, I think perhaps I ought to say, I have a great deal of confidence in Dr. Kelley and despite the partisan curiosity that I expressed yesterday, it does encourage me—and I want to accept Dr. Kelley's assertion.

I have a great deal of confidence in his integrity, his decision, and his recommendation that it was based completely as to location, was based completely on NASA's best interest and the Nation's best interest.

I am personally willing to accept his statement.

I think it was a fortuitous coincidence, perhaps, that the location announcement followed the election of the junior Senator from Massachusetts last year, and helped to immediately bear out his promise to his State.

Mr. KARTH. Can the gentleman recall his name offhand? Perhaps we would want to get that in the record.

Mr. MOSHER. Facetiously, I'd like to note; he referred to the "frontier of space." I hope that was a slip of the tongue.

Dr. KELLEY. There are many frontiers, Mr. Mosher.

Dr. WEAVER. Mr. Chairman, yesterday Dr. Kelley said he was going to place in the record, the other sites he considered.

The other sites considered, are covered in the April 3 hearings, p. 2215.)

When you evaluated these sites, did you have any board to assist? Did you use members of NASA or did you have a citizens' committee or advisory group that reviewed this with you before you made a recommendation?

Dr. KELLEY. There was no formal board convened for this.

Dr. WEAVER. Informally, you discussed this with people of the area and people of the industry. Is that it?

Dr. KELLEY. We feel we know pretty much where the capability is to start with—not just myself, but the management in NASA, and there were many and frequent discussions about the locations of this.

Dr. WEAVER. Dr. Kelley, will your report show the socioeconomic factors involved, besides the technical factors involved?

Dr. KELLEY. Any I would have.

Dr. WEAVER. It will be scientific?

Dr. KELLEY. Yes.

Dr. WEAVER. Make it stand on its own, the statistics you have of the research laboratory at Boston, versus the research laboratory at other areas in this country?

Dr. KELLEY. That is the only criteria on which my recommendation was made.

Dr. WEAVER. That's what I would like to see.

Do you consider the United States or Russia to be ahead in this electronic field?

Dr. KELLEY. That is a very, very, difficult question to answer.

It is involved in intelligence information and so forth, but I think in the electronic area we are probably about equal.

Dr. WEAVER. This then would have, perhaps a role in your decision such a center is necessary?

Dr. KELLEY. Yes, sir.

Dr. WEAVER. Thank you.

Dr. KELLEY. I don't think we are any smarter in electronics than anybody else.

I think we are good, but I don't think we are smarter.

Mr. KARTH. Doctor, yesterday, you and I agreed that if we had to have any more laboratories, probably one would be enough—I mean, one more.

We still agree, don't we?

Dr. KELLEY. One more space electronic laboratory.

Mr. KARTH. The reason I ask the question is because March 13, I received a memorandum which is in conformity with the authorization act from Mr. Webb, the Administrator. Well, this particular one was from Dr. Hugh Dryden, Deputy Administrator, asking for a reprograming of some funds and, apparently, calling our attention to the fact that some additional budgetary funds were being requested for a construction at the Mississippi test facility of Electronic Instrumentation and Materiels Laboratory, for the total of $5,153,000. Now, is this an electronic Laboratory, or isn't it?

Dr. KELLEY. I am not familiary with the details of that particular Laboratory, but I am aware of the facility and this is electronic hardware facilities to support the test operations.

Now, as I mentioned yesterday, I don't consider this an electronics research laboratory, either.

At many of our locations we have to have electronic capability—60 percent of our project dollars are in electronics.

We have to have people who know what they are doing on the projects. There has to be. We will get a reasonable distribution of people with electronic competence at the proposed new research center.

But I don't consider this an electronic research facility.

Mr. KARTH. Aren't you requesting funds also for Langley? You are requesting some electronic research funds for Langley?

Dr. KELLEY. Yes, sir, and this is associated with the flight test programs going on there that I mentioned the other day.

Mr. KARTH. This is all a part of research, isn't it?

Dr. KELLEY. Research has many names.

Mr. KARTH. Research going to find out whether or not what systems—whether or not the systems that we now have, can stand the rigors of outer space?

I assume this is one of the purposes of the laboratories. If not, I'd like to be corrected.

Dr. KELLEY. This is.

Mr. KARTH. And if they can't withstand the rigors of outer space, I suppose we try to evaluate and find out why, and where we can make corrections.

Isn't that pretty much what you are talking about so far as the purpose of the Boston laboratory proposal is concerned?

Dr. KELLEY. That is the purpose of the Boston laboratory.

Langley has a complementary role to the electronic research laboratory as I pointed out yesterday.

Right now, we have our heaviest concentration of electronic research personnel there and we would continue to want to exercise the Langley capabilities associated with the wind tunnels and flight tests at Wallops and so forth.

I think you are referring specifically to an electronics instrumentation facility.

Mr. KARTH. An "electronic instrumentation facility." All right, if that's what it is, that's fine.

I'm not just sure in my own mind, you see, we can assign a different word to each center and then say, "Well, gentlemen, this one is working on instrumentation."

I am not an electronic engineer, but I do happen to feel quite confident that all the electronic components are instrumentation, aren't they?

Dr. KELLEY. Some people use that name in the broad sense. We use it to mean the actual measuring instrument.

Mr. KARTH. That's not what you mean so far as Langley's effort is concerned, and the Mississippi test facility laboratories are concerned?

They are not just doing the kind of work they talked about insofar as your interpretation of the word "instrumentation" is concerned, are they?

Dr. KELLEY. Primarily as I understand, yes, sir.

Mr. KARTH. Primarily though they do work in addition to that, don't they?

Dr. KELLEY. Yes.

Mr. KARTH. One other question, Doctor.

We are going to have to let you go, because you are a very busy man and we have other witnesses from Dr. Bisplinghoff's office.

Mr. RANDALL. We will reserve the right to call Dr. KELLEY back.

A lot of us want to get into the record and read it and go through it a lot more thoroughly.

Mr. KARTH. I think what we ought to do; those questions we still have, we can submit to the doctor in writing, and Doctor, you could reply and both the question and the answer go into the record.

Dr. KELLEY. Yes, sir.

Mr. KARTH. In conclusion, I'd just like to point out that it was just about 1 year ago when some members of the Science and Astronautics Committee were questioning Dr. Seamans and Mr. Wyatt on in-house capabilities, and at that time it was their opinion that maybe NASA was moving in the direction of developing an in-house capability in everything and Dr. Seamans and Mr. Wyatt said, well, this is true, we needed some in-house capability; but so far as electronics was concerned, they pointed out here we depend on the universities and Government—all existing Government-owned laboratories and industry.

Dr. Seamans said this was good because—

A great deal of work has been done in this field. There is a danger that our people in NASA centers could repeat what has already been done or whatever is already going on in this field. We are relying very heavily on industries and the universities.

and so on and so forth.

This also applies to the Department of Defense in the department of electronic control.

Apparently, there's been a considerable change of opinion in this particular area since last year.

Dr. KELLEY. That was approximately 1 year ago.

Mr. KARTH. That was March 7, to be exact.

Dr. KELLEY. I was directed, in March, to look into the whole situation. That was the status quo at that particular time and, I believe, as a result of our effort, since that time, that we do feel differently.

Mr. KARTH. I want to thank you very much, Doctor.

I have enjoyed your appearance before the subcommittee and I'm sure the other subcommittee members have, too.

On behalf of the subcommittee, I want to congratulate you. You have done a tremendously able job calling to our attention your viewpoint and, apparently, those of NASA, on this particular issue.

If we should find reason to call you back later on, we hope we don't interrupt your busy schedule too much.

For the benefit of the committee, tomorrow we would meet in this room, at 10:15 and, Mr. Sloop, I would hope that you could be available for the committee at that time.

I would also like to announce the subcommittee intends to hold hearings Monday, Tuesday, and Wednesday next week. The place of the hearings has not yet been determined, but we will get that information.

Thank you very much. The meeting is adjourned.

(Whereupon at 12:10 p.m. the subcommittee was adjourned until 10:15 a.m., Friday, April 5, 1963.)

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1964 NASA AUTHORIZATION

FRIDAY, APRIL 5, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SPACE SCIENCES
AND ADVANCED RESEARCH AND TECHNOLOGY,
Washington, D.C.

The subcommittee met, pursuant to adjournment, at 10:15 a.m., in room 304, Old House Office Building, Hon. Joseph E. Karth (chairman of the subcommittee) presiding.

Mr. KARTH. The committee will come to order.

Dr. Bisplinghoff, I understand that Mr. Sloop has a prepared statement.

Dr. BISPLINGHOFF. Yes, sir; he is right here.

Mr. KARTH. You may proceed, Mr. Sloop. Perhaps it would be best if you don't follow the prepared statement verbatim, but summarize it, using whatever slides or other material you have.

STATEMENT OF JOHN L. SLOOP, DIRECTOR, PROPULSION AND POWER GENERATION, OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY, NASA

INTRODUCTION

Mr. Chairman and members of the subcommittee, Dr. Bisplinghoff has outlined to you our concept of advanced research and technology and described various programs. I shall amplify his remarks with regard to two of these programs: Chemical propulsion and space power. These programs are closely related as they both are energy conversion processes. The energy sources to be considered here are chemical and solar; nuclear energy is handled separately by Mr. Finger.

Propulsion is the key to space exploration and our push to the Moon in this decade will depend completely on chemical propulsion. We see a large and continuing role for chemical propulsion in the next decade. The advent of nuclear and electrical propulsion will greatly increase our capability and enable us to use each type in the application best suited to its characteristics. We see much larger chemical propulsion systems than we have today. Some of these may use air augmentation and will be capable of ferrying large payloads economically from Earth to manned satellites and between distant points on the Earth. We see chemical propulsion packages carried dormant for months on long space missions but ready at the touch of a button or a signal from Earth to perform their task. We see chemical propulsion systems for landing and takeoff from the Moon, Mars, and Venus where compact systems of high thrust per pound of weight are needed. Some may be carried as extra stored energy sources for emergency use.

Space power or electric power generation is the heart of a spacecraft, supplying its many parts with electrical power. It provides power for communications, guidance control, measurements, mechanical devices, life support, and in special cases, for propulsion. Present spacecraft use solar cell and battery power systems but the technology is developing so rapidly there will soon be many other systems available, each of which has its special application. We visualize large areas of inflatable structures covered with solar cells and connected with regenerative fuel cells for continuous power in and out of sunlight periods. We see an increasing use of regenerative or rechargeable fuel cells for use in mobile equipment. We see

the possibility of large foldable or inflatable solar mirrors to concentrate solar energy into boilers where it is first converted and stored as thermal energy and then converted into electrical energy by thermionic, thermoelectric, magneto-hydrodynamic, and conventional heat engines. We see other possibilities for power generation such as biological fuel cells and engines that operate on the fuel and oxidizers carried aboard the spacecraft. Many of these systems will also find useful applications on Earth.

It is our job to increase our knowledge about the processes that release chemical and solar energy and how to convert the energy into useful work in propulsion and power generation systems. We do this with advanced research and technology programs involving scientists and engineers in NASA centers, industry, and universities plus nonprofit organizations and other Government agencies. In fiscal year 1963, the division of effort in these three groups is 28, 68, and 4 percent, respectively. In the following discussion, examples of typical work are given and often the organization connected with the particular example is mentioned to give you a sample of the spread of effort. No attempt was made to include all the organizations contributing to the research and technology programs.

CHEMICAL PROPULSION

Figure 217 (p. 2301) indicates areas of interest in chemical propulsion. Included are engines with liquid and solid propellants and hybrids with a combination of both, rocket engines that use air (or planetary atmosphere) for thrust augmentation, and others that use solar energy. Some of these are pictured; starting at the top left, is a solid motor, a hybrid engine, a radiation cooled thrust chamber, a large booster engine, an engine with air augmentation, and a schematic diagram of a spacecraft engine. We are interested in high-energy propellants for these engines and in better knowledge of combustion phenomena.

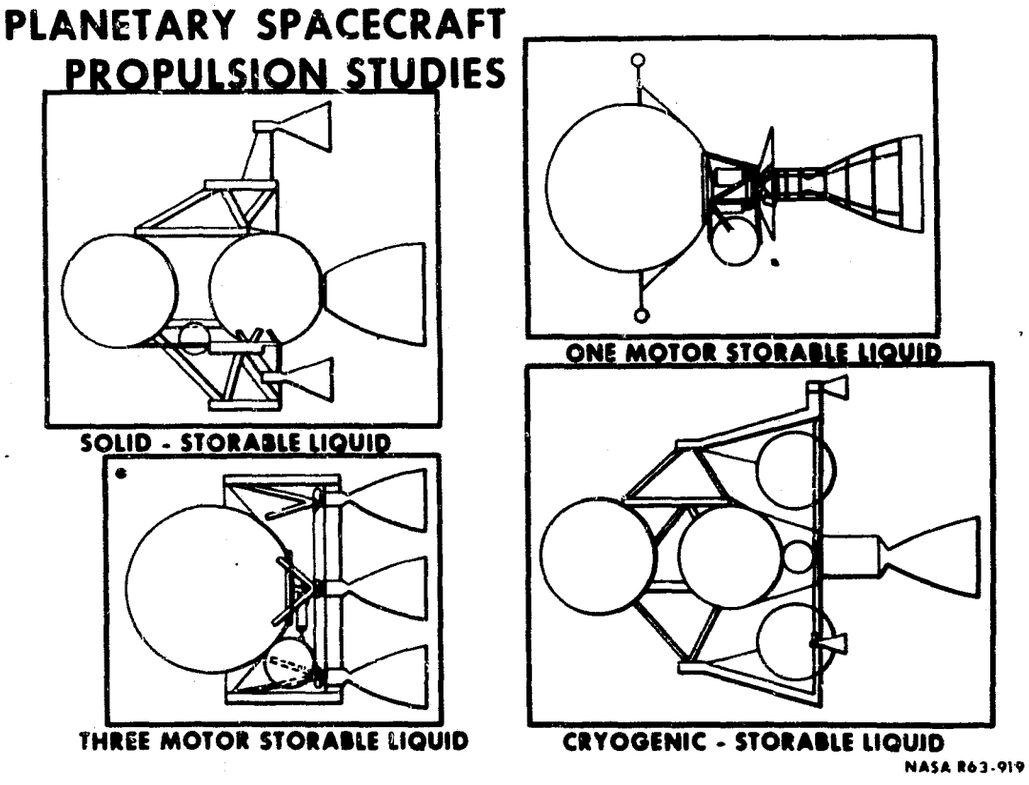
In fluid dynamics, we wish to learn more about propellant flow in tanks, pumps, lines, coolant passages, and injectors as well as gas dynamics of the combustion gases expanding through the nozzle. We need improved cooling techniques and materials capable of handling gas temperatures from 6,000 to over 10,000° F. For your convenience, these areas will be discussed in the five subdivisions given in the budget book.

Analysis, aerothermochemistry, and materials

System analyses related to possible future missions are needed on a continuing basis to guide research and technology programs in the most fruitful direction. In considering propulsion requirements for future missions, assessments are made of the state of the art and what information is needed to meet future requirements. They uncover gaps in the state of the art and indicate areas where more research is needed. For example, figure R63–919 shows some preliminary design layouts from a study of possible planetary spacecraft propulsion systems. As you can observe, the configurations are combinations of engines using solids, storable liquid, and cryogenic liquid propellants. Other studies consider the potential applications of hybrid rockets and liquid rocket engines with air augmentation. Often these studies and preliminary designs lead the way to new approaches and significant gains in propulsion technology.

Aerothermochemistry is a composite of thermodynamics, gas dynamics, and chemistry that considers the processes of propellant injection mixing and vaporization; ignition and combustion; and expansion of the combustion gases through the nozzle. Consider solid rocket combustion for example. Research on various aspects of solid combustion is underway at three universities (Princeton, Purdue, and Minnesota) and at three NASA centers (JPL, Lewis, and Langley). Last year we reported on work in low-pressure combustion where there were regions of stable and unstable burning. Since that time, an analytical method has been developed that correlates all the experimental data. The correlation predicts low pressure burning characteristics and hence, will be a valuable tool to engine designers. These results will be presented at the annual interagency meeting on solid propulsion at Seattle, Wash., this summer. The correlation will be extended to include propellants with metal additives.

Other research includes ignition, the effect of rapid pressure decay on quenching combustion, on reignition, and basic combustion phenomena. A combustion problem of great concern to us is combustion oscillations. These are pressure fluctuations in the combustion chamber which greatly increase heat transfer, and can destroy the combustion chamber by excessive heating, pressure, or vibrations if allowed to continue. This is probably the greatest single problem in liquid rocket engine development and we need to increase our efforts in both basic



studies of these complex phenomena and in engineering studies to devise techniques for controlling or eliminating these oscillations.

Research is underway at Princeton University, the Lewis Research Center, and the Naval Ordnance Test Station on this problem. Recent results by the Lewis Research Center map out combustion stability regions as functions of vaporization characteristics of the fuels, their burning rate and engine size. In the coming year the work will be extended to larger engines and engineering solutions will be sought. One approach we expect to investigate more fully is the use of chemical additives to influence burning rate and avoid combustion oscillations.

Dr. Kurzweg has described to you the basic research program on materials. We seek to apply this, plus related engineering knowledge of materials, to rocket engine applications. Work is underway at Armour Research Foundation to find high temperature coatings that resist the oxidizing atmospheres for use in rocket nozzles. Tungsten, for example, can withstand very high temperatures but oxidizes rapidly. When coated with a hafnia composite later, however, tungsten withstood oxidization successfully in a series of recent tests.

Work at Marquardt and JPL seeks to apply pyrolytic graphite to small thrust engines. This technique allows the chamber to operate at very high temperatures and radiate its heat to the surrounding space.

Propellants

The subject of rocket propellants is complex and often controversial. Unlike air-breathing engines where the oxidizer is always the same and the fuels have remained within the hydrocarbon family, rocket propellants come in many chemical varieties. Almost every chemical reaction that releases a large amount of energy has been scrutinized. Often, as the technology advances or requirements change, chemicals that once were examined and passed over may become attractive. In this changing situation, it is well to keep in mind a few basic guides. From an energy standpoint, we seek chemical reactions that result in high gas temperatures and low weight of combustion products.

This temperature, divided by average molecular weight of the gases, determines the specific impulse, or the amount of thrust produced per pound per second flow of propellants. From energy considerations, we generally confine ourselves to the first part of the periodic table with chemicals containing hydrogen, carbon, nitrogen, beryllium, boron, aluminum, oxygen, fluorine, and chlorine. If energy

were our only consideration our task would be fairly simple. We must consider other propellant factors such as desnity, storability in the space environment, compatability with materials of construction, flammability and toxicity, effectiveness as a coolant, properties affecting pressurization and pumping, availability, and cost.

In solid propellants, the Department of Defense (ARPA) has a fundamental chemistry program aimed at finding new compounds yielding an increase in specific impulse. Recently they added hybrid propellants to the program. We follow this work closely to apply the results to propulsion for space applications. We are currently investigating three solid propellants which are complex compounds containing boron, nitrogen, and hydrogen atoms. We contracted with the Callery Chemical Co., Food Machinery Corp., and American Cyanamid to produce approximately 100-pound quantities of these propellants which JPL will use in small-scale rocket evaluation tests. A current contract with Callery Chemical Co. on the third propellant is underway and we plan evaluation tests of it in fiscal year 1964.

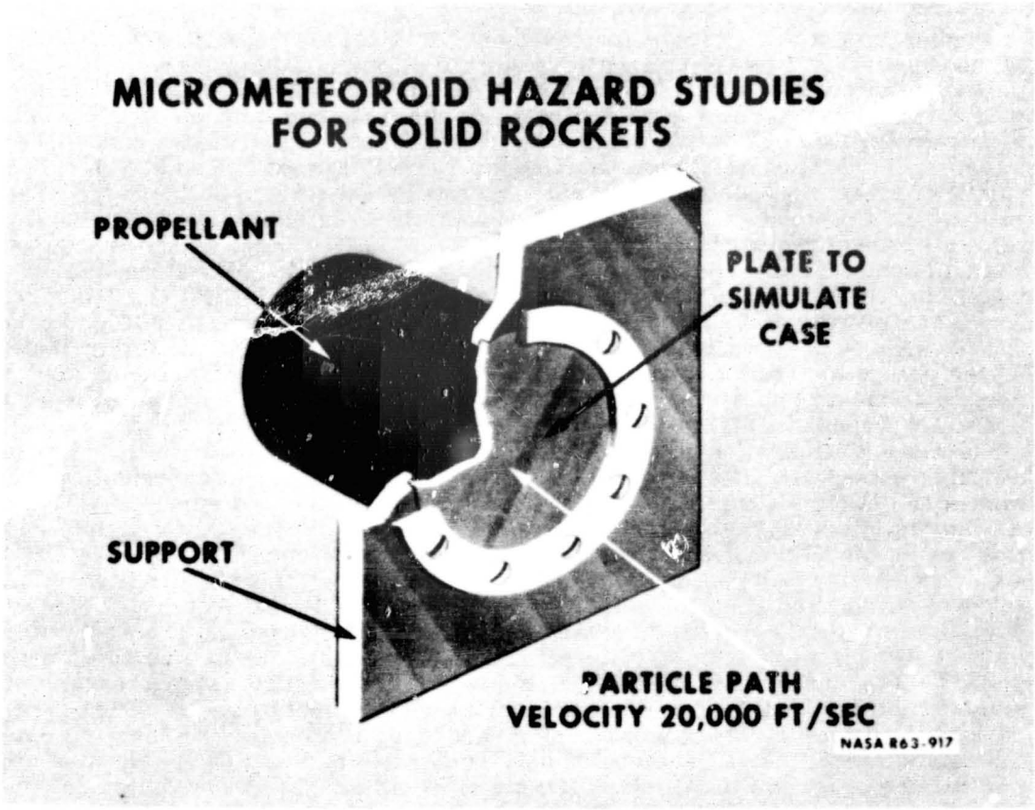
One of the problems we face in high-energy solid propellants is to obtain in practice the theoretically available performance. Figure 218 (p. 2302) shows an example of this problem. The vertical scale shows the relative performance of a solid propellant for various amounts of light metal additive as indicated by the horizontal scale. As the amount of metal additive increases the difference between theoretical and obtainable performance grows larger. This may be caused by incomplete combustion of the metal or may result because the solid combustion products leave the rocket nozzle at a lower velocity than do the gaseous products. These gas-particle flow phenomena are being investigated. Part of this study is to measure and determine the effect on performance of size of solid particles in the exhaust. Figure 219 (p. 2304) shows photomicrographs of aluminum oxide and beryllium oxide particles captured from motor firings inside a closed chamber.

Another important aspect of solid propellant research is the determination of physical and chemical properties and the effect of the space environment. In the coming year, the NASA will assume responsibility for a program ARPA started at JPL on the property studies of solid propellants. The program is directed toward research on the nondestructive testing of solid propellant rockets. The project goal is to determine generalized techniques whereby the abnormalities in solid propellant grains can be detected and the degree of malfunction predicted. Significant contributions toward the complete understanding of this problem have been made under this program in the past 2 years. Areas of concentrated effort include the study of propellant sonic, rheological, electric, and mechanical properties; propellant degradation mechanisms; photostress analysis, and flaw analysis. This work is augmented by studies of propellant properties at the California Institute of Technology.

In the space environment, a solid propellant must withstand the combined effects of the thermal environment, radiation, vacuum, and micrometeoroids. An example of work underway on the latter is shown by figure R63-917. High velocity particles are projected at a propellant sample and plate to simulate a case and the effects are measured. This work is being carried out at the Stanford Research Institute.

In liquid propellants, we are interested in cryogenic high-energy propellants that exceed the performance of hydrogen and oxygen, in storable propellants that exceed the performance of nitrogen tetroxide and a hydrazine mixture, or in propellants that offer some other advantages. Possible candidates for the first category are the addition of beryllium to hydrogen and oxygen, hydrogen-fluorine, and the addition of lithium to hydrogen-fluorine. We must learn how to introduce these additives into the thrust chamber and how to burn them to achieve high performance. The same type of gas-particle flow problems as mentioned previously apply here, also.

There are two liquid combinations of interest that contain boron. The Department of Defense (Air Force) is investigating pentaborane and hydrazine and we are investigating oxygen difluoride and diborane. The interest in the latter comes from calculations which indicate that while the theoretical performance of this combination is not as high as that of oxygen-hydrogen its density is three times greater; moreover, oxygen difluoride and diborane are liquid at a warmer temperature (−250° F.) than liquid hydrogen (−420° F.) and hence are more storable in space. Because of this theoretical promise, we contracted with Reaction Motors Division of Thiokol Chemical Corp. to determine certain properties of OF_2 and to determine combustion efficiency using a small-scale rocket. The engine tests were disappointing, however. The results are qualitatively



shown by figure 220 (p. 2306). The theoretical curve is relatively flat over a broad mixture region and one would use as large a proportion of oxidizer as possible to increase average bulk density. (The density of the oxidizer is almost four times greater than the density of the fuel.) The experimental data, however, are high only over a narrow range of mixture ratios and fall off rapidly on either side. More data are clearly needed and we expect to investigate performance more fully with a larger engine. When high combustion efficiencies are obtained it will be necessary to determine whether the gases will expand through a large nozzle to vacuum and yield a high specific impulse. Engineers compute two theoretical performance curves: The so-called equilibrium expansion assumes the gas composition adjusts instantaneously to rapidly changing pressures and temperatures, whereas the so-called frozen expansion assumes the gas composition does not have time to adjust and goes through the nozzle with composition unchanged. We expect to explore these gas-expansion effects in fiscal year 1964.

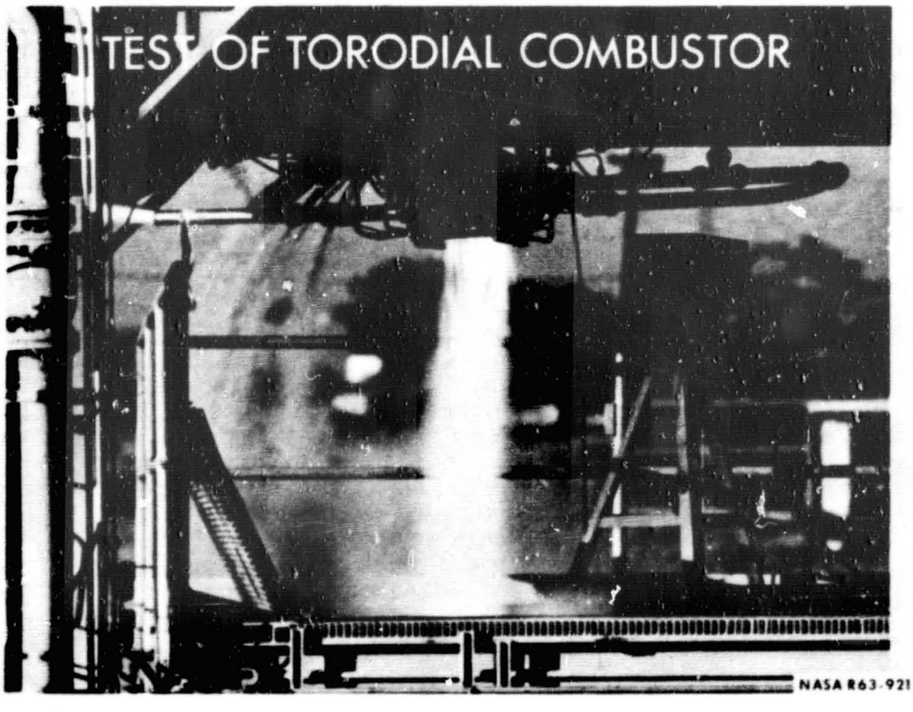
The greatest problem with the oxygen difluoride-diborane combination, however, is cooling. It has theoretical combustion temperatures approaching 8,000° F. which is far hotter than anything in use today. How will we cool the engine? The propellants themselves are poor coolants; they decompose and the oxidizer may attack the metal walls at elevated temperatures. Other cooling techniques must be examined such as the use of ablative materials, high-temperature materials with film cooling, etc. We expect to increase our efforts in these areas in fiscal year 1964.

Other propellant work of growing importance is the use of additives to current propellant combinations to improve ignition, combustion characteristics, or performance. In 1956 the Navy, General Electric Co., and the NACA investigated the advantages of additives to the oxygen-RP combination. There is a great potential in improving existing engines by following this path and we plan to pursue it in cooperations with other NASA program offices. Another additive of research interest is ozone fluoride. This powerful oxidizer added in small quantities (1 part in 2,000) to liquid oxygen can produce spontaneous ignition of the oxygen-hydrogen combination, according to work by the Stanford Research Institute. Other propellant research is investigating the possibilities of gelling liquids, including cryogenics, to improve their behavior in a zero-g environment.

Advanced launch vehicle engine technology

Engines now in use or in development for Earth takeoff have thrusts up to 1.5 million pounds and five of these will be clustered for the Advanced Saturn. The next step in booster thrust will probably be on the order of 20 to 30 million pounds or higher. For these large thrusts, new engine concepts are needed. Figure 86 (p. 1887) shows the scale-up of conventional and advanced concepts of large engines. The first engine starting on the left side of the slide is the F–1 engine of 1.5-million-pound thrust which represents the present technology. The scale-up of this technology to engines, say in the 24-million-pound thrust size, results in an excessively large engine—one over 50 feet high, as shown by the second engine. The engine size can be reduced to something more reasonable by increasing the operating pressure severalfold as indicated by the third engine. Accordingly, work is underway now and will continue for some time to come on the technology of using high operating pressures. We must learn how to make better pumps and turbines to produce high-propellant pressures, how to devise flow components and systems to handle high-pressure fluids, how to ignite and burn the propellants stably at high pressures, and how to keep the engine cool under the higher heatload. We want to conduct experiments with new nozzle concepts, some with air augmentation, that hold promise of more efficient operation in the Earth's atmosphere and which allow more compact engine envelopes. An illustration of an engine with such a nozzle is shown by the fourth engine. In this case, a multitude of combustors feed into a common nozzle. We know little about these concepts, especially at large sizes, and how they will operate over a range of normal and abnormal conditions, and how to obtain thrust vector control with them. All these must be examined. Oxygen-hydrogen is of considerable interest for this application. If oxygen-kerosene is used it may be doctored with additives to improve ignition and combustion characteristics. A photograph of one concept using multiple combustion chambers is shown by figure 87 (p. 1888) It consists essentially of a number of independent combustors discharging into a common nozzle. Each combustor may be fed by its own turbopump or there may be one or several turbopumps serving all combustors. An advantage of the former is that development of the turbopump-combustor subassembly can be brought to a high degree of refinement and reliability with facilities in the million-pound-thrust class and combined into the 24 to 30-million-pound assembly with relatively few tests and facilities.

Another concept is to use a toroidal combustion chamber such as shown by figure 222 (p. 2317). As shown by the insert, the propellants are injected on one side of the torus and the hot gases pass through slot-shaped throats between the tubes on the opposite side. This concept appears very promising and can be developed in segments or subassemblies as well as the other concepts. A photograph of such a toroidal combustor during tests at Rocketdyne Division of North American Aviation, Inc., is shown by figure R63–921.



I have mentioned the increasing interest in rocket propulsion with air augmentation. One problem with the large common nozzles just described is low pressure on the center portion in the Earth's atmosphere induced by the pumping effect of the exhaust jet. This can be eliminated by the use of air "ventilation" to this low pressure region. One such concept by the Lewis Research Center is shown by figure R63–973. Air enters from inlets on the vehicle sides and flows through the center of the nozzle.

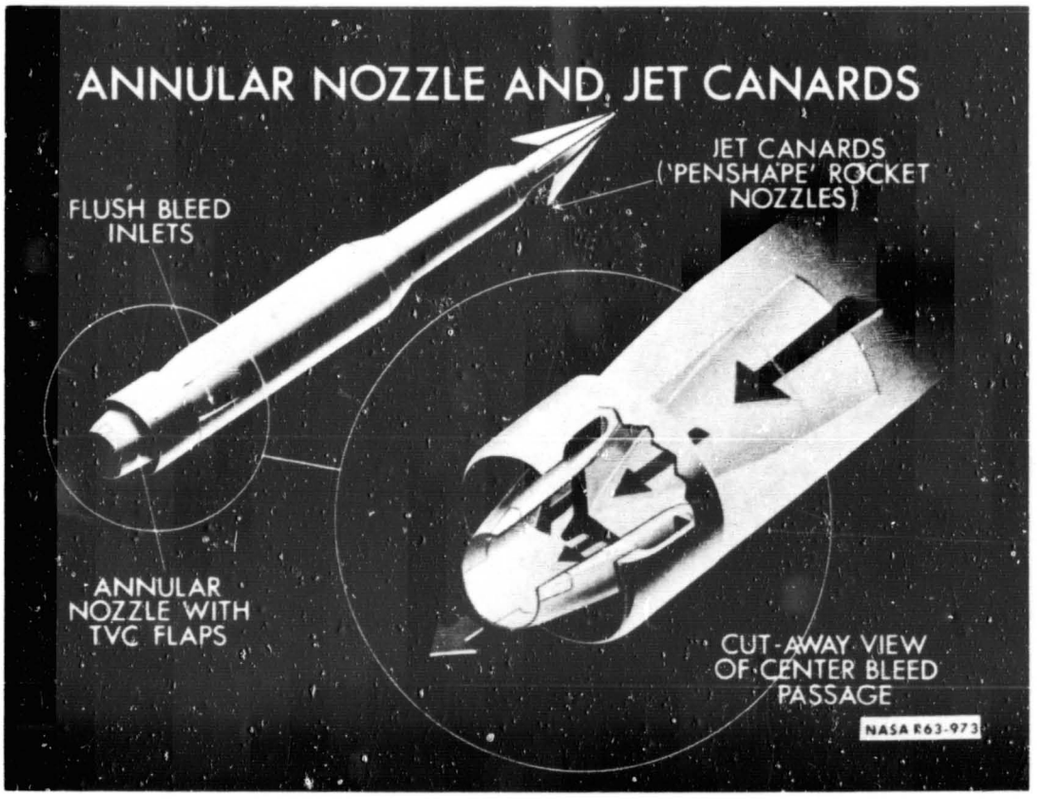
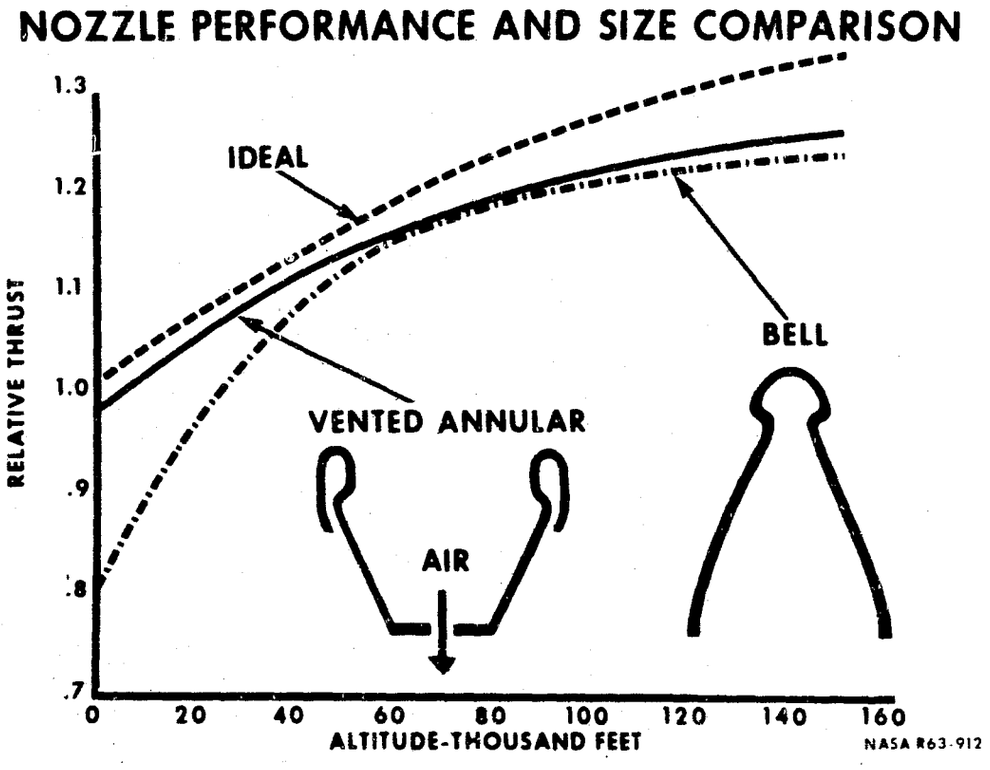


Figure R63–912 compares the performance with the ideal and the conventional bell-shaped nozzle. As you can observe there is substantial increase in thrust at altitudes below 50,000. We are planning to investigate this concept as well as examine concepts which use greater amounts of air augmentation for Earth takeoff applications. One such technique we wish to study is a variable or compensating nozzle which changes configuration as the vehicle increases speed in its climb through the atmosphere and into space. An illustration of such a nozzle, a concept of the Langley Research Center, is shown by figure 223 (p. 2318). It uses a segmented annular engine around a centrally cusped concave thrusting base and heat shield. The annular engine is in turn surrounded by a shroud made of multiple leaves which are hinged near their forward ends to structural fins on the main vehicle assembly. The shroud leaves can, by rotating about their hinge points, vary the air-inlet and exit-flow areas. The multiple leaves are self-actuating, and adjust themselves under the effects of atmospheric pressure outside and the rocket gas-air mixture pressure inside to provide optimum performance.

For maximum thrust at launch and at low subsonic speeds, air must be introduced through a bell mouth inlet; this feature is shown in the first sketch. The bell mouth is expendable and is automatically jettisoned when its drag exceeds the thrust it contributes. During supersonic flight in the Earth's atmosphere a sharp-lipped inlet is required. This requirement is met by the configuration shown in the second sketch, where the sharp-edged leaves form the inlet after the bell mouth is discarded. In addition, the leaves rotate outward to provide the larger exit area required at the higher altitudes. Finally, when the vehicle has left the Earth's atmosphere, no air inlets are needed. The unit reverts to operation as a nonaugmented rocket, and the maximum exit area attainable is desired in order to maximize thrust. These conditions are met by the automatic adjustment



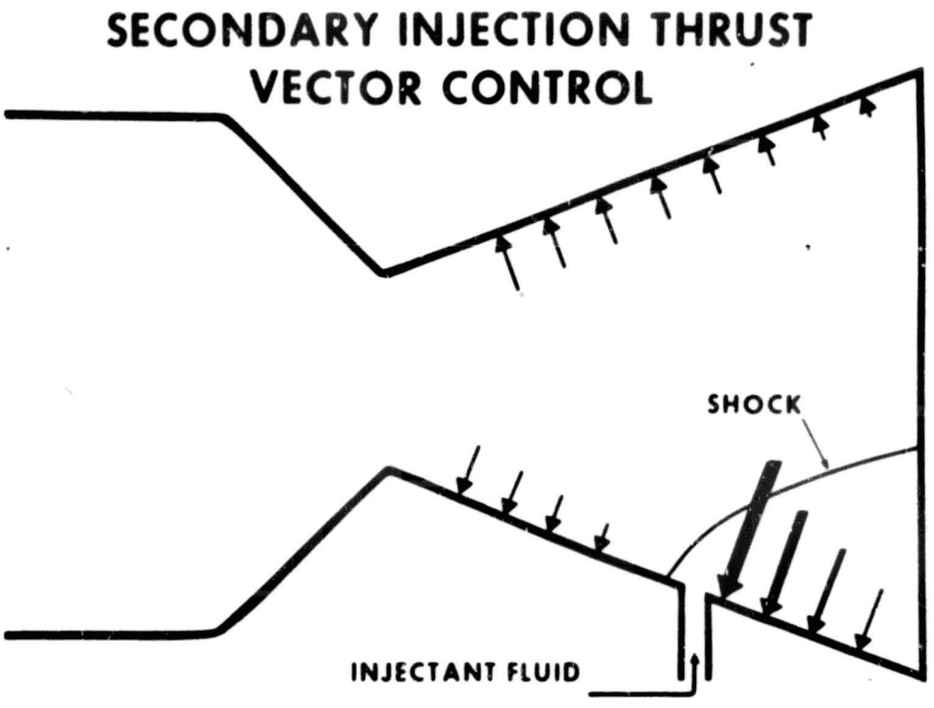
to the form shown in the third sketch. Here the leaves have rotated sufficiently to completely close the inlet and provide a large exit area nozzle for the rocket efflux flow.

We are also considering the potential of large solid rocket engines and hybrid types for Earth takeoff. NASA is working in close cooperation with the Air Force in a joint NASA–DOD solid engine technology program.

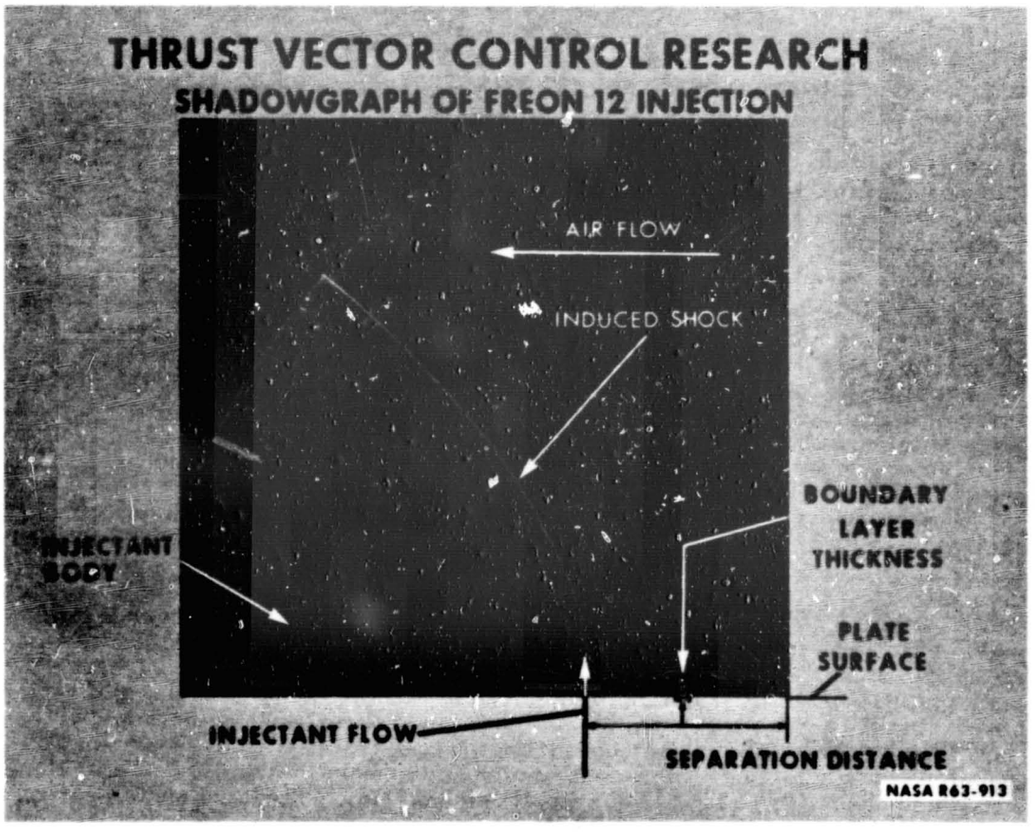
Engines for upper stages of boosters range from a few thousand pounds thrust for small boosters to the 200,000 pounds thrust of the J–2 engine for the Advanced Saturn. A large hydrogen-oxygen engine now in development, the M–1, has a thrust of over a million pounds. Upper stage engines generally complete their operation within minutes to a few hours after launch, and hence, boiloff of propellants or possible micrometeoroid damage to tanks are not major considerations. Most of these engines will use hydrogen and oxygen. Future trends for these types of engines will probably be toward high energy propellants, higher operating pressures, and new nozzle concepts similar to those previously discussed.

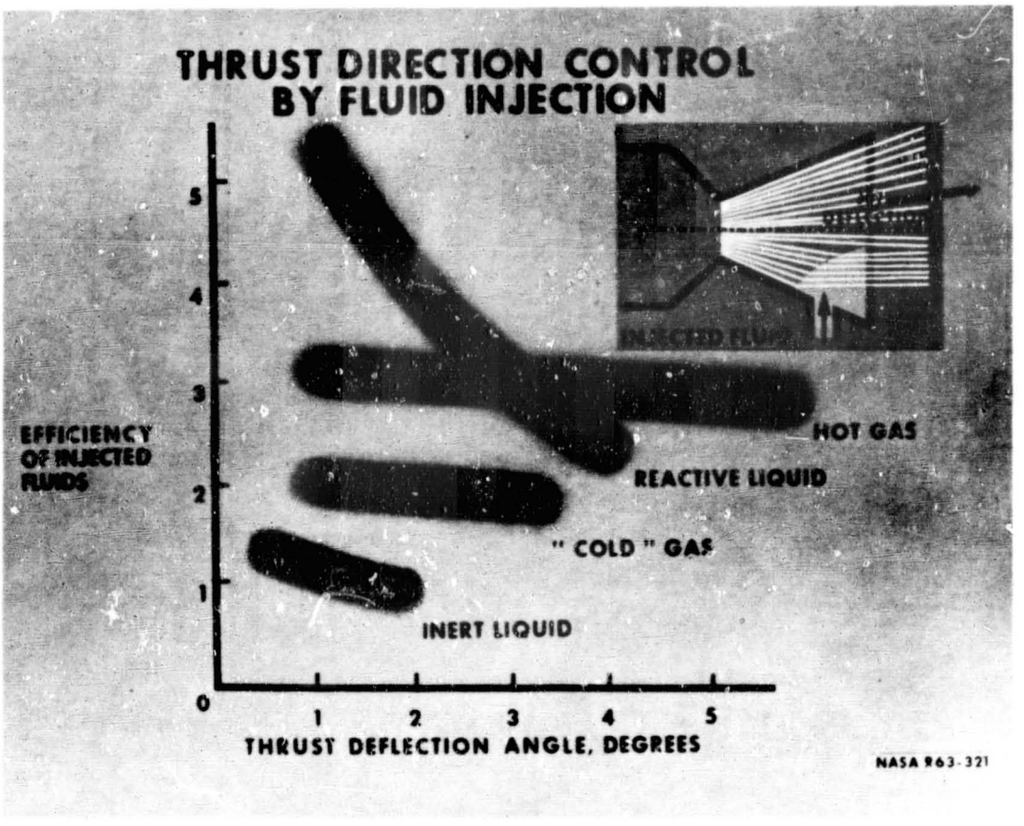
For large first and upper stage booster engines with large nozzles, some other method of trust vector control than the conventional gimballing is needed. One method which has received much attention is a technique of introducing a fluid in the nozzle as illustrated by figure R63–903. When the fluid is injected in the supersonic gas stream it induces a shock and the resulting higher pressure on local parts of the nozzle causes a side thrust. By using four such injection parts connected with suitable control valves, small thrusts normal to the main thrust axis can be achieved. Figure R63–913 is a shadowgraph of Freon 12 injection in a wind-tunnel study at JPL. The injectant body and the induced shock are clearly discernible.

Thrust vector control by secondary fluid injection has the advantage that the thrust produced by the incoming fluid is "magnified" in effect by its interaction with the main gas stream. The effectiveness of several types of fluids are illustrated by figure R63–321. The trends show potential advantages for hot gas and reactive fluids that should be further investigated.


SECONDARY INJECTION THRUST
VECTOR CONTROL
SHOCK
INJECTANT FLUID

NASA R63-903


THRUST VECTOR CONTROL RESEARCH
SHADOWGRAPH OF FREON 12 INJECTION
AIR FLOW
INDUCED SHOCK
INJECTANT BODY
BOUNDARY LAYER THICKNESS
PLATE SURFACE
INJECTANT FLOW
SEPARATION DISTANCE
NASA R63-913

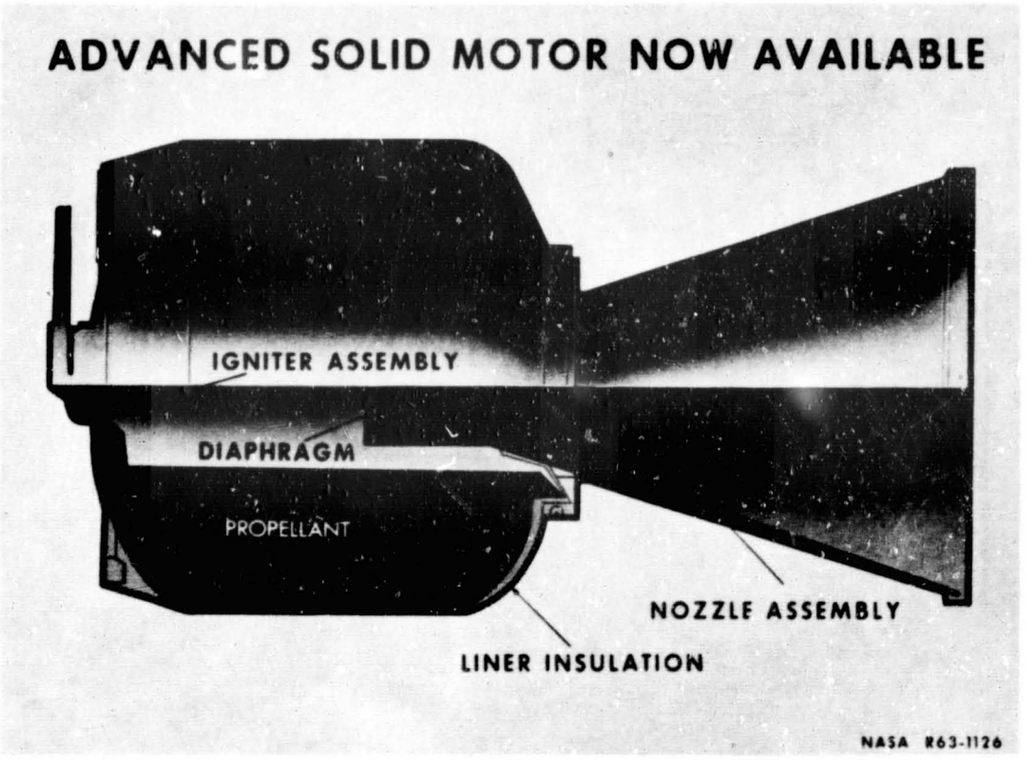


One of the methods of applying secondary fluid injection for thrust vectoring is to bleed combustion gases from the thrust chamber and inject them into the nozzle. This requires the use of a valve suitable for handling the hot combustion gases. In the past year the Allegany Ballistics Laboratory, under NASA contract, successfully operated such a valve for 76 seconds with 6,000° F. gas and during this time it was operated 27 times withoug leakage. Work will continue on this valve as well as on other studies to provide design criteria for thrust vector control by secondary fluid injection.

Advanced spacecraft engine technology

Engines for spacecraft must meet the stringent requirements imposed by the environment of space. In some cases, they must ride dormant or coast for long periods of time. Variable thrust and multiple starts are needed for most missions. This application places a premium on high-energy propellants, storability in the space environment, and high-propellant density. More work is needed on performance, cooling, and storability characteristics of various propellants in the space environment and the shielding necessary to safeguard the propellant tanks or cases against micrometeoroid penetration.

Figure 88 (p. 1900) shows the goals for solid motors for space use; high performance, compactness, stop-start capability, and thrust vector control. A typical present solid motor and an advanced concept with a swallowed nozzle are shown. The present state of the art of solid-rocket spacecraft motors is shown in further detail by figure R63–1126. The case is made of steel with titanium as an alternate possibility. The nozzle is partly submerged in the chamber and the hot sections are made of graphite and graphite cloth. The propellant contains polyurethane, ammonium perchlorate, and aluminum. The overall weight of this particular unit is about 71 pounds; it produces 900 pounds' thrust for 19 seconds. It has successfully withstood environmental tests of temperature, shock, vibration, and vacuum. The simplicity of a solid motor for one-time operation after a long coast in space is very attractive. Simple and precise thrust termination for one operation has been demonstrated but the problem gets more complicated if restart is required. Recent work at the Lewis Research Center showed that a very rapid decrease in pressure will quench combustion and this points the way to



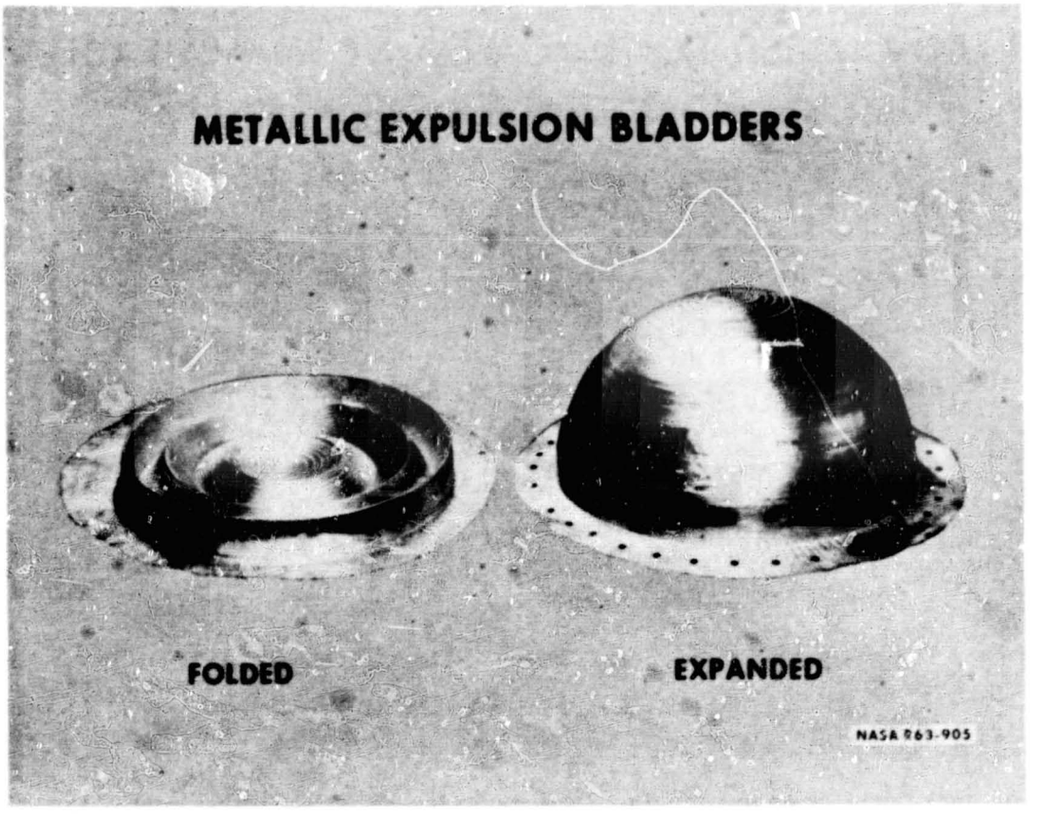
one technique for engine stop and restart. This, as well as other possiblities of stop and restart, will be investigated during the coming year.

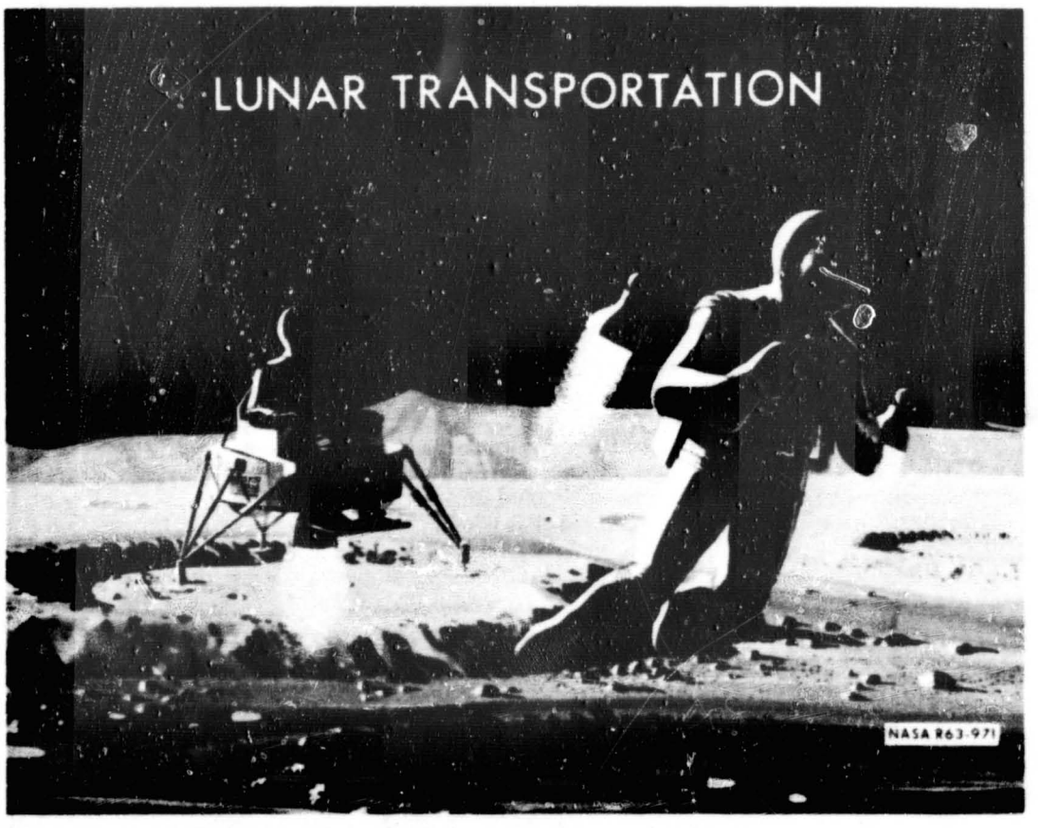
Hybrid rockets are more naturally adaptable to stop-restart and throttling requirements than solid rocket motors. This approach appears very promising and work on hybrids for such space applications will be investigated during the coming year.

Liquid-rocket engines for spacecraft must be able to start in a zero-g environment. The problem is mainly one of positive expulsion of propellants from the tanks to the thrust chamber. One method under investigation is by use of positive expulsion bladders. These must be able to withstand the corrosiveness of propellants and their operating temperatures. Figure R63–905 is an illustration of one investigation of a metallic expulsion bladder. Other types are being investigated and we are seeking techniques for self-sealing tanks in case of puncture by micrometeoroids. Other work is directed toward space-tank pressurization methods, catalysts for decomposing hydrazine, aerodynamic nozzle concepts, valves, zero leakage of components and fittings, variable-thrust injectors, and space-engine systems. Variable-thrust and multiple-operation requirements in space have opened up new possibilities in injector design. We started programs on controllable thrust several years ago and have three contracts underway at present (Reaction Motors Division of Thiokol Chemical Corp., Aerojet-General Corp., and Rocketdyne), which are examining different throttling techniques. Throttling has been accomplished successfully over a 10:1 range with a storable propellant and the work is being extended to cyrogenic propellants.

Another area of interest is a concept studied by Sperry Rand on instrumentation and control systems to sense an incipient engine malfunction and take corrective action in time to avoid the malfunction. Such a system is essentially a flight-weight computer which has built into it complete information of the normal and abnormal operating conditions of the propulsion system. As the monitored parameters vary the system would determine what the propulsion system would do next, makes a decision, and takes action to correct the problem. It would also inform the astronaut so he could take action if he chooses. In the limiting case the computer would shut down the propulsion system to avoid catastrophic failure.

Small space engines must be compact and versatile to meet the demands for attitude control, mid-course maneuvers, man-mobility, etc. They are generally called on for multiple operations spread over long periods of flight. To simplify fuel storage aboard a spacecraft a small space engine should use the same propellent


METALLIC EXPULSION BLADDERS
FOLDED
EXPANDED
NASA R63-905


LUNAR TRANSPORTATION
NASA R63-971

as the main propulsion system. It is more difficult to cool small enginess and obtain good performance than with large ones. Figure R63–971 shows the use of small space engines for lunar transportation, an area we wish to investigate in the coming year.

Experimental high-energy engine

We believe that the culmination of advanced research and technology is a feasibility demonstration which shows that the concept or system really works as predicted. It is desirable to do this before the start of a long and costly development program.

Much work has been done with fluorine as a high-energy oxidizer. It has been used in rocket engines with such fuels as diborane, ammonia, hydrazine, and hydrogen. The fluorine-hydrogen combination gives the highest performance yet obtained experimentally with a chemical reaction. Work accomplished at Rocketdyne, Bell, and the Lewis Research Center show that fluorine can be handled successfully and it gives high performance when used with several fuels. We want to carry his work a step further to a modest feasibility demonstration of a flight-weight engine. I say "modest" because it is not the intent to enter into a long and costly program with no end use definitely in mind. One possibility being studied is to build a small experimental engine in a size useful for a small solar probe but intended primarily as a research engine. Another possibility being studied is to use an existing engine with a minimum of modifications as a research tool. The latter possibility takes advantage of existing and developed hardware.

SPACE POWER

The major factors considered in power generation are the power level, duration, reliability, the environment in which the system must work, weight, volume, the hazard to people aboard, and cost. Figure 96 (p. 1919) shows a spectrum of space power with power level on the vertical scale and time on the horizontal scale. As previously mentioned, the space power to be discussed is that in which the energy source is solar or chemical. Power-generation systems using chemical energy generally fall in the short- to moderate-duration area and those using solar energy generally are of moderate to medium power levels for long durations.

Areas of interest in solar and chemical power generation are shown by figure 224 (p. 2321). These are solar cells, thermionics, thermoelectric systems, magnetohydrodynamics, solar heat engines, batteries, fuel cells, engines using chemical reactants, power conditioning and control equipment, solar concentrators, and thermal energy storage.

As for chemical propulsion, space power will be discussed in the subdivisions given in the budget book.

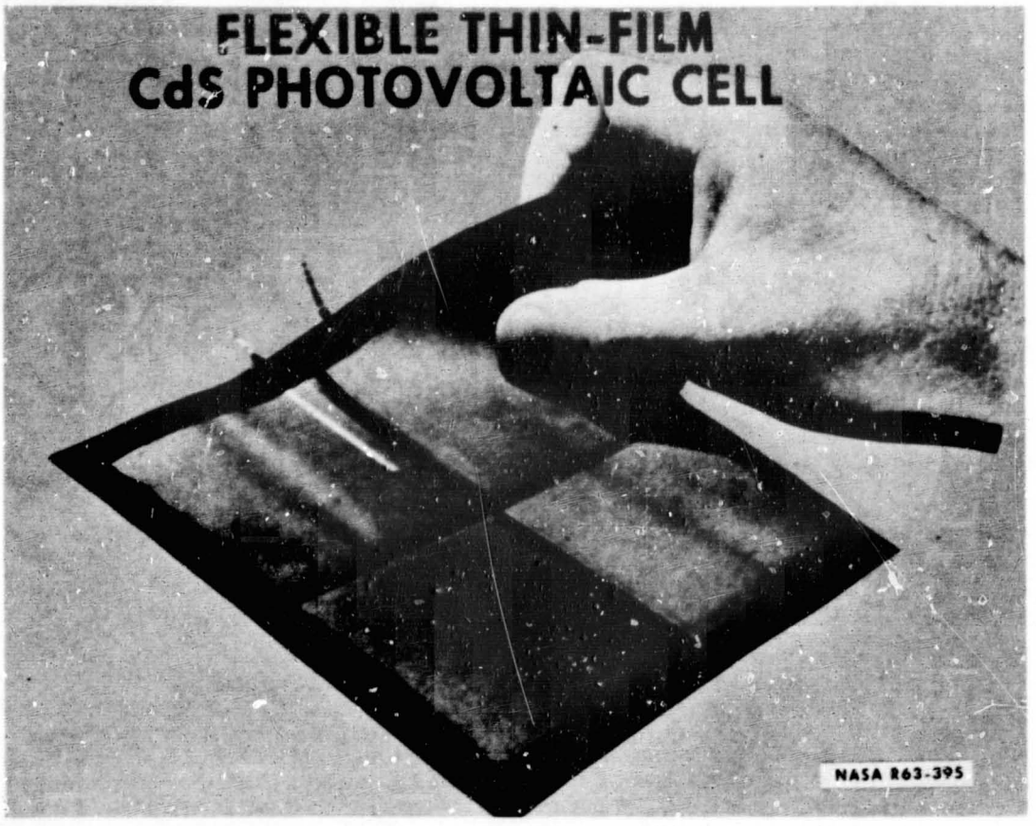
Solar cells

In solar cells, we wish to do more work to increase the efficiency over a wide temperature range, to increase resistance to radiation, and to decrease cost and weight. Solar cell power supplies, at present, vary from about 5 to 600 watts. The cells are capable of converting about 10 percent of the solar energy that falls on them directly into electrical energy. This amounts to about 13 watts per square foot. The total system efficiency is typically 5 percent based on total projected area of the solar panels. Temperature limits for solar cells are around 125° to 150° C. and at these levels efficiency is reduced to less than half its value at room temperature for some types. The development of types capable of maintaining high efficiency over a wide temperature range is one of our program goals. These will be needed for certain space vehicles which must operate in high temperature environments.

A major problem area in solar cells is their susceptibility to damage from space nuclear radiation. Last year radiation from a nuclear explosion in the upper atmosphere caused a rapid decrease in power of several satellites using conventional silicon "p-on-n" type cells. Figure 225 (p. 2322) shows how research has improved solar cell resistance to radiation. The comparison is made for an orbit similar to that of Telstar after a high altitude nuclear explosion. The conventional "p-on-n" silicon cell degrades rapidly in the first few days. A striking improvement can be realized by using "n-on-p" silicon cells now available and even further reductions in the rate of change of output power are possible with experimental "n-on-p" types being investigated for NASA by the Electro-Optical Systems, Inc. The efficiency of these cells, however, is somewhat lower than present ones and research is continuing.

We are interested in a number of other types of solar cells. Thin film solar cells, such as shown by figure R63–395, hold promise for reducing weight and allowing photovoltaic cells to be mounted on flexible surfaces. This work is underway at the Lewis Research Center and the Harshaw Chemical Co. A comparison of a present-day single crystal solar cell with the thin film goals is shown by figure 226 (p. 2323). If large thin film solar cells can be made to operate successfully on flexible surfaces then large solar cell areas can be stored in compact packages abroad spacecraft and unfolded in space or on the Moon or planetary surface. The technique holds promise for moderate power requirements in certain areas of the world as well. At present, thin film photovoltaics have very low efficiency and work to improve their efficiency and fabrication techniques for systems in the multikilowatt levels is one of our program goals.

Solar cells are quite expensive. Silicon cells are about $5 each or $300 to $400 per watt. Thin film cells may some day lead to significant cost reductions.



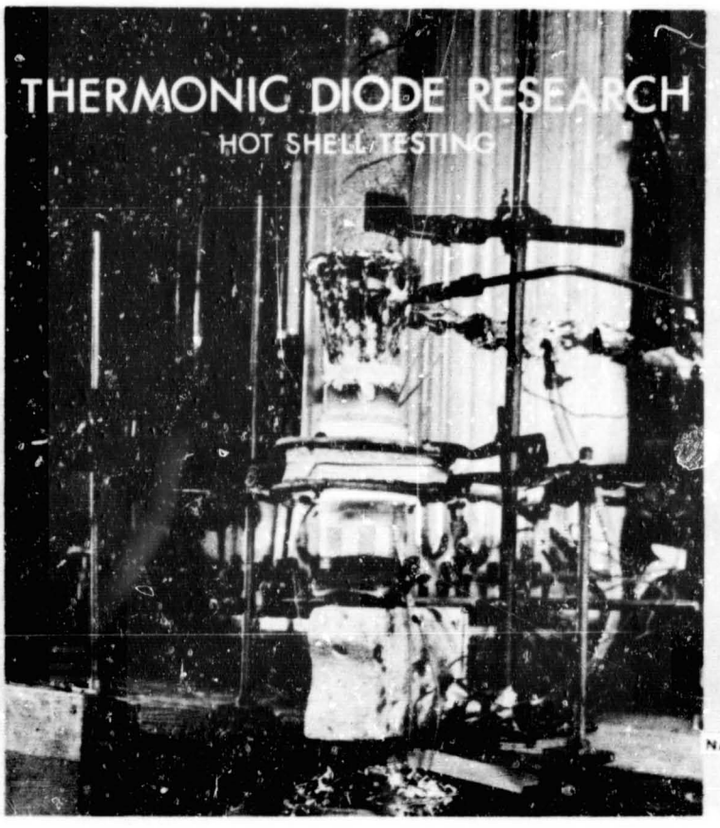
Thermionic power technology

Thermionic power conversion is of interest because of the absence of moving parts, high-power density, low weight, inherent resistance to radiation, capability of operation over a wide temperature range, and anticipated moderate cost. They are being studied for such applications as Mars, Venus, solar, and deep-space probes.

A thermionic diode converts heat directly into electricity. Picture two disks the size of silver dollars mounted parallel and very close to each other with the space between sealed. If one disk is heated and the other stays relatively cool by radiation, electronics boil off the hot surface (the emitter) and they migrate to the cooler surface (the collector). This creates a potential or voltage difference between the two disks making power available for useful work through an external circuit.

At present a generator the size of a baseball can put out about 60 watts. Present systems have efficiencies of 8 to 12 percent and a research goal is 20 percent.

Figure R63–920 is a photograph of a thermionic diode made by the Thermo Electron Engineering Corp. under test at JPL. The hot element must operate



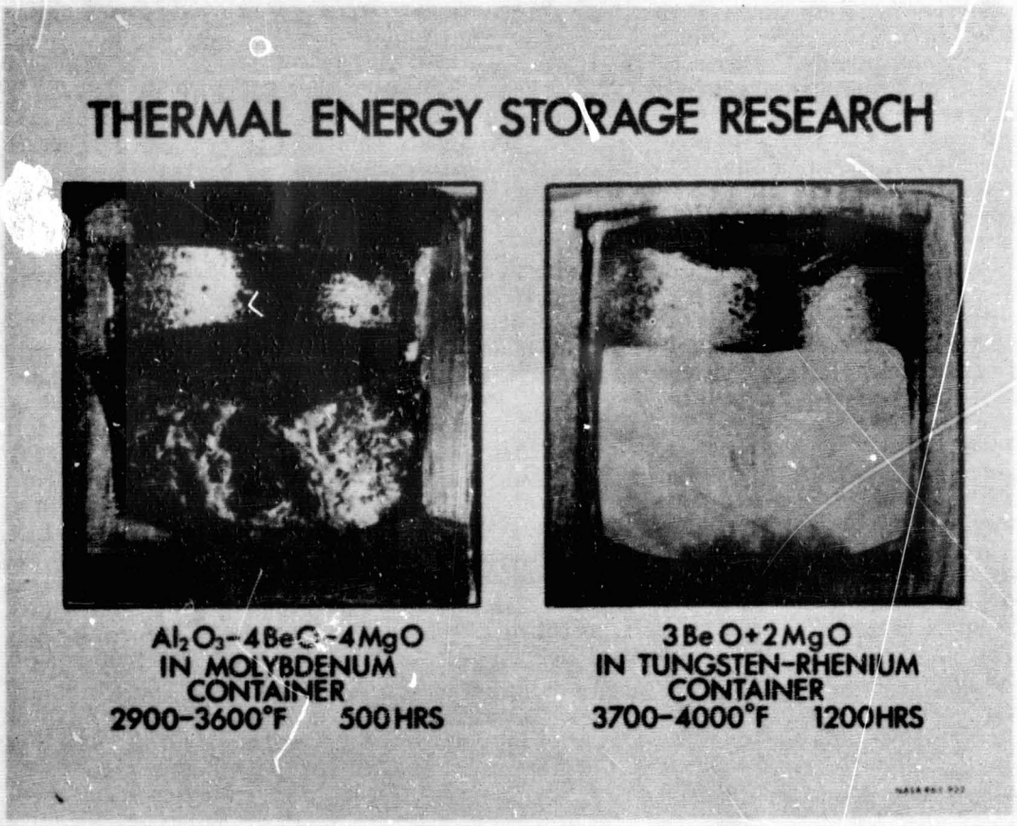
at temperatures above 3,000° F. for efficient power generation. In the past year a diode was operated for 1,000 hours.

The essential elements of the thermionic power system include a solar collector, an array of thermionic diodes, and associated energy storage and power conditioning equipment. Figure 97 (p. 1921) shows such a system with an array of five diodes enlarged by the insert. Work on this system is underway at JPL and with several subcontractors. The goal is a lightweight power system with a design goal of 135 watts at Mars, a 1-year life and a weight of the collector-thermionic diode array of about 30 pounds. The mirror or solar concentrator is 5 feet in diameter and is precision made by an electro-forming process. Figure R63–908 shows a 5-foot precision mirror made by Electro-Optical Systems undergoing tests in California.

Recently the collector-diode system was tested at Table Mountain, Calif., and delivered over 40 watts which is a record for this size system.

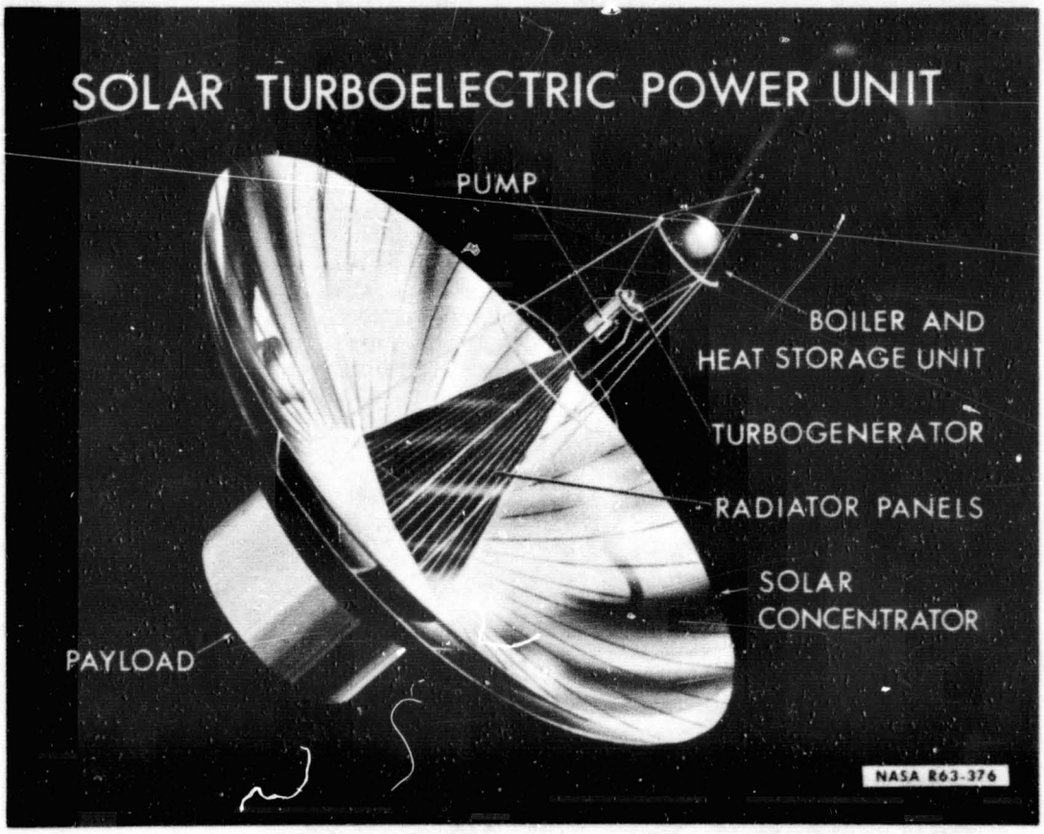
If a thermionic power system must operate for short periods in darkness, some substitute must be found for the heat from the Sun. This can be done by use of certain materials which operate on a principle similar to that of heated bricks placed in beds to warm the feet of children in early American days. This is termed "thermal energy storage" and a number of materials are being studied for this purpose. An example of two such materials are in work done by the General Electric Co., as shown by figure R63–922. One consists of aluminum, beryllium, and magnesium oxides and has been heated to 2,900–3,600° F. for 500 hours in a molybdenum container. The other is a beryllium-magnesium material which has been operated in a tungsten-rhenium container at 3,700–4,000° F. for 1,200 hours. We hope by research of this nature to find efficient means for storing energy in the form of heat for use at a later time. One can visualize all sorts of applications for such materials. In some distant time such materials in a home could use electricity in off-peak periods to store energy to be used later for heating or cooling.

EFFICIENCY TESTS ON FIVE FOOT CONCENTRATOR
NASA R63-908


THERMAL ENERGY STORAGE RESEARCH
Al_2O_3-4BeO-4MgO
IN MOLYBDENUM
CONTAINER
2900-3600°F 500 HRS
3BeO+2MgO
IN TUNGSTEN-RHENIUM
CONTAINER
3700-4000°F 1200 HRS

Solar engine technology

Solar energy can be harnessed to drive turbines which can power electric generators. Such a system is shownby figure R63–376. It consists of a solar concentrator, a boiler and heat storage unit, a turbogenerator and associated pumps, radiators, and other components. Work is progressing at present on a 3-kilowatt power unit called Sunflower, shown by figure 98 (p. —) During the past year, tests of the turboalternator, the boiler and radiator, and the 32-foot diameter foldable mirror were made by Thompson Ramo Wooldridge, Inc. The turboalternator operated successfully for 2,500 hours before a failure from a buildup of corrosion products in the mercury loop occurred. This long run was a significant achievement and improvements are being made so the life can be extended to the 10,000 hour goal. Results with the radiator, however, have been disappointing and a redesign is being studied. The 32-foot diameter petal-type aluminum honeycomb mirror has undergone launch environment and several optical tests. Work is underway for sunlight tests. Mirrors for such applications need not be as precise as for thermionic diodes. Those which can be folded or made from large inflatable structures may be useful. Figure 228



(p. 2326) shows such an inflatable concept. This work is carried out through the Langley Research Center. We visualize power generation systems of this type for 30 or more kilowatts.

Batteries and fuel cells

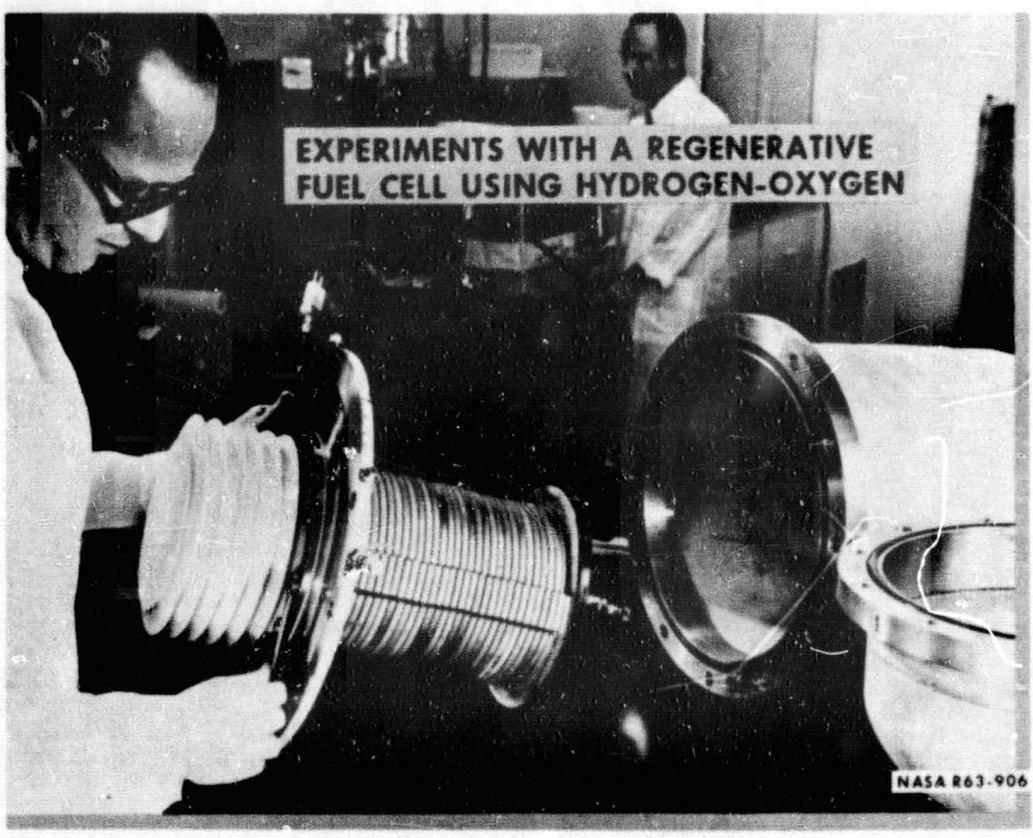
Batteries and fuel cells convert chemical energy directly into electricity. Batteries are the primary method used today for energy storage in space. They are complementary to solar cells as they take care of peakloads and provide power when satellites are out of the sunlight. Tiros, for example, uses 40 pounds of batteries for an average power consumption of 18 watts.

Space-rated batteries differ from the familiar ones in everyday use in that they are sealed and must be able to contain moderately high gas pressure. Most of the present rechargeable ones contain alkaline electrolyte and nickel and cadmium electrodes. Other types use silver and cadmium or silver and zinc electrodes, which hold promise of higher energy per pound, although at present their charge-

discharge cycle life is shorter. Program goals are to get higher energy per unit weight, lower sensitivity to thermal environment, and increased life (both in standby and discharge-recharge cycling). During the past year advances were made in better seals in batteries for longer life and greater reliability. Explorer XII was the first satellite to use sealed nonmagnetic silver-cadmium batteries. They performed very satisfactorily and showed no deterioration during the life of the satellite. A recent study by the Armour Research Foundation estimates that in 1967, up to 35,000 batteries will be used in connection with spacecraft missions. Major technical problems were identified as case-to-seal leakage, separator deterioration, and loss of electrode material. We are planning to do work in these areas and also conduct research on new types of batteries. Some work on new systems has indicated potential improvements up to 25 times in the useful energy per pound as compared with nickel-cadmium, and work is needed to explore these possibilities.

Fuel cells are like batteries in that they convert chemical energy directly into electrical energy. They are capable of high conversion efficiencies (over 50 percent), are compact, and have few or no moving parts. The oxidizer and fuel for fuel cells are fed to the cell from an external supply and the products of reaction are removed from the cell. Apollo and Gemini spacecraft will use oxygen and hydrogen and the product, water, can be used by the astronaut. The one for Apollo uses porous nickel metal plates as electrodes with an electrolyte of potassium hydroxide solution placed between them. Oxygen enters on the back of one electrode and hydrogen on the back of the other. The gases ionize, electrons are released at the hydrogen electrode and travel through an external circuit to do useful work and return to the oxygen electrode. The Apollo system is a Bacon-type cell, the initial work of which was first done in 1932. The Gemini cell uses an ion exchange membrane which is an example of an older technology being put to a new use in space applications.

In a regenerative fuel cell, the product formed is dissociated to regenerate the reactants so that they can be reused. An illustration of an experimental regenerative oxygen-hydrogen cell is shown schematically by figure 229 (p. 2327), and a unit built by Electro-Optical Systems is shown by figure R63–906. The regeneration, not illustrated, can be an electrolytic process. Other systems with other products may use heat or light in the regenerative process.



Regenerative-type cells will be especially useful in systems involving solar energy such as solar cells. During sunlight periods the solar cells can meet the power demand and regenerate the chemicals for the fuel cell and during periods of darkness the fuel cell can supply needed power. Regenerative fuel cells, like rechargeable batteries, should prove very useful for mobile equipment in many Earth as well as space applications. We are interested in other fuel cell types. We are seeking other high energy reactants on the main reactants carried aboard the spacecraft as, for example, oxygen-hydrogen, or nitrogen-tetroxide and a hydrazine mixture. Figure 230 (p. 2328) shows an experimental piston engine built by Vickers using hydrogen and oxygen. Problems encountered include lubrication, cooling, and oxygen injection.

Thermoelectric, magnetohydrodynamics, and advanced concepts

We are also studying and experimenting with other power generation devices. Some work on the direct conversion of heat to electricity by the use of thermoelectric couples is included. The principle is the same as that by which the common thermocouple operates. Unlike the classical bimetallic couple which did not deliver useful power, present devices of this type use semiconductors and are capable of converting about 5 percent of the heat to electricity. Although thermoelectric conversion has been used in connection with space isotope power supplies, our interests have been more limited because of the apparently great potential of thermionic conversion. New concepts are being studied, however, which may raise the energy conversion efficiency.

Magnetohydrodynamic power generation is the technique by which heat may be converted to electricity by passing high velocity ionized gases through magnetic fields. This is and those that offer advantages in the regenerative cycle. Also, we wish to increase the temperature range of operation and seek better techniques for removal of products formed as well as heat. Electrode research to reduce poisoning of catalysts and increasing catalytic activity and longevity are planned. Work is underway on a technique of pulsed operation of fuel cells to reduce sysem weight and extend operating life. Under this concept either the pressure of the oxidizer and fuel is pulsed intermittently or the current is chopped. Preliminary results are encouraging. Another type of fuel cell of interest is one using human waste products. Although this will require a net power input, the cell may be quite useful as part of a closed ecological system processing waste at a minimum energy expense and producing reusable products.

Chemical engines

Chemical engines are useful for missions lasting from a few hours to a few days or for intermittent use for longer periods. There are a number of different engine types—piston and turbine, that may be useful for space applications. Their weight is less than that of fuel cells but they are less efficient and use more reactants. Such engines should operate analogous to the conventional electric generation with the copper wires replaced by the ionized gas or conductive plasma. Some experimental work is being done to study the usefulness of this technique for generating space power.

In addition to the basic problems of power generation, a comprehensive research and development program must also be concerned with the related problems of conditioning, distributing, and controlling the electrical power throughout the spacecraft.

Typically required for this purpose are inverters (for changing d.c. power to a.c.), converters (for changing d.c. voltage), voltage regulators, battery monitoring and charge control circuits, current limiters, and electrical connectors.

As spacecraft missions become longer and more sophisticated, the electrical distribution and control system becomes proportionately more complex. For example, improvements in navigation and guidance capabilities can impose more severe frequency regulation requirements, more sensitive instrumentation for space experiments creates specialized problems such as closely regulated voltages over wide temperature ranges, minimum use of magnetic materials, etc. Longer mission times further emphasize reliability problems, and efforts to attain higher battery cyclic life must be supported by improved battery charge control methods. Power systems for space stations and for lunar bases are expected to introduce other unique electrical distribution and control problems. An example of such work is a contract with Westinghouse to adapt the "molecular electronics" technique to a power supply (inverter) synchronizer.

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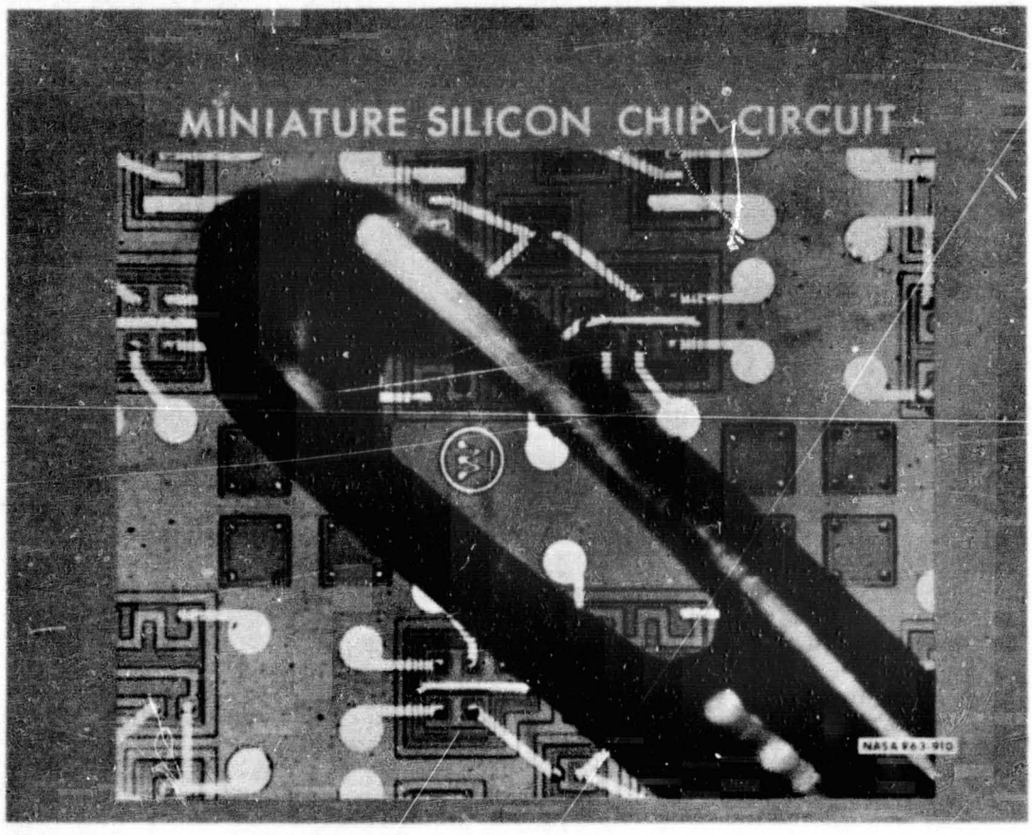
For a three-phase inverter, it is necessary that each phase be frequency controlled and the relationship between phases be synchronized. These functions are performed by a logic circuit generally referred to as the synchronizer.

Conventional synchronizer subcircuits include many transistors and resistors, require many electrical connections, and thus contribute severe quality control and reliability problems to the overall inverter.

The molecular electronics technique is expected to markedly increase reliability of the synchronizer through reduction of the number of discrete circuit elements and electrical interconnections. The reduction in circuit elements can be appreciated by consideration of figure 231 (p. 2329).

The developmental synchronizer is shown in the center of the figure with a coin for size comparison. The other parts shown are those which are presently required to fabricate an equivalent synchronizer from conventional transistor and resistor components.

While improved reliability is the primary objective, it is apparent that major reductions in size and weight will also result. Such reductions are, of course, highly desirable and can, in turn, enhance reliability through permitting more redundancy in the system. The size reduction is further evidenced by figure



R63–910, which shows a standard household needle in close proximity to the experimental device.

In summary, I have described some of the things we have done and plan to do in propulsion and space power. We hope, by coordinated efforts in Government centers, universities, and industry, to lay a solid foundation of knowledge in these areas as part of American leadership in space exploration and to benefit mankind in general.

Mr. SLOOP. Thank you.

I did think I would use some of the slides and talk informally about the material in the statement.

Mr. KARTH. I might say this, Mr. Sloop. This is of particular interest to the subcommittee. We feel we have many propulsion

problems, and we have a long ways to go in this area. So you just take your time; we are not going to hurry you at all.

Mr. SLOOP. All right.

I want to amplify the statements Dr. Bisplinghoff has made in the areas of chemical propulsion and power generation where the energy source is solar or chemical. I will start with chemical propulsion. This slide (fig. 217) shows the areas of interest in chemical propulsion. In engine components and systems: it includes engines using liquid propellants, solid propellants, hybrid engines, or both liquid and solid, those using solar energy, and those using air augmentation.

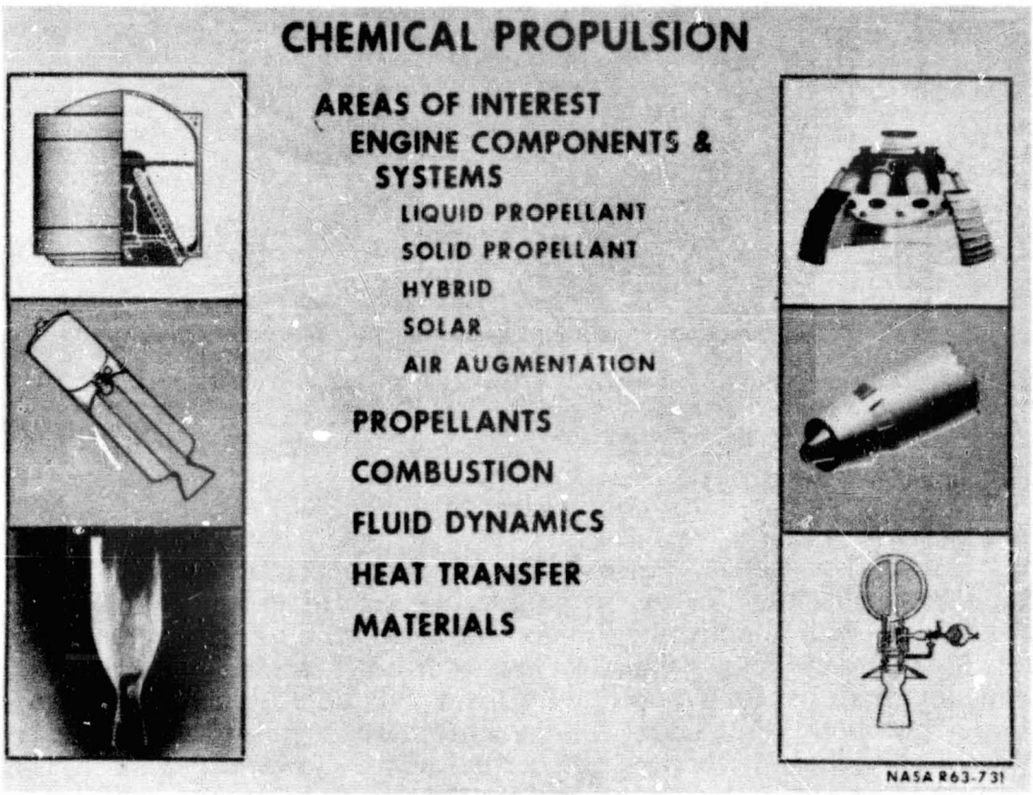


FIGURE 217

We are interested also in various disciplines concerned with these engines—high energy propellants, combustion phenomena; fluid dynamics (including the propellant flow from the tank through the pumps, valves, lines, cooling jacket, and the combustion of the gases as they expand through the nozzle), heat transfer, and materials.

Shown in this slide starting with the upper left is an advanced solid-propellant motor, a hybrid motor, a spacecraft engine being radiatively cooled.

In the upper right is a concept of a large launch vehicle engine, one using air augmentation; and finally, a schematic of a space engine.

Mr. KARTH. Is that the sample you have here?

Mr. SLOOP. Right. I will bring that up in a moment.

This slide (fig. 218) illustrates one of the problems we have been working on in the propellant area and in aerothermodynamics. On the left is shown a scale of relative specific impulse, which is the figure

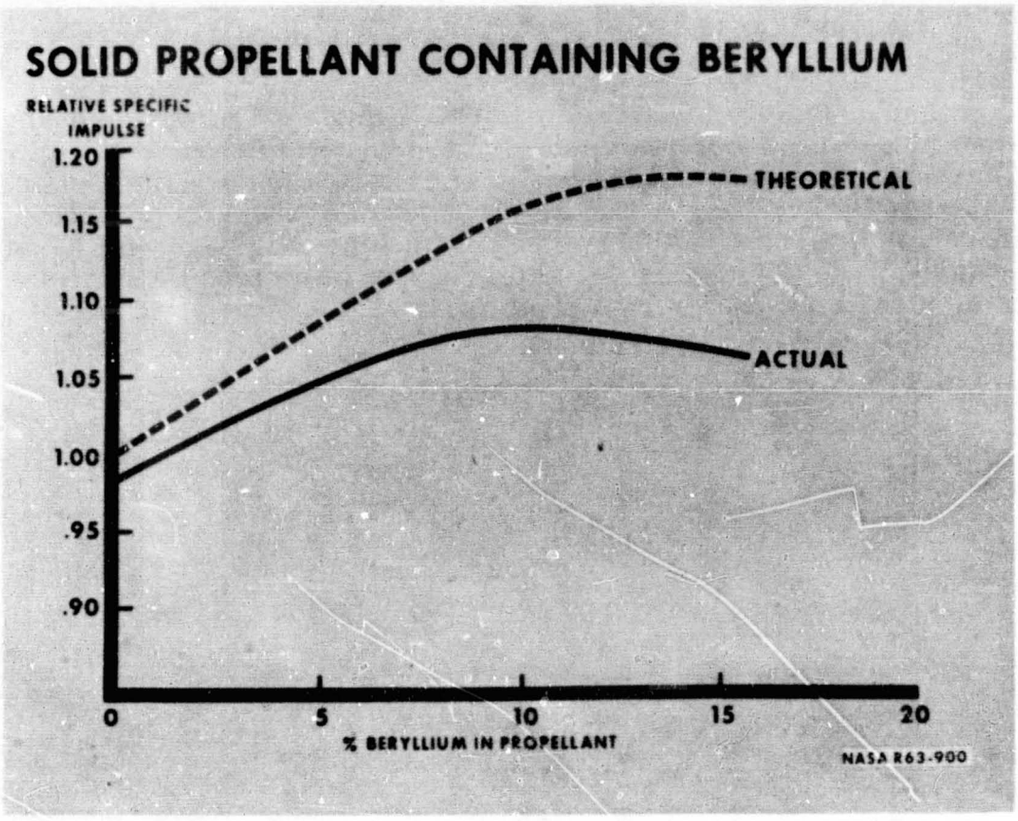


FIGURE 218

of merit that a rocket man uses to judge a rocket propellant. It is the thrust obtained for every pound per second flow of propellant. The horizontal line indicates the percent of beryllium in the propellant. The dotted curve shows what we expect from theoretical calculations. You notice the actual case doesn't bear this out. Theoretically we should get between 15 and 20 percent more impulse with, say, 15 percent beryllium, whereas the actual case shows the gain to be between 5 and 10 percent, and with a maximum at 10 percent.

Mr. KARTH. In basic engineering I was taught if the actual curve were substantially less than the theoretical curve that it might be because insufficient testing had been done and that you had some unknown mechanical limitations.

Let me ask you this: How much testing have we done? What kind of engine have we developed by which we test the new propellant containing beryllium? And is there a possibility that this is the shortcoming that throws the actual curve off so much from the theoretical curve?

Mr. SLOOP. What you say is possible, about the amount of testing. When you get anomalies like this you do go back and make more tests and examine the data and measurements, to be sure of the results. If you get the same result consistently you look for something else. For example, a number of years ago a young research worker at Aerojet General Corp. was given the job of calibrating a flow meter for the measurement of fluorine flow. Normally you obtain data by water or nitrogen calibration and convert by density ratio to the

fluid of interest. He obtained a curve parallel to what he expected, but lower than the actual case in which he measured fluorine flow. He repeated the test over and over again and finally started to suspect that there was something wrong with the basic data he was using. The density he was using was the standard text book value for fluorine, of 1.1 specific gravity. I think that was determined by a Japanese worker many years ago. This young man had the courage of his convictions to suspect the number was wrong. And sure enough, on new tests it was found that the real density of fluorine was 1.54, and so they had to correct the textbook values. A year or so ago I examined some engineering textbooks, and some still carried the old value. This is an example of testing and retesting when unsuspected results arise and if consistent it can mean something wrong in your basic assumptions.

Mr. KARTH. What was the thrust of the engine in the case where this solid propellant was tested?

Mr. SLOOP. I am sorry, I don't recall the thrust.

Mr. KARTH. Can you give me an idea? Was it 200, 300, 400, 500 pounds?

Mr. SLOOP. Generally in the area of 150 to 200 or 300 pounds thrust; that is, laboratory scale engines.

Mr. KARTH. Couldn't the curve be thrown off considerably for just this reason?

Mr. SLOOP. Yes. If you notice in this curve the difference between the theoretical and actual gets larger as the amount of beryllium increases. One reason could be incomplete combustion.

Also, in the exhaust you have solid particles and gas, and these two could be flowing at different velocities. The theory assumed the solid particles and gas were going out the nozzle at the same velocity. We conducted studies to examine the size of the solid particles and see if we could calculate what the actual velocity should be.

This slide (fig. 219) shows some results from tests where the solid particles in an actual rocket firing are caught and their size measured. On the left is aluminum oxide, on the right is beryllium oxide. The scale in one of the pictures is shown; the photographs are magnified 26,000 times. You can see that the particle sizes and shapes vary, depending on the material used. So we get a distribution curve of particle size, and this complicates the equations. This sort of thing could be one explanation for the discrepancy between actual and theoretical performance.

This work is still going on. I only bring it up to illustrate to you the nature of the work we are doing.

Mr. KARTH. I understand that; yes, sir.

How much money have we spent on testing this type of motor?

Mr. SLOOP. I don't have the breakdown for this motor. In fiscal year 1963 we spent $1,136,000 at JPL in the area of solid propellants.

Mr. KARTH. The whole area of solids?

Mr. SLOOP. At JPL.

Mr. KARTH. Do you recall how much we spent or will spend in fiscal year 1963, in the whole area of solids?

Mr. SLOOP. A little over $4 million for advanced research and technology in solids per se. If we apply some of the basic research Dr. Kursweg discussed that may have application to solids, then the total for OART will be $5,726,000 in fiscal year 1963.

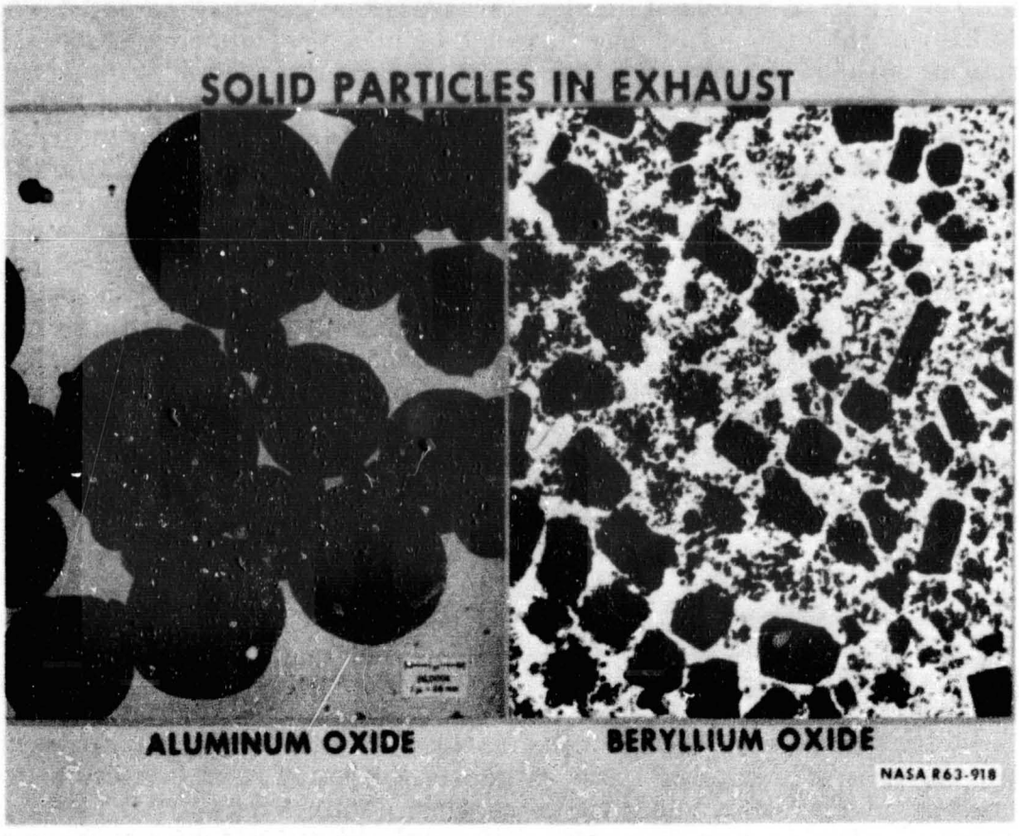


FIGURE 219

Mr. KARTH. Mr. Sloop, how much was budgeted in fiscal year 1963, and how much of it was spent?

Mr. SLOOP. The amount I quoted is the amount budgeted, and that is the amount we intend to spend.

Mr. KARTH. How about fiscal year 1962?

Mr. SLOOP. Fiscal year 1962, $2,041,000. This is what we call direct R. & D., not including personnel cost for advanced research and technology.

Mr. KARTH. I understand.

Mr. SLOOP. In fiscal year 1963, $4,026,000 for advanced research and technology.

Mr. KARTH. How much was requested in fiscal year 1962?

Mr. SLOOP. Plus—excuse me. Plus some additional funding which was in the area of high-temperature materials, handled by Dr. Kurzweg.

Mr. KARTH. Is that how much was requested and how much was spent, in fiscal year 1962?

Mr. SLOOP. $2,041,000, sir, in advanced research and technology.

Mr. KARTH. That was requested?

Mr. SLOOP. Spent.

Mr. KARTH. And spent.

Mr. SLOOP. I don't know about the requested portion. This was before I took charge of this work.

Mr. KARTH. I think it is rather important. Would you for the record be sure we have the information on how much was requested

in fiscal year 1961, and how much was spent, and how much was requested in 1962 and how much was spent, in these various fields, that is in this field of propulsion? I believe you might want to break it down, solids versus liquids, or whatever jurisdiction your office has in this field.

Mr. SLOOP. I believe those numbers are available to you. I will get them.

(This was to be submitted for committee records.)

Mr. KARTH. It would be nice to have them all together in the record. We have authorized large amounts of funds in the last few years. I would like to take a look and see whether these funds have been programed out of our area.

Mr. Randall.

Mr. RANDALL. For the record, from time to time in these hearings, Mr. Chairman, you have said "submitted in the record," and I can't find some of the things, I don't know when we are going to have them in the record. I am behind, but I am going to catch up pretty good in this thing. The only way I can do it is to read the record. Time and time again we have asked for those things and I can't locate them. I would like to know where we are on this thing.

Mr. KARTH. I will defer to Mr. Hammill, the counsel.

Mr. HAMMILL. The transcripts I have sent up to your office, Mr. Randall, did not include the items asked for from time to time by the committee for insertion in the record. Those are in various stages of preparation by NASA, and before we go to the GPO to have the transcript printed, we will be sure each one has been received.

Mr. RANDALL. If I may say so, I think we need them before we have it printed. I would like to know as we go along where we are.

Mr. KARTH. I think so.

Mr. HAMMILL. It takes NASA some time to prepare this material and to get it to us.

Mr. RANDALL. I wrote to NASA on March 10, I think it was, and got an answer this morning, and it is exactly like some of the things we asked for in committee. It wasn't what I asked for at all.

Mr. KARTH. Maybe we just don't mark up until after the hearings are printed, I don't know.

Mr. RANDALL. Yesterday, for example, there was a multitude of figures submitted which I don't have the benefit of. It was ordered to be submitted in the record. Now, are we going to have it in the record when it comes out in bound volumes, or will we have it in a week or two, or when will we have it?

Mr. KARTH. I think counsel understands we want it as soon as possible.

Mr. RANDALL. I want to say for the benefit of the chairman, I hope to go through every day of these hearings and find out where we are.

Mr. KARTH. I am in complete agreement.

I think we would like the figures for the last 3 fiscal years.

Mr. SLOOP. We are doing work in solid combustion at three universities—Princeton, Purdue, and Minnesota; and at three NASA Centers—Jet Propulsion Laboratory (the work of which I illustrated), Lewis Research Center, and the Langley Research Center.

I might mention in passing an example of cooperative effort between various Government agencies is the work at Princeton. I understand it is supported jointly by the Air Force Office of Scientific Research,

Office of Naval Research, ARPA, and NASA. These funds are lumped together in this work on fundamentals of combustion of solids at Princeton.

We are also interested in high-energy liquid propellants. One of the combinations we have examined recently, particularly for spacecraft, is oxygen difluoride and diborane. This combination is of interest because the performance is near that of hydrogen-oxygen, which we are using in our space program, and its density is about three times greater, so we can pack more energy into a given volume. It has another interesting point in that both the fuel and oxydizer are liquid at a temperature of around −250° F., and if a spacecraft designer is clever enough to design his insulation and shielding right he can maintain propellant tanks at −250° F. in space, and hence this combination has the possibility of being space storable. This is better than liquid hydrogen, at −420° F.

Mr. KARTH. What has been your experience with tests on this?

Mr. SLOOP. Here is a slide (fig. 220) that illustrates. Specific impulse is plotted on the vertical scale, and the ratio of oxidizer to fuel is plotted on the horizontal scale.

The theoretical specific impulse remains relatively high over a broad mixture region, and a vehicle designer would like to go as far to the right as possible because the oxidizer is four times as dense as the fuel, so the farther to the right he goes the denser the combination of the two.

Actually, experimental data, however, show a rather sharp peak at a mixture ratio of around three and a half, and this has caused us

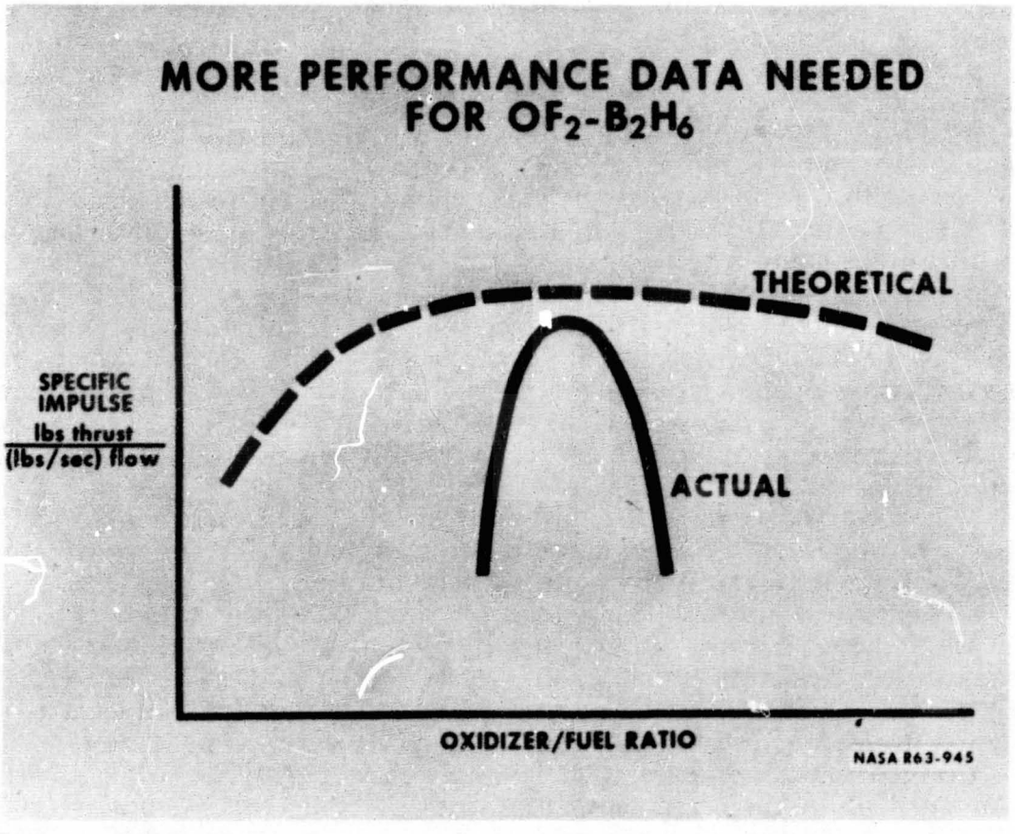


FIGURE 220

quite a bit of puzzlement. We are trying to find out now why this occurs: Was it the injector we used? Is it a combustion phenomenon? We don't know.

Mr. KARTH. Were all the injectors the same kind?

Mr. SLOOP. Three of them were, one was of a different type. They used four different injectors.

There is another problem here, in that the tests were conducted at fairly low chamber pressure because we were interested in low pressures for a space engine. Also, the engine was a fairly small one, 150 pounds' thrust. We have already started follow-on work to examine this question using a larger thrust engine. Our primary goal is to ascertain if we can get high performance over a broad mixture range. We think this is our first need.

After we get high performance over a broad mixture ratio we would like to examine whether or not we can get the theoretical performance in a large nozzle under altitude-simulated conditions.

If we pass those obstacles, there remains still a large one, namely, how to cool this combination. The theoretical flame temperature for difluoride-diborane, can be as high as 8,000° F., far higher than any materials which we have today will stand. We have to devise other methods of cooling. As you know, rocket engines use one of the propellants as a coolant whenever possible, but that is not possible in this case, because neither oxygen difluoride nor diborane are very good for cooling; both decompose when heated. Further, if OF_2 decomposes into oxygen and fluorine, and if the temperatures are very high fluorine will attack the metal itself, consuming it as a fuel. So we are considering other cooling methods, such as film cooling, a relatively cool layer of gas is maintained along the walls of the combustion chamber and nozzle. We are also considering ablative materials. We hope to find ablative materials to withstand this very high temperature and the fluorida atmosphere. This is a new area for us. And——

Mr. KARTH. Is the temperature requirement for the ablative material for the Apollo project unclassified information?

Mr. SLOOP. Yes. I can give you the flame temperature of the mixture. I think it is in the order of 5,000° F. I don't have the exact number in front of me.

Mr. KARTH. Thank you. I think that is all right. How much money have we spent on this combination fuel up to date, Mr. Sloop?

Mr. SLOOP. We have spent, as Dr. Bisplinghoff mentioned in his testimony, over $1 million in this area in fiscal 1963.

Mr. KARTH. This is peanuts, isn't it? In a $6 billion program, when you spend only $1 million in research on fuels; well, if you don't have the proper fuels you might as well forget the whole thing, and stay on the ground. I agree electronic components are very important indeed, but the magnitude of expenditures, I must say, is quite substantially different.

Mr. SLOOP. This is not peanuts in research.

Mr. KARTH. I am not so sure we are really meeting the need, at all, by spending such relatively insignificant amounts of money. This committee would like to help you, Mr. Sloop. If you feel you could and would do a much better job if you had more finances with which to do it I think this committee would very much like to take under consideration the possibility of helping you. This committee is not

here just to see where they can reduce the budget requests, I might say. We would like very much, if it is necessary, to take a look at areas where budget requests should be increased. This might be one of them.

Mr. SLOOP. We have a very competent contractor working on this program for us right now. One of the first and pressing questions, is, of course, can we get this high performance. Based on the results that we will obtain, or they will obtain for us, this will help us plan our next step, and how much and to what extent we should go into this in the future.

Mr. MORRIS. Mr. Chairman.

Mr. KARTH. Mr. Morris.

Mr. MORRIS. In line with the Chairman's question, exactly how much progress have we made in production since Redstone? What have we done to improve the propulsion of our vehicles since the Redstone? How have we improved them?

Mr. SLOOP. I have seen—if you would line up, say, the V–2, the Redstone, and the Atlas and H–1 engines all in a row, I think this would be brought out dramatically. We have decreased their size, decreased their weight, and increased their performance—and, I believe, reliability.

Mr. MORRIS. By performance do you mean specific impulse?

Mr. SLOOP. Yes, sir. The Redstone, used alcohol and oxygen, and the engines for our boosters, Atlas and the first Titan used oxygen and kerosene, which has higher performance than the oxygen and alcohol. The alcohol had water in it, it was not neat. The big gain in performance, though, Mr. Morris, came when we went to hydrogen and oxygen in 1958. The first contract for the development of an engine using oxygen and hydrogen, the RL–10, was started in about 1958. This was preceded by a number of years of research on the laboratory scale, similar to the types I have mentioned here in connection with oxygen difluoride and diborane. Some of this work on oxygen and hydrogen goes back to the 1945, 1946, 1947 period, and I recall a thousand pound thrust engine Aerojet ran in 1949 for the Navy, and at the Lewis Research Center I had a part in working with hydrogen from 1950 through 1960.

Mr. MORRIS. Couldn't you solve a lot of the problems in electronics, guidance, whatever you have, if you had the ability to pitch a large enough bundle up there?

Mr. SLOOP. If we can provide the muscle to get up into space, we still need the guidance to tell us where to go.

Mr. KARTH. Would the gentleman yield?

Mr. MORRIS. Yes. I assume you have to have something; but wouldn't these other problems be a lot simpler if you had the propulsion to get it up there?

Mr. KARTH. I think Mr. Morris' question really is: If we didn't need to pay as much attention to miniaturization and microminiaturization, this very sophisticated art, the need for less attention in that area could be brought about perhaps as a result of doing more work in propulsion; and wouldn't we be better off in the long run, and wouldn't we save some money, and solve some of our problems? I think that is his question.

Mr. SLOOP. The velocity of a vehicle depends on the specific impulse and the relative weight of the vehicle full and empty. If the

empty weight is high, meaning, say, you had heavy components instead of light ones, this weight would decrease the performance of the vehicle.

Mr. KARTH. Oh, surely. But Mr. Morris was inquiring whether or not the weight factor would be quite as important if we were developing propulsion at a much more rapid pace.

Mr. SLOOP. It is a matter of balance. Yes.

Mr. KARTH. I know it is difficult for us to ask a question here that is going to cause an argument between you and another division of the OART. Dr. Bisplinghoff is sitting right next to you, and that makes it doubly difficult. I am sure Mr. Morris understands, I certainly do. But I think sometimes the subcommittee has to have a better understanding, too, of the problem involved here. Mr. Morris' feeling apparently is that maybe here is an area where we are not giving enough attention, as opposed to, for example, the supreme effort and attention we are giving to very sophisticated microminiaturization in the field of electronics.

I don't want to do anything to kill Johnny Sloop. But see if you could address yourself to that, would you?

Mr. SLOOP. By my last slide you will see that I, too, am interested in weight reduction and increased reliability in electronics systems for power generation. In propulsion we can gain performance by reducing the empty weight.

Mr. KARTH. Well, we will take a look at the record after awhile and find out what you said. We will probably have to get back to you next week.

Proceed.

Mr. SLOOP. Thank you. I would like to go to the next slide (fig. 86, p. 1887), a repeat of Dr. Bisplinghoff's slide, showing scale up of conventional and advanced concepts in large vehicle engines. On the left is the F–1, of one-and-a-half-million-pound thrust, representing our present technology. If we scaled this up to a larger size engine of, say, the 24- to 30-million-pound-thrust category it would look as large as the second one from the left. That is over 50 feet high. We can reduce this size by increasing the chamber pressure, say, threefold, and get the third engine. Or, we can go to different nozzle concepts and combinations, as shown by the fourth engine, a model of which you see in front of you, that has a number of advantages. It illustrates one of a number of concepts being examined now.

This is the tank and this is the nozzle, and you see that it is a fairly short and squat engine. The transition piece between the tank and the nozzle is quite short, as represented by this part [indicating] and hence the load-carrying section is relatively small.

This particular engine consists of a single turbopump which pumps the propellants to a number of different combustion chambers, and they in turn discharge into this large nozzle.

There are many questions that this concept brings up. A lot of them are associated simply with using high chamber pressure.

Mr. KARTH. What are you thinking of for propellants for this engine?

Mr. SLOOP. Both oxygen and kerosene, and oxygen and hydrogen. The latter looks more attractive to us right now.

Mr. KARTH. We are having a few problems with Centaur. I suppose you have heard of that.

Mr. SLOOP. Yes, sir. But I think most of them are in other areas than the propulsion system. We are proud of the fact that the propulsion system is ready and waiting for the vehicle.

Mr. KARTH. There are a few problem areas with the propellant, aren't there?

Mr. SLOOP. Yes, there are.

Mr. RANDALL. We heard about those last year.

Mr. SLOOP. Yes.

Mr. KARTH. I am inclined to agree with you that probably this is the way to move.

We have put a lot of chips on Centaur, haven't we?

Mr. SLOOP. Yes.

Mr. KARTH. The RL–10 engine is the Centaur engine, developed by Pratt & Whitney?

Mr. SLOOP. Yes.

Mr. KARTH. I understand there is some speculation that this engine will be used as an upper stage in part of the test series of the Saturn vehicle. Is that true?

Mr. SLOOP. I don't know of such plans.

Mr. KARTH. All right. How much money have we spent in researching this type of engine?

Mr. SLOOP. It would be hard to say. So much technology goes into it: How much of the propellant studies of hydrogen-oxygen would you charge to it? How much research on high-pressure research should be charged?

Mr. KARTH. Give us your professional estimate on how much we have spent on researching this.

Mr. SLOOP. On the large engine concept?

Mr. KARTH. I was more inclined to pin it down to the engine you have on the table as a sample.

Mr. SLOOP. I don't know how to subdivide it on this.

Mr. KARTH. Here is one area where substantial funds have been taken away from you and reprogramed into other areas, isn't that right?

Mr. SLOOP. No, sir.

Mr. KARTH. Well, this engine here is well into the Nova class engine, isn't it?

Mr. SLOOP. Yes.

Mr. KARTH. During this fiscal year didn't NASA take $165 million worth of Nova funds and reprogram them?

Mr. SLOOP. We are talking of two different things. I am talking of establishing the technology base——

Mr. KARTH. I see.

Mr. SLOOP. For developing a Nova. I believe the funds you refer to were the start of the Nova development.

I feel that our work is to provide a sound technical base so that when Nova is selected we can get into it some new concepts and draw on a storehouse of fundamental knowledge to do a better job than merely scaling up what we have today.

Mr. KARTH. I am inclined to agree. Let me ask you again, how much money have we spent in researching the Nova size engine? I guess you can put the one before you in that class.

Mr. SLOOP. I would like to submit that for the record. It would be in excess of $2 million in fiscal 1963.

Mr. KARTH. You see, I am not sure that our proportions are right. If we had gone into the development of the Nova engine last year—I don't recall how much the experts estimated this engine development program would cost, but I assume it would be in the billions.

Mr. SLOOP. Yes, sir.

Mr. KARTH. I am not sure really that we have done enough groundwork, when there are those kinds of expenditures involved in the development of the engine itself. I am not sure the ratio makes much sense to me.

Mr. SLOOP. Our job is to try to provide the technical know-how prior to the selection of a particular configuration for development. If we have done our job well it will make the development easier and less expensive.

Mr. KARTH. I think that is right. I am not suggesting you have not done your job well. I think you have done remarkably well with what you have had to work with, in terms of money.

Mr. SLOOP. Thank you.

Mr. KARTH. The only doubt I have is that maybe your office has been neglected. I don't mean that is Dr. Bisplinghoff's fault, either. Maybe some of the fault is with Congress. Maybe some of the fault is the top NASA Administrators, who tell you how much you can spend in the area, in the final analysis—or the Bureau of the Budget. It may be all our faults.

How much did you ask for in 1962, 1963, and 1964, as opposed to how much the Administrator said you could go to the Bureau of the Budget with?

Mr. SLOOP. The way the budget reiterative process goes on, it would be difficult to answer your question.

What we do is plan our research program and then we fit it into a framework of budgetary numbers. This is a reiterative process. First, we talk about the program we want to do, then we work within the framework of a budgetary number. This framework, of course——

Mr. KARTH. First, you have to sell it to Dr. Bisplinghoff, is that right?

Mr. SLOOP. That is correct.

Mr. KARTH. And he might chop away at it a little bit himself, is that correct?

Mr. SLOOP. Well, he has a responsibility that is broader than mine, therefore he has to think of the other areas within the framework of his guidelines.

Mr. KARTH. I understand. But he might chop away at any one of the areas, all of them, or be very selective and just pick one of the bunch. Then he recommends to Mr. Webb, who looks at it, and he, too, may be very selective, or may chop it across the board. Then when it goes to the Bureau of the Budget, it may do the same thing.

My question is, "How much did your section of the OART suggest you needed in fiscal year 1961, fiscal year 1962, and fiscal year 1963?" And how much did you eventually get after maybe Dr. Bisplinghoff took off some, Mr. Webb took off some, if he did, and the Bureau of the Budget took away a little, if they did, and then maybe Congress reduced it, I don't know; this wasn't in my subcommittee last year?

Mr. SLOOP. $17,164,000 was spent in chemical propulsion in 1962, $25,119,000 in fiscal 1963, and we are asking for $35,075,000 in 1964,

so there is an increase over these years. The budgetary process is a long lead item, that goes on well in advance. I can only assure you that we have the money that we asked for in fiscal 1963.

Mr. RANDALL. I don't think the question is being answered. I would like to join the chairman in requesting an answer. Going back to fiscal 1961, would you give us the figures? If you can't do it now, give them to us subsequently, the very things he asked for. Somewhere along the line you came up with a figure of—your answer was apparently what you got and what you spent. That is a different answer.

Dr. Bisplinghoff, I believe, said you weren't here but a short time; maybe it was someone else. If you weren't here, to whom did you go? Have you been asking for anything, yourself, as head of your section?

Mr. KARTH. Yes, I think it would be interesting if you could provide these figures. Maybe Dr. Bisplinghoff could provide them for the record within the next few days, Doctor, if you will.

Dr. BISPLINGHOFF. We will see what we can do with this request.

Mr. KARTH. The amount of money requested by Mr. Sloop or his predecessor, then the amount that that section eventually got, in terms of dollars. I don't care who cut what out. We are not looking for that. I just want to know what the director of this section felt he needed, and what he eventually got to do the job.

Did you suffer any reprograming in fiscal year 1962, for example, and fiscal year 1963?

Mr. SLOOP. No, sir; not in fiscal year 1963.

Mr. KARTH. You did not gain anything, and you probably didn't lose anything; is that it?

Mr. SLOOP. The office was formed during this process, and it is difficult to answer your questions explicitly.

Research—there are two types of work supporting our chemical propulsion: one is supporting research and technology, and one is advanced research and technology; and I am talking of the advanced research and technology. It is our job to provide a base to look ahead into the future. The supporting research and technology is the work needed to get the job done for an approved project.

Mr. RANDALL. Mr. Chairman.

Mr. KARTH. Mr. Randall.

Mr. RANDALL. For the record, I don't know what the chairman had in mind, but we touched on this here, before Mr. Morris left, about the big boosters. Any person can read the papers and see it, and say it appears we are delinquent or behind in thrust or power, or that the guidance is coming along all right, but we can't get them off the ground.

I want to know where we are going. I want to know whether you have been really asking for the funds you need, yourself, as director of this, to push ahead?

Mr. SLOOP. The work we do is for the next——

Mr. RANDALL. Maybe you are not the right witness, I don't know.

Mr. SLOOP. I want to say our responsibility and the work we are discussing this morning is for the next step beyond Saturn V. The Saturn V and its development and success is the responsibility of the Office of Manned Space Flight. It is our work to provide the technical base for the next step beyond Saturn V.

Mr. KARTH. That is right.

Mr. RANDALL. All right.

Mr. KARTH. I don't think there is any doubt in our minds as to your responsibility for the movement. Some of us feel it took a long time to get the Saturn V, and we wouldn't like to take that long to get to the next state of the art. We would like to help you, if you think you need help. I guess that is all we are saying. I find it very difficult to find areas where we should reduce, because no matter what the budget request is, they will defend it to the last breath in them; and when we try to help somebody I find it is extremely difficult to do that, too, and I am not sure we can accomplish either of those goals unless we get some of the information we request.

Mr. SLOOP. We feel we have asked, in fiscal 1964, for a well integrated and balanced program in the area of chemical propulsion and space power. I am a partisan to the programs we have, and a partisan always feels he can do more. It is up to others with broader responsibilities to put it in proper context in favor of the overall NASA program.

Mr. KARTH. How much did your Office ask for in fiscal year 1963, the total budget request for your Office? Was it 20-some million?

Mr. MYERS. In chemical propulsion, $17,164,000, total research, development, and operation developments for chemical propulsion, and $12,256,000 for liquid propulsion.

Mr. KARTH. How much for just chemical propulsion?

Mr. MYERS. $17,164,000, total R.D. & O. funds, personnel costs, operations, installations, and direct R. & D. dollars to buy equipment to do research.

Mr. KARTH. How much of the $17 million was R. & D. dollars?

Mr. MYERS. The $7 million in 1962, that is still—$7,003,000. R. & D. in 1963 was $14,469,000.

Mr. KARTH. Out of what total?

Mr. MYERS. $25,191,000.

Mr. KARTH. This is what you asked for, Mr. Sloop, for 1963?

Mr. SLOOP. Yes, sir.

Mr. KARTH. You weren't there during 1962?

Mr. SLOOP. No.

Mr. KARTH. Do you know what they asked for?

Mr. SLOOP. No, sir.

Mr. MYERS. In 1962 it was—the number in 1962 is approximately correct. I would have to reconstruct all the manipulation in any program any year to give you the actual number.

Dr. BISPLINGHOFF. One of the problems with 1962 is that this budget formation occurred before the Office of Advanced Research and Technology was formed, which was a year ago November, and many of the parts that make up this office were brought from several other offices in the NASA, so it is hard for us to construct immediately what these requests were. 1963 is more clean cut.

Mr. KARTH. I understand. What are you requesting for fiscal year 1964?

Mr. SLOOP. $35,075,000.

Mr. KARTH. Is that what you originally requested when the budget was first being prepared?

Mr. SLOOP. Yes, sir.

Mr. KARTH. Mr. Staebler.

Mr. STAEBLER. I would like to ask our relationship to our chief competition in the rocket field, and if I touch any confidential matters please stop me. What fuel was used in the largest Russian rocket, to date?

Mr. SLOOP. We can't say positively. We think oxygen and kerosene.

Mr. STAEBLER. Is there anything publicly available on their work on other fuels?

Mr. SLOOP. Last year there was a committee report on some of the high-energy fuels, I believe, in which it was reported that the Russians were inquiring into boron fuels.

All countries, I might say, that are interested in rocket propulsion maintain an active interest in high-energy fuels that can release more chemical energy. Wherever you have imaginative people in chemistry you find interest and speculation in these high-energy materials. There is a good indication that Russia, too, is interested in these various propellants.

Mr. STAEBLER. There is no evidence of their using it yet in a successful rocket?

Mr. SLOOP. I don't know of any.

Mr. STAEBLER. So at the moment our application and their application in the field of fuel technology is roughly parallel?

Mr. SLOOP. We are active in hydrogen-oxygen, and in hydrogen-fluorine, and diborane-oxygen difluoride. I believe they are very active in this area also.

Mr. STAEBLER. Perhaps we have a storehouse of information that is likely to be as good as is available to the Russians? Do we have that?

Mr. SLOOP. I think so.

Mr. STAEBLER. The larger dimensions of their rockets at the moment, then, are not due to fuel superiority?

Mr. SLOOP. That is my belief. It is merely larger size, larger thrust.

Mr. STAEBLER. And this is attributable to which of the supporting technologies?

Mr. SLOOP. I think to a number of them; that is, chemical engineering, mechanical engineering, the people working in turbomachinery, such as pumps, and things of this sort, and the systems engineers who make the whole thing work as a unit. It is a multidiscipline group needed to do this job, as you can appreciate.

Mr. STAEBLER. You mean the field of materials? Perhaps I ought to ask Dr. Bisplinghoff.

In the field of high-temperature materials are we aware of any advance that they may have made beyond our present capacities?

Dr. BISPLINGHOFF. To the best of my knowledge I know of nothing that has come from Russia that exceeds our capabilities, either in rocket nozzle materials or reentry nose cone materials. Of course, we find it hard to get detailed information from them about their materials. But I know of nothing that exceeds our capabilities in either of these areas.

Mr. KARTH. Would the gentleman yield at this point?

Mr. STAEBLER. Surely.

Mr. KARTH. The Soviet spacecrafts that have been orbited and later on reentered, because of their disproportionately larger sizes, I assume the ablative material they use for reentry had to withstand greater temperatures than the ablative material we use for reentry.

Dr. BISPLINGHOFF. No; the reentry is really a function of speed, and the size of the vehicles is not important.

Mr. KARTH. Thank you.

Mr. Staebler.

Mr. STAEBLER. Doctor, is it in this area of systems, the combination of the different things that we already know, that they have achieved greater advances?

Dr. BISPLINGHOFF. I think Mr. Sloop's statement is correct, that the technological building blocks we have available with which to construct these systems are nearly equivalent in the two countries. Now, one's ability to put these building blocks together in a large system depends on two things, that is, one's skill, and also the amount of time one has put in; and I think it is in the latter area the Russians have licked us. They have been at this matter of putting together rocket systems a longer time than we have, and so they have been able to forge ahead of us as far as thrust is concerned, vehicle size. I don't believe they have any superior collection of technological build ing blocks.

Mr. STAEBLER. In the accumulation of information for the next set of advances—and in this we don't know how far the Russians are progressing—it would be important to have all the building blocks we can, I presume.

Dr. BISPLINGHOFF. Absolutely. This is the basic premise for doing research. That is the real reason for having the Office of Advanced Research and Technology, to develop these building blocks as far as we can before we undertake these large systems developments. Of course, we feel that the cost, and the probability of success of any large system development, is very greatly dependent on how well we do our job in preparing the way.

Mr. STAEBLER. Is the systems research in your field, Dr. Bisplinghoff?

Dr. BISPLINGHOFF. When we speak of systems we speak of the putting together of all the basic subsystems and components that have been developed, into a larger collection which could do the mission, and most of this is in the mission offices, such as the Office of Manned Space Flight and Office of Space Sciences.

We are, of course, interested in the matter of systems from the fundamental viewpoints of trying to understand how systems people can do their job better, but we are not responsible for the actual carrying out of the formations of these big systems. This is beyond our responsibility.

Mr. STAEBLER. Thank you very much.

Thank you, Mr. Chairman.

Mr. RANDALL. One question.

Mr. KARTH. Mr. Randall.

Mr. RANDALL. Going back, you mentioned that their superiority was not due to fuels, but due to three or four factors which you enumerated.

Dr. BISPLINGHOFF. Thermodynamics.

Mr. RANDALL. And you said pumps, and work on turbines, and ended by saying it was a multidiscipline proposition. Would you address yourself, if you would, as to which of those, in your opinion, we might be able to catch up on the quickest?

Dr. BISPLINGHOFF. That was Mr. Sloop's answer, Mr. Randall.

Mr. RANDALL. I am sorry. I thought it was yours.

I think you also mentioned materials, said there was no problem in materials, Mr. Sloop?

Mr. SLOOP. I think there are problems in materials in rocket engines. I think this is an area where we need more research. I mentioned this in connection with the problem of containing the 8,000° temperature gas resulting from burning oxygen difluoride and diborane.

We are constantly striving for better materials, and materials that can withstand the high temperature.

Last year I mentioned work on pyrolytic graphite, which is a type of graphite that conducts heat in one direction very well, but not in the other direction. It also can withstand very high temperatures.

On my first slide I showed a picture of such a chamber in operation. It cools by radiation. It gets hot and radiates the heat to the cold environment of outer space.

We are also interested in coatings for nozzles, so they can withstand both the oxidizing atmosphere and the very high temperatures. We deal with much higher temperatures than in other applications.

Mr. RANDALL. Of course, you understand what I am inquiring into. We have gone down the line on superiority, and you have said it is not due to fuels. Now you say there is a lot to be desired in materials, on the questions of pumps, materials, plumbing, and so forth.

How about the Centaur problem? Do you feel we are making progress on that?

Mr. SLOOP. I think we are, yes. I would like to talk about materials for a moment. Basic research in high-temperature materials is one problem and applied research of materials for rocket application is another problem. I was addressing myself primarily to the application of high-temperature-material technology to the rocket application.

Mr. RANDALL. What would be a simple definition of thermodynamics?

Mr. SLOOP. Thermodynamics is a part of science that has to do with heat energy involving gases and liquids in various physical states.

Mr. RANDALL. Expansion, contraction, so forth?

Mr. SLOOP. Yes. For example, the process of combustion and expansion of hot gases through nozzles, and the various states—the pressure, specific volume, temperature, viscosity, conductivity, and how these vary with operating conditions is a part of thermodynamics.

Mr. RANDALL. It is a question of control, is that correct?

Mr. SLOOP. Yes. Thermodynamics deals with the conversion of heat energy into useful work. This is another, probably simpler, definition.

Mr. RANDALL. May I have a question or two more?

Mr. KARTH. Certainly.

Mr. RANDALL. The scale here shows a man. Are these engines in the cylinder here about the size of an ordinary F–1 engine?

Mr. SLOOP. Yes, or perhaps a little larger. These might be as much as 2-million-pound thrust each, so they could be around 24 to 30 inches in diameter, it depends on the pressure we would use.

Mr. RANDALL. Though it appears more complex as a whole, have you achieved some simplicity there? Is that a central pump there?

Mr. SLOOP. That is one of the problems I was talking about. We

are examining whether or not to have a single pump or, say, four pumps, or a pump for each of these thrust chambers.

Each concept has its advantages. If you have a pump for each thrust chamber you can develop the pump and thrust chamber as a unit, and then assemble the units in the big nozzle. If you use a single pump it requires large facilities and has other problems. You have to balance this against reliability.

Mr. RANDALL. If one pump goes out, the whole would be out.

Mr. SLOOP. That is right. On the other hand, if you have a number of multiple units there is a good possibility one could go out. All of these things have to be balanced.

Mr. RANDALL. How far along are you with this?

Mr. SLOOP. We have programs in fiscal year 1963, and in 1962 as well, in the high-pressure technologies involved here. We have, for example, contracts on pumps, and on cavitation phenomena in inducers, the first pumping stage of a turbine-driven pump. We have contracts to examine the combustion and combustion dynamics of high chamber pressures, we have contracts on the problem of cooling at high pressure. We have some contracts on thrust vector control by secondary injection.

What will be needed in 1964, 1965, or perhaps later, is to bring some of these results together into a subsystem or into a complete system. For example, should this small combustion chamber have a small nozzle for some gas expansion before entering into the large nozzle, or, what is the spacing and entry angle for optimum performance? Or, is the optimum number of discrete jets 12, 8, or 32? We are also studying other concepts, such as I have on the next slide (fig. 222).

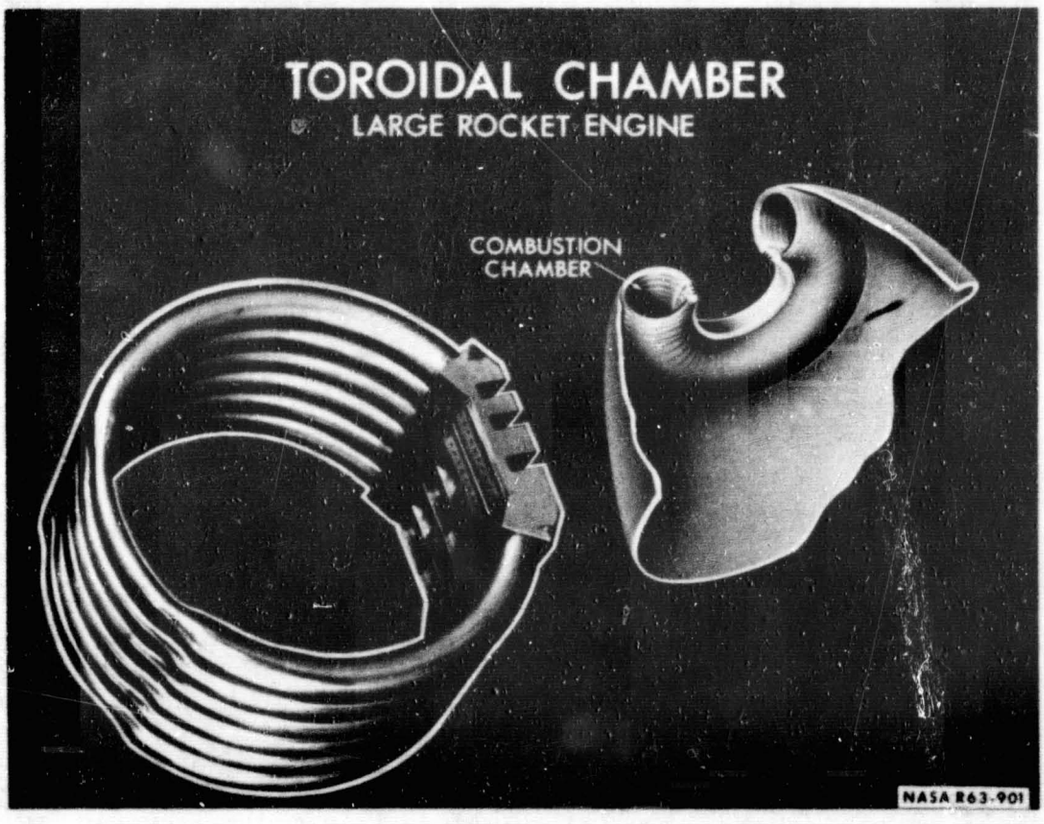


FIGURE 222

Instead of individual combustion chambers as on this model, we would replace them with a torodial combustion chamber. This is being worked out for us by Rocketdyne. An insert of this type of combustion chamber is shown, consisting of rings with injector on the right side, and hot gas pass through slots between the tubes on the left. This is a much more compact arrangement. Such a torus could fit in here (indicating) and replace all the individual combustion chambers.

In addition we think we could test a torodial segment. Take, for example, a 2-foot torodial segment and test it with a reasonably small facility. But one day we would have to face the problem of full-scale tests.

We did have a slide showing actual tests of this torus at Rocketdyne. I am sorry, I took that out.

Mr. KARTH. Proceed.

Mr. SLOOP. Another area we are quite interested in looking into is air augmentation of liquid rocket engines. The concept on this slide (fig. 223) came from Langley Research Center. It consists of variable mozzle configurations that adapts to the various speeds and allows air to mix with the main rocket exhaust and increasing thrust.

At the left is the configuration for lift-off and subsonic speeds. The air comes in as indicated by the arrows. The bell-shaped entrance is jettisoned as the speed increases. At supersonic speeds the inlet and exit are adjusted by a hinged mechanism and the jet expands as shown by the shaded area. At near orbital speeds, where there is no longer any atmosphere, the nozzle closes up and acts like a simple rocket nozzle. We have a request for proposals out to study air

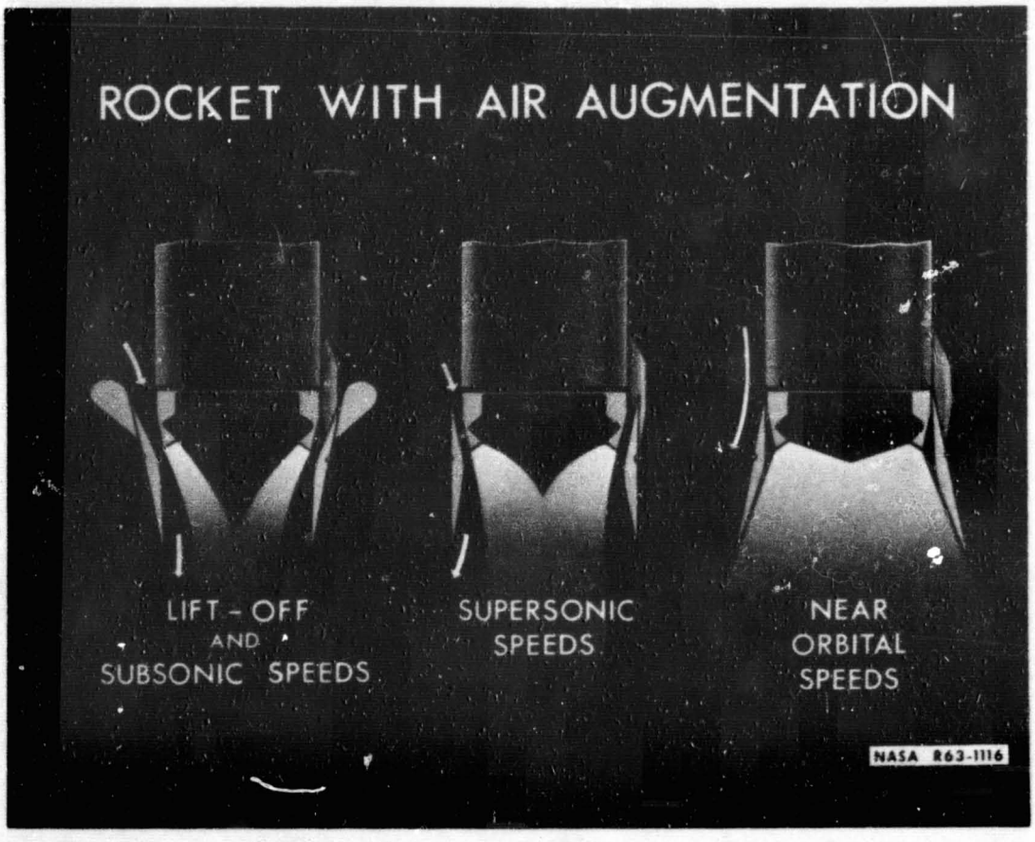


FIGURE 223

augmentation. In fiscal year 1964 we want to examine air augmentation models, using the facilities at Langley Field and at Cleveland, and perhaps other places.

I have a 5-minute movie with me, which is not a very polished affair, but was put together to illustrate a few other technology areas that we are working on. Do you care to see it at this time?

Mr. KARTH. Fine. If you think this is the appropriate time, we would be very much interested.

Mr. SLOOP [movie narrative]. This is a stroboscopic view of cavitation in the inducer of a pump. Cavitation is one of the big problems in pumps. This shows the cavitation on the leading edge. There is some evidence that this irregular cavitation causes pressure fluctuations that are felt in other parts of the systems, and could be a trouble source for combustion oscillations.

Mr. KARTH. Is that the trouble you are finding with the F–1 engine now?

Mr. SLOOP. It is a possibility.

Mr. KARTH. Are you familiar with what the problem really is and what they are doing to correct it?

Mr. SLOOP. Yes. They have an advisory group consisting of people in our research laboratories, who serve as consultants on this problem.

This is a firing of diborane and oxygen difluoride motors, and you note the characteristic green color from the boron.

These are the test conditions, with chamber pressure 75 pounds per square inch absolute.

The mixture ratio was 3, and almost 96 percent of theoretical, performance was obtained but that occurred over a narrow region as I showed you before.

The thrust of the engine was 150 pounds.

Mr. KARTH. Is that the test you showed by which you developed your curve?

Mr. SLOOP. That is correct.

The CHAIRMAN. It must be a short test.

Mr. SLOOP. That is correct. We would like to make longer tests.

This is one of the injector concepts that we are working on to provide a variable thrust. You can see a movement of a cylinder, which is the means by which the variable thrust is achieved.

Do you see that?

The CHAIRMAN. Yes.

Mr. SLOOP. It was this type of injector without the variable thrust feature that was used in the diborane test.

The variable thrust is needed for a number of applications in space. I think you are familiar with them. This is a test of the variable thrust concept.

Looking closely you see a variation in the flame pattern, which indicates the variation in the thrust.

Now you see the thrust increasing. Now it is decreasing.

The vapor you see is the water used in the test for cooling purposes.

During the test they varied the thrust up and down, as I think you can tell by the exhaust pattern that you see.

Here is another concept of variable thrust where the area of the injector is changed by means of needle-type valves as shown. This is a pantad type as we call it.

The white area is a high-temperature coating and surrounding that is an ablative material. These tests are conducted under contract with the Aerojet General Corp.

This could be coupled to a servomotor for variable thrust.

Here is a test of an engine using this type of variable injector.

I think that is all.

I would like to go now to solar and chemical power generation.

Mr. RANDALL. What is the advantage of variable thrust?

Mr. SLOOP. It is needed for lunar landing, needed for docking in rendezvous, it is useful in orbital corrections of trajectories, things of that sort.

Mr. RANDALL. Has it been used up to now?

Mr. SLOOP. Its first uses will be in Gemini and in the Apollo program for lunar landing.

Mr. KARTH. Of course this committee is interested in high-energy fields. I think one of my first questions was how much money are we spending in this research effort on fuels. I am interested in solids versus liquids, and high-energy fuels. How much did we spend on high-energy fuels research in fiscal year 1963?

Mr. SLOOP. $2,488,000.

Mr. KARTH. How much are you asking for fiscal year 1964?

Mr. SLOOP. $3,306,000, sir.

Mr. KARTH. Do you feel this is sufficient to do the research work that needs to be done?

Mr. SLOOP. A research man never feels there is sufficient work going on in his area. As a partisan I have to answer this way.

Mr. KARTH. Is this what you asked for?

Mr. SLOOP. This is what I asked for after we had some discussion on the guidelines; yes, sir.

Mr. RANDALL. That is what he was told he could ask for.

Mr. KARTH. How much were you asking for before the guidelines were established, if I am not invading executive privilege?

Mr. SLOOP. I don't recall. I would like to go back to the question——

Mr. KARTH. I was just asking how well your memory served you on this matter of high energy fuel funds requested prior to the establishment of the guideline.

Apparently, Mr. Sloop, your memory has failed completely.

Mr. SLOOP. I don't remember. [Laughter.]

Mr. KARTH. All right. But it was more? Is my assumption correct, that you did request more?

Mr. SLOOP. I think that is a safe assumption; yes, sir. [Laughter.]

Mr. KARTH. Proceed.

Mr. SLOOP. I might say as an aside that if all the initial requests were added together it would total many more times more than the budget NASA has asked for.

Mr. KARTH. Don't make it so accurate that you put us out of work, will you?

Mr. SLOOP. In solar and chemical power generation the areas of interest are illustrated on the next slide (fig. 224).

It includes thermionics, solar cells, thermoelectric, magneto hydrodynamics, solar engines, batteries, fuel cells, chemical engines, power conditioning, solar concentrators, thermal energy, and storage.

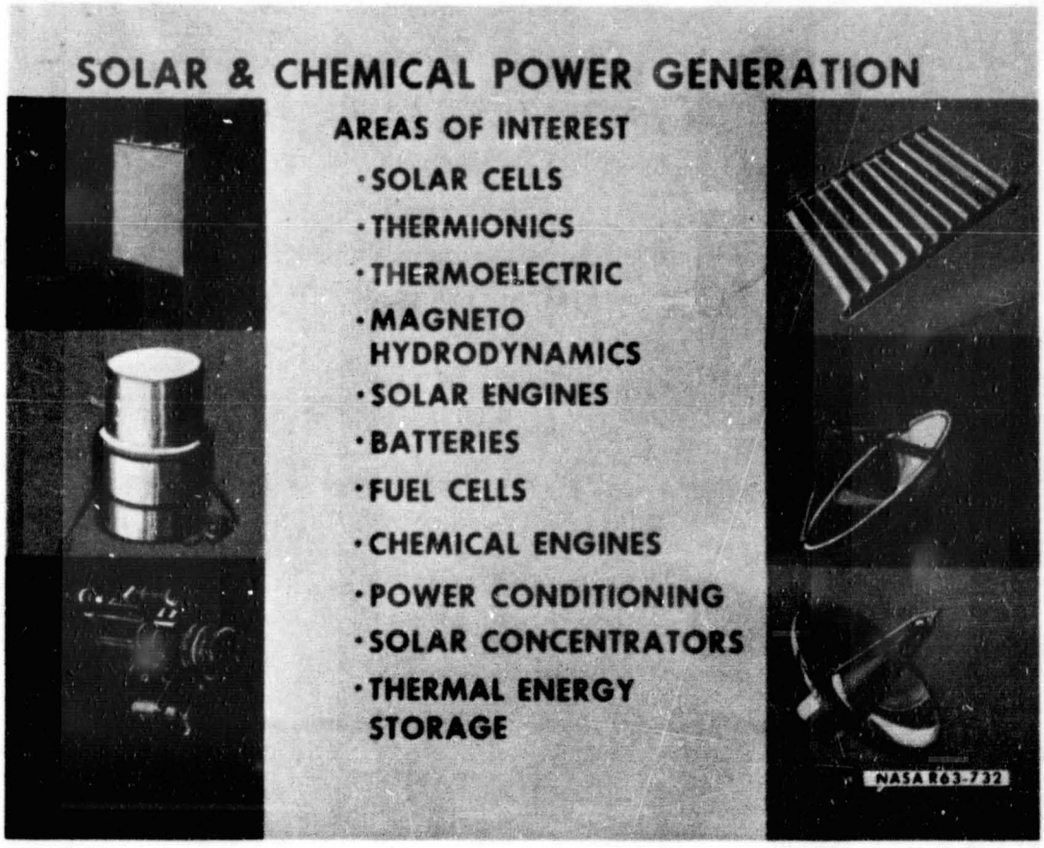


FIGURE 224

Here I have two types of batteries used in space exploration. The smaller is nickel-cadmium type battery of 6 ampere-hour capacity. This one is a silver-cadmium battery of 12 ampere-hour capacity.

Mr. KARTH. This is an advanced state of the thing, the silver-cadmium one.

Mr. SLOOP. Yes, sir. These have an improved ceramic seal to protect against the vacuum of space. These batteries develop an appreciable internal pressure in space operation.

The next slide (fig. 225) shows an important problem area in solar cells; that is, resistance to radiation. Last year there was a nuclear explosion in the upper atmosphere, that played havoc with three satellites. This slide illustrates the decline of power as a function of numbers of days in orbit for conventional and improved solar cells.

You will appreciate that this curve is based on certain assumptions of the amount of radiation, what particular orbit, and so forth, but it is on a comparable basis.

The conventional solar cells used up to the present time are called a "p-on-n." The positive side, p, is on top, and the negative, side, n, is on the bottom. If this order is reversed to "n-on-p" we get a higher resistance to radiation. There are other ideas in our program——

Mr. KARTH. Was it your section that got onto this "n-on-p" concept?

Mr. SLOOP. The "n-on-p" solar cells originated years ago in the laboratory. I believe the original work was done by the Army at Fort Monmouth, and Bell Telephone Laboratories picked up this

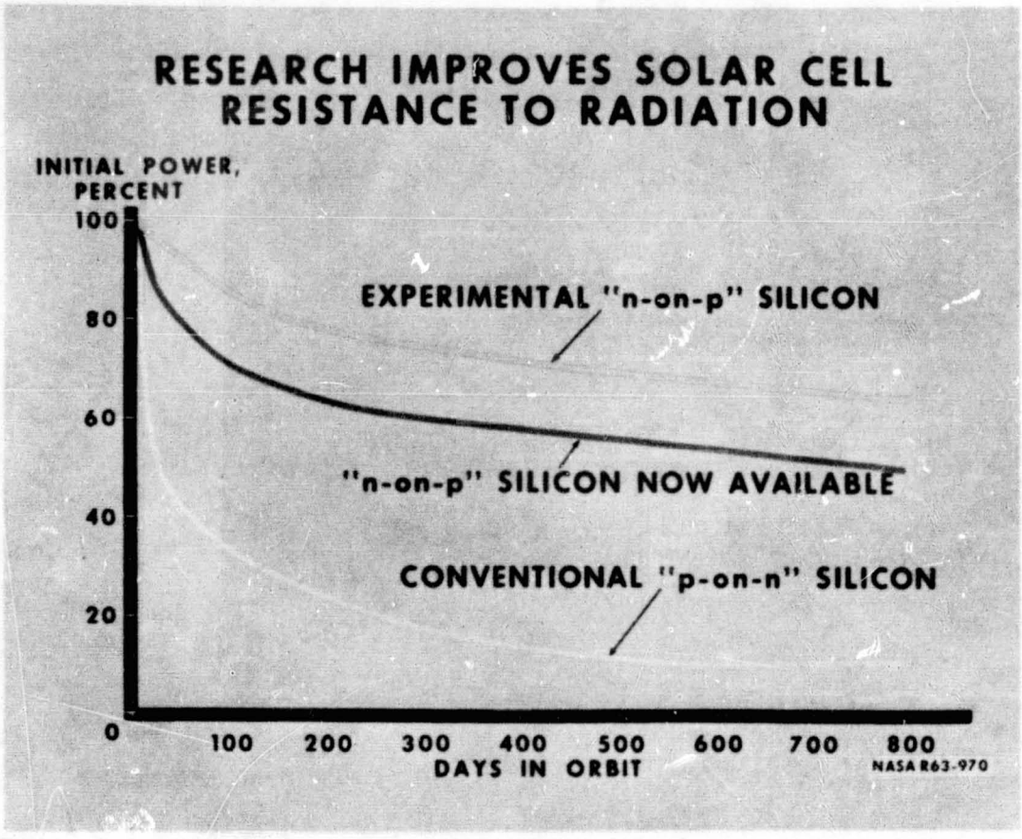


FIGURE 225

work and incorporated the "n-on-p" type in Telstar, and that is one of the reasons it worked when other satellites went out. The experimental "n-on-p" type shown is a "drift field" type.

A real interesting research area in solar cells, mentioned by Dr. Bisplinghoff, is shown by this next slide (fig. 226), namely thin-film solar cells. On the left is shown a single crystal of a conventional type cell, normally 1 to 2 centimeters. They are usually mounted as shingles are mounted, as you see in the center of the slide. They are around 20 mils thick.

Thin-film solar cells have a number of potential advantages: First, you can make them larger, and second, thinner, like 3 mils thick.

Third, you can mount them on flexible surfaces, thus opening up many new potential uses. You could carry them on a foldable or inflatable structure, which could be inflated into a large area in space.

Mr. KARTH. How much are you asking for research in this area?

Mr. SLOOP. Fiscal year 1964, $3,350,000.

Mr. KARTH. And in 1963, what was it?

Mr. SLOOP. $2,409,000.

Mr. KARTH. Who are the main suppliers of solar cells for NASA?

Mr. SLOOP. There are not too many who supply solar cells.

Mr. KARTH. Could you tell us who they are?

Mr. SCOTT. Most of the production to date has been from Hoffman Electronics and HelioTech. Recently Radio Corp. of America has started production of the newer type "n-on-p" and we have now also Texas Instruments coming into the market. International Rectifier

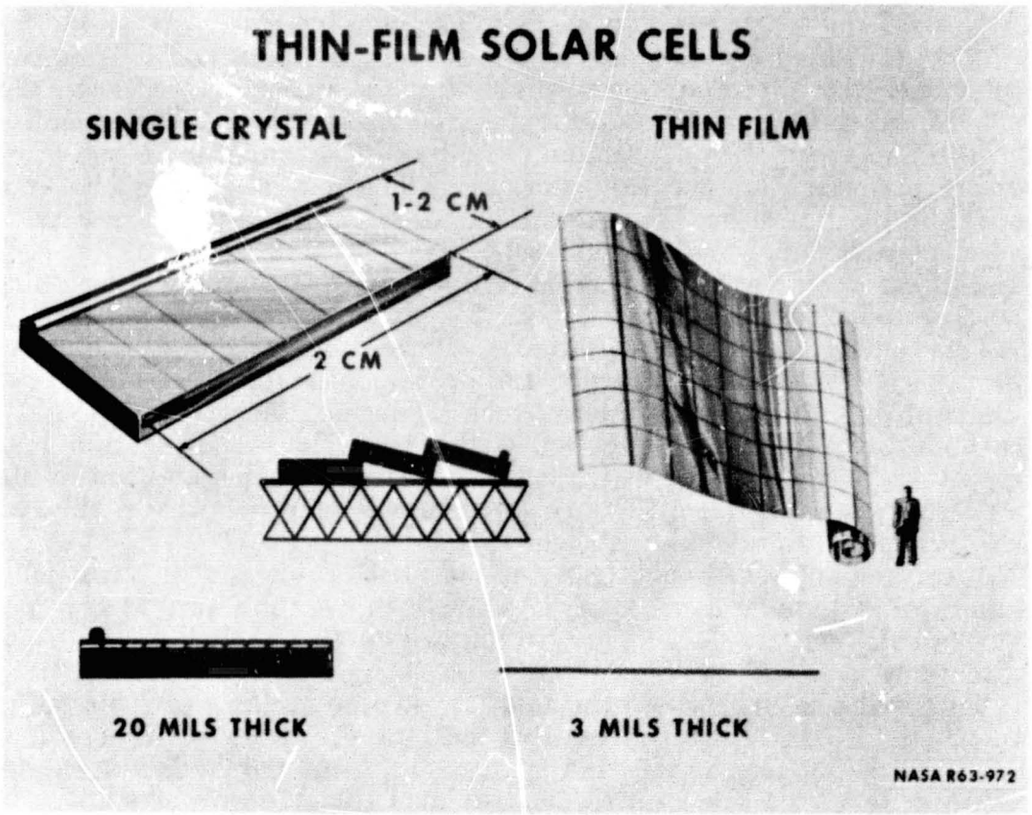


FIGURE 226

has also been doing work in this area. Production capacity is quite a bit in excess of our requirements.

Mr. KARTH. Thank you.

Mr. SLOOP. Here is an example of a thin solar cell, cadmium sulphide, made by the Harshaw Chemical Co. for NASA, and we have also a contract with RCA using gallium arsenide. We think thin-film solar cells have a great potential. If it works, as we hope it will, it could mean solar cells would be useful in larger power levels than now. At present they are used in small satellites, with power of 20 to 400 watts. We think we could extend the power to 2 to 3 kilowatts.

Mr. KARTH. Are you doing any research in the nuclear field?

Mr. SLOOP. Yes.

Mr. KARTH. For power systems?

Mr. SLOOP. For power systems, yes. Mr. Finger will cover that.

Mr. KARTH. Thank you.

Mr. SLOOP. We think solar cells on thin films could be used in large areas coupled with a fuel cell to provide power continuously. The solar cell could provide power and recharge the fuel cell in hours of sunlight and in periods of darkness the fuel cell could provide power.

Mr. KARTH. Are you doing any work on fuel cells?

Mr. SLOOP. Yes, sir. I will come to that. There is a catch in many things and the catch in the thin-film work at the present time is low efficiency, which is about one-fifth of that of conventional cells, and you see that almost wipes out its weight advantage. But we have just gotten started in this work, and are trying to increase this efficiency. There is no theoretical reason why it can't be made higher, and we are doing research in this area.

Now, I go to thermionic systems, shown by this next slide (fig. 97 p. 1921) which was also shown to you by Dr. Bisplinghoff. This is a solar thermionic power system under investigation for NASA by the Jet Propulsion Laboratory and associated contractors. The objective is to build a very light thermionic diode system capable of operating on a planetary exploration mission. Thermionic diodes are not affected by radiation. A thermionic diode is something similar to an electronic tube; the cathode is heated very hot, electrons boil off, and these migrate across to the anode and are available for doing work in an external circuit.

I have here in front of me an actual group of five diodes that have been used by the Jet Propulsion Laboratory of California Institute of Technology. They were made by the Thermo Electron Corp. The cathode temperature is over 3,000° F., and this small section here [pointing] is the radiator which keeps the anode cooler and maintains an electrical potential difference. Cesium is placed between the two electrodes to improve the efficiency.

I am not supposed to touch these diodes. This is still a workable laboratory item, and when JPL sent it to us they provided white gloves. If you would like me to show you this, I will follow their directions.

This is the cavity, where the solar rays come in and heat this body, to which are fastened the cathode end of the diodes. When used with the 5-foot mirror you saw in the slide, this particular array developed over 40 watts in a recent test at Table Mountain, Calif. In a laboratory test, one of these diodes generated 80 watts. The system is intended to generate as high as 300 watts in Earth orbit and 135 watts at Mars, with a design goal of only 30 pounds.

The efficiency of an individual diode in converting heat to electricity is around 8 percent at the present time.

Mr. KARTH. How does that compare in power output with the silver-cadmium battery you had there?

Mr. SLOOP. A battery is very efficient; it converts chemical energy into electricity, with an efficiency of around 70 or 80 percent.

Mr. KARTH. What is the output of the silver-cadmium battery that you have as a sample?

Mr. SLOOP. Twelve ampere-hours for the larger one.

Mr. KARTH. Can you make the comparison to the model you just showed us?

Mr. SLOOP. We compare the weight in power systems generally in terms of pounds per kilowatt, that is one of the ways we do this. With a thermionic system we hope to get down to in the order of 100 pounds per kilowatt.

Batteries—their figure of merit is—they are generally compared on the basis of watt-hours per pound, and—I thought I had those figures with me, but I don't. The silver-cadmium batteries are on the order of 30 watt-hours per pound. Isn't that correct?

Mr. SCOTT. Yes, sir.

Mr. Sloop. There is a depth of discharge factor that must be considered. The batteries that Tiros used, for example, weighed 40 pounds for total power output of 18 watts, and had a 60-watt total peakhour demand. Relay, for example, had 5 watts average power and the battery weighed twelve and a half pounds.

Mr. KARTH. What was the capacity in watt output of this one on the table?

Mr. SLOOP. The 5-thermionic diode output at Mars is 135 watts.
Mr. KARTH. Mr. Randall.
Mr. RANDALL. What was the figure of 100 pounds per kilowatt?
Mr. SLOOP. That is the goal, what we hope to get to.
Mr. RANDALL. I see.
Mr. SLOOP. It also depends on the place where you are using it.
For example in the Earth orbit or near the Earth this would put out 300 watts. It is closer to the Sun than at Mars. So 300 watts and 30 pounds would be 10 watts per pound, would't it?
Mr. KARTH. Yes, sir.
Mr. SLOOP. The catch in quoting some of these numbers is that we are talking about just a few of the total components needed for a complete system. We have the power-conditioning equipment that must be added to this, and there must be pointing equipment such as attitude control, to keep it pointed toward the Sun, and so forth.
We think the thermionic power system is a very promising one. And we want to increase our research in that area. We are requesting a total of $3,993,000.
Mr. KARTH. How does that compare with 1963?
Mr. SLOOP. $2,919,000.
Mr. KARTH. Thank you.
Mr. RANDALL. May I have a question on the thermionic diode?
Mr. KARTH. Certainly, Mr. Randall.
Mr. RANDALL. You mentioned the heat in the radiator, getting it started.
How is that accomplished?
Mr. SLOOP. The Sun's energy is focused by means of the mirror into this small cavity, and that can be controlled. If you tilt it slightly away from the Sun it would turn off the power. That is one of our problems, that we have to have solar collectors or mirrors of very high accuracy, to focus the energy into the small cavity.
Mr. RANDALL. Thank you.
Mr. SLOOP. And on that subject, I would tell you that we are planning additional research in solar collectors in 1964, and we think for thermionic systems the rigid type of mirror, single piece, is probably best. Other solar collectors that we are working on are the foldable umbrella-type. I have here samples of a very lightweight mirror construction technique. It is essentially a small honeycombed structure on which the mirror surface is plated, and there is a protective surface, over that. These three samples vary only in the thickness, I believe, of the surface beneath the mirror coating.
You can see the honeycombed substructure beneath, and this is a problem in diffusing the Sun's rays somewhat, which makes it more difficult to focus on the narrow cavity entrance I showed you.
This is one of the areas in which we are doing additional research in 1964.
Mr. STAEBLER. May I ask a question?
Mr. KARTH. Mr. Staebler.
Mr. STAEBLER. I am asking a question about this new conversion operation: I take it only one diode is used at a time?
Mr. SLOOP. No, these five are used as a single array. Each diode puts out a little less than one volt. It is conceivable that we would have an array with a number of these diodes, more than five. But five lends itself to a very neat geometric arrangement.

Mr. STAEBLER. How do you focus on five at one time?

Mr. SLOOP. The focusing is into this center body, this cavity, or collector, and this whole cavity gets hot, and heats the five cathodes in turn. The Sun's energy caught by the mirror comes right through the hole, where it is trapped, and heats up the emitter surfaces.

This next slide (fig. 228) is another idea for a solar collector, an inflatable rigidized solar concentrator, being worked on by the Langley Research Center.

It is more difficult to get a precision mirror by this technique, but it offers the advantage of providing very large mirrors in space.

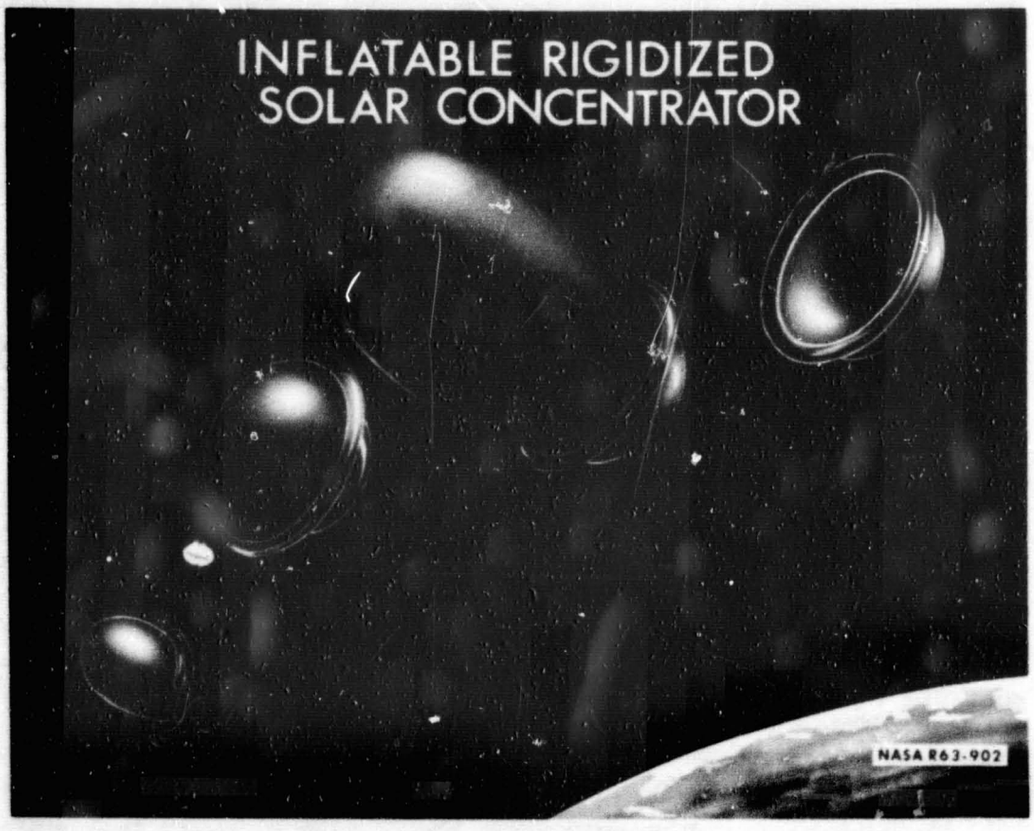


FIGURE 228

Now I would like to go to fuel cells. An example of a regenerative fuel cell is shown in the next slide (fig. 229). A fuel cell is like a battery, except the reactants that supply the energy come from an external source. A simple type uses hydrogen as fuel and the oxygen as oxidizer. Part of the energy is converted directly into electrical energy. That is, during the reaction under the right conditions 50 or more percent of the energy of reaction is converted directly into electricity, and the balance goes into heat, which has to be carried away.

This is an example of a research or technology program Electro-Optical Co., carried out under our cognizance. It is a regenerative fuel cell, using hydrogen and oxygen.

Mr. KARTH. Is this the type of fuel cell we are going to use in Project Apollo?

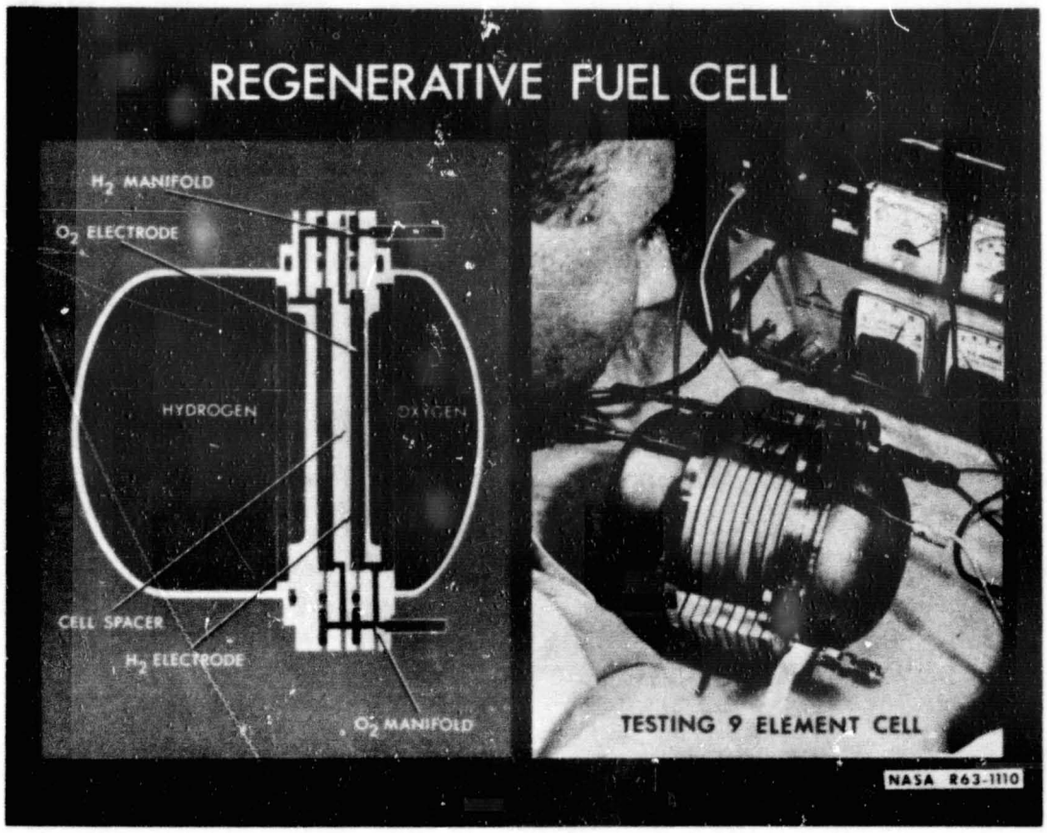


FIGURE 229

Mr. SLOOP. Yes. Project Apollo uses a type of hydrogen-oxygen fuel cell, called a modified Bacon fuel cell, after Dr. Bacon of England, who was a pioneer in this process. The water formed from reaction of hydrogen and oxygen is available for use by an astronaut for drinking or other purposes. It is being worked on by Pratt & Whitney. Prior to the contract of the Apollo fuel cell, Pratt & Whitney was doing a technology program for our office, and this is an example of work going on in the research and technology area prior to being picked up for development.

Gemini also uses a hydrogen-oxygen fuel cell.

Before I leave this illustration, I have in front of me the elements of the fuel cell illustrated. Here is an example of a porous metal electrode. In between the electrodes is a bed of asbestos. I believe this one has potassium hydroxide saturating the asbestos. The electrode has a catalyst on it, carbon black, in this case, and this is a nickel plated divider whose function is to bring hydrogen or oxygen against their respective electrode. To reduce weight the divider is made of polystyrene and plated with nickel.

The hydrogen flows to the anode and at the catalyst surface it is broken into positively charged hydrogen atoms, and the freed electrons pass through an external circuit to do useful work and back to the cathode. At the same time the oxygen comes to the cathode where it reacts at the catalyst surface hydroxyl radicals are formed which pass across the electrolyte combine with the hydrogen atoms at the anode, forming the water, which has to be carried off. This is a constant process.

In the regenerative fuel cell you can apply electricity and reduce the water back to its original constituents, hydrogen and oxygen and that is where it is like a rechargeable battery.

Mr. KARTH. So long as the regenerative process works you have a never-ending supply of fuel, is that what you are saying?

Mr. SLOOP. You have to supply energy to regenerate, and that could come from say an array of solar cells, or from a thermionic power system, or from a nuclear reactor.

Mr. KARTH. Yes.

Mr. SLOOP. This is an element of the Gemini fuel cell, which operates on a little different principle. You have heard of ionic membranes, which are sometimes used in desalting processes, and such a membrane is another way of providing the catalytic surface on which the basic reaction between hydrogen and oxygen occurs.

The wicks at the bottom remove water by capillary action and the tubes at the top carry away the heat. We intend to increase our effort in fuel-cell technology in 1964.

I wanted to illustrate one other method of generating power, by use of reciprocating engines or piston engines. Here is a picture of one (fig. 230). It looks like a lawnmower engine, and works on the same principle, only it uses hydrogen as a fuel and oxygen as an oxidizer, and drives a generator which produces electrical power.

This type of system is best used for short durations and could be carried aboard a spacecraft for intermittent use over longer periods of time. It is not as efficient as some of the other methods, but it

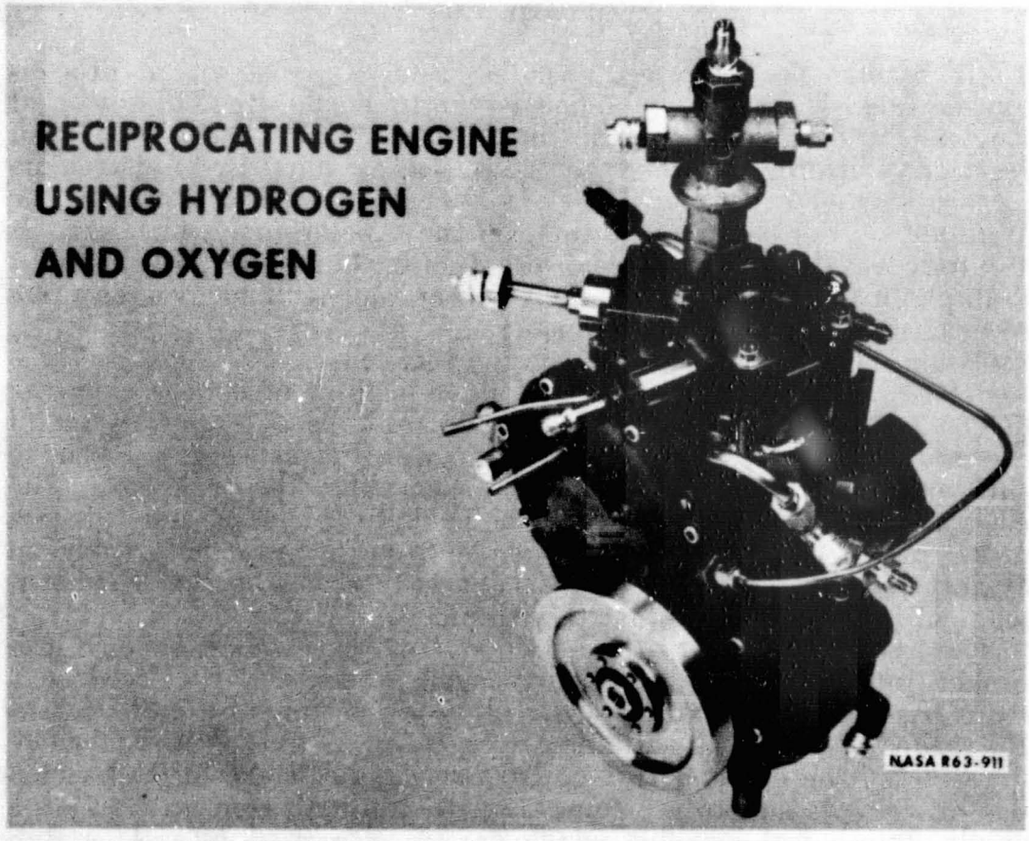


FIGURE 230

does have a very special application in the power spectrum shown to you by Dr. Bisplinghoff.

Mr. KARTH. Is the hydrogen used as a gas?

Mr. SLOOP. Stored as a liquid, and can be gasified before going into the engine. We can use other reactants.

Mr. KARTH. What about the normal boiloff. It is hard to store, isn't it?

Mr. SLOOP. Yes. One of the ideas considered as to use the boiloff of the tanks to drive this engine, or if the spacecraft carries a different fuel and oxidizer, an engine could be built for them. For example, there is a NASA contract for an engine of this kind that runs on nigrogen tetroxide and a hydrazine mixture.

Mr. KARTH. What are the possible consumer applications of those various sources of power we have been discussing today, if any?

Mr. SLOOP. I think the thermionic system coupled with a nuclear reactor is of interest and I think that Mr. Finger will mention it. Solar cells, thin-film solar cells in large surfaces might be used in certain remote or arid parts of the earth; and you are all familiar with sun-powered radios, and things of that sort.

Fuel cells, I think, will have an application for other purposes; as you know, and as you mentioned the other day, the Navy is working on fuel cells, and so is the Army, for terrestrial applications. I think fuel cells will have the greatest application on earth of those I mentioned.

Mr. KARTH. Thank you.

Mr. SLOOP. The last slide (fig. 231) is one that touches on the same area that Dr. Kelly mentioned in his testimony; namely, microminia-

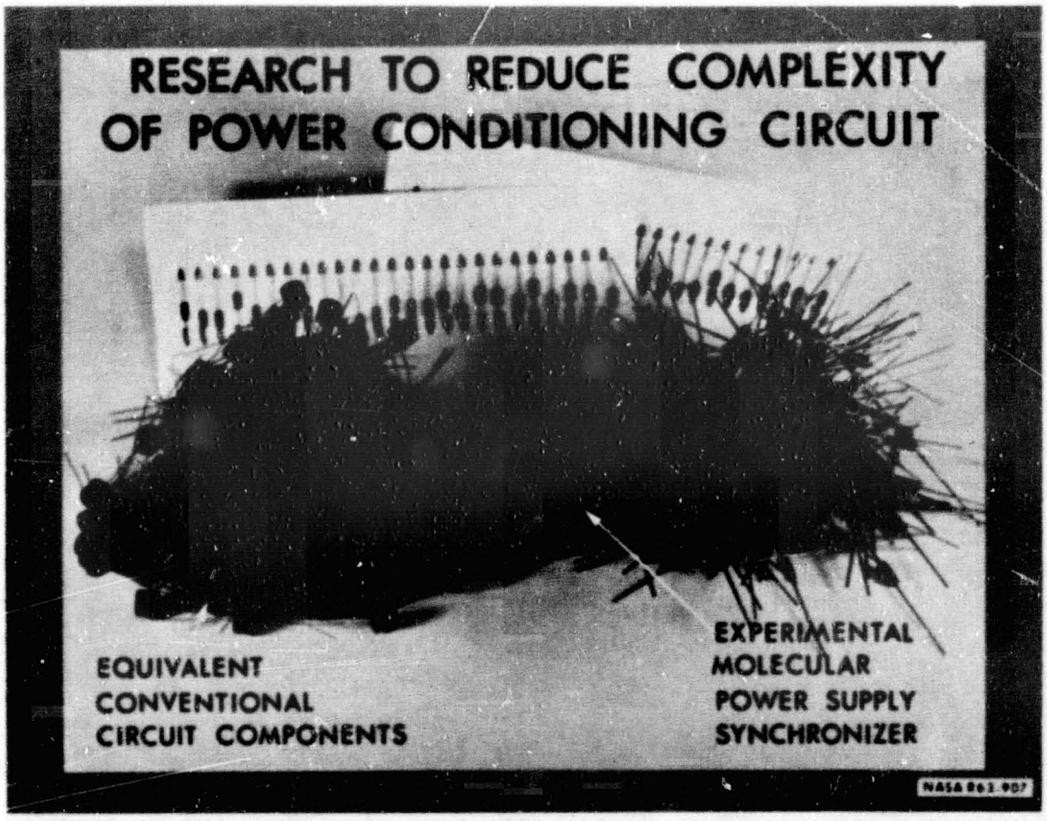


FIGURE 231

turization. In this case we are working on utilizing the miniaturization techniques coming out of the research laboratories to reduce the sizes of circuitry that is associated with a power system.

All this is meant to show is the great comparison between an experimental molecular power supply synchronizer, used in a three-phase synchronization circuit for power supply aboard spacecraft, compared with conventional components shown to the left and the right of it. There is a dime also pictured for comparison, so you can see there is quite a possibility of sizes reduction and, of course, increased reliability.

This concludes the summary of what I wanted to say.

Mr. KARTH. Thank you very much, Mr. Sloop.

Are there any further questions?

Unless the members decide later on they would like to have you back, I think we can adjourn today and meet at 10 o'clock on Monday for the purpose of hearing Dr. Konecci.

Dr. BISPLINGHOFF. Yes, sir.

Mr. KARTH. If there are no questions at this point, the meeting is adjourned.

(Whereupon, at 12 noon, the committee was adjourned.)

1964 NASA AUTHORIZATION

MONDAY, APRIL 8, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SPACE SCIENCES
AND ADVANCED RESEARCH AND TECHNOLOGY,
Washington, D.C.

The subcommittee met, pursuant to adjournment, at 10 a.m., in room 304, Old House Office Building, Hon. Joseph E. Karth (chairman of the subcommittee) presiding.

Mr. KARTH. The committee will be in order. Mr. Ames, I understand that you will be our first witness this morning.

I see you have a prepared statement. I wonder if you could summarize the statement, and give us the benefit of whatever slides or other visual aids you might have.

Mr. AMES. Thank you, sir. I appreciate the opportunity to appear before the subcommittee, Mr. Chairman, and would like to have my prepared statement in the record as you have indicated.

STATEMENT OF MILTON B. AMES, JR., DIRECTOR, SPACE VEHICLES, OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY, NASA

(The prepared statement of Milton B. Ames, Jr., is as follows:)

Mr. Chairman and members of the subcommittee, the objective of the space vehicle systems advanced research and technology program is to identify and solve critical technical problems bearing on present-generation space vehicles, as well as to advance the frontiers of knowledge that will enable the development of more advanced space vehicles for future space missions. The increased complexities of the advanced space vehicle systems that will be required to accomplish our national space objectives for the next two decades attest to the need for a broad, yet thorough and timely research program, to establish the technology required to insure the continued superiority of our country's space flight capability.

PROGRAM AREAS

The space vehicle research and technology program covers a broad range, as indicated by the areas of activity shown on figure 1. They are—

Advanced space vehicle concepts.
Space vehicle aerothermodynamics.
Environmental factors and technology.
Space vehicle structures.
Design criteria.
Vehicle technology flight experiments.

Such a program has many facets. It begins with conceptual studies of missions and related launch vehicles and spacecraft, in order to evaluate their feasibility, to identify major problems, and to provide guidance and perspective for ongoing research and technology programs. Manned missions to the planets, manned orbital space stations, and nuclear Earth-Moon ferries are but a few examples of such studies.

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In the space vehicle aerothermodynamics area, our objectives are to devise better systems for entry into the atmosphere and for recovery of spacecraft, as well as economical and reliable methods for recovering and reusing large and expensive launch vehicles. Aerodynamic characteristics of new and unusual space-vehicle configurations must be studied to establish stability, control, and performance characteristics. Extreme heating conditions at the base of large multiengined launch vehicles, as well as effects of aerodynamic heating on spacecraft during entry into various atmospheres, such as those of the Earth or the planets, must also be investigated.

Next, in the environmental factors and technology area, knowledge is required of the environments of the atmosphere and space, and their effects on vehicle design. Winds and atmosphereic turbulence create many control and structures problems. The harsh space environment with its many hazards to the spacecraft must also be thoroughly understood. The effects on space vehicles of high-energy radiation, meteoroid impacts, thermal radiation from the Sun, weightlessness, and hard vacuum must be defined and studied.

Space-vehicle structures will become larger and heavier, and they will be required to operate for longer periods of time to perform the advanced missions that will follow present programs. Aggressive research activities are required to maintain the weights of these structures at reasonable levels and, at the same time, to insure reliability under the severe environments and complex loading conditions which they will experience.

Information resulting from research and technology programs must be formulated into space-vehicle design criteria to insure prompt and proper application to vehicle design in an acceptable and uniform manner. We are undertaking the compilation, correlation, and assessment of the state of the art of space-vehicle research and technology, and the preparation, documentation, and updating of general design criteria standards. The effort encompasses the establishment of standard models of the environment within which space vehicles operate, and of criteria for the design of structures, propulsion systems, and guidance and control systems.

The demands for rapid technological progress are such that at times neither theoretical analyses nor experimental investigations conducted in ground-based facilities can be relied upon to provide timely answers to all of the important problems. Consequently, as a complement to these ground-based programs, carefully selected flight experiments have been planned to provide urgently needed data. In some cases, the answers to important problems can be obtained only by flight experiments. The determination of the nature and extent of the meteoroid hazard is a specific example of such a research problem.

While most of the activities in the space-vehicle research and technology program are general in nature, the results of these activities are applicable to all NASA space vehicles and missions, and in many cases, to military space vehicles as well.

In order to give you some further concept of the nature and scope of our programs, I will discuss examples of a few technical problems and some results of our research activities in each of the areas shown on figure 232 (p. 2346).

ADVANCED SPACE-VEHICLE CONCEPTS

NASA research programs have always been strongly guided by studies of future performance possibilities and mission requirements. Vehicles and missions such as the X–15 and Mercury were created as the results of in-house advanced conceptual studies. Today, the cost and complexity of space missions and vehicles make it vital that the advance planning which precedes them be based on the soundest research programs possible. In addition to in-house activities, an increased use of contractual studies with industry is required to provide depth and breadth representative of the industrial designer's veiwpoint.

Figure 233 (p. 2347) identifies our three main areas of study activity. They are—

Earth orbital operations;
Advanced lunar missions; and
Exploratory missions to the planets.

Each of these three areas poses special problems in design of space vehicles. For example, manned exploration of the planets confronts us with quite different technical problems than those of manned orbital missions or missions to the Moon. Obviously vehicles for planetary missions will be much heavier, and must operate effectively for much longer periods of time. The date on which any planetary mission is undertaken is of great importance with respect to vehicle size and mission time.

Advanced conceptual studies currently underway include: Earth-orbiting space laboratories; recoverable boosters; Earth-lunar transfer vehicles or ferries; and large advanced launch-vehicle systems with spacecraft capable of entering planetary atmospheres and returning to the Earth at velocities of 35,000 miles per hour, or greater. These studies have defined a number of important long-range problems in research and technology, and have indicated that some future missions may require radically new vehicle configurations and systems.

All advanced conceptual vehicle design studies result from asking the question, "What do we need to further our ability to operate in a given space regime?" Vehicle sizes and forms are the result of the complex interplay of all the technologies from structures to life support systems. And, "How do these studies help the research worker?" First, the studies point out that if we are to conduct future space operations using conventional missile and space vehicle technology, missions will become more costly and launch vehicles must get bigger—so much so that research must supply, for example, the technology for the construction of huge cryogenic tanks 60 by 200 feet, and rocket engines 20 times the thrust of the F–1, our largest to date.

Such results lead to speculation on the need for reusable launch vehicles, and this subject is a good example of the close and continuing relationship between advanced vehicle study effort and research programs. Present state-of-the-art technology suggested the use of parachutes or paragliders to bring back Saturn–5 launch vehicles, or perhaps adding wings and jet engines. On the other hand advanced conceptual studies indicated that such developments would be only marginally justified operationally or economically, and that much better techniques were needed. This has led to increased research and study effort on radically new launch vehicles—designed along radically new lines. Initial results indicate that we must be able to design a launch vehicle structure which will operate again and again with little rework, at temperatures which reach between 2,000° and 3,000° F., and through flight regimes from orbital speed to landing.

To such technical requirements the studies add the dimension of time—"When is it reasonable to expect a requirement for such an advanced vehicle system, and when could we be capable of producing one?" Such estimates, of course, are part of a circular or closed-loop process, and it is the research timetable which will determine when we will be capable of achieving the goals indicated by the studies. Thus, there is and must be a close and continuing relationship between research activities and advanced mission and vehicle studies. Since such a relationship should start early if its full value in research planning is to be obtained, the Office of Advanced Research and Technology has concentrated its initial efforts on the mission area furthest in the future—manned planetary exploration. Initial results have already identified a number of important research problems requiring a long leadtime if solutions are to be available when needed.

SPACE VEHICLE AEROTHERMODYNAMICS

The major areas of activity in space vehicle aerothermodynamics are indicated on the left side of figure 234 (p. 2354).

Our program encompasses the problems of atmospheric entry heating of manned and unmanned spacecraft at speeds ranging from near-Earth satellite speed upward to those characteristic of interplanetary flight on which we are not able at present to set an upper bound. The program also encompasses the aerodynamic performance, motion, and flight characteristics of spacecraft, to evolve advanced configurations for future missions. The landing and recovery item covers essentially the low-speed end of our activity, and includes research and advanced development on techniques for final letdown and landing such as paragliders and rotors, as well as lifting reentry vehicles capable of horizontal landing without auxiliary means. The area of launch vehicle aerothermodynamics covers the specialized aerodynamic and heating problems of our present families of launch vehicles and, with guidance from the advanced conceptual studies, the aerothermodynamic problems of advanced reusable launch vehicle configurations for future space flight missions. Finally, we are concerned with the problems associated with the generation, propagation, and possible alleviation of acoustic noise—primarily the intense low-frequency noise generated by large rockets and the noise generated in aerodynamic boundary layers.

I would like to treat two subjects in a little more detail: (1) Advanced manned vehicles for future missions; and (2) One facet of the spacecraft landing and recovery research program.

Advanced manned vehicles for future missions.—With regard now to advanced manned entry vehicles—"What can we say about the shape of things to come?"

Let us consider interplanetary flight. Without retrorocket braking, the irreducible minimum Earth return speed of our interplanetary vehicle is that of Apollo—about 36,000 feet per second. To this must be added the effective transit speed between planets, which is limited only by the propulsion available. We are, therefore, talking generally of Earth return speeds in the neighborhood of 50,000 feet per second. Manned flight is "g"-limited flight, and we are restricted to the most grazing approach trajectories to keep the deceleration within tolerable bounds.

Figure 235 (p. 2355) illustrates how the situation becomes more difficult with increasing speed. On the left side is the familiar picture of the entry corridor, greatly exaggerated in scale. The upper boundary is the highest altitude that will allow capture of the spacecraft in one pass. The lower bound is the lowest altitude that will not cause some limiting "g" load to be exceeded—in this case, 10 "g." On the right of the figure is a plot of corridor depth in miles as affected by speed. The narrowing of the corridor is already drastic at Apollo capture speed, and approaches the vanishing point for nonlifting vehicles at planetary return speed. A vehicle with moderate lifting ability, as represented by the curves labeled "lift/drag ratio 1/2" and "1," greatly improves the situation. Diminishing returns rapidly set in, however, and greater lifting ability produces smaller gains.

The use of lift extracts a penalty in total heating and therefore in heat protection weight. It has been found recently that this penalty can be substantially reduced by having the vehicle always trimmed at the attitude for maximum lift.

The photograph on figure 236 (p. 2358) is a model test of a configuration being studied to develop the technology for successful entry into the Earth's atmosphere at interplanetary speeds, and for entry into the atmosphere of other planets. This model is a typical lifting spacecraft configuration. Another point is significant—at interplanetary speeds, spacecraft temperatures are extremely high, not only at the stagnation point at the nose, but over all windward surfaces. They are so high, in fact, that in this flight regime materials—including the most refractory ceramics—will lose mass due to heating. Hence, there is nothing at this time to indicate any basic change in the approach of ablative materials for heat protection.

A number of factors in addition to those already mentioned will influence the final choice of any configuration, such as compatibility of large spacecraft with launch vehicles and efficient use of spacecraft volume. The indications are, however, that manned entry vehicles beyond Apollo will be lifting-body configurations having L/D ratios between 1/2 and 1.

Spacecraft landing and recovery research.—This leads naturally to one part of our program in the area of landing and recovery. Figure 237 (p. 2362) illustrates some work of the Flight Research Center on the flying and handling qualities of spacecraft configurations during approach and landing.

This lifting-body flight test vehicle will be towed to altitude and then released to be maneuvered in gliding flight and landed. The vehicle was designed at the Flight Research Center, using a configuration conceived and studied extensively at model scale by the Ames Research Center. A Plexiglas canopy and a transparent nose section permit a forward and downward view in the nose-high landing attitude characteristic of such vehicles. The flight tests are expected to begin this month.

Launch vehicle aerothermodynamics.—Continuing to look to the future, the aerothermodynamic characteristics of many new launch vehicle configurations are being studied. These studies include trajectories and staging, windloads and forces, hinge moments of gimbaled rocket nozzles and flow phenomena in regions of rocket exhaust, and wings or other lifting devices for returning the launch vehicles of the future to the launch area.

Acoustic noise propagation.—The noise generated by large rocket engines will become an increasingly severe problem. Studies of the noise field around the Kiwi nuclear rocket have been initiated. Analytical and experimental studies will be extended on the generation and propagation of noise from both chemical and nuclear rockets, and the effects of noise on space vehicles.

ENVIRONMENTAL FACTORS AND TECHNOLOGY

Space vehicle design becomes increasingly difficult for future missions because of the long duration of exposure to the hostile environments of space which are today only partially defined. The major areas of activity in the environmental factors and technology program are indicated on the left-hand side of figure 238 (p. 2363). They are—

High-energy radiation effects and shielding;
Meteoroid environment and impact hazard;
Thermal radiation and temperature control;
High-vacuum technology; and
Zero-gravity fluid behavior.

High-energy radiation effects and shielding.—In the high-energy radiation and shielding area, primary emphasis is placed on studies of the effects of radiation on spacecraft components and materials, and on both passive and active means for shielding men and sensitive equipment from charged particle radiation. Since all space vehicles will, to some degree, be exposed to high-energy radiation, a wide variety of problems require theoretical and experimental investigation.

In view of its importance, we have an active and growing program in the area of high-energy radiation. As is indicated in figure 239 (p. 2364), we are concerned primarily with the charged particle radiation environment which includes galactic cosmic rays, solar protons, Van Allen belt protons and electrons, and artificial belt electrons.

First, the environmental data obtained by the space sciences program are used to assess the nature and extent of the radiation hazard for foreseeable missions. Such evaluations then guide our generalized research on various aspects of the shielding problem including the generation of basic data on the interaction of the radiations with materials, the generation and development of advanced shielding concepts such as electromagnetic shielding, the development of advanced methods for calculations of detailed doses inside complex shields, and the verification of the shielding effectiveness of final vehicle configurations. The generalized information and techniques resulting from these programs are made available promptly to all projects for application to the design of shield systems for specific vehicles.

I would like to mention one study which, if successful, will result in a useful technique for verifying final vehicle shielding design. This scheme involves the correlation of gamma ray penetration with the penetration of protons. It should, in principle, be accurate for cases where secondary radiation produced in the vehicle is not important. This application is illustrated on the left side of figure 239a, where a gamma radiation source is shown inside the vehicle with a mobile detector being used to scan the outer vehicle surface, surveying the emerging radiation. The position of source and detector could be reversed equally well to obtain the same results. It is obvious that a technique of this kind could vastly simplify the job of full-scale testing of a vehicle radiation shield.

Another use of the gamma probe is illustrated on the right side of the figure. Here, various typical spacecraft "black box" components will be scanned to determine their shielding effectiveness. The data so obtained will be helpful in shield design since the use of onboard equipment to stop radiation is an important factor in reducing shield weight. Such studies may result in recommendations concerning the design of such components to aid in shielding against the effects of high-energy radiation.

Meteoroid environment and impact hazard.—The second area of the space environment is that of the meteoroid hazard. Of all the areas we are dealing with, this is the one we have known the least about. Our overall program, shown on figure 240 (p. 2366), includes space flight experiments for direct determination of the population of hazardous penetrating particles; ground-based radio observations of meteors that constitute a hazard to spacecraft and laboratory investigation of hypervelocity impact and penetration phenomena. The most interesting item to report to you at this time is the results we have been getting from the Explorer XVI satellite.

Figure 241 (p. 2367) is a photograph of the Explorer XVI spacecraft (S–55g). This satellite was launched by a Scout vehicle on December 16, 1962. It has an exposed area of 25 square feet and a total of five different kinds of meteoroid sensing elements. After more than 3 months, everything is still working properly. As of the first of March, 20 punctures of the cans and 3 punctures of printed circuit gages had been recorded. The punctures represent a fairly good statistical sample compared with the complete absence of such data last year. However, we still must extrapolate these data a long way to reach an estimate of probable

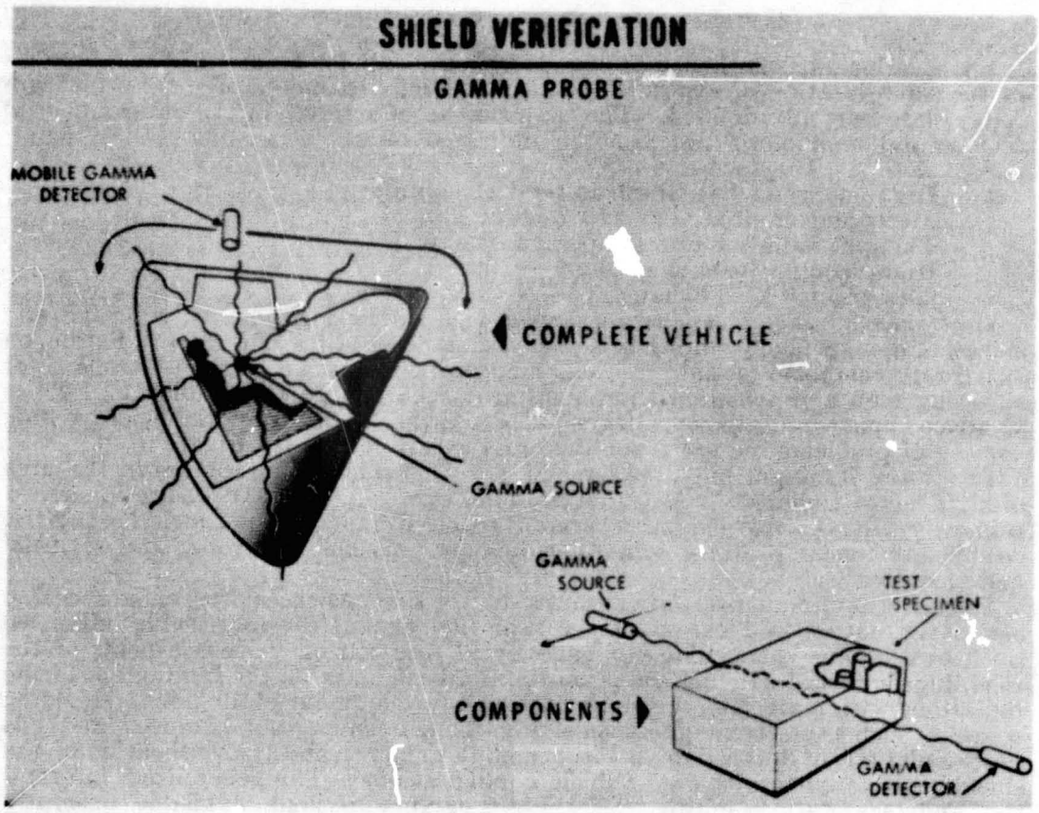


FIGURE 239a

puncture rates for practical spacecraft skin thicknesses, but at least we now have a much better starting point for the extrapolation.

We can say this much about what we have learned to date: (1) We have direct confirmation that fairly numerous penetrating particles do exist in space; (2) we can say that on the basis of the data obtained, previous predicted penetration rates which have been used most often in vehicle design appear to be too conservative.

The program is continuing, with an effort to obtain considerably larger exposed areas (approximately 2,000 square feet) to direct meteoroid penetration, and hence greater allowable skin thicknesses, using a Saturn-launched meteoroid satellite. The ranges covered by the various flight experiments in our program, as well as ground-based radio observations, are shown on figure 242 (p. 2369).

The band between the solid and dashed diagonal lines on the figure is indicative of the wide differences between the two most frequently used predictions of meteoroid penetrations in various thicknesses of aluminum. It can be seen, starting from the upper left that the thin skin of the recoverable meteoroid probe should experience a large number of impacts and penetrations by the very small particles. The cross-hatched areas in the center show the coverage of particle size and penetration probabilities which will be obtained in the S–55 and Saturn-launched meteoroid satellite experiments. The artificial meteor experiments and the ground-based meteor observations by radio techniques shown on the far right are concerned with the larger meteoritic particles.

The S–55 and Saturn-launched meteoroid experiments and other experiments on the figure will provide data on the meteoroid hazard in the vicinity of the Earth. There also appears to be a need for similar information about cis-lunar space and near the Moon's surface, to determine the nature of the meteoroid hazard for manned lunar missions. An advanced meteoroid experiment to provide such information is needed.

Thermal radiation and temperature control.—The temperatures of space vehicles must be controlled in order to satisfy the requirements of instruments or internal payloads. Transistor networks and batteries are efficient only within narrow temperature limits. Biological processes also require strict temperature controls.

The internal temperature of space vehicles is governed largely by the temperature of the external surface, and this in turn by the thermal radiation characteristics of the surface, the external environment, and internal heat generation.

The problem of temperature control of new, larger, and more advanced spacecraft while in flight has become so complex that the currently used methods of passive control of temperature seem possible only for spacecraft of simple shapes such as cylinders and spheres.

The problems of conduction of heat through the spacecraft, and of reflection and radiation of energy from one external part to another, have resulted in almost insurmountable design problems if one attempts to compute the equilibrium temperatures of various parts of a complex spacecraft. The problem is being solved temporarily, at least, through full-scale testing of spacecraft under simulated conditions of solar radiation and of heat received from the Moon or a nearby planet such as the Earth or Venus. However, this solution is not as easy as it sounds since no completely satisfactory method has yet been found for simulating solar radiation. Various light sources are being used as developed for the high-intensity illumination and motion picture industries, but these match the spectrum of solar radiation only approximately.

In addition, the problem of projecting this illumination within a vacuum chamber via systems of lenses and mirrors has brought out a lack of knowledge of the way in which such systems absorb and otherwise lose energy under high intensity conditions. This situation has resulted in the introduction of a research and development program in solar simulations, a problem which only a few years ago was thought to be solved. Needless to say, even the solution of this problem would only lead to the development of larger solar simulators as space vehicles become larger unless corollary programs are established to forestall their need.

The first of these programs is one of developing scaling techniques for thermal testing of spacecraft models in simulators of the size of those now being constructed. The second is that of obtaining better knowledge of the flow of heat within complex spacecraft when exposed to vacuum conditions, so that better predictions can be made of internal heat flow and accurate methods of computing temperature balance conditions developed. Such developments will not only aid in the final checkout of thermal balance of spacecraft prior to launch, but in the actual design where thermal characteristics can be varied to satisfy requirements.

Two additional alternatives are being explored which may make unnecessary the construction of extremely large simulators in the future. These are: (1) the use of active thermal control surfaces wherein the ratio of radiant energy absorption and emission can be controlled in flight, and (2) the use of onboard atomic heat sources making it unnecessary to use external heat from the sun and thereby cut down on a major source of temperature variations as space vehicles move closer to or farther away from the Sun or dip into the shadow of planets such as the Earth.

Zero-gravity fluid behavior.—An improved understanding of zero-gravity fluid behavior is important with regard to fuel storage, tank design, fuel pumping and engine restart, and fuel container heat-transfer problems. Of immediate aid would be the formulation of better theoretical explanations of the zero-gravity effects observed to date.

The basic problem is that of developing an understanding of the behavior of fluids in the weightless state and using this understanding to develop means for the positive control of fluid masses. This work is conducted at the Lewis Research Center. The facility used is a 110-foot-high drop tower; the free-fall time is just slightly over 2 seconds.

A large number of experiments have been run in this simple but effective drop tower facility over the past 2 years. A great deal of qualitative understanding has been developed and the effort is now to put this understanding on a solid, quantitative basis. A new, larger facility has been requested which will permit a free-fall time of 5 seconds, and eventually a zero-gravity time of 10 seconds, by catapulting the experimental package upward from the bottom. This will permit tests to be made of larger and more complex systems that include pumping equipment, piping, and the like. Where still longer times in a weightless state are required, we must resort to flight experiments.

SPACE VEHICLE STRUCTURES

Future space vehicle structures will be larger and heavier, and they will be required to operate for longer periods of time than those required for present approved missions. Aggressive research will be required to maintain weights at

reasonable levels and to predict structural behavior with greater accuracy, to insure reliability under the severe environments and complex loading conditions which space vehicle structures will experience.

For example, the launch vehicle component of a space vehicle system is one of the most efficient structures that has been devised for transportation. In the table which follows are shown weights of various major components of a launch vehicle compared with those of other means of transportation.

Relative weight breakdown for various forms of transportation

	Propellant	Propulsion	Payload	Structure
Launch vehicle	88	4	6	2
Airplane (jet)	43	7	10	40
Ship	15	10	25	50
Automobile	3	22	25	50
Train (75-car)	1	3	77	19

As can be seen, the relative weight of the structure of the launch vehicle is exceedingly small compared with other transport structures. This small relative weight of structure is required to contain the propellant, support the engine, and support and protect the payload in the presence of very severe environments. The margin of safety is, consequently, exceedingly small.

The environment which this structure must resist includes many static and dynamic factors as illustrated in figure 243 (p. 2387). Before engine ignition, but after the gantry has been removed, ground winds can induce rather severe loads—both a steady drag load and a dynamic response in a direction mainly normal to the wind direction.

At engine ignition and launcher release, longitudinal transients are induced which can be rather severe and are important, not only from the standpoint of basic structural strength, but also with regard to effects on smaller components. Also, the engine noise in the presence of the ground is of high intensity and, for the larger, more powerful vehicles, new problems are being uncovered.

During flight through transonic speeds to the maximum-dynamic-pressure regime of flight, the thrust and various steady-state and oscillating aerodynamic loads become important. These inputs include high steady-state acceleration, boundary-layer noise, winds and wind shear, and static high-pressure peaks around geometric discontinuities at transonic speeds upon which are superposed buffeting loads. In this same flight regime, consideration must be given to the vehicle control in the presence of high-velocity horizontal winds such as the jet stream, as well as the stability and the coupling of the control sensor with the flexibility of the vehicle. Another structural stability problem involves flutter, either of the components such as fins, or of a localized area involving thin structural panels. Finally, stresses from internal pressure are also present during the launch period.

Once our lightweight space vehicle structure leaves the Earth's atmosphere, it becomes even more apparent that when consideration is given to protection from space hazards, we should not expect conventional earthbound structures to satisfy the unconventional requirements imposed on space vehicles. The larger, more complex space vehicle structures of the future will certainly challenge the resourcefulness and ingenuity of the designer, and require a significantly broader based technology than exists today.

Structural dynamics.—One of the most important structural problems in space vehicle design is the accurate prediction of structural dynamic characteristics. Calculated dynamic properties leave much to be desired and full-scale tests are difficult and expensive to make. Before dynamic loads and responses can be predicted, or the control system designed, the lateral vibration modes and frequencies of a complete space vehicle must be known. Some of the newer configurations are quite unconventional and exhibit unusual vibration characteristics which are extremely difficult to predict analytically. The difficulties of determining these vibration characteristics experimentally, on full-scale hardware in simulated flight, are obvious when vehicles the size of Saturn are considered. These considerations have led to the concept of replica modeling as a tool for space vehicle design.

The Langley Research Center designed, constructed, and tested a ⅛-scale replica model of the Saturn SA–1 launch vehicle in an attempt to develop a tech-

nology for launch-vehicle dynamic models as well as to investigate the vibration characteristics of clustered configurations. The ⅛-scale model is shown on the left of figure 244 (p. 2389). A full-scale Saturn (SAD–1), suspended in a test tower to simulate dynamic conditions, is shown on the right. The model is 32 feet tall and weighs 7,500 pounds, compared to 160 feet and almost 1 million pounds for the full-scale vehicle. The model was designed by using replica scaling techniques which required that joints, cutouts, fittings, and so forth—with stiffnesses that could not be accurately predicted—be duplicated by dimensional scaling.

An example of the vibration test results and a comparison with full-scale results are shown in figure 245 (p. 2390). Results shown are for the first bending mode, at a weight condition corresponding to the maximum-dynamic-pressure point in the launch trajectory.

A scaled frequency of 2.80 cycles per second (c.p.s.) was measured on the model, compared with 2.83 c.p.s. on the full-scale vehicle. The mode shapes measured on the model and on the full-scale vehicle agree very well, as indicated by the circles and squares plotted in the figure. The flagged circles in the area of the first stage represent points measured along an outer tank in the cluster, and indicate that these outer tanks follow the centerline motion. This tank motion is further illustrated by the cross-sectional sketch of the first stage, where the arrows indicate the motion of the various tanks within the cluster. All the tanks are seen to move together, with a resulting vibration mode shape very similar to a beam bending mode.

A more complicated vibration response is illustrated in figure 246 (p. 2391). This is the mode shape at the second resonant frequency of the vehicle. The model frequency was 5.20 c.p.s. compared with 5.68 c.p.s. for the full-scale vehicle—less than a 10-percent variation. Again, circles represent model data, squares represent full-scale data, and flagged symbols indicate deflections measured on an outer tank. Note the different behavior of the outer and inner tanks within the cluster. This is shown better by the arrows on the first-stage cross section at the right. The center tank is seen to deflect in one direction, while the outer tanks tend to move tangentially, but predominantly opposite to the motion of the center tank. This unconventional mode, which results from the clustered-tank construction of the first stage, has been termed a "cluster" mode. Notice that, when circles and squares are compared, model behavior is essentially the same as that of the full-scale vehicle.

The results in these last two figures indicate that dynamic models can be used to determine the vibration characteristics of complex launch vehicles. The unusual vibration characteristics of this particular clustered-booster arrangement were also identified. As new configurations evolve, it is anticipated that dynamic modeling techniques may be used to great advantage to study their dynamic structural properties. In fact, we plan to conduct studies similar to those described, using models of the Advanced Saturn–5, during the coming year.

It is apparent from the foregoing discussion that considerations of structural dynamics are a most important factor in the design of present and future space vehicles. In the past, our research in this area has been severely limited in scope by lack of adequate space and modern test equipment. We are, therefore, requesting funds in our fiscal year 1964 budget for construction of a Structural Dynamics Laboratory at the Ames Research Center, in order to extend the scope of the significant work being done in transonic buffeting of launch vehicles, dynamics of liquid and solid fuels, effects of landing impacts on structures, and other such problems where we must study in detail overall dynamic systems with complex interactions, interfaces, and environments.

Space hazards control.—Protection against the hazards of the space environment requires consideration of the major items such as: Temperature, radiation, vacuum, zero gravity, and meteoroids (as mentioned earlier).

As one example, we are studying structural systems for control of the meteoroid hazard. Figure 247 (p. 2392) shows a comparison of structural weight with exposure time. The upper curve illustrates the growth of structural weight if a single sheet skin is used as meteoroid protection. Based on a 99-percent probability of being puncture free, it is apparent that single-skin structure is not practical for long missions where meteoroid impact is the controlling design factor. On the same basis, the next curve shows a bumper arrangement which represents a considerable reduction in structural weight. Our studies have indicated that this reduction in weight can be as much as an order of magnitude, depending upon the spacing of the bumper from the main skin and the materials used in the space between. Polymeric foams of various densities appear to be effective in absorbing the energy of meteoroid particles after impact with the bumper.

We are also studying various methods of self-sealing after puncture. The lower curve shows that self-sealing systems can offer a weight advantage for longtime periods. These systems provide a fail-safe approach to prevent excess leakage. Our studies have been limited to feasibility demonstrations and some samples of systems have been sealed within a few seconds after penetration. We will continue to explore other approaches, favoring those which incorporate the lightest weight and greatest reliability.

An example of temperature control is shown on figure 247a. Here we have plotted weight of a hydrogen tank relative to that required for launch for various lengths of time in space. In this case, maintaining low temperatures inside the vehicle requires more than a surface treatment or coating. It requires use of additional strength, plus insulating material. The curves are based on an optimized design, wherein the least penalty was involved for maintaining temperature

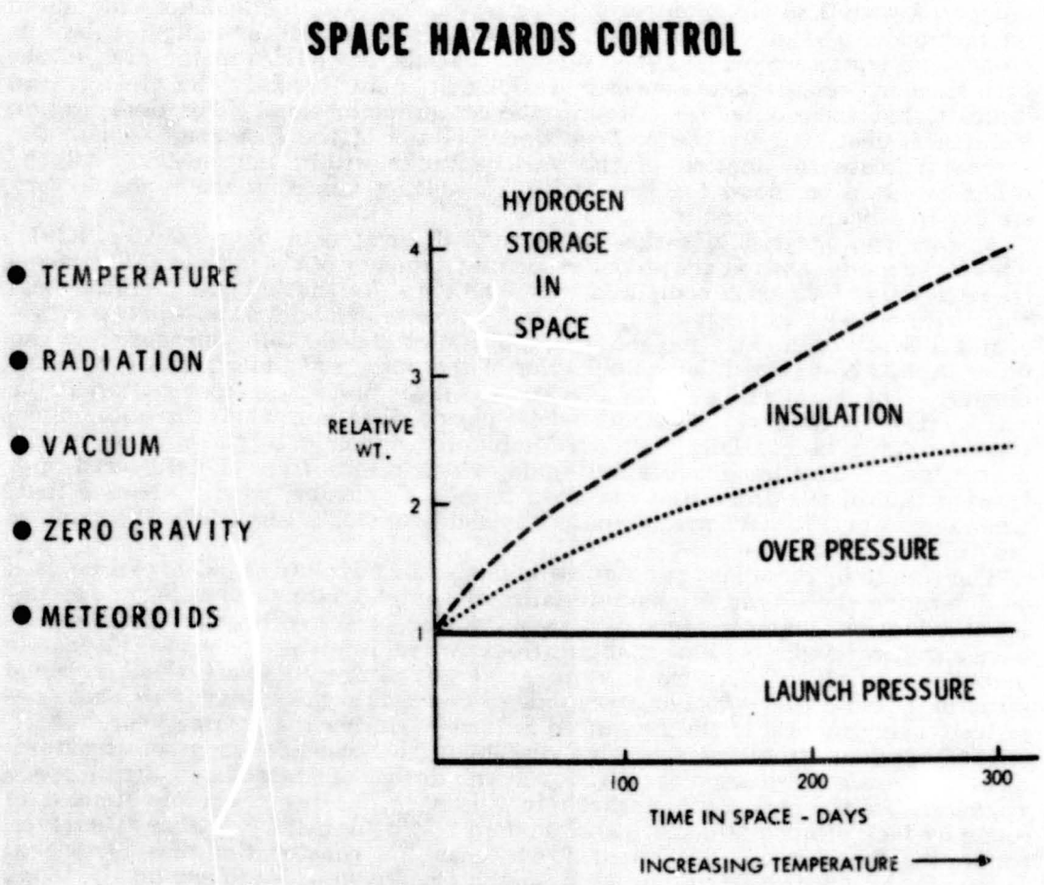


FIGURE 247a

control. As can be seen from this example, the additional structure for maintaining overpressure of a cryogenic fuel (due to rising temperatures over a 300-day period), plus the insulation (the best we know of today), can greatly increase the weight over that required for launch.

Progress is being made toward developing more effective insulation and lighter structures for hydrogen storage. Glass filament reinforced plastic tanks are inherently better insulators, and have demonstrated in excess of 2-to-1 superiority in strength weight, as compared with metal tanks.

Advanced structural concepts.—Studies of various advanced space systems for future missions continue to reveal a host of structural problems and barriers. Solution of the problems and removal of the barriers will require advanced structural concepts which differ radically from the conventional. The manner in which they vary is shown on figure 248 (p. 2349).

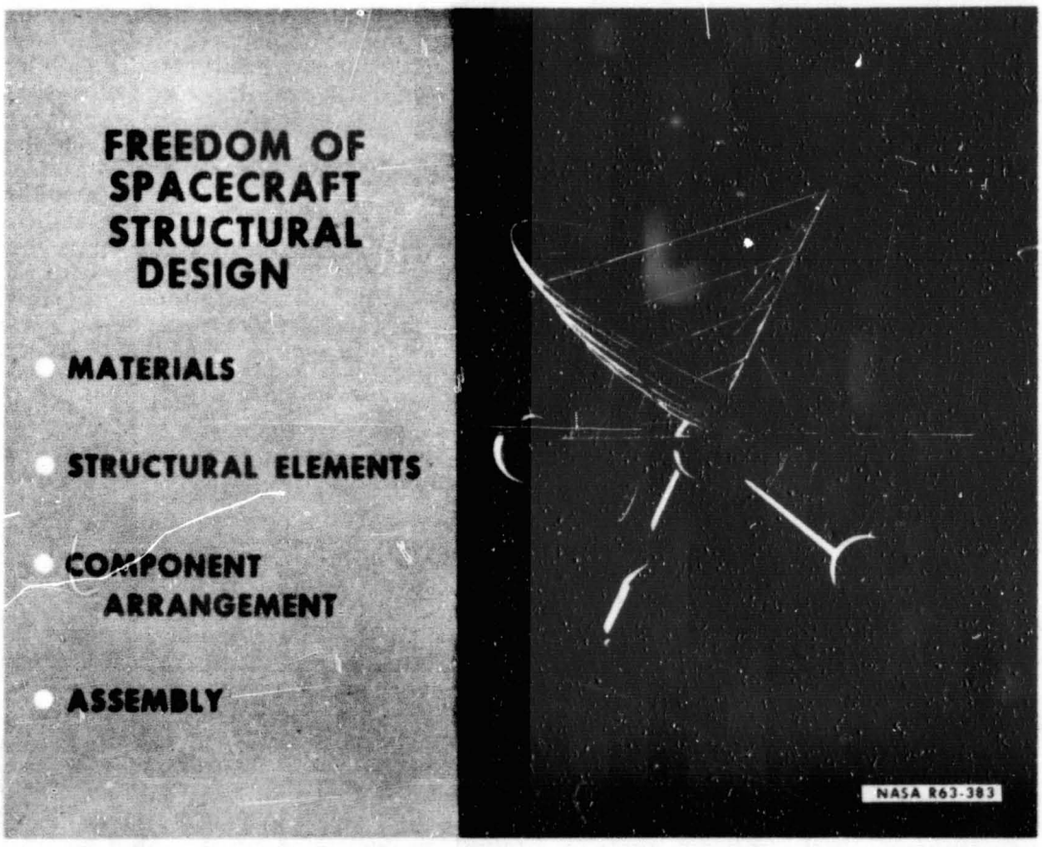
Depending upon function, they vary from the conventional in materials, geometry, fabrication, and assembly. Our program is aimed at early structural application of a wide variety of materials in different sizes, shapes, and combina-

tions. In this program we are bringing to bear sources and talents of many industrial specialists not previously associated with space research.

We are also studying new geometries and sizes of structures capable of functioning in the space environment free of winds, weather, and gravity. We are also examining advanced fabrication and assembly techniques for these new material structural forms.

One method of vehicle assembly being investigated involves expandable structures which deploy themselves in space after having been launched in a packaged condition. Mechanisms for achieving this feature include inflation, unfolding, spinning, etc. An orbiting manned space laboratory is an example of a vehicle that might unfold in space.

The picture on the right in figure 248 (p. 2394) represents an advanced orbiting radio telescope. This is an example of an advanced concept which would utilize the results of research in materials application, geometry, fabrication, and assembly. This is a research program in which we are assessing the structural feasibility of such a system, working with our Electronics and Control Office in OART.



Freedom of spacecraft structural design.—Figure 20 shows several other unconventional aspects of spacecraft design. Such odd characteristics result from relaxed constraints on configurations in cases where aerodynamic forces are no longer a consideration. Here the structural loadings are peculiar only to the spaceflight phase of a mission.

Freedom from configuration constraints should enable design of space vehicles which make efficient use of unusual materials and structural elements such as (for example) cables and trusses. Essential structural components might also be positioned so as to improve mass distribution and temperature control.

As mentioned earlier, the structural designer may have a choice of methods of spacecraft assembly or erection in space. These unusual approaches are therefore appealing from the standpoint of their influence on the size of future launch vehicles.

High temperature structures.—The designer's viewpoint is, of course, reversed again when he considers structural design of spacecraft capable of withstanding the high temperatures of atmospheric entry at very high speeds. Here, heat

shield design becomes a major factor. The severity and duration of heating and loading varies widely with vehicle type and trajectory; consequently, a large number of materials and structural concepts have evolved. Proper selection of concepts, and prediction of their performance as mission times and entry speeds increase, is a large and challenging research task.

A broad picture of the role that the heat shield plays in determining the feasibility of future entry vehicles is presented in figure 249 (p. 2395). Vehicle kinetic energy, heat shield capability, and vehicle heat load, all expressed in B.t.u. per pound, are shown as a function of entry velocity. The range of velocity shown must be considered if exploration of nearby planets is to be carried out. Of the tens of thousands of B.t.u.'s of kinetic energy possessed by each pound of the entering vehicle, the major portion is dissipated in heating the atmosphere, with only a small fraction returning as a heat load on the vehicle surface. At the lower velocities heat transfer to the vehicle is primarily by convection, whereas at the higher velocities radiative transfer from the highly heated shock wave or gas cap contributes importantly.

The width of the heat load band at a given velocity reflects differences in vehicle configuration and entry trajectory. Vehicles entering on ballistic trajectories encounter heat loads near the lower edge of the band, whereas vehicles flying lifting trajectories move higher in the band. Detailed knowledge of the heat load to be encountered by a given vehicle at the higher speeds is admittedly sketchy because of currently unresolved uncertainties in heat transfer mechanisms at these conditions.

Heat-shield capability can be represented by a broad band encompassing the range from 2,000 to 20,000 B.t.u. per pound. That is, with currently known materials, each pound of heat shield can be expected to dispose of a certain amount of heat energy within this range while maintaining an acceptably cool vehicle interior for the duration of the entry maneuver. The diminishing separation between the bands of heat-shield capability and vehicle heat load suggests an increasing degree of difficulty in preserving a useful payload margin as spacecraft entry speed increases. Observations of meteors in the Earth's atmosphere reveal a greatly diminished chance for survival at speeds in excess of 55,000 feet per second or 38,000 miles per hour. Clearly, at the higher speeds, vehicles must be designed for minimum total heat transfer, and must utilize the most advanced heat-shield technology if reasonable payload margins are to be preserved.

Multifunctional structures.—From the foregoing discussion it is clear that, as shown on figure 250 (p. 2396), future space vehicle structures will be expected to provide simultaneously—

Adequate strength;
Stiffness;
Tolerance to temperature; and
Integrity against all space hazards.

Earlier experience with the first three areas on the figure indicated that the desirable solution was to separate the load-bearing and temperature-bearing abilities of a space vehicle structure. However, when meteoroid protection, high-energy radiation shielding, tolerance to vacuum conditions, and thermal control of radiation effects are required, it appears more fruitful to combine the necessary protective feature into a single structural wall. The diagram on the right on figure 250 (p. 2396) illustrates this idea.

The outer layer (shown on top) is a charring ablator for heat protection during atmospheric entry; it also provides limited protection against radiation and meteoroids. The inner wall provides strength, along with additional means for temperature control. A self-sealing mechanism, in this case honeycombs filled with hollow rubber spheres, provides integrity of the pressure vessel. This diagram is, of course, only conceptual and is used merely to indicate a possible trend in space vehicle structures.

SPACE VEHICLE DESIGN CRITERIA

The NASA space vehicle design criteria activity is an engineering effort to enhance the flight worthiness and reliability of future NASA space vehicles. The general design criteria and basic guidelines to be evolved are to provide the designers of NASA space vehicles with a basic and uniform set of conditions for use in designing launch vehicles, spacecraft, and reentry vehicles, as well as integrated space vehicles. Included within this activity are the compilation, correlation, and assessment of state-of-the-art research and technology, and the preparation, documentation, and updating of general design criteria, standards, and basic guidelines. The effort encompasses the establishment of standard

models of the environment within which space vehicles operate, and of criteria for the design of the structure, propulsion system, and guidance and control system.

The work is being primarily accomplished "in-house" by outstanding professionals at the field centers, through a steering committee, working subordinate subcommittees, and ad hoc professional groups. The method of intermixing advanced research and technology—oriented and space flight—oriented professionals from the centers on the steering committee, subcommittees, and groups insures that the knowledge gained from research and technology activities applicable to space vehicles, and from flight experience, is available to evolve, expand, and update the criteria.

The initial or preliminary NASA criteria are planned for completion in fiscal year 1964. As the technology changes, these documents will be updated and expanded.

VEHICLE TECHNOLOGY FLIGHT EXPERIMENTS

While much of the Office of Advanced Research and Technology (OART) fundamental and applied research program is devoted to improvement in theoretical and analytical techniques, practical limitations of theoretical, methods and the limited capabilities of ground-based technical facilities are such that they cannot be relied upon to provide timely answers to all important technical problems. Consequently, as a complement to our ground-based programs, carefully selected flight experiments have been planned to provide urgently needed data.

The Space Vehicle Research and Technology Office provides management service for all OART space flight projects except those directly connected with the nuclear program. This activity requires close cooperation with the other technical program offices in OART, and also with our counterparts in the Office of Manned Space Flight and the Office of Space Sciences.

Figure 251 (p. 2398) is a listing of current OART flight experiments. The major flight projects fall in the areas of hypervelocity reentry and meteoroid hazard. We also conduct a wide variety of experiments using small launch vehicles.

As shown at the top of the figure, reentry flight tests include Scout reentry heating experiments and Project Fire. The objectives of the Scout experiments are to measure at speeds of about 28,000 feet per second the total heat transfer and radiative heat transfer component during atmosphere entry, as well as to determine thermal effectiveness and structural integrity of charring ablators and other high-temperature materials. Two experiments have been flown. Additional experiments will measure the effectiveness of several types of charring ablator materials. One of these is a new and interesting low-density charring abalator which may be suitable for use on Apollo.

Figure 253 (p. 2399) is schematic pictu e of Project Fire. The primary objective of Project Fire is to investigate the heating environment and heating effects around a vehicle having a blunt shape similar to Apollo, during an actual reentry flight at 37,000 feet per second, or 25,000 miles per hour. Two ballistic flights are planned.

The launch vehicle is an Atlas D with an Antares II A–5 velocity package. The reentry vehicle comprises a highly instrumented 185-pound payload. Project Fire is an extension of Scout reentry heating experiments, and will provide radiative heating data at speeds slightly higher than those corresponding to the return from a lunar mission.

In the next phase of Project Fire, for which we are requesting funds in the fiscal year 1964 budget, attention will be given to the more intense heating phenomena which occur at the considerably higher reentry speeds of interplanetary flight.

Flight experiments concerned with the meteoroid hazard are—

S–55 satellites.
Saturn-launched meteoroid satellites.
Recoverable meteoroid probe.
Artificial meteor experiments.

Results of the first successful S–55 meteoroid satellite (Explorer XVI) have already been discussed. The next meteoroid spacecraft. the S–55c, will expose thin stainless steel skins (in the form of pressurized cells) to the environment, and will also provide a flight evaluation of a promising new meteoroid detector of the capacitor type that has the attractive feature of being continually reusable after penetration.

The final spacecraft of this series, the S–55d, will use this new capacitor-type detector bonded beneath either thin aluminum or thin stainless steel sheets to determine frequency of penetrations in these materials.

SATURN - LAUNCHED METEOROID SATELLITE

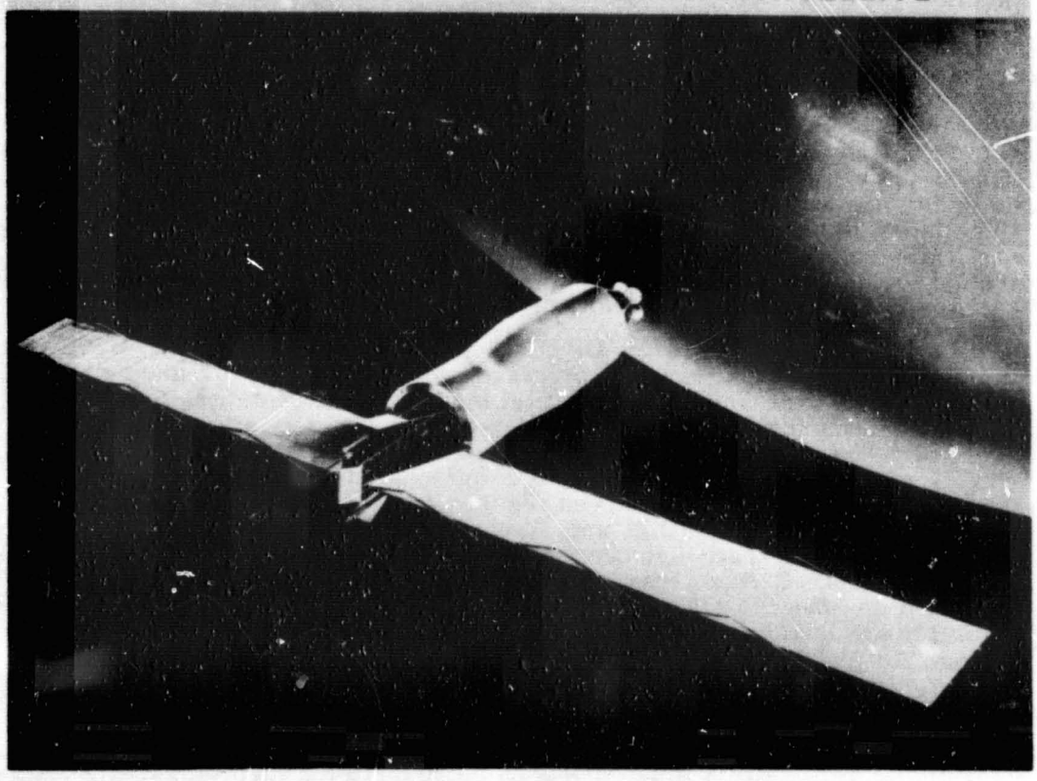


FIGURE 253a

The Saturn-launched meteoroid satellite, shown in figure 253a, will be launched by Saturn C–1, Block II vehicles 9 and 8, and will have an area about 100 times greater than for the S–55 spacecraft. By virtue of the large area (more than 2,000 square feet), the experiments will provide frequency of meteoroid penetration in aluminum sheets having thicknesses approaching nominal vehicle wall thicknesses. When erected, the spacecraft will have a span of 96 feet and weigh more than 4,000 pounds.

The recoverable meteoroid probe project will develop a technique for obtaining direct measurements of the frequency of impact of small particles, and the resultant penetration depth. These experiments, using a 200-square-foot paraglider configuration, are recoverable, so that direct studies may be made of any imbedded meteoritic particles. Two launches from the White Sands Proving Ground are approved.

Artificial meteor experiments have been conducted on the Trailblazer project. A pellet which simulated a meteor was launched downward from space, and entered the atmosphere at about 33,000 feet per second. As a follow-on, the artificial meteor experiments will provide data on the luminous efficiency and ionization efficiency of simulated meteors of known mass (1 gram), composition, material, size and shape, at velocities of about 40,000 feet per second and 75,000 feet per second. From these results, together with the optical and radio observations of meteors by the Harvard College Observatory, it should be possible to obtain a measure of the mass of meteoroids, thereby lessening the uncertainty in predicting the expected penetration rates from meteoroids considerably larger than those which will be encountered in any reasonable time by a satellite.

Nike-Cajuns with a pellet accelerator will be used to fire pellets into the atmosphere at velocities up to about 40,000 feet per second. Trailblazer II vehicles will be used to enter pellets to velocities of about 75,000 feet per second.

All of the foregoing meteoroid experiments will provide data on the meteoroid hazard in the vicinity of the Earth. A need also exists for information about cislunar space and near the Moon, to determine the nature of the meteoroid hazard for manned lunar missions. Studies will be conducted during fiscal year 1964 to develop an effective flight program to provide the required information.

Under the heading of small vehicle flight experiments, as shown in figure 251 (p. 2398), those on "cryogenic fluids at zero g." will investigate the heat transfer mechanisms, stratification effects, and venting characteristics of liquid hydrogen in simulated propellant tanks under weightless conditions. Zero-gravity experiments lasting about 20 minutes have been flown piggyback using separable pods on Air Force Atlas vehicles. About 5 minutes of zero-gravity flight are obtained using Aerobee 150–A launch vehicles. Seven experiments have been flown and others are to be flown during 1963 and 1964.

The objectives of the wind shear measurements program are to obtain wind profiles at the Atlantic Missile Range and the Wallops Station over a period of a year to provide wind shear data required for use in structural response, guidance, and control studies for space vehicle design. The project utilizes photographic observations of a visible smoke trail from a vertical-rising NIKE rocket.

CONCLUDING REMARKS

My objective has been to give you a clearer picture of the activities and progress achieved in the space vehicle systems advanced research and technology program. These activities are broad in scope and range from conceptual studies of advanced vehicle systems for future missions, to the identification and solution of critical technical problems bearing both on present generation as well as future space vehicles. There are many problems urgently in need of solution, if our country is to achieve the space flight capability which is required. In addition, I want to emphasize that the nature and extent of our advanced research and technology activities today play a most important part in establishing our space flight capability in the next decade. The continuing objective of these programs, then, is to provide the timely and sound technological foundation which is essential to our country's mastery of space. .

Mr. AMES. This morning, I want to speak on our activities in the area of space vehicle systems advanced research and technology.

Now, the objective of our space vehicles advanced research and technology program is to identify and solve critical technical problems bearing on present-generation space vehicles as well as to advance the frontiers of knowledge that will enable the development of more advanced space vehicles for future missions.

The increased complexities of the advanced space vehicle systems that will be required to accomplish our national space objectives for the next two decades, attest to the need for a broad yet thorough and timely research program to establish the technology which is required to insure superiority of our country's space flight capability.

The space vehicles research and technology program covers a broad range, as indicated by the areas of activity on our first slide (fig. 232).

We begin with advanced space vehicle conceptual studies (taking a look toward the future as a guide for research); space vehicle aerothermodynamics; environmental factors and technology; and, pausing here, I might comment on these two: Space vehicle aerothermodynamics concerns problems in the atmosphere. Environmental factors and technology is concerned with problems encountered in the space environment.

Next we have space vehicle structures, and then design criteria.

You can see from this list that in space vehicle aerothermodynamics, environmental factors and technology, and structures, we deal with research and technology disciplines, while in advanced vehicle concepts and design criteria we are concerned with overall space vehicle systems of the present and the future.

In addition, we have the responsibility for managing all space flight projects in the Office of Advanced Research and Technology, except those involving nuclear energy sources, as indicated by the vehicle technology flight experiments item on the chart.

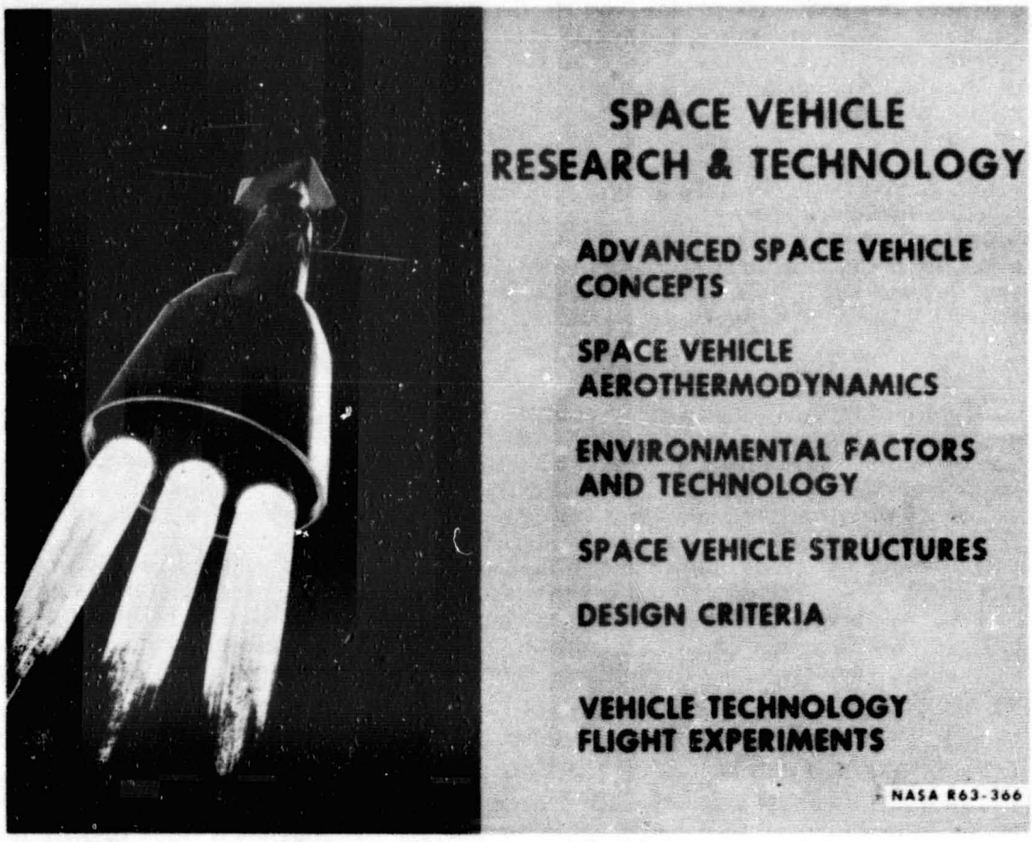


FIGURE 232

I will review our program with you in the order listed.

May I have the next slide, please (fig. 233).

I would like to discuss briefly our activities relating to advanced space vehicle concepts. NASA's research programs have always been strongly influenced by studies of future performance possibilities and applicable mission requirements. Vehicles and missions such as the X–15 and Project Mercury were created as the result of in-house advanced conceptual studies.

Today, the cost and complexity of space missions and vehicles make it vital that the advanced planning which precedes them be based on the soundest research programs possible.

In addition to in-house activity at our centers, an increased use of contractual studies with industry is required to provide depth and breadth representative of the industrial designer's viewpoint.

As indicated by this slide, our major activities are concerned with future Earth orbital operations, advanced lunar missions, and exploratory missions to the planets. Each of these three areas poses special problems in design of space vehicles.

For example, manned exploration on the planets confronts us with quite different technical problems from those of manned orbital missions or, say, missions to the Moon. Obviously, the vehicles for planetary missions will be much heavier and must operate effectively and reliably for much longer periods of time.

Mr. KARTH. Mr. Ames, are you talking only about manned missions?

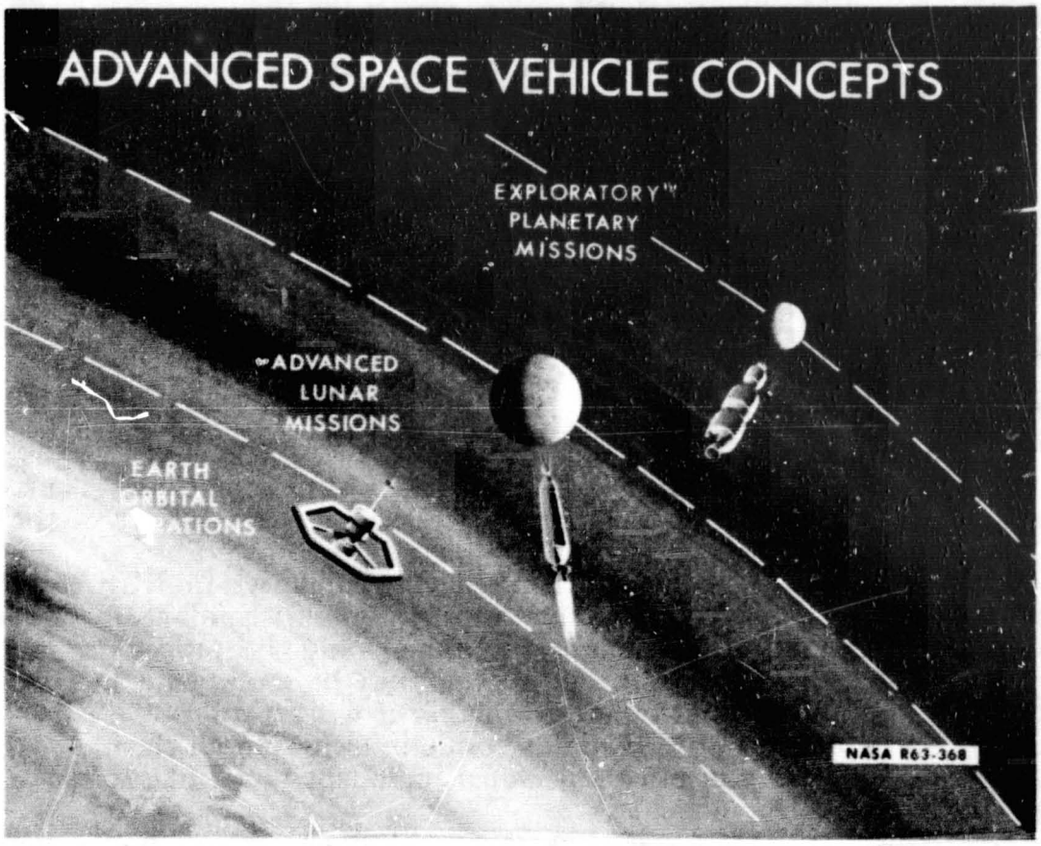


FIGURE 233

Mr. AMES. Manned and unmanned, sir.

Mr. KARTH. Both; manned and unmanned.

Mr. AMES. Yes, sir.

Mr. KARTH. I would like to ask you at this point whether you've had anything to do with Dyna-Soar?

Mr. AMES. Yes, sir, I did.

Mr. KARTH. Was this kind of a joint venture between NASA and the Air Force, or what particular part of your program?

Mr. AMES. The Dyna-Soar program was a joint Air Force and NACA study effort beginning as early as 1956. At that time, it was considered as a follow-on research program to the X–15.

In other words, a stepping stone to spaceflight.

In 1958, prior to the formation of NASA, there was an NACA–Air Force agreement to work closely together on this project, and we in NACA did much to provide the background of technology along with the various industrial firms involved in the Dyna-Soar (X–20) competition. When NASA was formed this agreement was updated and we continued to cooperate and support the Air Force in the X–20 program from a technological viewpoint.

Mr. KARTH. Have there been any NASA moneys that have gone into Dyna-Soar?

Mr. AMES. Oh, considerably so; yes. From the standpoint of inhouse research activities we have put in some 7,000 to 8,000 hours of testing time in NASA facilities. We have had more than 50

individual professionals consult actively with the Air Force on Dyna-Soar.

I, myself, served personally as a technical aid to General Haugen on the Air Force Source Selection Board during 1959, although I was not a member of the Board. I was a NASA consultant.

We are responsible for the flight instrumentation and the measurement of the results of flights of the X–20 and hope that NASA would——

Mr. KARTH. Is this Dyna–Soar the "X–20"?

Mr. AMES. Dyna–Soar is X–20, sir.

Mr. KARTH. How much is involved in the budget request this year for X–20?

Mr. AMES. Very little this year in the NASA budget. I would say, perhaps, a half a million dollars for instrumentation. I can get the figure for the exact amount, if you wish.

We have been studying sophisticated instrumentation, so to speak, to measure temperatures and pressures over the critical parts of the vehicle.

I might say that, from my research viewpoint, we in NASA are interested in the X–20 as a vehicle to provide us with full-scale flight confirmation of our ground-based experiments and theoretical studies.

Mr. KARTH. I understand the program may be scrapped. Do you have any inside information as to whether it will or will not be?

Mr. AMES. No, I don't have any inside information on this.

Mr. KARTH. Do you have a personal judgment you'd like to make at this point?

Mr. AMES. If I may speak personally, I hope we can find some efficient economical means to go ahead and fly the X–20, because I feel it will fill an important gap in our technological background.

Mr. KARTH. What about the launch vehicle. Do we need a new launch vehicle for Dyna-Soar?

Mr. AMES. The present Dyna-Soar X–20, is slated to go on the Titan III vehicle.

Mr. KARTH. That is right. It's a long way down the road, isn't it?

Mr. AMES. Yes; it is.

Mr. KARTH. About a billion dollars' worth.

Mr. AMES. I don't know the exact figure. I believe the Air Force number today is a little less than that but I believe they also have in the Air Force other uses for the Titan III.

Mr. KARTH. My point is, you can't have one without the other. One isn't much good without the other.

What you are really saying is, we need them both, are you? So, you are talking about a very, very expensive program.

Mr. AMES. Yes, we are, sir. This program, however, is a complementary program to our work on Project Mercury, Project Gemini, and Apollo.

It is an entirely different concept for entry and recovery from orbital flight.

Mr. KARTH. That's true. But can't we design something that can be launched with one of our present launch vehicles or one that is well down the road in design and development, such as the Saturn?

Mr. AMES. There are possibilities of putting it on the Saturn. However, the Saturn will require some modification to take the Dyna-Soar.

The point here is that the Dyna-Soar configuration imposes rather severe loads at the top end of the launch vehicle.

This must be taken into consideration in adapting a launch vehicle to the Dyna-Soar spacecraft.

Mr. KARTH. Oh, no question in my mind but what there needs to be special adaptation.

My question was whether or not at reasonable cost any one of our vehicles in the present stable could be so modified.

Mr. AMES. Well, several years ago, we looked at the possibility of modifying a Saturn vehicle to take Dyna-Soar. One of the conclusions was that while this could be done, it would interfere with the lunar programs because of the schedule of production of Saturn vehicles.

I believe sooner or later we will have the capability with Saturn, and/or Titan III, to handle the Dyna-Soar vehicle.

Mr. KARTH. What if the Titan III program is scrapped? Then what do you think we should do with Dyna-Soar?

Mr. AMES. I think we should study it in great detail to determine if there's some other way in which we could fly these gliders. The technology for the gliders seems to be well advanced.

I don't want to give classified numbers in the hearing. I would be pleased to do this in executive session, but there are paramount questions to be answered as to the heating and flow phenomena on the X–20 which can only be obtained by flying the full-scale vehicle.

Moreover, as I'm going to get into this when I discuss the advanced conceptual study program on recoverable launch vehicles, I feel very strongly that the technology which the X–20 can provide would give us some bench marks so we can go ahead and design the next generation of launch vehicles so we could fly them back to Earth and reuse them. I think there are so many contributions the X–20 can make that I would not pass it off lightly, solely on the basis of the launch vehicles. I would like to find an opportunity to "skin the cat" economically.

That is my personal opinion.

Mr. KARTH. The Titan III is not that economical way to skin it?

Mr. AMES. I have not followed that program closely enough to answer your question, sir.

Mr. KARTH. What about M–2?

Mr. AMES. I am going to show you some pictures of M–2 shortly.

Mr. KARTH. That's pretty similar to Dyna-Soar, isn't it? Isn't that a glider concept, like Dyna-Soar?

Mr. AMES. The M–2 is really a lifting body. Dyna-Soar is a winged body.

I will get into this in further detail in my later remarks here.

Mr. RANDALL. Mr. Chairman.

Mr. KARTH. Mr. Randall?

Mr. RANDALL. I just came in, of course, but I couldn't help ask a question, too, about this modification of the Saturn.

You mean to say to us that some little modification on the Saturn would upset the Apollo program?

I mean, here we are talking about waiting if Dyna-Soar is good, we are talking about a whole new Titan III booster.

Can't they be modified? Tell us why they can't.

Mr. AMES. The initial studies which were made at the Marshall Space Flight Center, with respect to putting Dyna-Soar on top of

Saturn, indicated that the vehicle would have to be strengthened considerably to take the loads, and also that it would require very large fins on the base of the vehicle.

Mr. RANDALL. May I interrupt you?

What do you mean by "strengthen"? I thought Saturn was one of our biggest craft.

In other words, isn't it strong enough? What do you mean, "strengthen" it, internally, in its framework; or what?

Mr. AMES. Mr. Randall, when you put a shape like the X–20 on top of a slender launch vehicle, you put a lot of additional bending in the booster due to the additional aerodynamic loads on the spacecraft. Every pound of weight in the vehicle is critical to us so we use as little material as we can. We design to the bare minimum; I was going to get into this in my discussion of structures, to show you just how we slim down the weight of launch vehicles to put the maximum payload in space.

Now, Apollo is a relatively ideal configuration for Saturn in contrast to something like Dyna-Soar which has a larged winged area.

On the ground it will experience wind loads. As it flies through the jet streams, velocities, perhaps as high as 200 miles an hour, act on the top of the vehicle which is controlled with swiveling rockets at the bottom. That causes a great deal of bending in a 260- to 300-foot-long vehicle.

Mr. RANDALL. Then that is the answer. The modification would cost as much as the other new vehicle?

Mr. AMES. Let me speak a little more precisely.

Modification would be necessary and it would cost a fairly substantial amount.

I don't have any exact estimates of the cost.

Mr. RANDALL. What I'm trying to raise is this, Mr. Chairman; every time we get a new idea it looks like we have to start over completely. I was in hopes the modification costs would be much less than waiting for Titan III.

Mr. AMES. Well, I think the question to which we are speaking here is one that I'm not prepared to answer.

It is really, what is the Air Force need and justification for Titan III beyond Dyna-Soar? I do not have any information in that area. In fact, I don't feel it appropriate that I speak to the Air Force need for Titan III.

Mr. KARTH. I understand they have been speaking for NASA insofar as your facilities requirements are concerned.

You care to comment? Proceed.

Mr. RANDALL. Well, just one more question, Mr. Chairman. You indicated they had sort of a leaning toward the top. You mentioned the swivel, and so forth.

You working on anything that—some means to balance that top load as much as you do in Apollo craft?

Mr. AMES. Yes.

Mr. RANDALL. You making any progress on that?

Mr. AMES. We have made wind-tunnel tests on Dyna-Soar configurations, both on Saturn and Titan III.

Titan III wind-tunnel work is still underway at the Ames Research Center at Moffett Field, in order to provide information which is needed to design Titan III.

Mr. RANDALL. What is the weight comparison between Dyna-Soar and the Apollo spacecraft?

Mr. AMES. Dyna-Soar would weigh upward to 16,000-odd pounds and, I believe, Apollo is considerably less. I don't have any offhand numbers here.

Mr. RANDALL. I thought it was the other way around. I am glad to be enlightened.

Mr. AMES. If you speak of the Apollo reentry configuration, that is one total; but the engines to lift it off the Moon and the service module that goes on it. I'm sorry, sir, I don't have those detailed figures available.

I will be glad to get them and discuss them with you.

Mr. RANDALL. Thank you, Mr. Chairman. That's all.

Mr. KARTH. Proceed, Mr. Ames.

Mr. AMES. Well, I was referring to the fact that obviously vehicles for planetary missions will be much heavier and must operate for much longer periods of time; say a year to a year and a half.

Also the date on which planetary missions are undertaken is of very great importance to us with regard to this vehicle size and mission time.

All advanced vehicle concept design studies result from our asking the question, "What do we need to further our ability to operate in a given space regime?"

A recent study pointed out that if we are to conduct future space operations using today's missile and space-vehicle technology, our missions would become more costly and launch vehicles would become much larger than, say, Saturn–5. So much so, for example, that we would have to undertake research and advanced technology programs to supply information in order to be able to construct huge cryogenic tanks on the order of 60 feet in diameter and 200 feet long, and rocket engines, as indicated by Mr. Sloop the other day, providing 20 times the thrust of the F–1 engine, which is our largest to date.

Now, frightening results like these lead us to speculation on the need for reusable launch vehicles, and here we have a good example of the close and continuing relationship between advanced vehicle study effort and research programs.

In another instance, today's technology suggests the use of parachutes or paragliders to bring back a spacecraft or to bring back Saturn-5 launch vehicles or, perhaps, adding wings and jet engines to the Saturn–5.

On the other hand, advanced conceptual studies indicate that such developments would be only marginally justified operationally or economically, and that we need much better techniques.

This has led to increased research and study effort on radically new vehicles designed along radically new lines.

Initial results indicate we must be able to design a recoverable launch vehicle structure which will operate again and again with little rework at temperatures which reach between 2,000 and 3,000° F. at flight speeds from orbital to landing, the speed range of the X–20, the Dyna-Soar. So, in addition to contributing to spacecraft technology alone, the Dyna-Soar would contribute to recovery of the next generation of launch vehicles.

Mr. KARTH. What do you mean when you say recovery of launch vehicles? Are you classifying that as a launch vehicle?

Mr. AMES. No, sir. I mean that we might advance the present state of the art on tank design, electronics, and control systems, conventional rocket engines and spacecraft, to an advanced launch vehicle system which perhaps has very small wings and rocket engines, to take off vertically, go to orbital speed, then inject its spacecraft into orbit and glide around the Earth in 90 minutes, and land at the launching site. It would then be erected on the launching facility, refurbished, and launched again. This is the recoverable vehicle I think we might have in the future, in say 10 or 15 years from now, following Saturn–5.

One might look at it another way. Compare this with the airline situation where we are committed to amortize the costs of the DC–8 and the Boeing 707's. We have committed our country to launch vehicles like Saturn–5 and Titan III.

What I'm trying to say and explain is that the next time we develop a launch vehicle, I think it should be radically different and far beyond the capability of either of these two current large rocket vehicle systems we have discussed.

Mr. KARTH. How much work have we done on this recoverable or reusable launch vehicle system, Mr. Ames?

Mr. AMES. We are really just getting into this, sir.

Mr. KARTH. How much are you requesting in the fiscal year 1964 budget for this purpose?

Mr. AMES. This comes under the advanced concepts part of our program, under "Launch vehicle concepts" and "Mission analysis and operations," and comes to $4.12 million.

Mr. KARTH. How does that compare with fiscal year 1963?

Mr. AMES. In 1963 we had $2.4 million. I would like to point out our program only got underway last August.

Mr. KARTH. Really, we are just getting a start.

Mr. AMES. We are just getting started, and that's why I hope my indications today of favoritism toward certain launch vehicle concepts will be taken with a grain of salt.

I hope I have the opportunity to appear next year and bring you up to date on some real progress.

Mr. KARTH. All right, pursue your discussion, Mr. Ames.

Mr. AMES. Next—this is an important point that we were just referring to. Let's consider the dimension of time. When is it reasonable to expect the requirement for such an advanced vehicle system and when could we, in this country, be capable of producing one?

Gentlemen, it is the research timetable which will determine when we will be able to achieve the goals that are indicated by our studies. Thus, I hope you see that there is a close and continuing relationship between research activity and advanced mission and vehicle studies. Such a relation must start early if its full value in research program planning is to be obtained.

Our advanced conceptual studies currently underway include Earth-orbiting space laboratories; recoverable boosters as we have discussed this morning; Earth lunar transfer vehicles or ferries to follow the Apollo mission; and large advanced launch vehicle systems and spacecraft capable of entering planetary atmospheres and returning to the Earth at velocities of, say, 45,000 feet per second or greater.

Now, in the short period of time we have had this program underway, we have already defined a number of important problems in

research and technology which require a long leadtime if solutions are to be available when needed, or when the panic button will be pushed and someone will say, "What do we do next?"

Mr. KARTH. In other words, your office works very closely with the various NASA centers depending upon their interest.

Mr. AMES. Yes; we do.

Mr. KARTH. With Goddard, for example, as they develop the orbiting observatories and some other center, depending what their particular interest is?

Mr. AMES. Yes, we are trying to take a broad general look down the road and to do our very best to identify, as soon as possible, those critical technical problems we must address ourselves to in our programs in order to have adequate information available so that we will get sound proposals from industry and have a sound mission plan.

Mr. KARTH. Well, then, your office cooperates with the Goddard people, for example.

Mr. AMES. We cooperate with all the centers in this activity.

Mr. KARTH. Well, I was thinking in particular about the orbiting observatories, just to use one program as an example.

People from your office cooperate with the Goddard people who have this part of the unmanned space program?

Mr. AMES. Yes, and we have addressed ourselves, particularly to the most advanced vehicles and missions.

Mr. KARTH. Well, is that both research and development? When do you quit working on the project that Goddard takes over completely, for example?

Mr. AMES. We sort of phase ourselves out of it from the time they get an approved project. There may be a few critical general problems applicable to their mission, as well as missions in manned space flight, and as we resolve these general problems and provide the technology we phase ourselves out and go on to things further down the road.

Mr. KARTH. Pretty generally, what you are saying then is as soon as they come to the Congress with a budget request, let's say, for the Orbiting Astronomical Observatory; you are phasing yourself out at about that stage?

Mr. AMES. Yes. We are now looking to the use of man in an orbiting laboratory.

Mr. KARTH. I see.

Mr. AMES. The same situation applies with respect to the technological capability of going to the planets. This will be developed by OART. If we are to be capable of going to the planets and returning our spacecraft to Earth, or if we want man to go to Mars and Venus, as Dr. Kurzweg mentioned week before last, it is our responsibility to provide the general technology.

Mr. KARTH. Are you working with JPL doing any redesign work on Ranger?

Mr. AMES. Not specifically, sir.

Mr. KARTH. What does that mean?

Mr. AMES. I mean in our general or basic areas of research some results may be pertinent to Ranger, whether it is in advanced design criteria, or whether it is in, say, Dr. Kelley's field of electronics, some new technological development might come along.

Mr. KARTH. I see.

Mr. AMES. Perhaps a structures problem or, in the case of the Mariner, which experienced overheating, we are very much interested in trying to resolve and provide a better general understanding of these problems because they indentify, at an early date, problems that are likely to be common to other programs.

Mr. KARTH. Thank you.

Mr. AMES. May I have the next slide, please (fig. 234).

I would like to speak now to our activities in space vehicle aerothermodynamics.

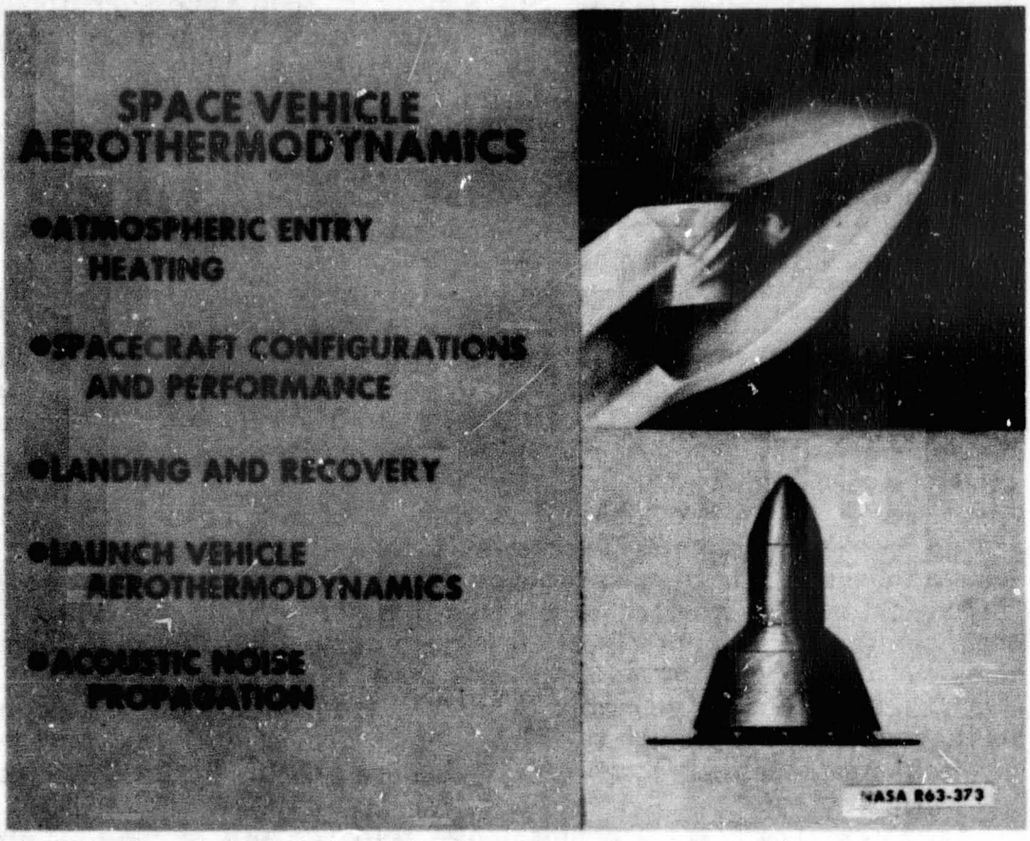


FIGURE 234

The areas of activity are indicated on the slide: atmospheric entry heating, and I refer here to the atmosphere of the Earth as well as any planet which has an atmosphere which we may desire to enter; spacecraft configurations and performance, suitable for all types of missions; landing and recovery of spacecraft here and on the planets; launch vehicle aerothermodynamics; and acoustic noise propagation.

I'd like to treat two of these areas in a bit more detail. First, the advanced manned spacecraft for future missions; and then one facet of spacecraft landing and recovery research.

In manned interplanetary flight, the question we ask ourselves is, "What can we say about the shape of spacecraft to come?" Now, in considering manned interplanetary flight, without the use of the retrorockets to reduce our velocities, the minimum Earth return speed of our interplanetary vehicle is that of Apollo, about 36,000 feet per second or 25,000 miles per hour, to which we must add the

effective transit speed between the planets, which is limited only by the propulsion available.

We are, therefore, talking generally of Earth return speeds in the neighborhood of 50,000 feet per second—36,000 miles per hour.

Now manned flight is "g"-limited flight, or flight limited by the decelerations which a man can endure. We are, therefore, restricted to the most grazing approach trajectories in order to keep this deceleration within tolerable bounds.

May I have the next slide, please? (Fig. 235.)

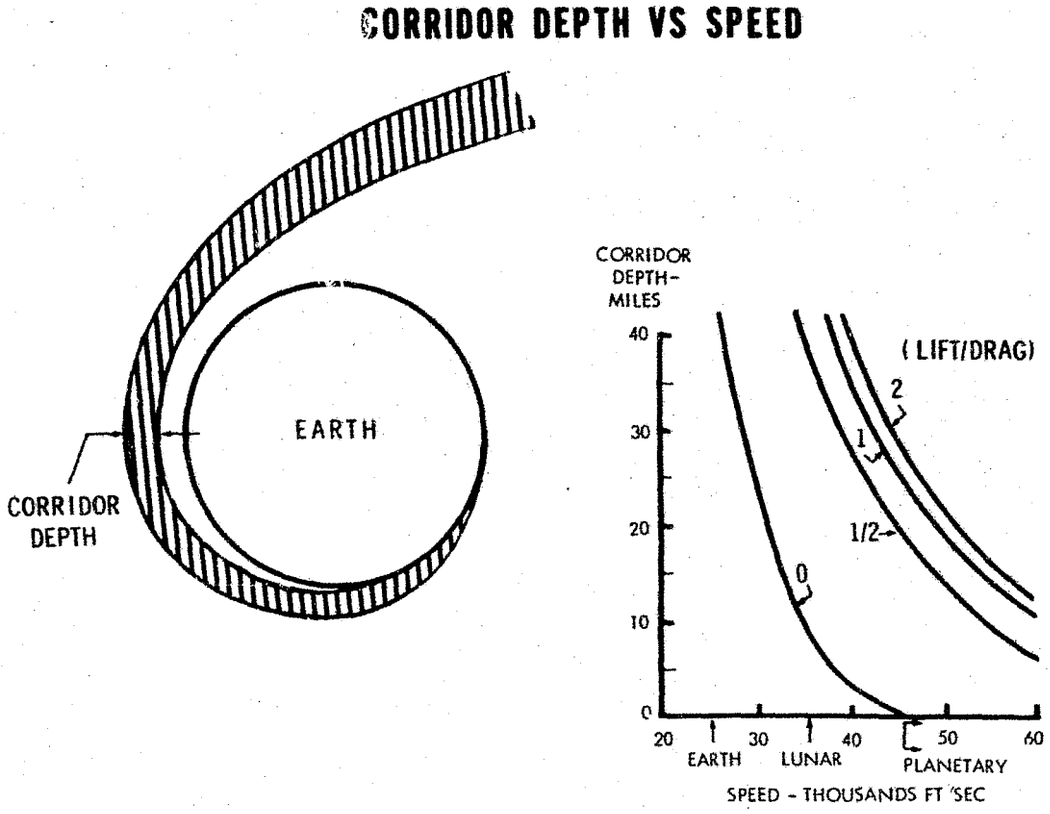


FIGURE 235

This slide for corridor depth *versus* speed entering the Earth's atmosphere illustrates how the problem becomes more difficult with increasing speeds.

On the left we have a greatly exaggerated entry corridor for return to Earth, whereby the spacecraft would be captured in one pass around the Earth.

The upper bound indicates the maximum altitude at which a spacecraft could graze the Earth and be captured.

The lower bound of the shaded area indicates the region where the decelerations would become intolerable. Also it is a boundary where the vehicle would experience excessive heating.

I have plotted the corridor depth in miles, from 0 to 40 miles on the vertical scale—then the horizontal scale is the velocity in thousands of feet per second on entering the atmosphere of the Earth.

You will notice the word "Earth" with the arrow indicating around 26,000 feet per second as the orbital velocity, and then the lunar

velocity around 36,000 feet per second, the next arrow to the right. At planetary velocities, the vehicles return at 46,000 feet per second or higher.

Mr. KARTH. Could I interrupt to ask a question here? Let us say on the return leg of the lunar flight we decided to go into Earth orbit for, oh, maybe two or three orbits. Wouldn't that then slow us down to the regular Earth orbit speed and our reentry problem would not be quite so great from the heat standpoint?

Mr. AMES. That is true, sir, but I fear the orbit which we would have would probably cause the vehicle to pass through the artificial electron belt several times and the Van Allen Belt. We'd like to come through that as fast as we can.

In addition, when a man has been on a 10-day mission, we'd like to get him home as soon as we can.

Mr. KARTH. Better take a few more hours, rather than burn them up.

Mr. AMES. That is right, but I am afraid the additional hours, unless we have additional time for deceleration, may end up in several days.

Mr. KARTH. I see. How many orbits would it take to slow one down from lunar reentry speed to Earth reentry speed?

Mr. AMES. Of course, that depends on how close we come to the Earth in this first grazing pass.

Mr. KARTH. I understand.

Mr. AMES. If we miss the Earth completely, it may go on indefinitely. As one example, Explorer XVI orbits the Earth at between 400 and 700 miles.

We hope it has an orbital life of a year.

Mr. KARTH. Of course, when you are talking about the Earth orbital speed and the reentry being some 26,000 feet per second, this is what I had in mind for the return lunar flight so you get into that kind of an orbit.

How long does it take the lunar return flight to decelerate from 36,000 feet per second to 26,000 feet per second?

Mr. AMES. If we had no breaking force, sir, the vehicle would go into what we call cis-lunar orbit between the Earth and the Moon, going elliptically around the Earth and out toward the Moon. We must come within this 40-mile corridor here.

Mr. KARTH. Yes, sir.

Mr. AMES. Which is around, say, roughly 200,000 feet.

If its much higher than that we are going to have a much longer orbital life of our spacecraft.

Mr. KARTH. I see.

Mr. AMES. Unless we have some additional braking or deceleration force, which again involves additional weight for retrorocket systems.

Mr. KARTH. Thank you.

Mr. RANDALL. You said "cis-lunar" orbit—an ellipse? Did you say elliptical?

Mr. AMES. Elliptical between the Earth and Moon.

Mr. RANDALL. What forces would produce that?

Mr. AMES. We would have a rather high velocity as we pass the Earth and the Earth's gravitational force tends to pull the vehicle as it passes. It then turns and goes out into elliptical orbit.

Mr. RANDALL. You mean the centrifugal force would keep it going around and then pull it back?

Is that your answer?

Mr. AMES. Yes; the spacecraft has a very high velocity, 36,000 feet per second when it comes back to the Earth, about 10,000 feet per second too fast for orbital velocity of 26,000 feet per second at an altitude of a hundred miles. It would make perhaps 7, 10, or 20 orbits.

Mr. RANDALL. Mr. Chairman, many of us can't always picture those things. I hope NASA would sometime try to demonstrate these concepts.

Mr. AMES. Well, I feel we ultimately should develop a capability to go into space wherever we want to go, and come home when we want to, and wherever we want to; but, gentlemen, we are a long way from this capability and this is the idealistic, long-range objective of our advanced research and technology programs.

But, realistically, when we come down to building hardware on a time schedule it would be foolish to try to wait for such a technical capability to develop.

Mr. KARTH. Well, the point is that your Office's job is to develop that capability, isn't it?

Mr. AMES. Yes, we take it very seriously.

Mr. KARTH. I am sure you do.

Proceed, sir.

Mr. AMES. The curves in the chart on the right represent various lift/drag ratios—the ratio of vehicle lift to drag.

The corridor identified as zero would represent that of the Mercury capsule. It is a ballistic entry.

You will see that the corridor depth diminishes greatly as we increase speed, until we get to a point at the lowest planetary return speed, say, 44,000 to 46,000 feet per second where we have no corridor depth whatsoever.

This means our vehicle must enter and follow a perfect trajectory to be captured in one pass around the Earth.

It has no capability of deviating above or below a precise trajectory. This is well beyond our guidance capability and the accuracy we could predict and expect in the foreseeable future.

However, we see if we go to lift/drag ratios of one-half as we move over toward the right and take the planetary return speed of 40,000 to 50,000 feet per second, we can see a corridor depth of approximately 20 miles, which is quite a bit of license in contrast to no corridor depth for the ballistic entry.

Now, as we go on up to the curve for lift/drag ratios of one, perhaps the depth would increase to 25 or 30 miles, but you see that we have diminishing——

Mr. KARTH. Would you explain the figure "1" there as you use it in the lift/drag ratio?

Explain what this means, precisely.

Mr. AMES. This curve represents a ballistic vehicle such as Project Mercury, and at Earth orbital velocity Project Mercury would have a rather wide band of altitude above the surface of the Earth where we could come back safely without overheating or experiencing excessive decelerations.

Mr. KARTH. Mercury has a lift to drag ratio of zero?

Mr. AMES. It's ballistic. Out here at the velocity for lunar return speed, you see, we have a corridor of, say, 7 miles.

If you use a little bit of lift and, I believe, the lift/drag ratio of Project Apollo is around 0.25, you increase the corridor more.

Mr. KARTH. What is the lift/drag ratio on Dyna-Soar?

Mr. AMES. On the order of two; but it is limited to velocities in this range, say, 26,000 to 28,000 feet per second.

Now, you see, as we go to a lift/drag ratio as high as one-half at this higher velocity, you have a fairly large corridor.

Even at one, you get a pretty large corridor.

At two we begin to run into diminishing returns.

Mr. KARTH. Do you have a model of anything here that has a lift-to-drag ratio of one-half, to give the committee an idea what you are talking about.

I think this is Mr. Randall's concern, at least it is mine.

Mr. AMES. Yes, the M–2 configuration which I'll show you pictures of in a few minutes.

Mr. RANDALL. I wondered about that.

Mr. KARTH. We want to have an idea of what you are talking about.

Mr. AMES. Now another problem in going to higher lift/drag ratios is that we pay a greater penalty in heat protection. Since more heat protection is required, we pay a weight penalty here. We are always trying to save weight in spacecraft and launch vehicles, so we have to run what we call parametric studies to know how much weight we can allow to achieve a desired mission capability; and just as importantly, what design will our state of technology support, and how accurately can we predict the lift/drag ratios and heating?

May I have the next slide (fig. 236).

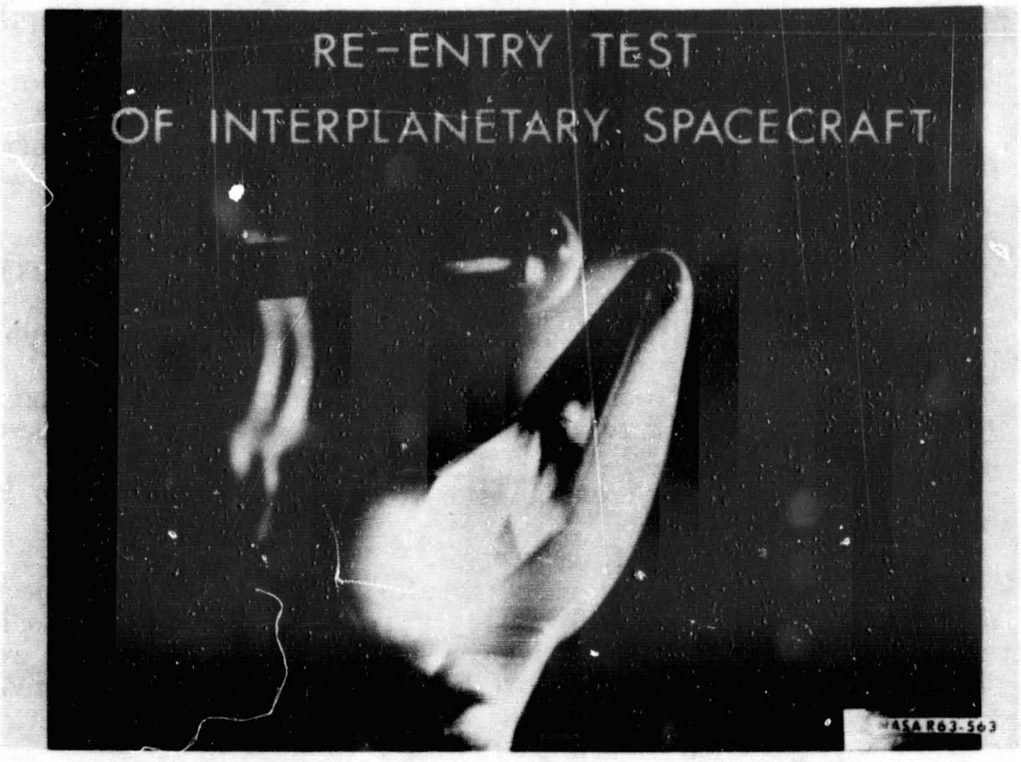


FIGURE 236

This is a picture, incidentally, of the M–2 configuration being tested at the Ames Research Center: it is a configuration representative of a high-velocity reentry vehicle and severe heating is experienced, as you can see.

You see also the flight attitude of the vehicle is very steep. It comes in at a high angle of attack, and the flow is coming across the vehicle here and around the sides.

One of the problems we must solve in a vehicle of this type is that not only is the stagnation point at the nose of the vehicle very hot, but the entire exposed lower area of the vehicle and the sides get extremely hot. The higher velocities to which we are directing our attention relate to interplanetary flight; hence, we have a temperature problem not only on the nose where we can put a heat shield or cap, but also along the whole lower side of the vehicle.

We also have some afterbody heating which is a difficult problem to deal with because you can well imagine the flow on this side is very hard to predict. We will probably have to run some full-scale tests to determine more accurately the nature of the flow.

Here, sir, is where the X–20 will come in, because there we will get information on the nature of the flow in reentry flight from orbital velocities between 26 and 28,000 feet per second, and we will get these data full scale. This is my motivation, sir.

Mr. KARTH. I think it is a very worthy desire, but we can't use, in all cases, the precise vehicle, just to give us information we'd like to have; I think we should get much of it experimentally in our various chambers.

Mr. AMES. I understand there are economic problems and we have to make our choice. If we don't have the X–20 program we will have to find some other way to get this information, and we will have to face whatever the circumstances are and we'll do our very best.

Mr. KARTH. This can be a very, very expensive proposition.

Mr. AMES. In return from interplanetary flight, I wanted to mention that these reentry velocities are going to be so high that we can expect that even our best materials, our refractory ceramics, are going to burn away to some degree. This is a very high temperature materials problem and a structures problem, as well as an aerothermodynamics problem.

Now the configuration of this model is one similar to the M–2 but was developed at the Langley Research Center; it is, we believe, suitable for interplanetary missions where lifting capability will be required.

This differs from the M–2 as I will show you on my next photograph.

Mr. RANDALL. Before we leave the point of refractory ceramics, I understood you to say they will burn away. Is that right?

Mr. AMES. We are going to lose structural material off the vehicle by burning, ablation, sublimation, or any of the processes that take materials away at the extreme temperatures these vehicles will experience at the high velocities required for return from interplanetary missions.

We might also expect, as indicated in Doctor Kurzweg's discussion, similar high-temperature heating problems in entering the atmospheres of Mars and Venus. This is a major area for research, and is an example of a long leadtime research problem where the materials

researchers, structures researchers, and aerothermodynamics researchers all have to work together for a solution.

Mr. KARTH. Here is an area, Mr. Ames, we have done very little, really. Isn't it?

Mr. AMES. Yes, we have, and yet I think that the reentry capability of our country is outstanding. I don't think we have to apologize to anyone for our ballistic missile reentry performance or Project Mercury and I have great confidence in our ability to handle the reentry problems of Apollo.

Mr. KARTH. I don't think we need to, either. My point is that here we have made considerable progress with very few research dollars in comparison to some of these other areas where we have spent tremendous numbers of research dollars, and feel that we have got to spend even more substantial sums to get answers for the unsolved problems at this point.

Mr. AMES. I don't want to get too far——

Mr. KARTH. Haven't we achieved a good deal in this area with relatively few research dollars as compared to the other parts of the program?

Mr. AMES. Let me put it this way.

We are beginning to break the ice. I wouldn't want to stake my reputation on these interplanetary vehicles coming back safely today. Next year I can tell you more about it. I hope we will be further down the road than we are today.

Practically all of our work up to the present time is based on very small models in ballistic ranges and wind tunnels. For example, if I test a shape like this ½-inch model in a ballistic range, I would not dare predict the characteristics of a full-scale vehicle of this configuration large enough to hold three to five men and return safely from Mars.

It is just too great a gap in our technological understanding of scaling laws. We are conducting tests with these small objects and we are beginning to advance our theories.

We are also beginning to understand the gaseous states that exist when these vehicles come into the atmosphere at very high speeds, and I would expect that a great deal of refinement of these vehicles will develop.

What I'm trying to emphasize here is that we are working very hard on a long leadtime problem, hoping we will have a very sophisticated high-velocity flight capability one of these days. This is what I meant in my earlier remarks about trying to run our program on a timely basis.

I agree with you that this is a very modest effort today, but I feel that to defer this effort to concentrate only on, for example, Mariner or approved missions like Apollo, would be a serious mistake.

This is my personal opinion because I am dedicated to the research point of view. I feel we must do all we can between now and the time someone says "What do we do next?" after both we and the Russians have reached the Moon.

Otherwise we will not have enough information to answer that question quickly.

Mr. KARTH. The only reason for my expressing my viewpoint on this was to ascertain whether or not research is like the squeaky wheel that gets the most grease. Seems to me that we've spent—I

don't say too much, but in proportion to the problem and the need for some solution, it seems to me we have spent a good deal more money in some areas than we have in others; and this might well be one of the areas that's been neglected, if you don't mind my saying so, with the research dollars that have been spent.

I agree with you, I think we have made tremendous progress—outstanding progress. I am not sure you want to comment on that, but if you are inclined to, go ahead.

Mr. AMES. No, I don't believe I have any comment. I appreciate——

Mr. KARTH. This is my personal opinion. I don't know if I've stated it correctly or not.

Does this coincide with your opinion? Is it true in certain research areas a squeaky wheel gets more grease than that one which doesn't squeak?

Mr. AMES. The squeaky wheel is the approved project. In certain cases we, in research, have to conduct crash programs to "pull the irons out of the fire" where the Nation is committed to a project like Mercury and unexpected problems have come up, or Saturn, both the Saturn I and the Saturn-5 types, before we felt that we had all the information at hand that we needed.

Mr. KARTH. Those really haven't been crash programs, have they?

Mr. AMES. We have dipped to the bottom of the research barrel to produce the information needed, though.

I have a comment here——

Mr. KARTH. They have been energetic undertakings, but they haven't been crash programs; isn't that correct?

We have so much testimony to that effect, I would hate to have it changed now.

It would be a major undertaking to investigate this one.

Mr. AMES. When someone comes to me and tells me, "We have a difficult problem here, if you don't stop and help us we will be in trouble," it sounds like a crash request.

Mr. KARTH. I understand.

Mr. AMES. Maybe it's a manner of speaking.

Mr. KARTH. Perhaps so.

Mr. AMES. I'd like to go now to our next slide (fig. 237).

Here we have the M-2 configuration, Mr. Randall—can you see this?

What we have here is a full-scale glide model of the M-2 reentry configuration which was conceived by the Ames Research Center and on which a great deal of research of the type I was discussing was conducted at small scale.

This vehicle, I believe, is a flying mockup, you might say, which has been designed and developed at our Fight Research Center in order that we might tow it to altitude, glide it, and fly it, and determine its approach and landing characteristics. Really, this is not a lifting wing arrangement like the small model I have here.

If you look at this configuration on the figure very carefully, you will see that this is half of a nose cone. This is one type of a lifting body. It has a low lift/drag ratio.

You see we had to add stabilizing surfaces to it to make it flyable.

Mr. KARTH. What is that made of?

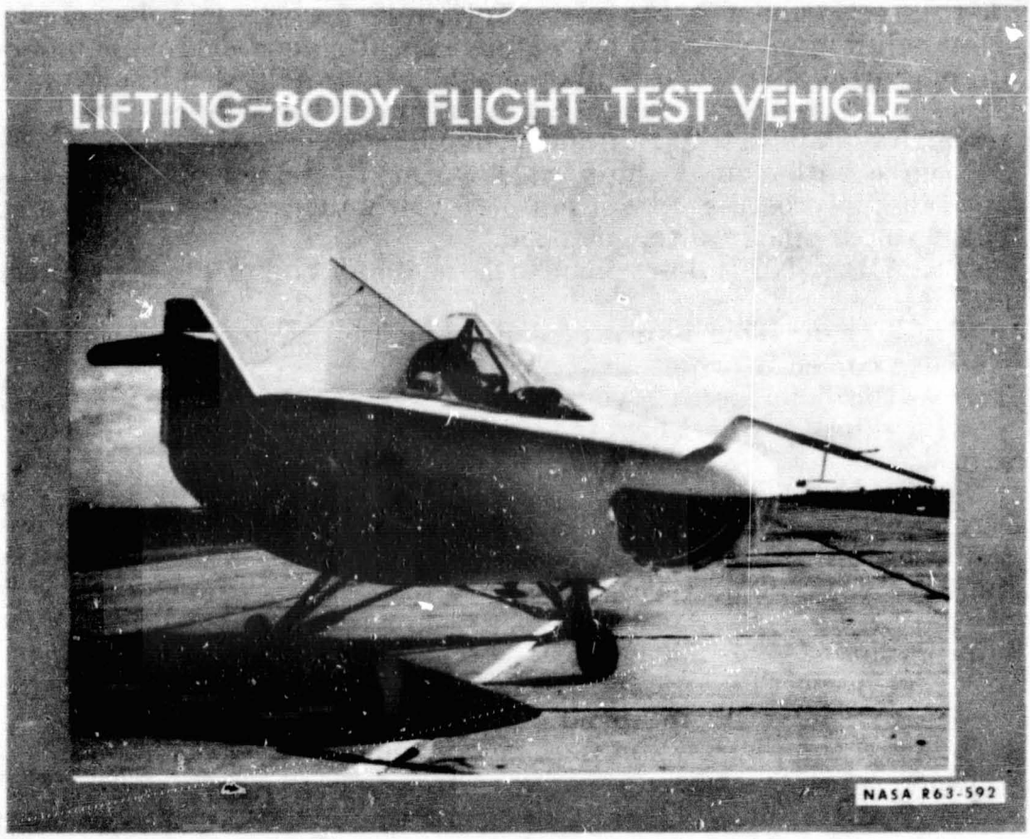


FIGURE 237

Mr. AMES. That is constructed very much the way you'd make a sailplane or glider. It has a steel truss, plywood covering on the top and a Plexiglas nose on the forward section, to permit the pilot to have good visibility in landing.

He will be landing at a very steep attitude, say 35 degrees.

Mr. KARTH. Has someone actually flown in this?

Mr. AMES. Not yet. We are towing it first.

Mr. KARTH. I was hoping that you were.

Mr. AMES. That vehicle has been in the 40- by 80-foot wind tunnel at the Ames Research Center in order to obtain full-scale wind tunnel measurements, and then we will proceed with flight tests most cautiously.

I feel that if we are going to have advance spacecraft configurations, which we can fly back and land tangentially——

Mr. RANDALL. What was the word?

Mr. AMES. Tangentially, the way you would land a conventional airplane; we have studied the characteristics at landing speeds. That is essentially the objective of this flight program.

This type of relatively inexpensive flight testing will continue and be extended to other types of vehicles in our flight work at Edwards.

Mr. KARTH. Thank you. Mr. Randall?

Mr. RANDALL. What is the comparable configuration—the comparable size of Dyna-Soar?

Mr. AMES. No, the weight of Dyna-Soar would be quite a bit heavier than this vehicle.

Mr. RANDALL. This is a smaller size.

Mr. AMES. This is simply a hollow shell. It is very lightly loaded so that we can be sure we can fly it.

You've heard the old saying, "You can fly anything, including the barn door, if you give it enough power."

We don't have any power in this, so it's our idea to give the pilot every opportunity to change his path and make a touchdown by making the vhicle very light.

Mr. RANDALL. You say you are towing it. What will be your subsequent steps?

Mr. AMES. We tow it along the ground to determine the ground run stability. Gradually, we will increase the speed and the pilot will hop it off the ground and back again until he learns to approach and settle back to the ground properly.

Ultimately, we would hope to tow it in flight by a cargo-type airplane or perhaps a B–52, and if this program is successful, we would like to take the more attractive configurations indicated by our research and drop them from high altitude and let the pilot glide them back after he'd become sufficiently experienced in handling vehicles of that type.

Mr. RANDALL. That's all.

Mr. AMES. Let me have the next slide (fig. 238).

I'd like now to discuss our environmental factors and technology program.

Here we are concerned, of course, with the space environment.

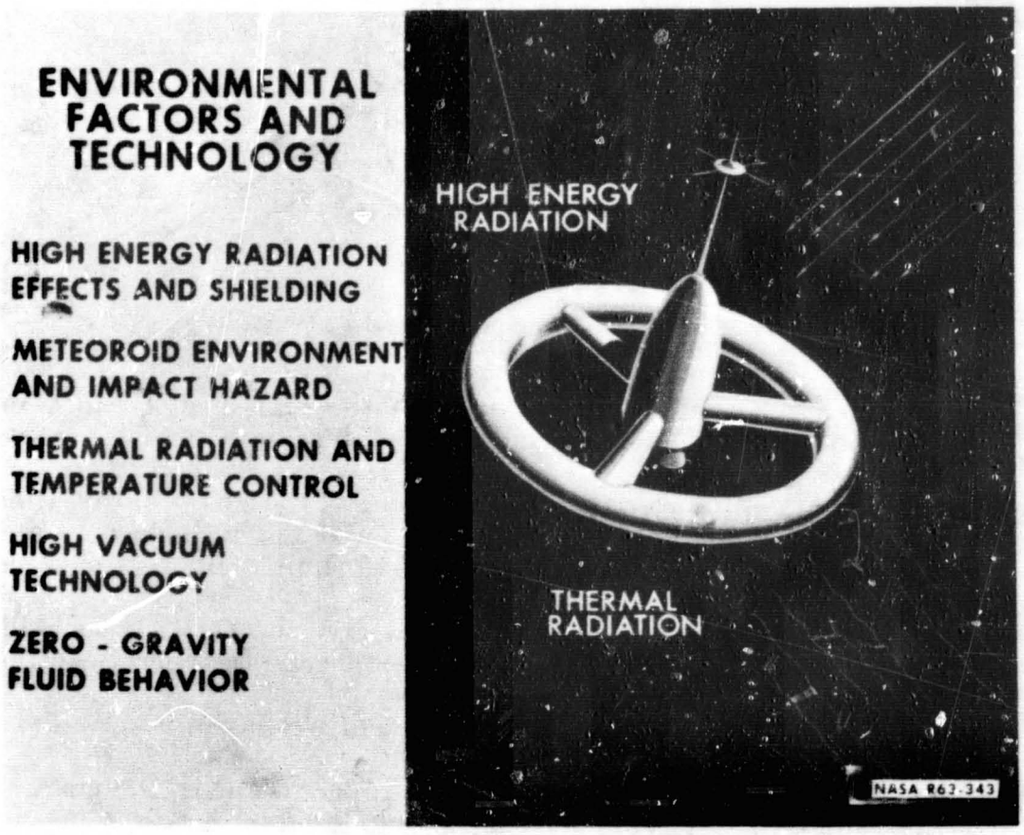


FIGURE 238

Prior to this point, we have been discussing problems in the atmospheric environment.

Space vehicle design becomes increasingly difficult for future missions because of the long duration or exposure to the hostile environments of space, and these environments today are only partially defined.

The major areas of activity in OART in environmental factors and technology are indicated on the left-hand side of our slide. They include high-energy radiation effects and shielding; meteoroid environment and impact hazard; thermal radiation and temperature control; high vacuum technology; and zero-gravity fluid behavior.

May I have the next slide please (fig. 239).

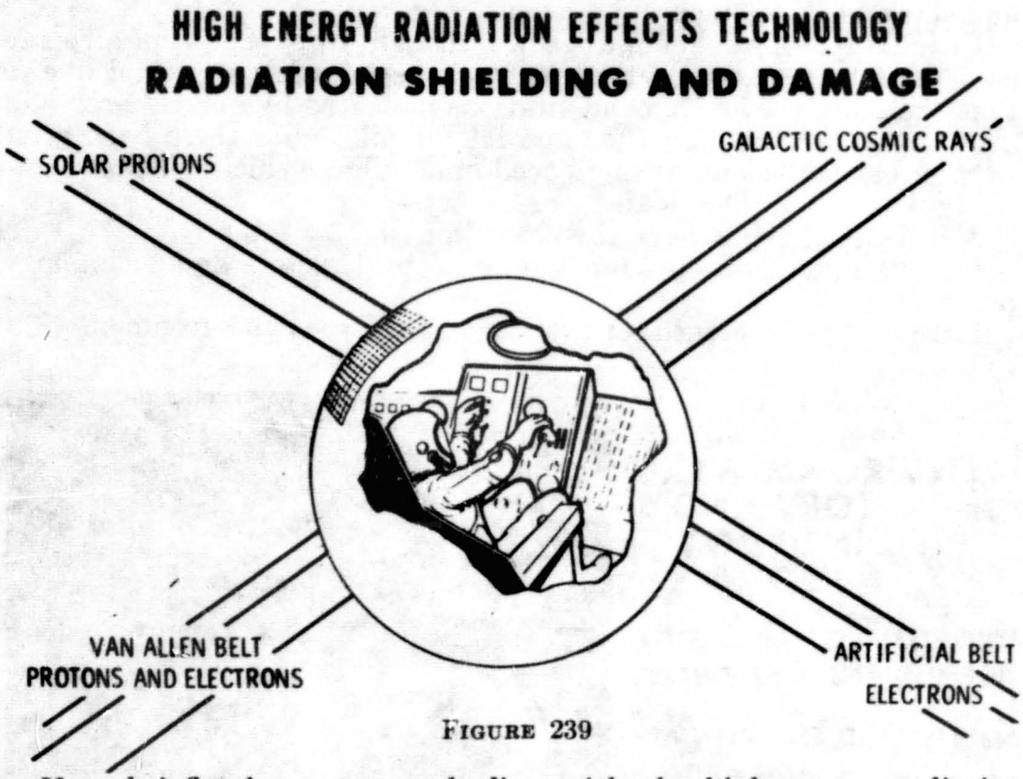


FIGURE 239

Very briefly, here we are dealing with the high-energy radiation effects technology and which is concerned with radiation shielding and damage.

Now, primary emphasis is placed on studies of the effects of radiation on spacecraft components and materials, and on both passive and active means for shielding men and sensitive equipment from charged particle radiation.

Since all space vehicles will, to some degree, be exposed to high-energy radiation, a wide variety of problems require theoretical and experimental investigations.

In view of the importance of this problem we have an active and growing program on high-energy radiation.

Now, as indicated on this slide, we are concerned with the charged particle radiation environment which includes solar protons on the left, galactic cosmic rays on the upper right, Van Allen belt protons and electrons, and artificial belt electrons.

First, the environmental data obtained by Doctor Newell's space sciences program are used by OART to assess the nature and extent of the radiation hazard for foreseeable missions. Such evaluations guide our generalized research on the various aspects of the shielding problem.

Some of these include: First, the generation of basic data on the interactions of these radiations with materials; secondly, the generation and development of advanced shielding concepts such as electromagnetic shielding, the type of shielding which you could turn off and on as needed, if solar flare occurred.

I would like to comment here, so that you do not misunderstand me, such a type of active shielding is many, many years away.

Mr. RANDALL. Did you say "active"?

Mr. AMES. Active shielding.

Mr. RANDALL. The one you can turn on and off; would you care to comment? Would that be weight and size?

Mr. AMES. Weight, size, and thickness of material. That is the means we use today.

Mr. RANDALL. More specifically how would this active shielding operate?

Mr. AMES. We would try to create magnetic fields around the vehicle which would be strong enough to repel the high-energy radiation particles, stated very simply.

Mr. RANDALL. Very interesting.

Mr. AMES. We are also expending effort in the direction of advanced methods for calculations of detailed doses inside a complex shield. First we study a simple sheet of material and determine what radiation comes through it. Then, we must know what happens when you have a complicated spacecraft like Apollo or an interplanetary vehicle where you have a more complicated problem due to the shielding effects of equipment, fuel tanks, oxygen pressure vessels, and other components of this nature. We would like to know really what the radiation dosage is inside the vehicle. This is a very complex problem of calculation.

Lastly, we hope to develop means for the verification of the shielding effectiveness of final vehicle configurations.

Now, the generalized information and techniques resulting from these programs are made available promptly to all projects for application to the design of shielding systems for specific vehicles.

I'd like to turn now, on the next slide, to the meteoroid environment and impact hazard. Of all the areas we are dealing with, the one we know the least about is the meteoroid hazard. Our overall program is shown on this slide (fig. 240).

The first item is our flight projects. Here we have the S–55 satellites, such as the Explorer XVI which was launched last December.

We have the Saturn-launched meteoroid experiments, and I'll speak to this later.

We have the recoverable meteoroid probe, which I discussed with the subcommittee last year, and we have the artificial meteor experiments. I'll show you a little later how these programs fit into an overall program. Then we go to ground-based meteor observations where OART, in cooperation with the Offices of Space Sciences and Manned Space Flights, have a joint contract with Professor Whipple at the Harvard Observatory for meteor observations using a radio technique which he has developed.

OART
METEOROID HAZARD RESEARCH

- FLIGHT PROJECTS
  - S-55 SATELLITES
  - SATURN-LAUNCHED METEOROID EXPERIMENTS
  - RECOVERABLE METEOROID PROBE
  - ARTIFICIAL METEOR EXPERIMENTS
- GROUND-BASED METEOR OBSERVATIONS
  - HARVARD RADIO METEOR PROJECT
- LABORATORY RESEARCH
  - HYPERVELOCITY IMPACT INVESTIGATIONS (ADVANCED FACILITIES, TESTS, AND THEORY)

FIGURE 240

Lastly, we have ground-based laboratory research which is primarily concerned with hypervelocity impact investigations.

I have noted here that part of our effort is in developing advanced facilities, test techniques, and theories on the ground. I don't believe we can afford to do all this work in flight.

Now, the most interesting item which I believe I can report to you at this time would be the results that we have been getting from the Explorer XVI satellite which is shown on the next slide (fig. 241).

I also have here a model of the Explorer XVI satellite.

We have five experiments on this, but I won't go through all of these. This is an actual can—a pressurized can—which is represtened by this part of the vehicle, as you can see on the satellite there on the slide.

This satellite was launched on December 16, 1962, and after more than 3 months, everything seems to be working quite well.

I might point out that the area exposed to the meteoroid environment is only 25 square feet. While I have some more up-to-date information here on the notes I have before me, by mid-February, we had 20 punctures of the cans and 3 punctures of the electrical circuits on the lower part of the spacecraft.

Mr. KARTH. In what length of time, Mr. Ames?

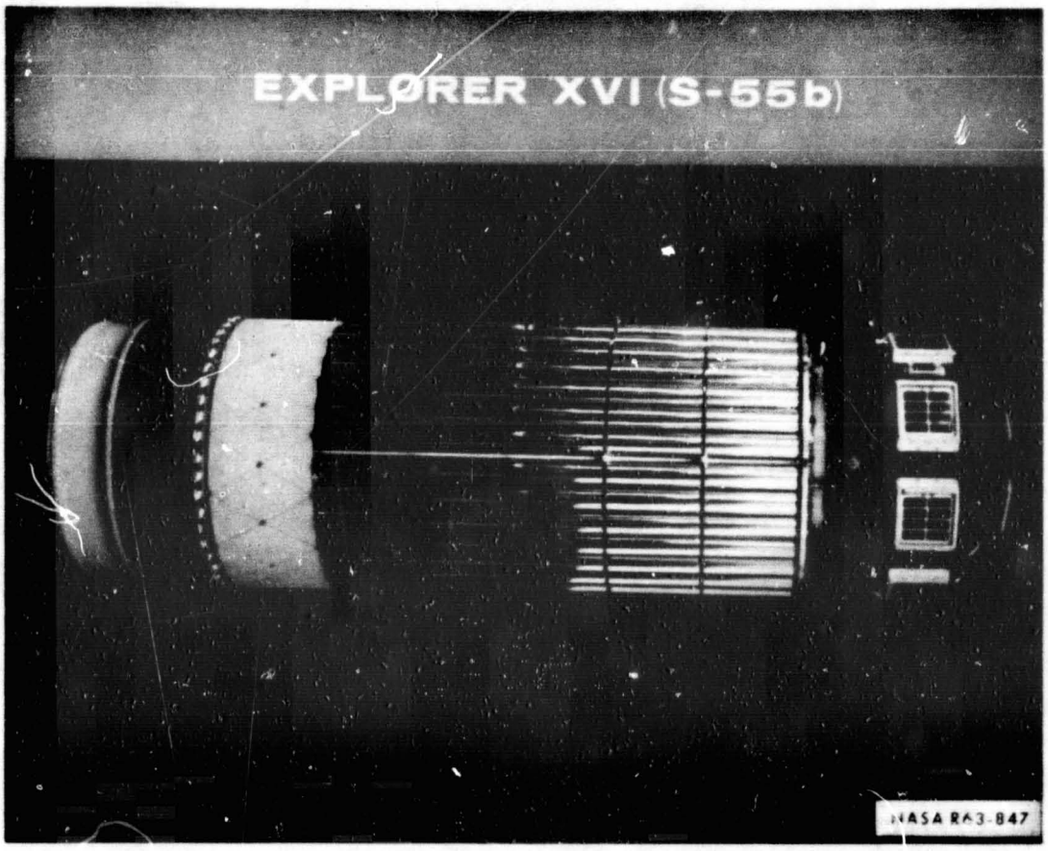


FIGURE 241

Mr. AMES. From December 16 to February 20. Let me slip ahead just a minute because I have just received some new information.

The latest information I have is that we now have 37 punctures of the spacecraft; we have 34 punctures of the cans of the type you have before you. We have 160 cans on the satellite—34 of them have been punctured.

Mr. KARTH. What kind of an orbit is this Explorer in?

Mr. AMES. This is in an Earth orbit of approximately 400 to 600 miles, somewhat elliptical.

Mr. KARTH. Does that get in the Van Allen belt at all?

Mr. AMES. Yes; it does.

This was one of our problems in assuring that it would have a lifetime of 1 year. You see, as the Earth rotates around the Sun we would like to have our satellite operate for 1 year to see if there is any seasonal variation in the meteoroid problem.

Now, to obtain a year of lifetime, we had to go to very special means to protect the solar cells from radiation damage and to provide excess battery power, so we have been—hopefully we believe—conservative in developing this vehicle and allowing weight to give it a lifetime of a year.

Mr. KARTH. Those solar cells, are they P over N or N over P?

Mr. AMES. I don't know, sir. All I know is as of the moment they are working and we are very pleased with them, and they have a three-sixteenth-inch special coating to protect them from radiation damage.

We use a special coating which we hope will not be affected by discoloration.

Mr. MOSHER. Mr. Chairman.

Mr. KARTH. Mr. Mosher?

Mr. MOSHER. Do these punctures—you refer to the 37 punctures—do they vary greatly in their nature and size?

How destructive are they?

Mr. AMES. The only thing we can tell, sir, is when a thin can such as we have here, made of beryllium copper and pressurized, is punctured. A signal is then transmitted to the recording part of the satellite. Such a signal is later transmitted back to the ground, and by monitoring the data, we can determine the time at which the can was penetrated.

That is all we are getting.

Mr. MOSHER. How large are these cans?

Mr. AMES. You have one there of the size we are using.

Mr. MOSHER. This is the actual size?

Mr. AMES. Yes. We have 160 of them on board; I believe I gave you the figure earlier. The thicknesses vary from one-thousandth of an inch to five-thousandths of an inch. These are very thin cans, so very small particles are probably penetrating the cans.

Mr. MOSHER. You say the cans are different thicknesses?

Mr. AMES. Yes.

Mr. MOSHER. They have any statistics the thinner cans are the ones being punctured?

Mr. AMES. That is correct, sir, and I'll speak to that a few minutes.

I have a chart on that to show you how the whole meteoroid program goes together.

Mr. MOSHER. I see.

Mr. KARTH. Mr. Randall?

Mr. RANDALL. Of course, the whole purpose of the project is to find the size and number of these meteoroids.

Now is there any relation, any possible relation, up to now you have been able to pinpoint in your research between the existence of what you call meteoroids?

First, you never said what size they are?

We don't know what size they are. Is that right?

Mr. AMES. Right.

May I go to the next slide, please?

Mr. RANDALL. All right.

Mr. AMES. Here (fig. 242) we summarize our meteoroid program for you.

This shows the penetrations per 100 square feet over a 10-day period based on two predictions, the more conservative one indicated by this dotted line here on top, and the less conservative one is indicated by the solid line.

Now, the cans on the S–55 satellite is covering the band shown here—you can see—this is skin thickness indicated across the bottom of the slide.

For instance, here is the thousandth-of-an-inch thickness.

Here is a hundredth of an inch.

You see the S–55 covers this range, so we are covering these data points which we have received from the S–55.

OART METEOROID HAZARD PROGRAM

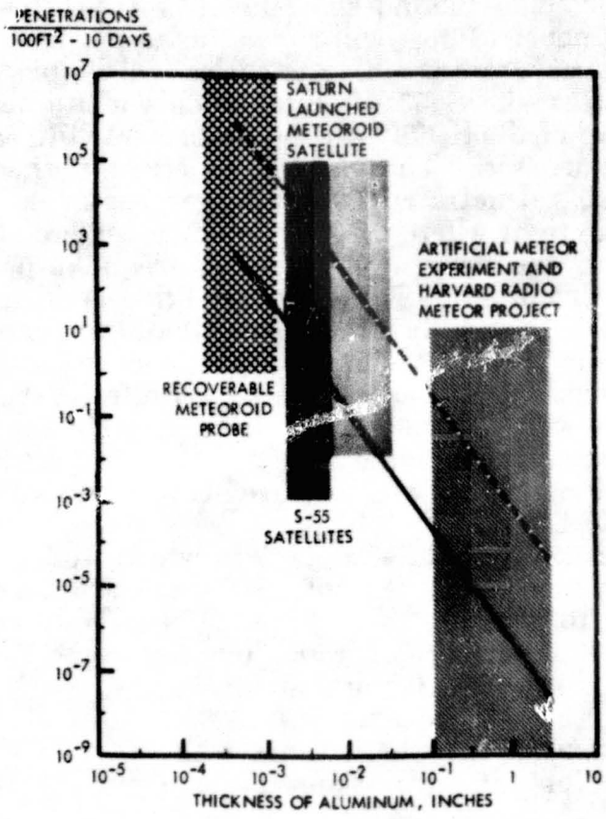


FIGURE 242

So, we are covering small meteoroid particles which penetrate thin cans at high frequency. This would be one penetration on the vertical scale. This is 10. This is a thousand and on up.

This is a log scale, a compressed scale here. So, you see we are operating in this range here and, therefore, these are very small particles, in all probability.

Now, this is a very good statistical sample considering that a year ago we had no information whatsoever, of this nature. Yet, it certainly is not enough to tell us to what level we can design.

We are reasonably convinced, however, that this upper curve which has been used in design before, is too conservative. We don't have enough data to determine where the curve should be, or whether it should be a curve or straight line. It does look like this lower line might not be conservative enough, however.

Also to study to the larger particles, we have planned a Saturn-launched meteoroid satellite which will go from the 25 square feet of exposed area on the S–55 or Explorer XVI, to 2,000 square feet of exposed surface.

Skin thicknesses will be larger in size—in fact, to say, sixteen-thousandths of an inch on certain parts.

Now, for the very larger particles, these are the particles that succeed in getting into the Earth's atmosphere long enough for us to observe them from the ground, Professor Whipple's program is assisting in providing data.

Going back to the small particles, the recoverable meteroid probe is in a sense a paraglider, which we hope to launch from White Sands

into predicted meteoroid showers. We expect the frequency of impacts and penetrations, will cover this upper band on the slide.

In summary, you see, fine particles will be picked up by the paraglider and by the S–55 satellites. This white band in the center is the overlap of the S–55 with the Saturn satellite experiments, for correlation purposes. The Saturn experiment then takes us out to thicker skins penetrated by the larger particles. Then we get over here on the right where the Harvard Meteor project will observe from the ground the very large and less frequent particles. One other aspect of this program is that we are firing artificial meteors of known mass, velocity and direction from Wallops Island, so that we can measure the luminous efficiency and correlate this with the ground observations and estimates made by Professor Whipple.

So, here we are trying to cover completely the meteoroid problem to determine just how bad it is.

I'll deal later with what we are going to do about it, after we find out how bad it is.

You can see that the sample data which we have are too limited to draw any conclusions, except that there are particles up there that are going to give us trouble even if they only erode the surface or puncture thin surfaces or knock out electronic components.

Mr. MOSHER. Mr. Chairman.

Mr. KARTH. Mr. Mosher?

Mr. MOSHER. Are there times when two or three go out at the same time or any indication that one particle is damaging several cans?

Mr. AMES. That is a very interesting question. I have not looked at the data myself. I would like to find out, and give you an answer on this. The data are being received at Goddard and transmitted to the Langley and Lewis Research Centers, and Goddard. The three centers jointly are analyzing the data. The interesting think is that Langley, Lewis, and Goddard all have experiments on Explorer XVI, so I would like to go back and look up that point myself.

Mr. MOSHER. You might draw some conclusions about size from those matters?

Mr. AMES. Yes sir, the larger particles exist in much less frequency than the smaller particles. That has always been our understanding and there's nothing to refute such an understanding.

Mr. RANDALL. Mr. Chairman?

Mr. KARTH. Mr. Randall?

Mr. RANDALL. Is there any evidence on our returned manned space vehicles of meteoroid damage?

Mr. AMES. We have examined Mercury capsules and parts of Atlas launch vehicles to determine whether they were impacted by meteors. It is difficult to determine whether this is so or not.

I have one slide which I'd be happy to show you, or show you a glossy print of a ballistic probe which was launched, I believe, up at Fort Churchill and recovered. We are reasonably sure that the crater in this vehicle part was caused by a meteor because we have simulated such craters in ground experiments. I'm not sure whether it was before this subcommittee last year or not or in some other appearance, but I showed a picture of a——

Mr. RANDALL. Well, it wasn't this same committee last year. You understand, it was a different committee.

Mr. AMES. Yes.

Let me look this up and I'll be happy——

Mr. RANDALL. Just one further question.

I know this is speculative. Maybe it has no merit.

Is it possible that the object which our astronauts have seen, these fireflys, or whatever they call them, is it possible they are meteoroids?

Mr. AMES. I don't think so, sir.

Mr. RANDALL. You don't think so?

Thank you. That's all.

Mr. KARTH. Mr. Ames, where are these meteoroids coming from and what direction are they going?

Do they have any pattern of direction to them—or do they just come from no place?

Mr. AMES. There are known meteor showers that are predicted.

In fact, we had such a shower in January.

Mr. KARTH. These all emanate from the direction of the sun?

Mr. AMES. I don't know if we could pin it down that precisely or not.

For example, some of it could be dust from comets. Some could be from other planets.

Mr. KARTH. Are they in orbit around the earth?

Mr. AMES. Presumably some of it would be in orbit around the Earth, because the Earth has a large gravitational effect.

We would think the Earth would be like a vacuum cleaner and pull this dust in toward it. Our purpose is to study the Earth orbital environment, and we would expect the greatest hazard to exist in this area.

Mr. KARTH. I know, but if our satellite is moving in the general direction of the meteoroids, how valuable is it, as opposed to how valuable it would be if it were moving in the opposite direction?

Probably you would have all the cans punctured in 10 minutes.

Mr. AMES. We probably would have punctures. If we are going in the opposite direction, of course, the relative velocities of impact would be less.

Mr. KARTH. You mean if you are going against it, it would be less? What direction is this going?

Mr. AMES. If the meteoroid was going in one direction and we were going in the opposite direction, the relative velocities are greater.

If we are going in the direction in which the meteoroids are moving.

Mr. KARTH. What direction are we going? I just assumed we were going in the same direction. I assumed the satellite was moving in the same general direction.

Mr. AMES. The satellite is orbiting the Earth and the Earth is rotating, going around the Sun. We are sweeping this area of space with our Earth going around the Sun and with our satellites around the Earth; so we could have a number of directions.

I believe most of the meteor observations, or the impacts that we have experienced, have come in the early morning hours.

I haven't thought back as to the implication of this, but the velocities are very high, in any event.

I agree with you they would be less if we operated in certain directions. I don't think that is a significant factor in design. I think we have to use the maximum velocity.

Mr. KARTH. The vast majority of them could be moving in the same direction as they orbit the Earth, the same direction of the satellite, except there are a few that are lost or going indiscriminately?

Mr. AMES. As the Earth goes around the Sun it passes through masses of meteoroid particles from time to time during the calendar year. However, I am not on the space sciences side of this.

This is where we have to work with Dr. Newell, and one of the reasons we are very happy to have Professor Whipple associated with us. My viewpoint here is primarily that of the engineer and designer, to answer the question "How bad a problem is it and what can I do about it?"

I would have to refer you to Dr. Newell's staff.

Dr. BISPLINGHOFF. I might say, most of these particles are in orbit around the Sun. As Mr. Ames said, there are two sources, the tails of comets producing the very fine particles. The larger ones come probably from grinding in the asteroid belt.

Most of these particles are more or less in orbit around the Sun. So far as we know, the directions that we observe from Earth orbiters are fairly random.

Mr. KARTH. Fairly random?

Dr. BISPLINGHOFF. Fairly random in direction, yes.

Mr. KARTH. That means they are also fairly precise?

Dr. BISPLINGHOFF. No, one might find directions of impact in almost any direction in the ecliptic plane. We don't know anything about their impact, their population, outside the ecliptic plane, but in the ecliptic plane the directions are quite random in nature.

Mr. KARTH. So this experiment then, does give us a pretty good idea——

Dr. BISPLINGHOFF. Yes. Yes.

Mr. KARTH (continuing). Of the density and the velocity.

Dr. BISPLINGHOFF. Yes. The velocity.

Mr. KARTH. That is the reason for my question.

I wasn't sure in my own mind. Counsel pointed out here that maybe this thing would be going in the same direction as the meteoroids and if it were, then how valuable is the experiment, as opposed to how valuable it might be if it were going in the opposite direction. You would get different answers, completely different answers.

If it were going some other direction, straight away, again you'd get different answers.

You are pretty much of the opinion no matter what direction this thing is traveling, you will have the same effect?

Dr. BISPLINGHOFF. Yes, but if you were looking at a vehicle orbiting the Sun, then this matter you mentioned may become important.

Mr. KARTH. Yes.

Dr. BISPLINGHOFF. In interpreting the Mariner data, the microphone data on Mariner on meteorites, we were concerned whether it was not following a swarm of metoroids around the Sun or whether it was going in the opposite direction. I think, however, on the Earth orbits we'll find pretty much a random distribution.

Mr. KARTH. Thank you.

Mr. RANDALL. One question, Mr. Chairman.

You mentioned you thought that the source of these might be from a grinding from the asteroid belt.

Dr. BISPLINGHOFF. Asteroid belt, yes.

Mr. RANDALL. Would that indicate then as time goes on these meteoroids will all become smaller? Is that it?

Dr. BISPLINGHOFF. I couldn't speculate on that, sir.

Mr. RANDALL. All right.

Mr. KARTH. All depends on how big the mass is, I guess.

Mr. AMES. I notice, sir, the time is fleeting away. I have become so engrossed in my subject. I will try to speed it up.

What I have been doing, while Dr. Bisplinghoff was talking, is unfolding the spacecraft we hope to launch on the Saturn vehicle in order to obtain more definitive information than that which I showed you on the slide.

This vehicle would be launched on Saturns 9 and 8, and would expose more than 2,000 square feet of area to the meteoroid environment, in an Earth orbit somewhat similar to that of our Explorer XVI. It would unfold somewhat as I have shown you here.

The span, when unfolded, is 96 feet, roughly equivalent to the wing span of a DC–6.

The vehicle weight would be about 4,000 pounds and we are planning on a vehicle life of 1 year.

Now, a year ago we spoke to you about an advanced meteoroid satellite program but this is quite a departure from our plans of last year.

We were going to go ahead with small vehicles, but it just didn't seem to be on the right time scale. After a great deal of activity we have developed a program in which we are cooperating very closely with the Office of Manned Space Flight and which was initiated this year in lieu of our S–65 program. This new program will use Saturn, and here we are saving money. We are riding on Saturns 9 and 8. We are putting our money in the larger spacecraft instead of launch vehicles. I think the new program will cost us less than the one we previously planned.

It will also give us more data, sooner.

Skin thicknesses on a vehicle of this sort can approach nominal wall thickness of component parts of the Apollo system.

Mr. KARTH. Who is developing this satellite?

Mr. AMES. This satellite is being manufactured by Fairchild Stratos in Hagerstown, Md.

We had competitive bidding on this a few days before Christmas and the contract was awarded the 1st of March. We have a very tight schedule in order to make the Saturn 9 and Saturn 8 launchings. We are very confident we will do it.

Mr. KARTH. What is the cost of this program?

Mr. AMES. It is hoped it will not exceed $7½ million. Previously——

Mr. KARTH. That is for the two satellites?

Mr. AMES. The two satellites and data handling.

Previously, We estimated the program would cost $12 million.

The contract is for $6.6 million, but you realize we have inhouse costs, for fabricating the service module to take the spacecraft, and to pay for range operations and handle the data, and I've simply——

Mr. KARTH. Is this under the Office of Space Sciences?

Mr. AMES. This is an OART meteoroid satellite program. We have the meteoroid program, as Dr. Bisplinghoff has said. It is a vehicle technology program.

Mr. KARTH. Yes, except you are getting into the development of hardware.

Mr. AMES. I see.

Mr. KARTH. I am trying to develop in my own mind where the overlap may be, where the division of powers might go.

I don't know I can do it now.

Mr. AMES. Well, let me go to this then. I hope this will help you.

The question is, is there a meteoroid hazard? If there is, how bad is it? Thirdly, if it is a bad problem with respect to meteoroids, what do we do about it in vehicle design?

The answers to these questions are pertinent to all of our programs whether we put up Tiros or Nimbus or the Orbiting Observatory or Gemini or Apollo or conduct some sophisticated rendezvous operations or put up Echo–2; but it is a program directed at providing the technological and engineering answers to permit us to design structures to cope with this problem.

Mr. KARTH. Oh, I have no argument with you there, except that 20 minutes or so ago, I thought we had established that your Office carried out the very basic research design, et cetera, et cetera, for these things and once a program was initiated, that is, where some hardware was to be made, then it would be turned over to somebody else.

Mr. AMES. Well, there are certain cases in our program, for example, on reentry and in the meteoroid problem, to take two examples, where we are practically beyond the state of the art in say, Apollo and some of our other vehicle programs. So the Office of Advanced Research and Technology has assumed, I believe, its rightful responsibility to work with the other offices to conduct general research and to get the programs on a timely schedule, and then extend our studies beyond the information needed for today's programs.

I don't want to imply this information is needed solely for Apollo. There is a general lack of information on the meteoroid problem.

Mr. KARTH. Oh, I know. The information that the Office of Space Sciences gets from their experiments, aren't necessarily applicable onto Apollo, either.

Mr. AMES. Their information with respect to the meteoroid problem is primarily impact of small particles on microphones. They are not concerned with the penetration problem of structures due to the meteoroid.

Mr. KARTH. No, but they well would be, if that responsibility were assigned to them.

Mr. AMES. The responsibility was assigned to them until November 1961. With the creation of the Office of Advanced Research and Technology, it was assigned to us.

I remember this came up in earlier testimony.

Later, in my remarks——

Mr. KARTH. Actually, you people follow two courses of action. One, your Office has the responsibility of getting basic research done in various areas and then after that's done when there's a request made upon the Congress for appropriations to support a program, it's turned over to somebody else, and also your responsibility is in some areas where you do request funds for the development of a piece of hardware that actually will fly as a program then in some instances you continue on and carry that program on to conclusion.

Is that right?

Mr. AMES. I think for efficiency and economy, yes.

Dr. BISPLINGHOFF. Mr. Karth, I believe this is really an anomaly in the organizational pattern of the OSS and OART. He gives a special case which exists which is not like the regular pattern that we have.

Mr. KARTH. Well, it might be we would want to explore this a little later.

Mr. AMES. I would like to point out here that our objective is to obtain data on structural penetration phenomena—structural penetration probability.

This is how you get information for design of a vehicle to cope with the meteoroid problem.

Mr. KARTH. Mr. Hammill.

Mr. HAMMILL. Well, what would you say would be the responsibility of the Office of Space Sciences when it comes to this whole question of meteoroids?

Mr. AMES. I would say their concern is the nature of the matter; how much of it is there and where it comes from—the scientific side of it.

If we had that information today it would be quite helpful to us.

Now, the S–55 program was a program of the Office of Space Sciences, but was transferred to us because it was dealing more with the meteoroid puncture of the structural elements.

Also, the space sciences program does deal with the meteoroid problem from the standpoint of the fact that they have little microphones for the finer particles on some of their experiments.

The forward part of the S–55 has the Space Sciences experiment on our vehicle. It is an impact microphone. I think the mission of the Office of Advanced Research and Technology is to develop the design technology, and in order to develop the technology we need to know the penetration probability.

I'll give you an example, in case——

Mr. KARTH. What about the manned lunar landing technology? Why don't you conduct the manned lunar program?

You see the thing I can't get clear in my mind, Mr. Ames, is why OART does work on some programs and why not on others; and where is the line of demarcation.

What distinction do we make?

I'm not sure that I understand it at this point.

Mr. AMES. I have a slide on meteoroid protection which I would like to show you. Maybe that's not the best way to answer it, yet I wanted to get to it in the case of the structural design.

The question today is how do you design a structure to withstand meteoroid penetration, and how much weight penalty do you pay and that depends on the probability of puncture, the size of the particles, and the thickness of the structure.

We have tried, because of time and necessity, to condense all of this program quickly in an accordian manner to get a gross indication of penetration probability for various sizes of particles using certain skin thicknesses.

The way we measure meteoroids is to take the various thicknesses of materials and determine how frequently they are penetrated.

Mr. KARTH. Yes, sir. There is no argument about that, Mr. Ames. If this is your interest insofar as meteoroids is concerned, what about your interest, for example, insofar as radiation is concerned.

Why don't you conduct the experiments to decide what kind of shielding we need in the Van Allen Belt, for example, or beyond it, or inside of it?

Shouldn't you actually prepare the experiments to find out what the radiation is in each of these areas, just as you are applying the experiment to determine approximately how many meteoroids there are?

Mr. AMES. Are you talking on what we call the interface between the various offices?

Mr. KARTH. That is right.

Mr. AMES. It is very important that we recognize and maintain these interfaces.

Now in the radiation program, I commented that the basic radiation data came from Dr. Newell's program, but we are developing the techniques for computing the shielding.

Mr. KARTH. Right. This is fine, I agree. Now what about this experiment? Shouldn't they be doing it and giving you the data? Then you could decide how thick the skin of manned spacecraft must be to fly to the Moon or fly to one of the planets.

Shouldn't this be your job then? Okay, so you got the information and you decide how thick the skin must be to withstand the onslaught of the meteorites.

Isn't that where the interface is?

Mr. AMES. No, I consider this very much like the reentry program.

Should the Office of Space Sciences go in the reentry plan?

Mr. KARTH. I'm not sure they should.

I'm not sure that is part of the Office of Space Sciences. Maybe there is distinction. Maybe that should be manned spaceflight, but I'm not sure it should be your office.

Mr. AMES. The reentry program? Well, the competence rests with OART.

Mr. KARTH. Once you get the idea and once you set down some of the basic research items, then you go into a hardware stage.

I am not sure this belongs in OART.

Mr. AMES. We do not design heat shields for Apollo, but we provide the data to permit them to design the shield.

We provide materials for design.

Mr. KARTH. Right. If this was in the Office of Space Sciences and provided them with the data, provided the thickness of the skin; this, it seems to me, follows pretty much the program that I thought you were following.

Mr. AMES. Well, in the decision made by Doctor Seamans back in the November 1961 reorganization, after he had examined the S–55 program, it was generally concluded that the S–55 program was directed at impact and penetration technology which is an integral part of vehicle design.

At that time, the program was transferred to my Office.

From November through January, I had frequent discussions with Doctor Newell, Mr. Cortright, and Doctor Clark, so that the transfer

of this program would run smoothly and effectively in OART. All three agreed.

All of the centers participating in this new OART program gave their full concurrence to its plan.

Mr. KARTH. Where was it before?

Mr. AMES. It was in the Office of Space Sciences.

It was making relatively slow progress because of the activity in other more scientific areas; but it is an urgent structural research problem, and I have space vehicle structures as a program responsibility.

The problem was transferred to us because of its very close relationship to the structure.

Now we have worked quite actively with Mr. Dubin and Mr. Aucremanne of Space Sciences on this meteoroid program. We don't have formal groups, but there's a great deal of interchange on this plan.

Mr. KARTH. I notice by the backup books, Mr. Ames, that in fiscal year 1962, Office of Space Sciences had $363,000 in their budget.

This year, fiscal year 1963; $744,000.

Fiscal year 1964, $800,000, I don't know why they are involved in it, if they turned it over to you.

Mr. AMES. I think this is a complementary study.

Mr. KARTH. Let me complete my statement.

I find also in Manned Spaceflight Systems there is more of it under Meteorites and micrometeorites; not in fiscal year 1962 or 1963 but in fiscal year 1964 they are beginning a meteorite and micrometeorite program.

They are asking for $100,000.

So, I find it in the Manned Spacecraft Systems section.

I find it in the OSS section and find it in OART.

Now, is there any place else you might find a little of this?

You see, there are so many of these programs going on, I am not sure when you are doing this kind of work, you can correlate the effort and even if you could, I'm not sure you are.

Mr. AMES. I would like to assure you, this is one of the best coordinated programs we have.

Now, if we obtain this information related to the structures, I certainly feel Mr. Dubin in the Office of Space Sciences would like to use and analyze the results with respect to updating his knowledge and thoughts on the meteoroid environment from the scientific viewpoint.

Mr. KARTH. He better not spend $800,000 in doing it.

Mr. AMES. I can't speak to what he would do in detail.

On the Harvard radio meteoroid project OSS is putting money on our contract. Manned Space Flight is putting money on our contract.

It is a three-cornered contract managed out of my Office.

Mr. KARTH. I am not sure why we have to go through all this paperwork, you see, to support a program.

If it's going to be under your direction, then let us have all of the requests from your Office in the budget so we can pretty well define in our own mind how much money is being spent on projects.

If it's going to be under OSS, please, the same thing, or under the Manned Spacecraft program.

Here we find these budget items scattered throughout, so my offhand opinion would have been moments ago that the $4½ million you are requesting is the total amount that we are called upon to fund for this project.

I find this isn't ture. It's much more than that. It's scattered all over the place.

I am not sure, you see, that this is the proper accounting system that should be used.

I am not sure that this is the system that should prevail insofar as the assignment of various budget requests, to the agencies witnin the agency or the offices within the agency.

I am not sure this makes much sense. It's very confusing and in many instances, I think that these little $800,000 requests here, and million-dollar requests there, will slip through and, certainly, on the other hand we will be able to justify the four and a half million dollar request.

So, all in all, I think this could, indeed, be a very confusing accounting system that's being used and whether or not these various offices actually get this money to spend or not, I'm not at the moment satisfied.

It may be, you see, they just turn it back to you. I really don't know.

Mr. AMES. Only a portion of it.

Mr. KARTH. Only a portion of it.

This makes it even worse.

Mr. AMES. You see, at the moment we are working very closely with both the Office of Space Sciences.

Mr. KARTH. Oh, I assume you are.

Mr. AMES And the Office of Manned Space Flight, on how to study the meteoroid problem in the lunar environment. It is presumed in these discussions that OART would run that flight technology program.

Mr. KARTH. Well, I am going to look up the testimony.

In fact, just let me call it to the attention of council now—the testimony that was given by the Offices of Space Sciences as it related to their justification for the $800,000 for the meteorites and micrometeorites and I also suggest to counsel that he get from the Manned Spacecraft group the justification used for the request over there.

See if we can make some sense out of it as to whether or not all three requests should be allowed.

Mr. RANDALL. May I supplement that?

Mr. KARTH. Pardon me?

Mr. RANDALL. May I supplement that request.

Before making any comment, so far as this committee is concerned, our witness has been very informative and very sincere and a very fine witness and this exploration we are making here is not in criticism of anything you are doing but we must find out these things.

I would be hopeful counsel would not only give it out, but give every member of the committee a summary or recapitulation of it right away.

Mr. Chairman, that's all.

Mr. KARTH. Fine, thank you very much.

If for no other reason, Mr. Ames, so that the subcommittee can better understand how we do this, and I might say, too, we have noticed this in several other areas where various offices throughout NASA have pretty much undertaken the responsibility for another thing that another office has taken responsibility for.

We are not quite sure in our own mind how these experiments and activities can be dovetailed, one office with the other.

So, it may be, we may have to call you back later on for further explanation on this.

How much more time do you think you will need, Mr. Ames? If we keep quiet, how much more will you need?

Mr. AMES. Well——

Mr. KARTH. I know you are not feeling well.

Mr. AMES. Perhaps I could run through these slides in 10 or 15 minutes. I have a movie I would like to show you next, if I could, on the zero gravity problem of fluids.

Mr. RANDALL. Mr. Chairman, may I have just one request on the record.

Mr. KARTH. Yes.

Mr. RANDALL. When you come back, there is very much interest in this project of active shielding. It seems to me, perhaps, it has military significance and even those of us who work on other committees, such as the subcommittee of military operations, are quite interested in it for possible civil defense applications.

That may seem a little farfetched, but I'd like for you to try to work up something for us, at least, such as you can and let us know where we are going in this direction.

I am exceedingly interested in what you mentioned of that and I do make that request of you.

Mr. AMES. All right.

Mr. RANDALL. Thank you.

(The information requested is as follows:)

The presence of intense fields of highly ionizing charged particle radiation in space is now a well-established fact. The existence of such high-energy radiation in space presents a severe hazard, particularly for manned missions. At the present time, the only practical means for protection from effects of such radiation is through the use of passive means such as massive radiation shields to protect occupants and critical spacecraft components.

On the other hand, it is also well known that the Earth's magnetic field affords us protection from cosmic rays and this fact suggests the possibility of developing methods for actively shielding spacecraft. The basic principle involved may be explained as follows. When a charged particle moves in a magnetic field, it experiences a force in a direction which is perpendicular to both the field lines and the velocity of the particle. Consequently, a magnetic field can be used to deflect a charged particle from its direction of motion. Since the hazardous naturally occurring particles (such as solar protons, galactic cosmic rays, and Van Allen belt radiations) are indeed electrically charged particles, the idea of using magnetic fields to shield vehicles by deflecting the particles away immediately comes to mind.

However, when we consider the power requirements for conventional electromagnets, they do not show any promise for improvement over the use of bulk or passive shielding for spacecraft of the present or immediate future. On the other hand, superconducting magnets do offer some promise. Such use, however, involves a large technological advance over the present state of the art in superconductors. NASA research programs therefore include basic studies aimed at

advancing the state of the art in superconducting materials, and techniques for the magnetic shielding application, as well as general theoretical and experimental studies of configurations, methods, etc., to provide realistic applications in spacecraft of the future.

The question might also be asked, "Can an electromagnetic field be used to protect humans from radiation produced by reactors or nuclear bombs?" Since, as explained earlier, only charged particles experience the repelling force when moving through a magnetic field, this type of radiation protection system is unfortunately not applicable for protection against the harmful radiations of neutrons and gamma rays which are neutral in charge.

Mr. KARTH. Is there anyone else who could finish this tomorrow, Dr. Bisplinghoff, if we did have some time to go into this phase?

Dr. BISPLINGHOFF. Yes, I'm sure there is. I'd rather check with Mr. Ames in the morning and see how he feels.

Mr. AMES. I will be here tommorow, if you want me to. I think I will be better.

Mr. KARTH. All right, the meeting is adjourned.

(Whereupon at 12:05 p.m. the subcommittee was adjourned.)

1964 NASA AUTHORIZATION

TUESDAY, APRIL 9, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SPACE SCIENCES
AND ADVANCED RESEARCH AND TECHNOLOGY,
Washington, D.C.

The subcommittee met, pursuant to adjournment, at 10 a.m. in room 304, Old House Office Building, Hon. Joseph E. Karth (chairman of the subcommittee) presiding.

Mr. KARTH. The committee will be in order. Nice to have you back with us this morning, Mr. Ames. Very pleased to know that you are feeling better. I understand you'd like to continue and finish your testimony today.

Mr. AMES. Yes, sir; I would.

Mr. KARTH. Fine. Please proceed.

FURTHER STATEMENT OF MILTON B. AMES, JR., DIRECTOR, SPACE VEHICLES, OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY, NASA

Mr. AMES. When we recessed yesterday we were discussing the part of our program concerned with space vehicle environmental factors and technology.

May I have the next slide, please (fig. 238, p. 2363). This is a slide I used earlier.

I'd like to address ourselves for the moment to this last item, "zero-gravity fluid behavior."

Now, an improved understanding of zero-gravity fluid behavior, or behavior of a fluid in a weightless environment, is important with regard to fuel storage, to tank design, to fuel pumping, to engine restarts on long missions, and to the fuel-container heat transfer problem.

Now, the basic problem here is the developing of an understanding of the behavior of fluids in the weightless state, and using this understanding, to develop means for positive control of fluid masses.

I would like to demonstrate this problem with a film. The zero "g" tests or the weightless tests which I'm going to show you on this film were conducted at the Lewis Research Center.

At Lewis we have a facility 110 feet high which is used as a drop tower, and it gives us a free-fall time with our model specimens of slightly under 2 seconds.

What you will see in the film first is this glass sphere, here in my hand, containing alcohol, and it will be dropped down the tower. You will see that once the effects of gravity, which hold the fluid in

the bottom of this sphere, are no longer acting on the fluid, the fluid will climb around the sides of the sphere and there will be a gaseous ball in the center of it.

That's the first film sequence.

In the next sequence, we will drop a configuration such as this other one, which has a standpipe in it which you can see. There are holes in the bottom of the standpipe and you will see the fluid climb up the walls of the standpipe when the weightless state is reached.

May I have the film, please.

Now the vehicle is falling. You see the fluid rising around the side, and a big bubble of gas forming in the center.

These are, of course, slow-motion movies. There is the impact and that part of the experiment is over.

Now, here is the standpipe, and these are the holes in the bottom. The sphere will fall with the standpipe horizontal.

Watch the surface tension take over when gravitational forces are no longer predominant. See the fluid pull around the side and up the pipe.

We have a gas bubble in this region on the right and here is our fluid in this part of the tank at the base of the standpipe.

Mr. KARTH. What principle takes over on that last picture, Mr. Ames?

Mr. AMES. Well, the forces of surface tension become predominant and take over when the gravitational forces are no longer the major forces operating on this wetting type fluid—which in this case is alcohol.

The surface tension takes over, and the fluid is drawn around the wall and up the standpipe.

Mr. KARTH. In that last picture it looked as though the surface tension was greater on the pipe than on the outside of the wall.

Mr. AMES. Yes; it was. The pipe was filling up and the purpose of the standpipe is to provide us with a way of locating the fuel in a tank in weightless conditions, so that we can start pumping in the bottom of the tank and get the engine restarted.

This is just one concept of locating and separating the fluid from the vapor in a tank that has been stored in space, in order to get an engine restart.

Now, in the experiments——

Mr. KARTH. If you had a sphere like this [indicating glass top side down].

Let's say this is a sphere and you pumped your fluid right from the very edge. Wouldn't that take care of the problem?

Mr. AMES. No.

Mr. KARTH. Inasmuch as your gaseous ball is in the middle and your fluid adheres to the inside surface?

Mr. AMES. I don't think so.

I think there is an advantage of locating a sufficiently large amount of fluid in the standpipe and drawing through from the standpipe when we start the engine. We are sure we have the mass of fuel that we need to start.

The fuel could be contained in another part of the tank, and when you begin pumping part of it you may get to a condition where the fuel and oxygen ratio may not be what you want. We want to have

positive control of the fluid in the pumping stage. That is the purpose of the standpipe.

Now, in our studies we have obtained a qualitative understanding, and our effort is now being put on obtaining a quantitative understanding of fluid behavior in the weightless state. We are proposing a new and larger facility for the Lewis Research Center to provide a free-fall time up to 5 seconds. Eventually we hope to have a technique at this facility of providing 10 seconds of free-fall time by first catapulting the tank or sphere up a shaft and letting it fall back again.

Tests of longer duration and in a larger facility would permit us to study larger and more complex systems, and would include tests on just the point you raised on pumping, and also on the equipment and the type pipe you would have to use.

No pumping went on in this case, and we don't know what would happen if you began to pump.

Where longer times in the weightless state are required, we must, of course, resort to flight experiments, and I will touch briefly on this a few minutes later. I'm sure you must recognize that the longer this tank is exposed to the solar environment in space, the more problems we have of the liquid changing into gas and the heat transfer problem cannot be studied in the short duration experiments which I have shown you.

I would like to turn now to——

Mr. KARTH. Could I ask this question. How much work had your office done on this before Centaur got into development?

Mr. AMES. This work has been underway at the Lewis Research Center for, I would say, 3 or 4 years, but on a very, very modest scale. The tower in which these drop tests were conducted was an existing tower, simply adapted as an expedient to perform these very short-duration 2-second tests.

Mr. KARTH. You weren't doing this work on Centaur?

Mr. AMES. No.

Mr. KARTH. This was being done by the general contractors?

Mr. AMES. The Centaur work was done by Pratt & Whitney and General Dynamics Astronautics.

Mr. KARTH. Yes. So the research work on the high-energy fuels was being done, I suppose, by one of the subcontractors to the general contractor?

Mr. AMES. I don't know the answer to that question, sir. I do know the Lewis Research——

Mr. KARTH. But there was no in-house research work being done on that program?

Mr. AMES. On Centaur?

Mr. KARTH. After it was assigned, yes.

Mr. AMES. Only on Centaur? Only in the case where it appeared we were having some trouble with engine combustion. At that time the Marshall Space Flight Center, which had management of the Centaur program, called on the Lewis Research Center, to assist them in working with the contractor, Pratt & Whitney, on the engine problems.

As Mr. Sloop testified the other day, I know of no engine problems at this time with that engine. The tankage and the staging which goes on top of the Atlas which completes the Centaur vehicle, as you know, were contracted to General Dynamics. So, we have an engine contractor and a vehicle or upper-stage contractor.

Mr. KARTH. The point I'm getting at is this: This was really a problem on Centaur; it is a deep space vehicle. We had considerable time and money spent on the coast period and restart and what happens to the high energy fuel during this period, so on and so forth.

The reason I bring this point up, is that some of the answers you seek may have been received as a result of the research done on Centaur.

Mr. AMES. No; I think that the people who have been conducting the zero-gravity experiments with fluids were knowledgeable and are knowledgeable about the status of Cenaur and its problems.

Lewis Research Center really is the center in this country which fostered the hydrogen-oxygen engine program as a research program, beginning well before 1957.

Now, this problem of restarting the Centaur was followed by the Lewis people, and one of the realizations that came out of this activity was the lack of a basic understanding of fluid behaviour in this weightless environment, which did tend to urge us on in doing the kind of experiments, simple experiments, to get the fundamental understanding which we are striving for today. We still do not have, in my opinion, adequate theoretical relationships which we can use on the problems of fluid behavior in the weightless state, especially when you add the complex questions of heat transfer.

I think we simply ran headlong into a whole host of problems there, and I hope you will see that in our advanced technology and research program we are trying to tackle them from a basic viewpoint to get the fundamental understandings that will help us to go on and avoid these in the future, rather than fix up and patch up an ongoing program.

We are not ignoring the Centaur program as having problems, but we are trying to go ahead and get a basic understanding which would permit us to avoid such mistakes in the future.

Mr. KARTH. What you are saying, Mr. Ames, is that we proceeded in an erroneous fashion so far as Centaur is concerned, aren't you?

Mr. AMES. I don't know that it was erroneous, sir. We were in, I admit, quite a mad rush to obtain advanced propulsion capability, and if we followed the same course as our competitors across the ocean and stuck with oxygen and kerosene, we could see we would be a long time in overtaking them and surpassing them. It was obvious that oxygen and hydrogen as a fuel and an oxidizer offered great potential, if we could learn how to use it.

We do have extreme heat transfer problems in this combination.

Mr. KARTH. Oh, I don't say that we shouldn't proceed in exploring the payoffs of advanced technology in the cryogenic fields. I say that we should.

But, by proceeding in the fashion that they did, without doing the so-called bassic research in advance that you are now talking about, it seems to me that a very grave mistake was made when the decision was made to go ahead and develop this thing without having the answers to some very basic problems of behavior, and this is what you have been saying to me. This is why you say you are doing it.

My basic question is, if this has got to be done, then because we don't understand the behavior of liquids in a weightless state, et cetera, et cetera; certainly we must have developed improperly when we made the decision to make the Centaur, if we don't yet have the answer to these basic questions.

Mr. AMES. You see, the reason I am not qualified to answer——
Mr. KARTH. I think you are perfectly qualified.
Mr. AMES. I did not follow the history.
Mr. KARTH. I am not going to tie you down on this.
One side or the other is right, and they both aren't right.
Mr. AMES. I certainly agree, we should push ahead as rapidly as possible on our research problems. We ought to have the research results in hand before we try to design these advanced vehicles.
Mr. KARTH. I assume from what you have said, we have not answered these basic problems.
No. 1, the behavior of these liquids in a weightless state; and that is the reason you are asking for funds to proceed with more research.
Isn't that correct?
Mr. AMES. Yes, because we are going to have long times in space, much longer than even Centaur would experience.
Mr. KARTH. Yes, so the problem apparently is not answered with Centaur; the research that went into Centaur up to the present development state, apparently has not solved this problem.
Mr. AMES. Sir, I believe Centaur as a successful vehicle system will be operational before too long. I believe we made a great deal of progress in correcting the difficulties that have been experienced with Centaur.
Mr. KARTH. I don't think there is any question about it. We have made a great deal of progress.
The only question that comes up is whether or not we can afford to make progress that way. We spent a great deal of money on Centaur.
Mr. AMES. Here, I certainly agree with you.
I like to make progress by research.
Mr. KARTH. This way probably is a much more efficient way and a much more economical way.
I think certain questions are going to be answered with Centaur, but when you do it the trial-and-error method, I assume this gets to be an awfully costly way of doing things.
Mr. AMES. It certainly is.
There is an important contribution being made to Saturn by this work on Centaur. The S–4 stage of Saturn is an oxygen-hydrogen stage and had we not started with the oxygen-hydrogen engine development of the Centaur, I doubt if we would have made the decision to put this advanced upper staging in the Saturn vehicle.
So, there are some payoffs here. I agree, it is costly when we make errors because we don't have information in hand. I believe strongly that we should go ahead with our research plan and try to pin down as soon as we can the fundamental understandings of these problems in advance, if possible, so we can cope with them before we do design these big pieces of hardware which are very costly.
In fact, I want to get into the structures area next and show you one reason we certainly want to do this thing.
Mr. KARTH. Proceed.
Mr. AMES. I certainly agree with what you say, but I don't know in detail the story of Centaur.
I only know from hearsay, and from off-and-on contacts.
Mr. KARTH. I will send you a copy of this report. We made quite a study of this and, certainly, we don't pretend to know all the an-

swers either. We are probably farther away from the answers than we realize.

We realize though that if today we are studying the very basic fundamental problems going into the design and the engineering of the Centaur, it just seems to me that some place along the line we made a mistake.

Either this work has been done already so we need not do it now, or if it hasn't been done, it seems to me we took an awful gamble with Centaur and we got a vehicle about which we don't know some of the basic principles. For instance, the behavior of the fuels when they are in a weightless state.

Mr. AMES. To make it clear, I lean very strongly to your view, doing the research first. If I may have your permission, I would like to quote a statement from Mr. William A. Mrazek of Marshall who has been concerned with the Saturn vehicle from the very beginning.

This was written January 1963.

Mr. KARTH. Saturn or Centaur?

Mr. AMES. Saturn, because it speaks to the same problem.

This is what Mr. Mrazek said:

> Never before has the designer been faced with so many critical decisions with such a minimum of available data from which to make assumptions for design.

He points out—

> The aircraft industry uses regulations and manuals defining safety aspects, safety factors, and fatigue requirements for structures and materials in airplane construction. There are no such regulations or manuals to govern the design and construction of the large launch vehicles which we are now developing to carry multiple-man crews on training flights around the globe, and finally on to lunar exploration.

This gentleman is concerned, directly, with the development of the Saturn.

Without going too much into detail, I would like to read his conclusions.

He said:

> It can be stated that with this design—

Here he refers to Saturn—

> we were able to achieve and retain the initial leadtime advantage.
>
> We dipped deep into the barrel of our present knowledge to fill all requests of the engineers. I am somewhat fearful that the next time we may find the barrel empty unless we replenish it by recognizing the urgency of research in all areas of large launch vehicle structures and the materials used in them.

This could apply to any of these facets of our space program.

With your permission, sir, I would like with this little introduction to go to space vehicle structures.

Mr. KARTH. Yes.

Mr. AMES. Our future space vehicle structures will be larger and heavier, and as we have discussed, will be required to operate for longer periods of time than those for present missions.

Aggressive research will be required to maintain weights at reasonable levels and to predict structural behavior with greater accuracy, to insure reliability under the severe environments and complex loading conditions space vehicle structures will experience.

May I have the next slide, please (fig. 243). This slide is concerned with launch vehicle problem areas.

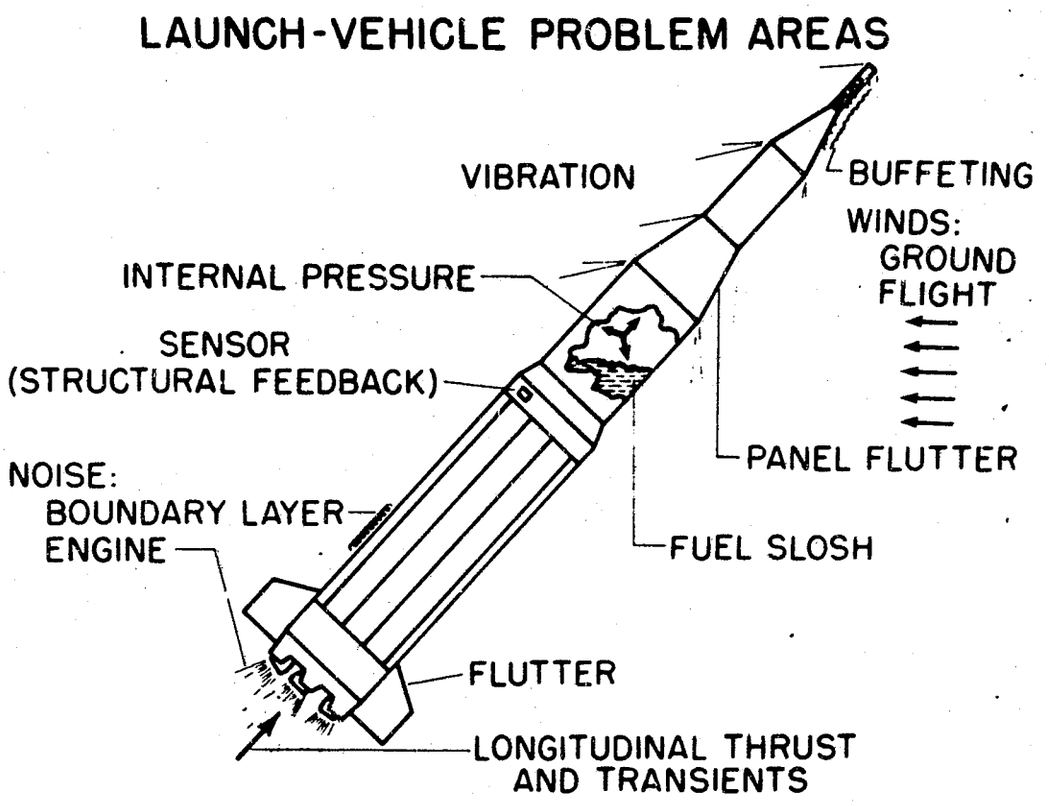


FIGURE 243

I'd like to point out here that the launch vehicle component of the space vehicle system is one of the most efficient structures that has been devised for any form of transportation. This very lightweight structure is required to contain the propellant, to support the engine, and to support and protect the payload in the presence of severe environments.

Now, the margin of safety in design is consequently exceedingly small.

The environment this structure must resist includes many static and dynamic factors and some of these are shown on this slide.

For example, let's start down the bottom there with "noise."

When the engine starts up, we have a noise environment reflected back from the ground onto the vehicle and, as our vehicle accelerates, we have boundary-layer noise due to the air flowing over various parts of the vehicle.

As we go faster and faster, the "q," or the load factors increase. Of course, we have various forms of vibration, too.

As we go up and look at the payload on top—one of these loadings is caused by buffeting due to flow separation. Other vibrations could be caused by shock formations due to discontinuities in the body, and we also have high aerodynamic pressure peaks and flow separations.

Also, as our vehicle is accelerating, we have longitudinal thrust from the engine on the base of the vehicle, and we have large aerodynamic loads acting in the other direction at the top. We attempt, as Dr. Seamans once said, to push on both ends of a limp piece of spaghetti.

Now, we have wind problems both on the ground, on the launch pad, and in flight. For example, when these large vehicles stand on

the ground, horizontal winds can cause them to oscillate back and forth. If the wind is going in one direction, the wind vortices may shed first from one side and then the other, and the vehicle can move from side to side causing stress and strains in the vehicle structure. This type of loading has often caused destruction of tall chimneys in high winds.

More importantly, as our vehicle accelerates and climbs out of the atmosphere, we may go through wind shears where we experience the jetstream with velocities on the order of 200 miles an hour, and while these act on the top of the vehicle, we are swiveling the nozzles on the bottom for control. Under such conditions there is a great deal of bending and structural response of the vehicle.

Also indicated on the figure is the problem of internal tank pressure. We also have fuel slosh as we lighten the mass of the vehicle at the bottom and fuel is burned in the first stage. That means we have a very heavy load on the top of the vehicle, and a relatively empty structure in the first stage.

Fortunately, as we go out of the atmosphere we are able to get away from this problem.

Yesterday we talked about Dyna-Soar and I think you see from figures of this kind what the problem would be if we had a winged spacecraft with its large aerodynamic loading on top of the launch vehicle.

One of our major problem areas with launch vehicles is one we call structural dynamics, and here we need to predict accurately the structural dynamic characteristics of large vehicles in the design stage.

Calculated dynamic properties of very complicated structures leave very much to be desired, and full-scale tests are difficult and expensive to make.

May I have the next slide, please? (fig. 244.) Before dynamic loads and responses can be predicted, or the control system designed, the lateral vibration modes and frequencies of a complete space vehicle must be known. Some of the newer configurations—and here I include Saturn, which is an eight-engine, eight-tank, clustered vehicle—some of these configurations are quite unconventional and illustrate very unusual vibration characteristics which are extremely difficult to predict analytically.

The difficulty of determining these vibration characteristics experimentally on full-scale hardware in simulated flight is a problem which, I think, you'll recognize as working on a problem after we have built the vehicle. It's obvious that you must do something about this before the full-scale vehicle is constructed.

Facing up to these difficulties, we are now looking to the concept of replica modeling as a tool for large space vehicle design.

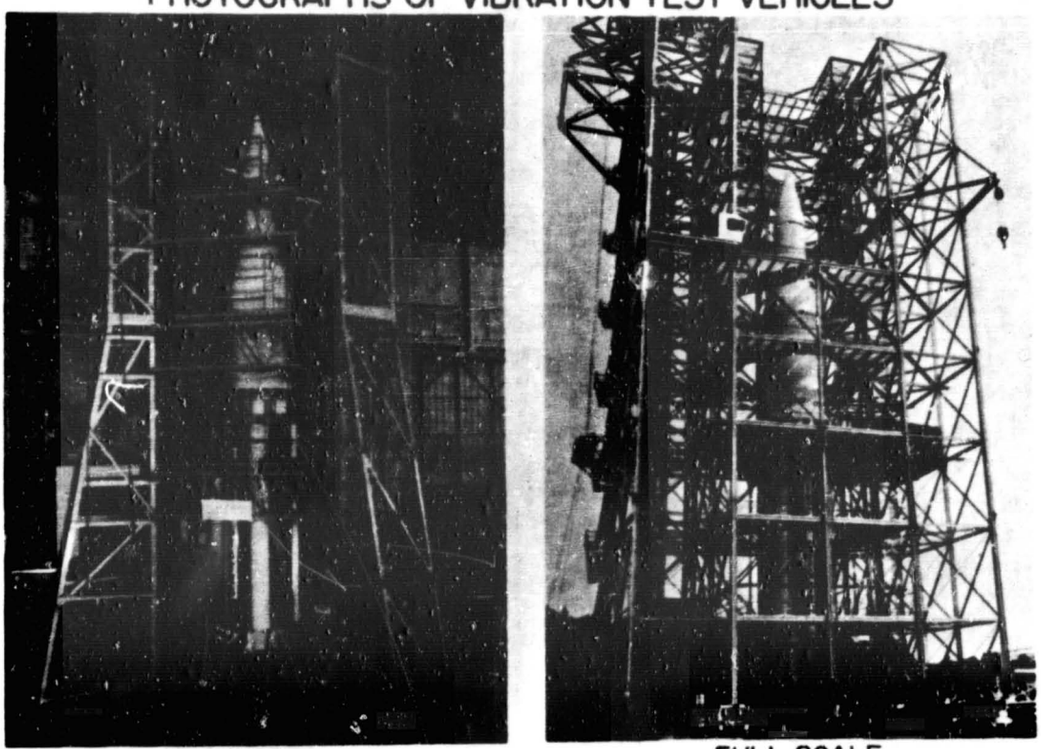
On the left of the figure is a scale model of the Saturn SA–1 vehicle. The scale model is 32 feet high, and weighs 7,500 pounds.

On the right is what you might say is a full-scale "scale" model. That's the full-scale model on which we have attempted to determine the full-scale vibrational characteristics.

The vehicle on the right weights approximately 1 million pounds and is suspended in a relatively free state.

Now, we have tested both the model and the full-scale version, by imposing lateral vibrations on it at various frequencies in order to establish the vibrational characteristics.

PHOTOGRAPHS OF VIBRATION TEST VEHICLES



MODEL FULL SCALE

FIGURE 244

I think you recognize that if we can do this in model scale, we can save ourselves a lot of trouble before we build a full-scale vehicle and find we made mistakes we have to correct later.

The next two slides will show you some of the results of this preliminary effort to perfect this technique (fig. 245). Here we have the first vibration mode—what we call q_{MAX}.

This means we have a certain vehicle weight and aerodynamic loading condition. Indicated also is the relative bending deflection of the vehicle in this direction you see here on a schematic drawing of the vehicle.

Section A–A is where these lateral vibrations were imposed on the vehicle. Next we have the relative deflections from the vehicle centerline. Over here in the table in the upper right, you see the frequency in cycles per second for the one-fifth scale model was 2.80. For the full-scale model which I showed you on the other picture, it was 2.83.

That's a pretty good correlation for this first simple vibrational mode. This is like shaking it at a relatively low frequency and getting the simple bending of a willow as you shake it back and forth.

On the left here, where we have relative deflection, you see the bending we would get along the center line of the vehicle. This is a typical first beam bending mode.

I have shown the clustered tanks on the lower right-hand corner. The arrows on each of these tanks indicate that they are all moving in the same direction in this very simple bending mode at 2.8 cycles per second.

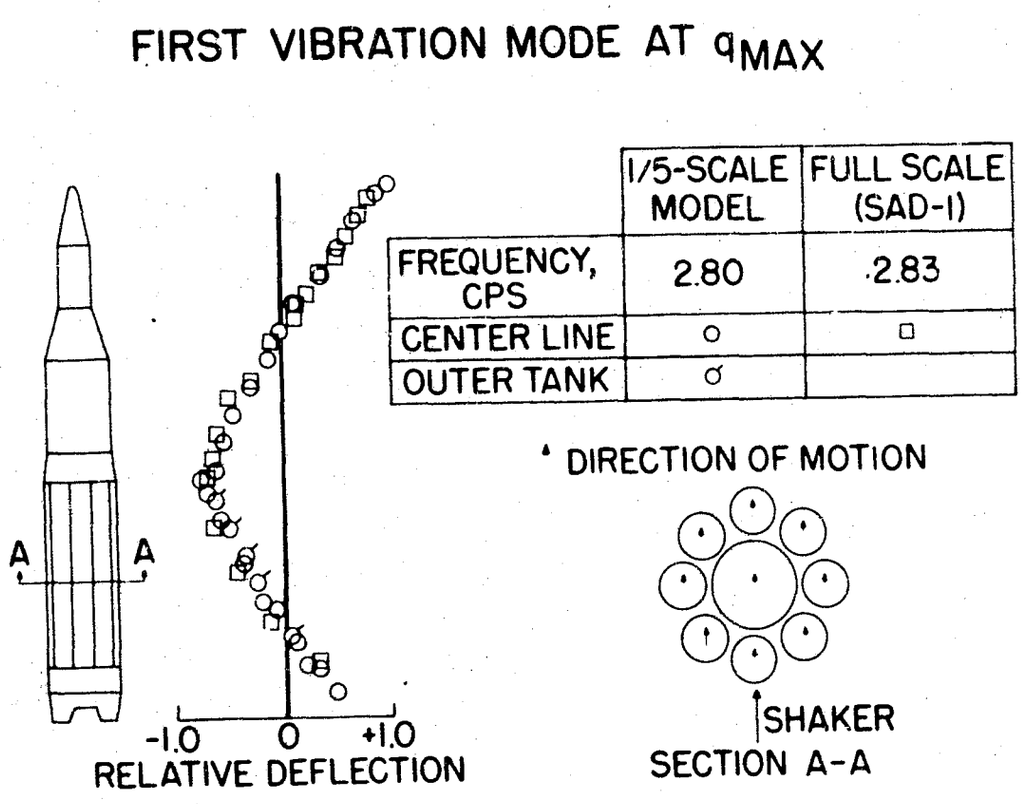


FIGURE 245

Now, let's look to a more complicated mode on the next slide (fig. 246). This is the second vibrational mode which occurs at a higher frequency.

Here with the model we found scaled frequency of 5.2 cycles per second, but on the full-scale model, 5.68. We are off approximately 10 percent in this more complicated mode.

Now, you will notice that the relative deflection on this diagram next to the sketch of the Saturn is a rather unusual sort of thing. The circles and squares represent the bending of the center tanks on the model and the full-scale vehicle, respectively.

The behavior of an outer tank was also measured and we have indicated this for the model using a little circle with a flag on it, and for the full-scale vehicle with a square with a flag. Notice the very unusual bending of the outer tank indicated on the relative deflection diagram here on the left.

Now, if we look at the arrows on section A–A in the lower right-hand diagram, you find the inner tanks moving in one direction and the outer tanks in the opposite. This shows you the confused behavior of a cluster configuration such as this. This simply demonstrates the difficulty of predicting the vibrational characteristics of a complex vehicle of this type which I think indicates the desirability of learning as soon as we can how to do this by use of scale models.

We plan to go ahead with this program, building a one-tenth scale model of the Saturn–5 and correlating it with the full-scale data.

In addition, we hope to build a one-fortieth scale model.

The point I'm trying to make here, sir, is that we are trying to develop a scaling technique so we don't have to do everything full

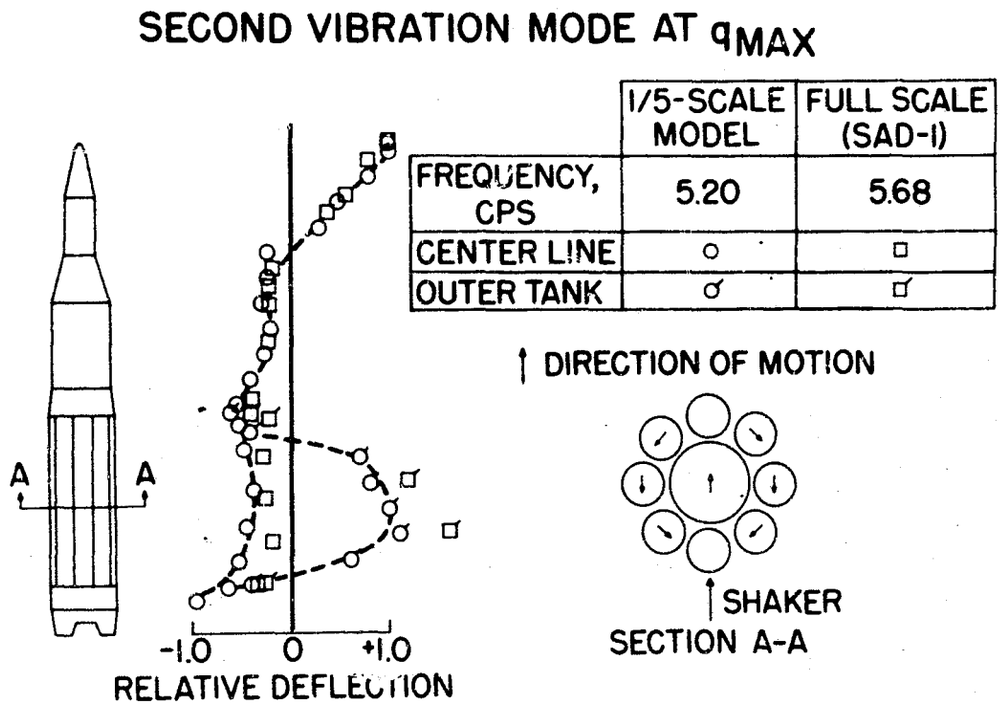


FIGURE 246

scale. In this way, we can eliminate many of the major problems well in advance of construction of the final vehicle.

Mr. KARTH. What about the differences you actually experience though between a full- and a small-scale model?

How are you going to compensate for these?

Mr. AMES. This is going to take a lot of clever work. Actually, the scale model was joined together in such a way as to simulate, as well as we know how, the behavior of the joints on the full-scale vehicle.

Experience is needed and a great deal of study and thought must be given to this complex problem. A simple structure is relatively easy to simulate in model scale.

As we go to the more complex vehicles which I spoke about earlier, we are going to face a considerable difficulty here, and we will have to put a great deal of effort in advanced research and technology if we are going to really succeed in this area.

Mr. KARTH. Yes, but my question is, if the results of your tests are off by a factor of 10——

Mr. AMES. Ten percent.

Mr. KARTH (continuing). Then what good are they?

Mr. AMES. These were pretty good in this instance. Actually, these results were obtained before the full-scale vehicle was flown, and I would say they were generally within the ballpark.

For example, if I divert momentarily to the heating problem——

Mr. KARTH. You feel within 10 percent——

Mr. AMES. In this instance it is relatively good. It's not good enough. We must do better.

Mr. KARTH. I didn't think it was.

Mr. AMES. It wasn't. You are right.

If we have to predict the heating of the Apollo heat shield, we might find ourselves to be off by 20 percent. The point I'm making is that in these launch vehicles we take extreme weight penalties in all the structures problems, in meteoroid protection, and in heating protection because we do not have all the information I think we should have.

This is my whole theme in the discussion today of OART's programs.

I want to bring this before the subcommittee. This is why I feel so concerned that we must close the gap so we can design these vehicles more accurately, and avoid these catastrophic failures, and also avoid redundances in weight and such large safety factors. This is a firm objective in our program, sir. That's why I point out this discrepancy, but in this instance 10 percent is very good considering how little we know about this very complex problem.

With your permission, sir, I would like to go on to another subject, space hazard control, and if I may have the next slide, I will deal with meteoroid protection systems—what we are doing about this problem (fig. 247).

Once our lightweight space vehicle leaves the Earth's atmosphere, it becomes apparent that when we consider protection from space hazards it would be agreed that we should not expect conventional earthbound structures to satisfy the unconventional requirements imposed on space vehicles.

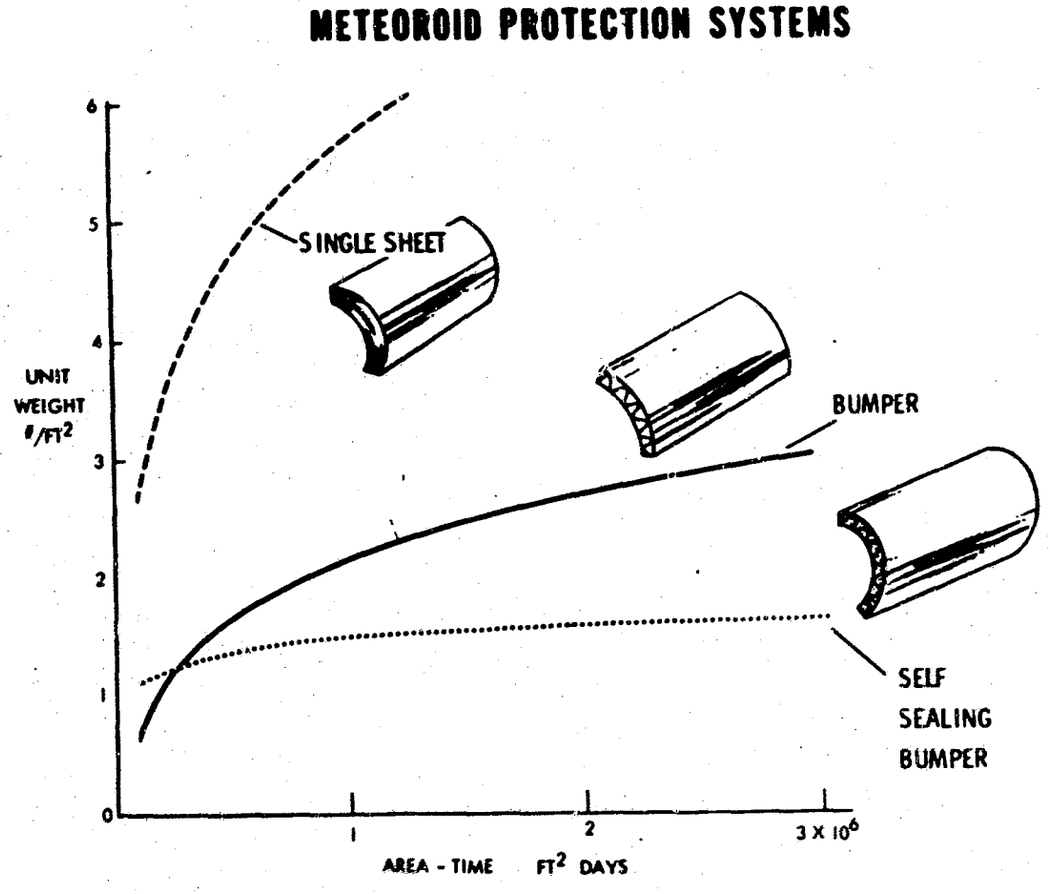


FIGURE 247

Here we must protect against the hazards of the space environment, which include heat from the Sun and that generated by components in the vehicle; high-energy radiation; hard vacuums; zero gravity, as I indicated earlier; and meteoroids.

Now, in discussing structural systems for control of the meteoroid hazard, I have attempted to summarize some of our work for you on this slide.

A comparison is shown of unit structural weight which is plotted vertically against exposure time of our space vehicle, which is the horizontal scale.

The time increase starts from the left at zero and goes to the right—time in space.

Looking at this upper dotted line, you can see from this that the weight would increase rapidly if we resorted to simply thickening the skin of the space vehicle to give protection against the meteoroid hazard as we understand it today.

The next curve, the one in the middle, indicates that if we were to go to what we call the meteoroid bumper concept to absorb the energy of the high-velocity impacts, we would obtain some weight reduction over the single-skin approach with increase in time.

The lower curve, which I have dotted in because we don't have all the answers but it is a very promising one, indicates that in some cases we may resort to a self-sealing type of concept. That is, we might accept a penetration in certain areas of a space vehicle and provide for automatic resealing of the structure.

I have here a few samples of some of our structural work where we have impacted typical space vehicle structural components and checked out the self-sealing capability. We have ripped off the back of this one, which I showed you yesterday, to indicate that the particle went all the way through, but it did seal itself at this point.

I'd like to pass these specimens around to you.

Incidentally, this work is tied in very closely with our meteoroid flight work and our fundamental studies of impact phenomena. This is an attempt to find a reasonable, practical solution we can offer to our cohorts in the other offices of NASA and to the military services.

The next area I'd like to deal with, using the next slide (fig. 248), is concerned with advanced structural concepts. Studies of various advanced space systems for future missions have revealed a host of structural problems requiring advanced structural concepts which will differ radically from those we consider as being conventional today.

For example, once in space, we have certain "relaxed" constraints on space vehicles.

For example, in cases where aerodynamic forces are no longer a consideration the structural loadings on our vehicle are peculiar only to the space flight phase of the mission. Now, such freedom from configuration restraints should enable design of space vehicles which make efficient use of unusual materials and new or unusual types of structural elements.

Essential structural components might also be positioned so as to improve mass distribution and temperature control in the vehicle once it is in space.

One method of vehicle assembly being investigated involves expandable structures that are constructed to deploy themselves in

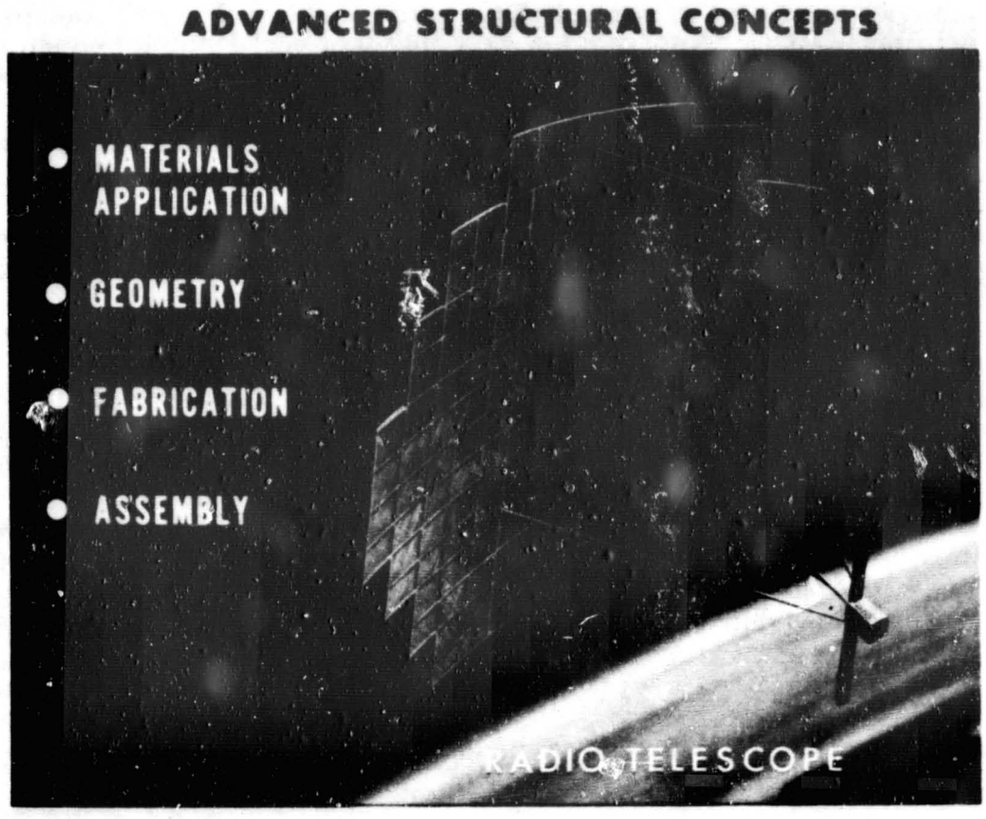


FIGURE 248

space after having been launched in a packaged condition. Mechanisms for achieving this feature include unfolding, spinning, and certain other types.

An orbiting manned space laboratory is an example of a vehicle which might well unfold in space.

I have a few samples here indicating some of the types of structures we are talking about.

For example, if we could launch a package of this nature on a launch vehicle, we could greatly reduce the complexity of launch vehicle design and loading and when we get into space, we can erect it this way.

Other examples we have here represent other structures we have been studying that can be packaged and folded and unfolded. I will pass some of these around.

I won't undo all of these. I think you might enjoy unfolding some of them yourselves.

Could I have the slide back on again, please?

Now, the picture shown on the right is certainly a structural monstrosity, yet it represents an advanced orbiting radio telescope. This is one example of an advanced concept which might utilize the results of research in materials application, geometry, new fabrication techniques, and assembly in space.

We are now studying the structural feasibility of such a system, working closely with our Electronics and Control Office in OART, Dr. Kelley's office, in order that we might have a reasonably practical base as a guideline.

Now, I would like to discuss high-temperature structures. In the structural design of spacecraft capable of withstanding the high temperatures of atmospheric entry at very high speeds the heat shield design becomes a major factor.

The severity and duration of heating and loading varies widely with vehicle type and trajectory as well as with mission; consequently a large number of materials and structural concepts have evolved. Proper selection of concepts, and prediction of their performance as mission times and entry speeds increase, is a large and challenging research task.

A broad picture of the role the heat shield plays in determing the feasibility of future reentry vehicles, is shown on the next slide. (fig. 249) I will try to help you through this rather complex figure.

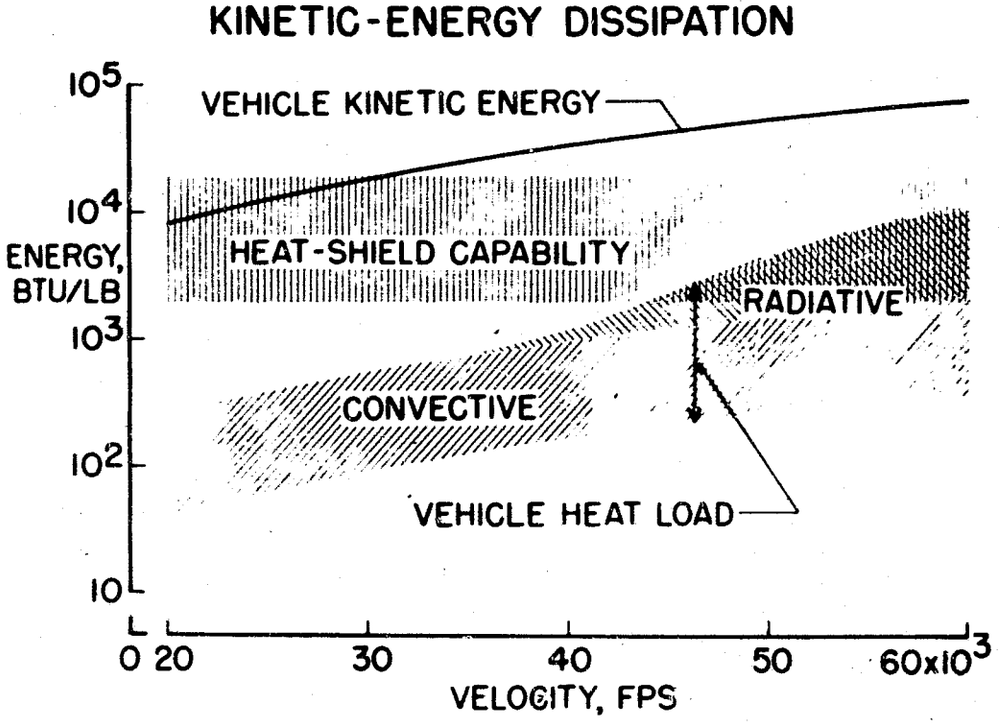


FIGURE 249

The vertical scale is energy—British thermal units per pound of vehicle. The horizontal scale is entry velocity into the Earth's atmosphere, in thousandths of feet per second.

This is a log scale, but in order to get the data on here we have to resort to this condensed scale.

The upper line is the kinetic energy per pound of vehicle weight as it enters the Earth's atmosphere at various speeds.

This is 26,000 feet per second for oribital speed. This is 36,000 feet per second for lunar missions, and this is 46,000 feet per second for planetary missions.

During reentry most of this energy is cleverly dissipated back to the surrounding atmosphere of the vehicle in the form of heat and the heat energy which actually reaches the vehicle is much less and is shown by this lower wide band. This is the vehicle heat load, the heat load

which the vehicle experiences. Only a small part of the total heat energy gets to the vehicle. Most of it goes into the atmosphere.

Now, this center band shows our present heat shield capability.

First, let me go back to the vehicle heat load. We have a wide band here because the amount of heat that gets to the vehicle depends on trajectory and configuration. In other words, a ballistic vehicle could be along the lower part of this boundary. However, as I pointed out to you yesterday, if we use a ballistic vehicle, we'd have to follow a very precise trajectory at the speeds for interplanetary flight.

We don't have that kind of control capability.

If we resort to a lifting vehicle, the heat load would be somewhat higher up in the band. Now, heat shield capability based on present materials is within this center band. This is our ability to dissipate heat by heat shields, whether it soaks up the heat or whether it melts away.

The point I want to make here is that as we reach these higher velocities, the heat load which the vehicle experiences begins to overlap the present heat shield capability, depending on the kind of material we use and the vehicle configuration.

You can see that while we have a large payload at lower speeds, the payload rapidly diminishes in this region of very high speed.

I'd like to make very clear that if we had a reentry vehicle which experienced a very large heat load you'd have to use a material whose characteristics fell on the upper part of the heat shield boundary. This means we must push up the heat shield capability as well as advance the configuration capability to keep down the heat load that reaches the vehicle itself, if we are to have any payload capability left.

May I have the next slide, please? (fig 250.)

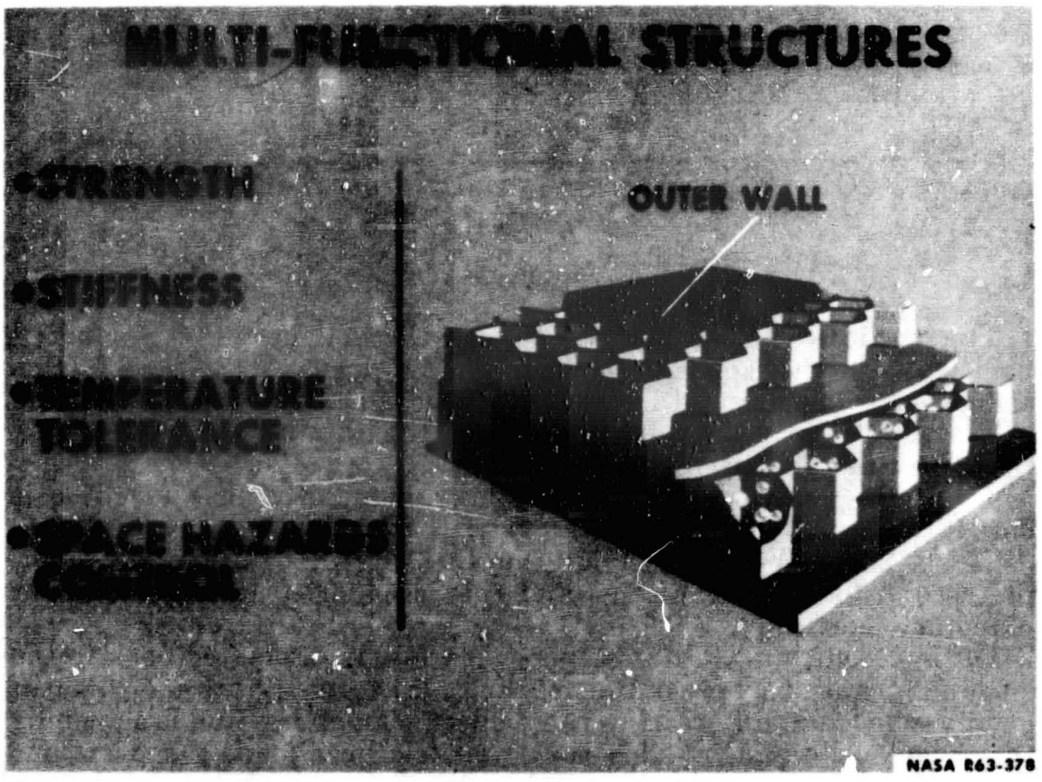


FIGURE 250

Now, from our foregoing discussions, I hope it is clear that future space vehicle structures will be expected to provide, simultaneously, adequate strength, stiffness, tolerance to high temperatures, and to withstand space hazards as well.

Earlier experience with the first three areas on the chart, adequate strength, stiffness, and tolerance to temperature, indicated that the desirable solution was to separate the load-bearing and the temperature-bearing abilities of a space vehicle structure.

However, when meteroid protection, high-energy radiation shielding, tolerance to vacuum conditions, and thermal control of solar radiation effects are required, it appears more fruitful to combine all these protective features into a single structural wall.

The diagram on the right of the figure, and the specimen which I have here, conceptually illustrate this idea. This is the heat shield on the outer surface, and it has been honeycombed to give it some strength. I would like to pass this around.

The outer layer is a charring ablator to protect the vehicle during atmospheric reentry and it, and its reinforcing honeycomb, will provide protection against radiation and meteoroids.

The inner wall provides strength, along with additional means of temperature control. In a way, it's a kind of insulator.

The little rubber spheres which you can see in the end there provide a self-sealing mechanism and provide integrity of the pressure vessel where we have a human occupant or a fuel tank.

This concept is used merely to indicate a possible trend in space vehicle structures.

To state my point here very simply, we'd prefer not to end up with a separate heat shield, then a radiation shield, then some insulation to take care of internal or external heat we may have on the vehicle, and then a structure to give strength.

If we can come up with composite structures to do all of these jobs, I believe we can save weight and develop more efficient and reliable space vehicle structures.

With the next slide (fig. 251), I would like to turn to the vehicle technology flight experiments in the Office of Advanced Research and Technology.

Practical limitations of theoretical methods, and the limited capabilities of ground-based technical facilities, are such they cannot be relied upon to provide timely answers to all of the important technical problems to which we must address ourselves. Consequently, as a complement to our ground-based programs, carefully selected flight experiments have been planned to provide urgently needed data. The meteoroid hazard program is one such program.

We know of no way to achieve the necessary velocities and determine the nature of the meteoroid hazard on the ground, so we must therefore resort to flight experiments.

On this figure are listed OART's current flight experiments, and you will notice that our major projects fall in the areas of hypervelocity reentry and the meteoroid hazard. Also, we conduct a wide variety of experiments using very small launch vehicles, as shown on the lower part of the slide.

This whole program requires very close cooperation and development of close working relationships with our counterparts in the Office of Space Sciences and in the Office of Manned Space Flight.

OART FLIGHT EXPERIMENTS

- REENTRY
  - SCOUT REENTRY HEATING EXPERIMENTS
  - PROJECT FIRE
- METEOROID HAZARD
  - S-55 SATELLITES
  - SATURN-LAUNCHED METEOROID SATELLITE
  - RECOVERABLE METEOROID PROBE
  - ARTIFICIAL METEOR EXPERIMENTS
- SMALL VEHICLE FLIGHT EXPERIMENTS
  - CRYOGENIC FLUIDS AT ZERO "G"
  - WIND SHEAR MEASUREMENTS
  - SOLID ROCKET THRUST VECTOR CONTROL
  - RADIO ATTENUATION MEASUREMENTS
  - REENTRY DETECTION
  - HORIZON DETECTION (SCANNER)
  - SPACECRAFT ORIENTATION CONTROL SYSTEM

FIGURE 251

Our reentry flight test programs include Scout reentry heating experiments and Project Fire.

The objectives of the Scout experiments are to obtain measurements at speeds of about 28,000 feet per second of the total heat transfer and radiative heat transfer components during atmospheric entry, as well as to determine thermal effectiveness and structural integrity of charring ablators and other high-temperature materials.

The next slide (fig. 252) is one I used last year which shows the Scout reentry experiments. Here we are studying reentry problems up to 28,000 feet per second. We are studying various materials. One of our scheduled shots this year will demonstrate a new low-density material which we believe from a mission viewpoint may have application to Apollo, and the Manned Spacecraft Center people are very much interested in a test of this material.

The next slide (fig. 253) is a schematic chart of Project Fire, which is a reentry flight experiment. Our purpose here is to investigate the heating environment and the heating effects around a configuration having a blunt shape similar to Apollo, during an actual reentry flight at 37,000 feet per second, or 25,000 miles per hour.

This velocity is slightly higher than that which would be experienced by Apollo, and would provide us with information which would indicate the severity of heating which Apollo might experience if it had an emergency steep descent beyond that which is presently planned.

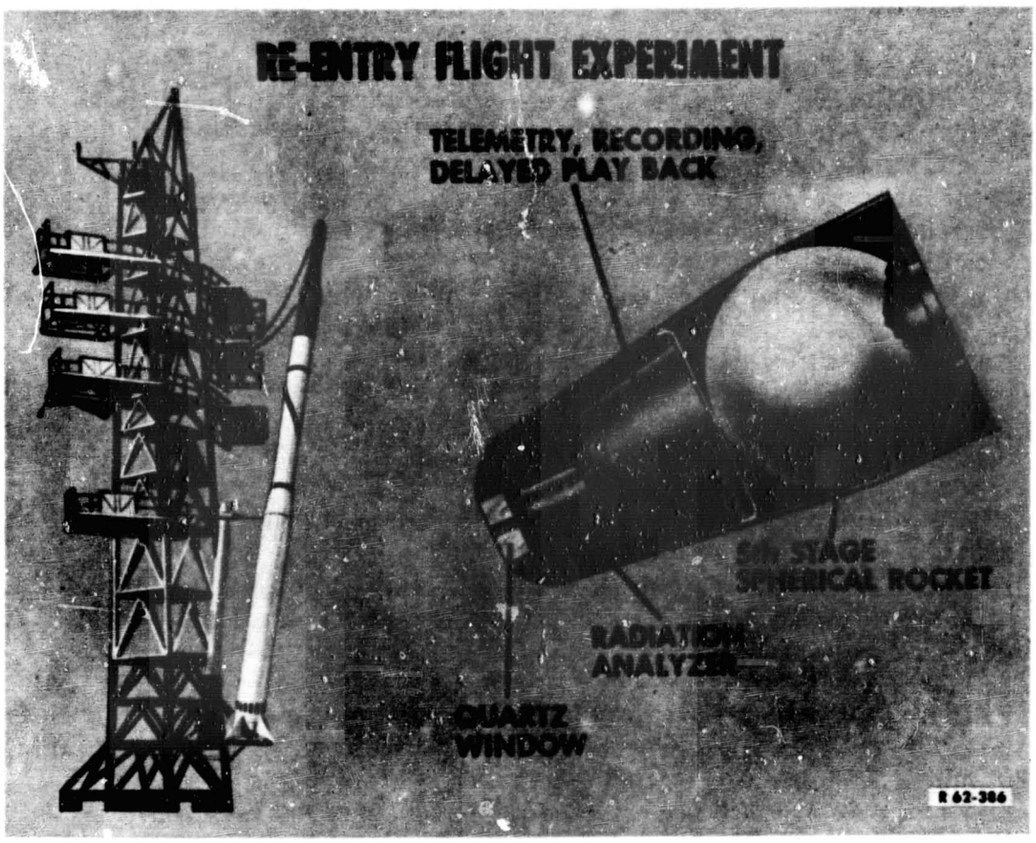


FIGURE 252

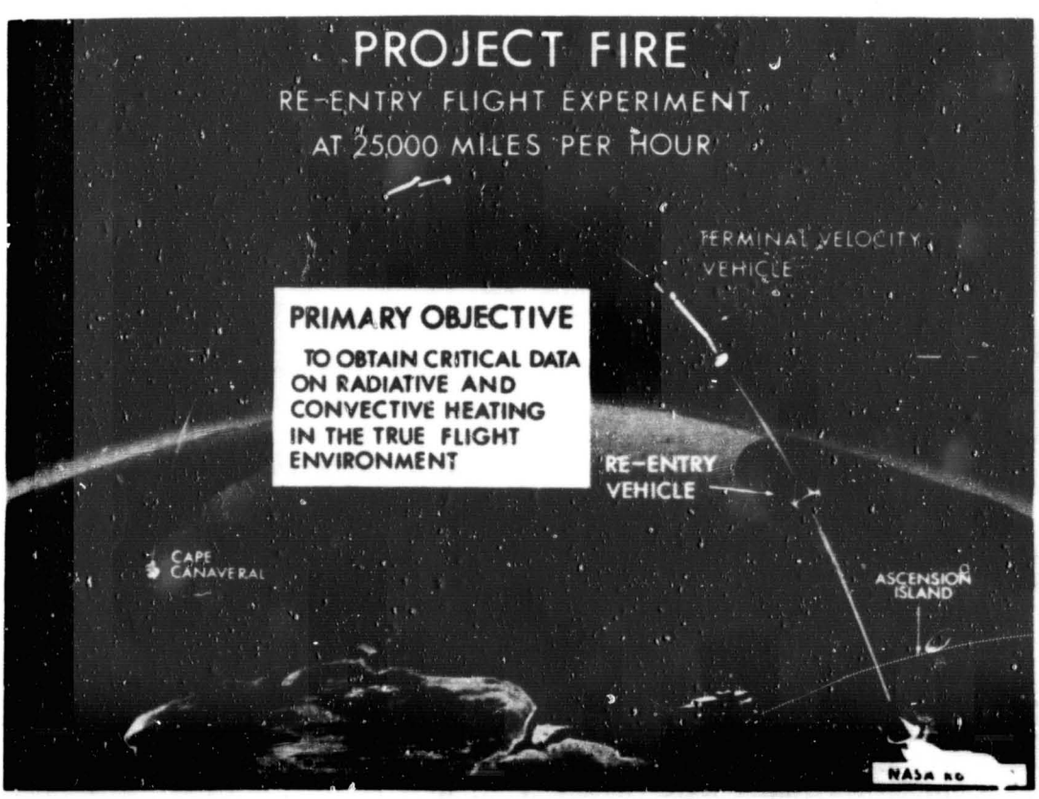


FIGURE 253

More importantly, it is a stepping stone in our reentry program to higher velocities for interplanetary flight.

I have here a model of part of the Project Fire experiment. Once it gets into space, this nose covering will come off, and then as you see in the trajectory shown on the slide, this part of the vehicle with its guidance package will go over the top of the trajectory. Then it separates.

In the descending part of the trajectory, we have an Antares II rocket motor and payload on the front. As the vehicle approaches the Earth's atmosphere, the rocket will accelerate the payload and then separate, and a blunt shape of this sort will enter the atmosphere at a velocity around 25,000 miles per hour.

This, sir, will be a very important step forward in our reentry program, and will exceed the reentry speed for Apollo. It will give us information for correlation with our ground-based experiments and theoretical studies.

As I indicated to you yesterday, we have been running tests in ground-based facilities with items this size, only half an inch in diameter, to obtain heating and gas flow data photographically.

Also, we have run some experiments of models 2 to 4 inches in size, but there is a serious problem in scaling.

Again, I want to emphasize the scaling problem. When we go to our Scout experiments, the reentry vehicle will be about 11 inches in diameter. The diameter of the Project Fire reentry vehicle is about 26 inches—a little more than 2 feet.

So, you can see, we are trying to get some scaling data to help us to project more accurately the information which we've been obtaining with small models on the ground to the design of large flight vehicles.

Mr. KARTH. Are you saying, Mr. Ames, the closer you get to actual size, the more accurate you will come?

Mr. AMES. Yes. I don't think you have to go all the way. I would not want to go all the way. It would take too long and would be too costly; but you might say we are getting "benchmarks" up the curve which permit us to extrapolate information which we have with a great deal more accuracy than we have today.

It will help us to minimize some of these redundancies or contingency factors we have to use in design to insure success of our vehicles.

Mr. KARTH. Two or three experiments using slightly larger sized vehicles each time should develop enough of a curve so you can have a pretty good idea.

Mr. AMES. Yes; on Project Fire we have only two experiments planned, one of which should go later this year.

If successful, we would seriously consider calling off the second experiment unless there were some measurements we had not obtained that we should obtain. We could then devote the launch vehicle to another program.

Mr. KARTH. This is to accumulate data on reentry at the lunar speed?

Mr. AMES. Let me show you a slide that will answer this (fig. 254).

This is a slide I used last year. With high velocities we have this radiating hot gas cap around the nose of a reentry spacecraft. It radiates heat back to the vehicle.

I have shown horizontally here the total speed in miles per hour; and vertically the heat load to the vehicle. Here is "satellite" speed

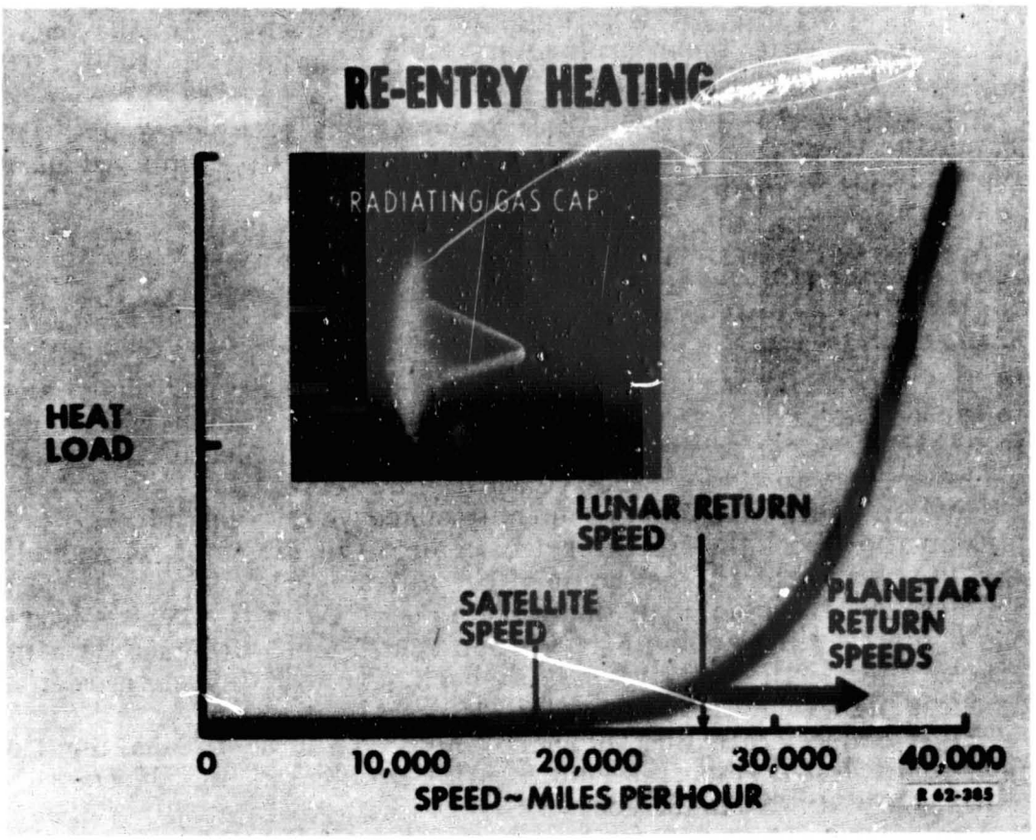


FIGURE 254

where the heat load has not risen much. Here is the lunar return speed and you see the heat load is beginning to rise, in fact, three orders of magnitude over "satellite" speed.

As we go to "planetary return" speed, we don't know exactly how high the heat load is. Our experience with Project Mercury goes up to this velocity. The Scout experiments go up here, about 15 percent higher. Apollo would take us here—Project Fire would be slightly above the point for Appollo. We have requested in our budget this year money for "advanced fire" to take us up into the knee of this curve, in this region of interplanetary flight.

Then we will have a much better feeling for, and understanding of, the nature of the heat environment we must contend with at these very high speeds.

Mr. DOWNING. Mr. Chairman.

Mr. KARTH. Mr. Downing?

Mr. DOWNING. Doctor, why is it the planetary return speed is of such magnitude?

Mr. AMES. Partially because of the very, very high velocities for escape from the Earth's gravity. As a vehicle comes back into the atmosphere, we have this high velocity situation in contrast to Project Mercury.

Project Mercury enters the atmosphere around 17,000 miles per hour. Our planetary vehicle is going to enter the atmosphere on the order of 30,000 miles per hour.

Mr. DOWNING. That is my question. I don't understand "why."

Mr. AMES. Well, we have two factors in the heat load here, sir. One is as the air flows over the body we have what we call viscous shear. This is where the skin friction is causing local heating of the body.

Mr. KARTH. I think, Mr. Ames, the question is why does an object coming back from a planet return at 30,000 miles per hour when an orbiting vehicle returns to the atmosphere at 17,000.

That is the question.

Mr. DOWNING. It's not because of the pull of gravity?

Mr. AMES. Gravity would certainly have an influence on it.

Mr. DOWNING. It would have an influence.

Mr. AMES. As we launch a vehicle out toward the Moon, we have to have a velocity which would give us enough energy for this vehicle to exceed the pull of gravity. We have to achieve velocities of 33,000 to 35,000 feet per second, and to escape the influence of the Earth, we have to go to these higher velocities for escape.

Now, in addition, as we get out into space we may have to add propulsion to correct the trajectory, to change the course of the vehicle, and to shorten the time of some of the missions.

There is a time factor in the mission also. After the vehicle leaves the planet it will be going at very high speed, and will be accelerating also as the Earth's gravity pulls it back. It will, therefore, reenter at these high velocities indicated.

We can decelerate the vehicle by aerodynamics—by making this nose blunt, but this increases our heating problem at high speeds.

Mr. DOWNING. Thank you.

Mr. KARTH. Only up to a certain point, isn't it true?

After you reach a certain point in the curve of the blunt end, actually it causes a decreased amount of speed.

Mr. AMES. This gas cap gets so hot at high velocities we cannot cope with it. At lower velocities we have adequate knowledge to cope with it.

At the lower speed, it is true that the whole purpose of the blunt shape is to cause what we call a "discontinuity" or "bow shock" in front of the vehicle, so that the heat generated by the bow shock radiates back to the atmosphere rather than to the vehicle. In the lower velocities, such as orbital velocities up to Apollo speeds, a blunt shape is most attractive because the shock wave in front is where most of the energy is expended and the heat energy doesn't get to the vehicle.

On the other hand, when we come back from interplanetary missions, at the return speeds of interplanetary flight we may want to go to a vehicle which is more pointed so that initially it will not form this very hot gas cap. Eventually the configuration may change by burning the point off and become blunt as we get to lower velocities.

I discussed our meteoroid flight program with you rather completely yesterday, and covered the results of Explorer XVI which was launched last December. We have two more S–55 spacecraft, the S–55c and the S–55d. The S–55c will continue the experiments of the type I described to the subcommittee previously, plus an evaluation of a new type of meteoroid detector—a type of detector that once it has been penetrated, would be capable of recharging itself and accepting further penetrations.

If you recall, I showed you a little pressure vessel yesterday, a pressurized can, which when penetrated the gas leaked out and it is no longer useful to us for meteoroid detection.

We are trying to develop an improved detector and I believe this was on one of Dr. Bisplinghoff's charts in his earlier remarks.

Then we have the final vehicle in the S–55 series, the S–55d, which will also get an Explorer "number" once it achieves a successful orbit.

We will use the new detector on this vehicle. This type of meteoroid detector will go also on the large Saturn-launched meteoroid satellite of which I showed you a model yesterday.

I mentioned also our meteoroid paraglider experiments. I won't belabor that any more.

I would like to comment briefly, though, about our meteoroid observations from the ground. I described to you our program, using the equipment developed by Dr. Whipple, to observe meteoroids by radio techniques, and by optical techniques. Certain assumptions have to be made in these experiments as to the kinds of meteoroids he observes and to their luminous efficiency, for example.

Now, in order to assist in getting a better correlation, we have an artificial meteor program which is being conducted at Wallops Island as a part of the Trailblazer program. Here a pellet which simulates a meteor will be fired downward from a vehicle.

The vehicle will be launched upward and we will fire a pellet downward at two velocities; one at 40,000 feet per second, and we hope ultimately one at 75,000 feet per second, and Dr. Whipple will use his equipment to observe the luminous efficiency of the particles.

These will be known particles of known mass and known material so we can then take this information and use it for correlation with the data he has obtained in the past and which he is continuing to obtain for us.

In the small vehicle flight experiments, one of our experiments is on cryongenic fluids at zero "g." Here we are investigating the heat transfer mechanisms, stratification effects, and venting characteristics which are problems characteristic of tanks containing liquid hydrogen under weightless conditions.

We have conducted several zero "g" experiments riding piggyback on Air Force Atlas vehicles.

We funded the payload.

In these experiments we got about 20 minutes of zero "g."

We also obtain 5 minutes of zero "g" in flight experiments using Aerobee vehicles launched at Wallops Island.

Mr. KARTH. Can you tell us how you intend to fire back toward Earth, a projectile thirty or forty thousand feet per second?

Mr. AMES. Yes, sir. We have already achieved 33,000 feet per second.

We have a six- or seven-stage vehicle depending on the mission—seven rocket stages, which ignite one after the other.

The first three stages launch the vehicle upward and then the vehicle will separate; then the other three or four stages, depending on the mission, will fire downward.

First we fire out into space and then we fire downward and accelerate the particles.

Mr. KARTH. You are talking about firing toward Earth, two or three stages of the vehicle itself?

Mr. AMES. That is right. This is done at Wallops Island. We fire offshore and our launch vehicle goes up several hundred miles, and then comes down between the coast and Bermuda. We have

done this a number of times, but our objective of 75,000 feet per second will not come easily.

In that case, we may have to use a shaped charge to accelerate our material mass.

For 40,000 feet per second, perhaps, we can use a kind of rifle on the end of the last stage to add velocity.

The remaining experiments in the OART flight program are mostly in Dr. Kelley's technical area but are managed in my office, to provide central management of OART-conducted flight programs.

This brings my remarks to a conclusion. I'd like to sum it up very briefly with your permission, sir.

My objective has been to give you a clearer picture of the activities and, I hope, the progress achieved in the space vehicle systems advanced research and technology program. These activities are very broad in scope, and range from conceptual studies of advanced vehicle systems for future missions to the identification and solution of critical technical problems bearing both on present generation as well as future space vehicles.

I hope that I have made it clear to the subcommittee that our programs involve not only basic research, but also applied research and technology, as indicated by the name of our organization, Office of Advanced Research and Technology.

There are many problems urgently in need of solution, if our country is to achieve the space flight capability which I believe is required.

In addition, I want to emphasize that the nature and extent of advanced research and technology activities today play, as you have also indicated, a most important part in establishing our space flight capability in the next decades.

The continuing objective of our programs is to provide the timely and sound technological foundation which is essential to our country's mastery of space. Thank you.

Mr. KARTH. Thank you very much, Mr. Ames.

Are there any further questions?

If not, Dr. Bisplinghoff, we are prepared to begin with Dr. Konecci.

Dr. BISPLINGHOFF. He is here, prepared to start.

Mr. KARTH. Dr. Konecci, we would like to have you proceed in much the same fashion as several of the last witnesses have proceeded.

I have your prepared statement. I think it would be more advantageous for the committee to hear a summation of it, together with whatever visual aids you might like to use to provide a better understanding.

STATEMENT OF DR. EUGENE B. KONECCI, DIRECTOR, BIOTECHNOLOGY AND HUMAN RESEARCH, OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Dr. KONECCI. Thank you very much, Mr. Chairman. [Reading:]

I would like to outline the "human factors systems" program of the recently formed Office of Biotechnology and Human Research. This program is designed not only to do human research and development of adequate life support and protective systems for man's survival in the aerospace environment, but to adequately determine man-machine relationships, and integrate them properly into the advanced aerospace systems. Our success and progress in the next 10 to 20 years depends upon the biotechnology and human research we do today. A

systems parametric analysis was performed to determine the organization and program required to fulfill the mission of biotechnology and human research, as laid down by Dr. Robert Seamans on June 27, 1962 (see fig. 261, p. 2417).

ORGANIZATION

Biotechnology and human research, as you know, is one of three life science organizations within NASA.

The NASA programs are summarized as follows:

Office of Space Sciences (OSS) is principally responsible for the scientific investigation of space and planetary environments.

Office of Manned Space Flight (OMSF) is principally concerned with the operation of approved manned space flight projects.

Office of Advanced Research and Technology (OART) is principally responsible for manned and unmanned advanced research and technology for aerospace systems.

It should be recognized that there are interfaces between these various offices. Basic research in biology, conducted by biosciences (OSS) in the space environment can be utilized by biotechnology and human research (OART) as a basis for applied animal and manned research, which will answer specific design problems for the "human factors systems" programs. In turn, biotechnology and human research activities will establish human design requirements and a technological base with proof of concepts and working models of such things as advanced life support systems, bioinstrumentation, and protective devices, which can be utilized in future manned aerospace systems.

Aerospace medicine (OMSF) will, in turn, utilize the human data equipment and subsystems obtained from this research and advanced technology and apply it to the development of the future approved operational manned space systems.

SYSTEM ANALYSIS

The Office of Biotechnology is an interdisciplinary organization composed of biomedical, biophysical, nuclear, and design engineering personnel. We are systems oriented in order to accomplish the planned NASA goals of providing the required technology planned (a broad technological and research base) for manned aerospace systems. Consequently we have looked at the possible future missions that NASA will be expected to perform. As seen in figure 270 (p. 2427), this entails a detailed look at the various systems complexes involved in the missions, then the specific systems within the complexes. In reality, our program is involved with all three aspects—man, or human research; machine, or biotechnology; and vehicle, or man-system integration, in the following manner:

Man.—We do specific human research regarding man's body systems as seen on figure 270 (p. 2427) at level D to level E, however, when necessary, to answer a specific problem, we go down into the F or G levels to do research. This means that we may actually look at a specific organ or chemical and study relationships under specific environments, functions, configurations, and materials.

Machine.—We call this area biotechnology. This involves life support systems, protective systems, and man-machine control. Here, too, you can see that we must, at times, depending upon the particular problem area, go down into the machine subsystems, for example, in the life support subsystem, and, in fact, into detailed components. If we talk about a specific subsystem like a life support superoxide system, then we are dealing with the detailed G level, or chemicals.

Vehicle.—On the vehicle side, the vehicle can be considered as an overall container. In reality, the vehicle could come under the machine, however, it is considered separately for ease of description. In our program we consider the vehicle as being man-system integration. As you can see in figure 2, levels A through G, we are each concerned with the parameters of environment, function, configuration, and material. In other words, every one of the levels has these as common denominators, in order to adequately describe the total man, machine, and vehicle.

We will now examine the biotechnology and human research program which evolved from a detailed examination by systems analysis as related to the possible NASA future missions (fig. 267, p. 2424). This is an example of our program, which is at the D level. The analysis of the missions, system complexes, and systems brings us to the D level. Figure 273 (p. 2429) is a more detailed breakdown of our program. The horizontal parameters of environment, the requirements, the bioengineering, simulation, test and evaluation, and advanced concepts are involved in all of the three program elements.

If we take man or human research, we study man's body systems in relation to the total environment. For example, we must study the total spectrum of radiation and its effect on body systems, not just cosmic radiation. This, in turn, imposes certain design requirements on equipment that is needed to do human research. These requirements are translated into specialized biosensors, which are then utilized back in a specific environment to obtain data. That data is then transferred to a specific situation where you can put it under a simulation test. The next step is to evaluate the equipment, and, if need be, you may have to go to advanced concepts to try to solve the problem, since it is possible we do not have equipment or data that is required to answer these questions. The same is true of the psychophysiology, which is really the mental and physical aspects of man. The method of analysis is the same as for body systems.

Once we do get physiological and mental limits to establish the design requirements for man's equipment and habitability, we then impose them on the next area, which we call man-machine or biotechnology. Here you can see that we have life support systems, protective systems, and man-machine control. We go through environment, design requirements, etc., as we did for man-body systems.

After considering the parameters from environment through advanced systems, we establish design requirements for the equipment. Finally, we take this equipment and also the requirements of man, and translate them into the next area, man-system integration. We actually, again, look at the overall system that is involved with the environment, the various systems requirements, and so on. Finally, the proof is when we put all of these together to test them, and demonstrate a workable system. In most instances research will not be accomplished at the D level since this is not basic enough to provide adequate data for establishing design requirements. Therefore we must go from this D level into the E level.

Figure 268 (p. 2425) is a description of the E level and specifically shows the matrix on human research with environment versus basic body systems. As you can see, the body systems are composed of the integrated total body, including the cardiovascular system, and digestive system, etc. These are plotted in relationship to the environment. We have shown only a few selected examples of the environment, which are acceleration, atmosphere, radiation, and thermal. Let us take an example of the cardiovascular system in relation to just acceleration, one aspect of the environment which we may define as a task area requiring research (fig. 269, p. 2426). We then may have to go to the F level to obtain more specific data and here the cardiovascular system breaks down into many subbreakdowns of which a few are mentioned here, the heart, the coronary arteries, etc. Meanwhile, acceleration breaks down into a number of subparameters, i.e., here we mention only zero-G, subgravity, linear gravity (plus and minus), vibration, and noise.

Now all of these factors, when added together, make up a tremendous total number of tasks and interactions that must be looked at if we are to evaluate those variables that effect man. When this is done (fig. 271, p. 2427), we find that we have something like 12,500 task areas. An example of a task area, i.e., E level, would be the total nervous system versus radiation spectrum. This radiation spectrum would include cosmic rays, ultraviolet, infrared, all the way through to radiowaves. When you take the matrix, and count the numbers of specific tasks, i.e., F level, you now have something on the order of 187,500 tasks to be performed. An example of a task is the effects of solar flare protons on the peripheral nerves. This effort is prohibitively large, therefore, it becomes necessary to categorize these various tasks in terms of priorities (fig. 255).

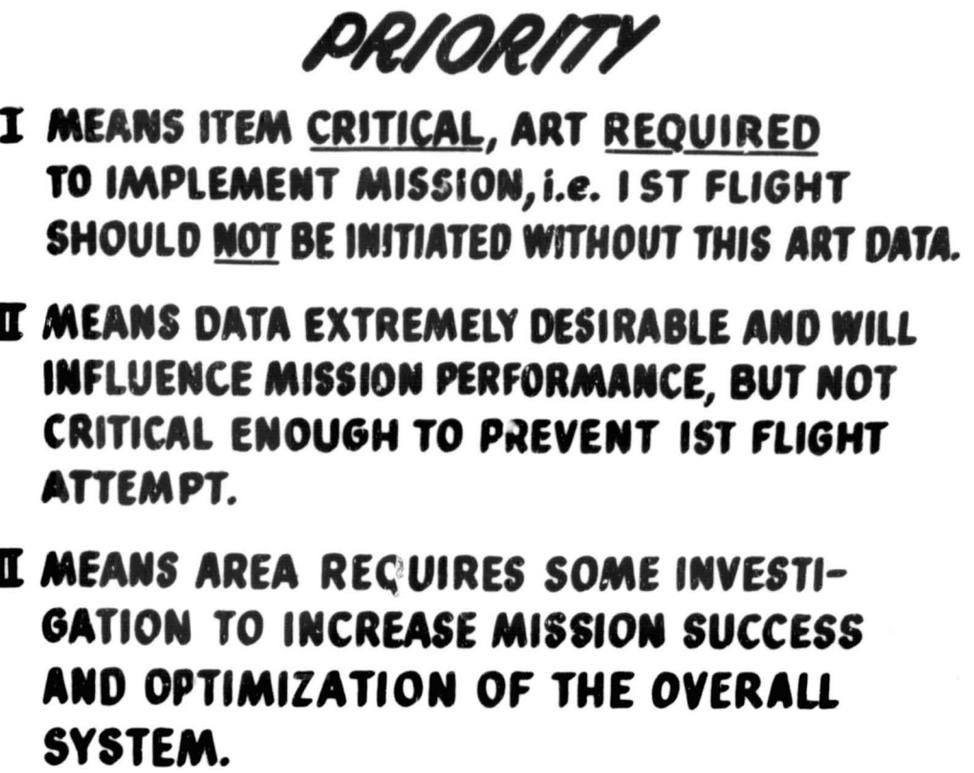


FIGURE 255

PRIORITY ANALYSIS

Priorities may be broken down in many ways, and for our purposes here, we will only list priorities as shown in figure 255.

Priority I means this item is critical, that the advanced research and technology is required to implement the mission, and the first flight should not be initiated without the advanced research and technology data.

Priority II means that data is extremely desirable and will certainly influence the mission performance, but is not critical enough to delay the first flight attempt.

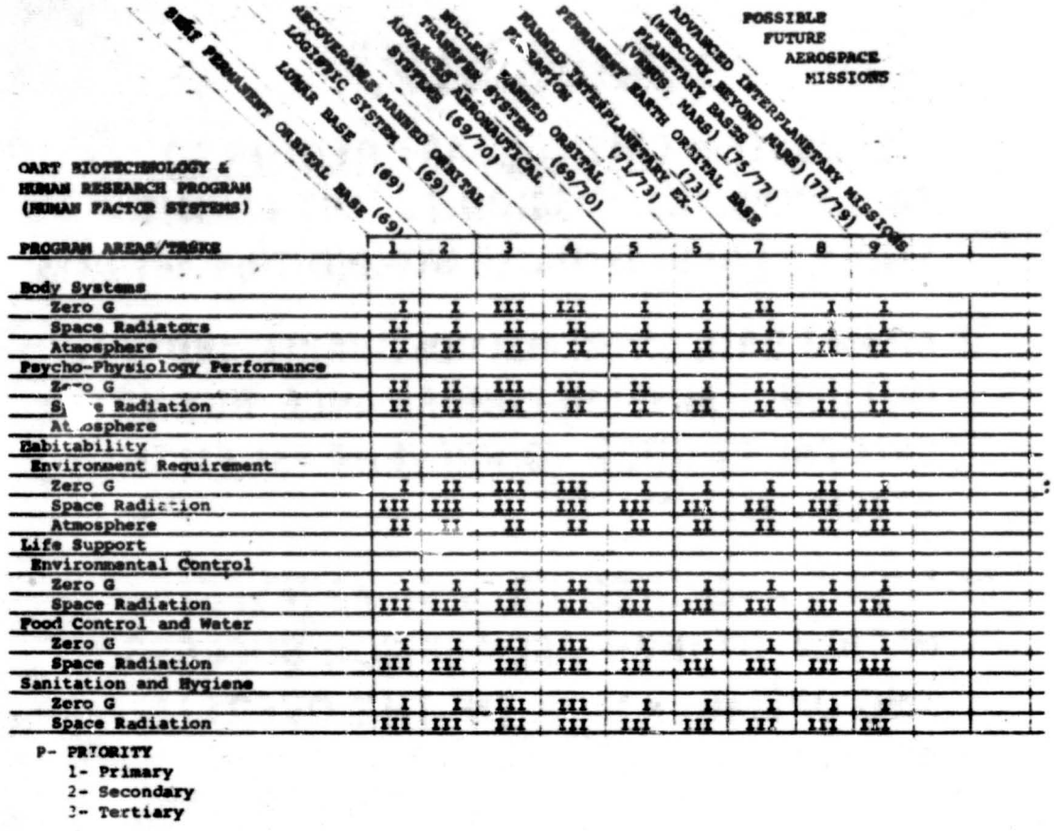
Priority III means it requires some investigation to increase mission success and optimization into the overall system. We will not go down to lower priorities at this time.

The establishment of priorities reduced the magnitude of the effort from an enormous one requiring a prohibitive budget to do something that is more reasonable.

The summarized results can be seen in figures 256 and 257. As an example, the status of knowledge and technology is unknown for such critical areas as prolonged zero g, sub g, radiation and atmosphere in relation to body systems, life support, etc., in most of the aerospace missions. Figure 272 (p. 2428) for purposes of discussion shows a summary of the mission evaluation for only three missions, that of advanced aeronautical systems, lunar base, and manned interplanetary flight. It shows the relation of the body systems for the parameters of zero and subgravity, space radiations, and atmosphere, as well as for life support.

We can see here that future advanced aeronautical systems like the hypersonic transport in the area of zero gravity is a III priority item in view of data obtained from Project Mercury and Soviet animal flights and manned flights. However, we still must study the area to obtain the optimum design requirements for passengers, since passengers may not be able to take transitioning from gravity to zero gravity and back again during hyperbolic flights.

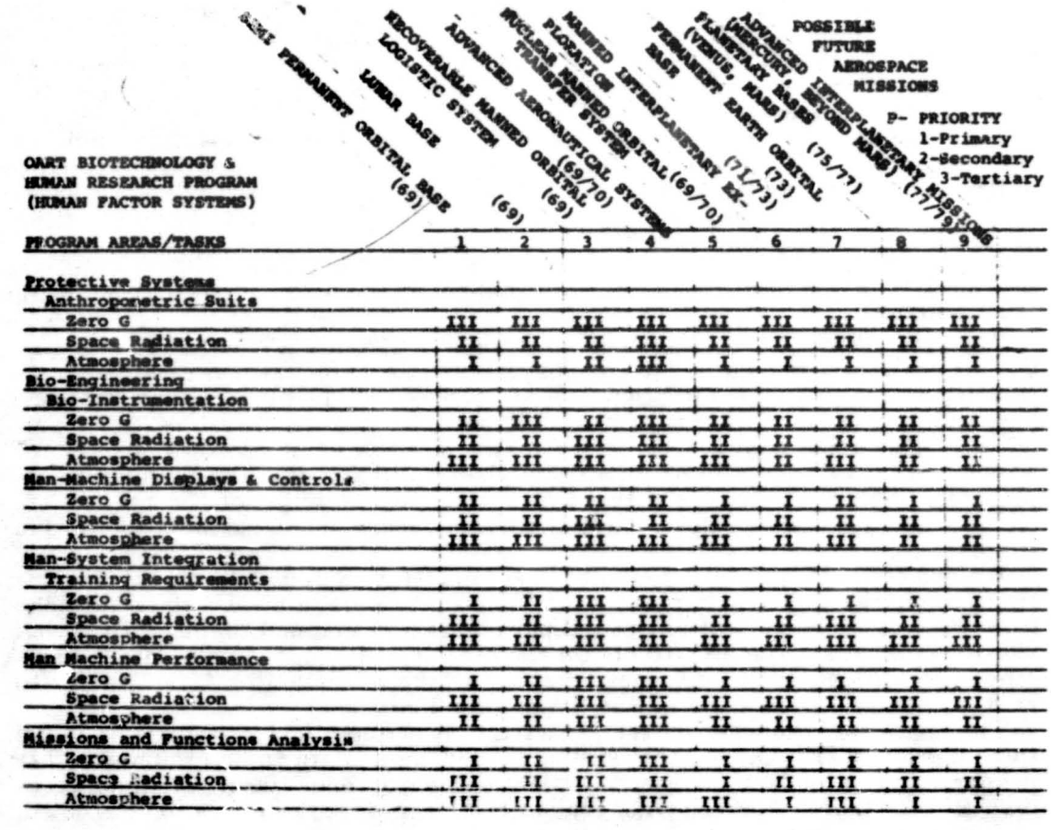
The space radiation parameter for advanced aeronautical systems was found to be a priority II item, since we still have inadequate data to determine whether primary and secondary cosmic radiation will effect man during frequent very high altitude flights over the polar regions. This area will continue to be studied,



OART BIOTECHNOLOGY & HUMAN RESEARCH PROGRAM (HUMAN FACTOR SYSTEMS) / PROGRAM AREAS/TASKS	1	2	3	4	5	5	7	8	9
Body Systems									
Zero G	I	I	III	III	I	I	II	I	I
Space Radiators	II	I	II	II	I	I	I	I	I
Atmosphere	II	II	II	II	II	II	II	II	II
Psycho-Physiology Performance									
Zero G	II	II	III	III	II	I	II	I	I
Space Radiation	II	II	II	II	II	II	II	II	II
Atmosphere									
Habitability									
Environment Requirement									
Zero G	I	II	III	III	I	I	I	II	I
Space Radiation	III	III	III	III	III	III	III	III	III
Atmosphere	II	II	II	II	II	II	II	II	II
Life Support									
Environmental Control									
Zero G	I	I	II	II	II	I	I	I	I
Space Radiation	III	III	III	III	III	III	III	III	III
Food Control and Water									
Zero G	I	I	III	III	I	I	I	I	I
Space Radiation	III	III	III	III	III	III	III	III	III
Sanitation and Hygiene									
Zero G	I	I	III	III	I	I	I	I	I
Space Radiation	III	III	III	III	III	III	III	III	III

P- PRIORITY
1- Primary
2- Secondary
3- Tertiary

FIGURE 256



OART BIOTECHNOLOGY & HUMAN RESEARCH PROGRAM (HUMAN FACTOR SYSTEMS) / PROGRAM AREAS/TASKS	1	2	3	4	5	6	7	8	9
Protective Systems									
Anthroponetric Suits									
Zero G	III	III	III	III	III	III	III	III	III
Space Radiation	II	II	II	III	II	II	II	II	II
Atmosphere	I	I	II	III	I	I	I	I	I
Bio-Engineering									
Bio-Instrumentation									
Zero G	II	III	II	III	II	II	II	II	II
Space Radiation	II	II	III	III	II	II	II	II	II
Atmosphere	III	III	III	III	III	II	III	II	II
Man-Machine Displays & Controls									
Zero G	II	II	II	II	I	I	II	I	I
Space Radiation	II	II	III	II	II	II	II	II	II
Atmosphere	III	III	III	III	III	II	III	II	II
Man-System Integration									
Training Requirements									
Zero G	I	II	III	III	I	I	I	I	I
Space Radiation	III	II	III	III	II	II	III	II	II
Atmosphere	III	III	III	III	III	III	III	III	III
Man Machine Performance									
Zero G	I	II	III	III	I	I	I	I	I
Space Radiation	III	III	III	III	III	III	III	III	III
Atmosphere	II	II	III	III	II	II	II	II	II
Missions and Functions Analysis									
Zero G	I	II	II	III	I	I	I	I	I
Space Radiation	III	II	III	II	I	II	III	II	II
Atmosphere	III	III	III	III	III	I	III	I	I

FIGURE 257

in more detail, to determine whether a completely sealed cabin will be required at high altitude approaching 100,000 feet.

In the case of the lunar base, we see that it is not zero gravity, but subgravity that becomes a priority I. There are some questions as to whether man will be able to coordinate on the lunar surface with just the one-sixth "g," so that experiments must be performed in either simulated or actual gravity situation to resolve this problem area. A recent Soviet study "Motor Activity of Intact Animals Under Conditions of Artificial Gravity," by Yuganov, et al., indicates "that the artificial gravitation that arises at acceleration of 0.28 to 0.3 g may be recognized as the minimal effective acceleration which will be adequate to prevent unfavorable effects on motor reaction of animals." Since one-sixth gravity on the lunar surface is lower than this, muscular coordination may prove to be a major problem. Simulated lunar tests have been conducted on the ground with man being supported by balloons and other devices, such as the Langley Research Center horizontal body support system, which permits walking on a vertical plane. This has proven to be an important area of research. However, it still does not answer the problem of whether man can or cannot accommodate himself to prolonged subgravity. In the cases of space radiations, priority I is listed for lunar base, since we do not have adequate data on free space radiation, let alone background data on radiation on the lunar surface.

The lunar atmosphere is a hard vacuum requiring a sealed cabin for protection of a crew. We are therefore concerned with the meteoroidal penetrations of the sealed cabin or lunar base structure which could result in a decompression.

We are also concerned with the kind of atmosphere that would be involved inside of the lunar base whether it should be equivalent to the air that we breathe on the Earth's surface at the same pressure at 14.7 pounds per square inch, or whether it should be various other mixtures of gases. This area requires a substantial amount of research. In the final example in figure 272 (p. 2428), we have analyzed manned interplanetary flight missions. The zero gravity parameter is a priority I item, since a round trip to Mars as envisioned today would require at least 1 year. At present, NASA plans 14-day missions in Gemini and we are aware of the 4-day man Soviet flight, and the several day weightless experiment of Laika. It is impossible to project such meager data to a long duration interplanetary flight. We can perform man and animal experiments in near-Earth orbit for prolonged periods of time to obtain this critical zero g data without actually completing the Martian flight. This point will be amplified later.

In space radiations, we have a priority I, since we have inadequate information on physical environment, both solar and galactic cosmic radiation, let alone their effects on living systems. Continued ground based and flight research in this area could help reduce this to priority II or III. Utilization of magnetic fields has been suggested as a possible protection against space radiation. However, this opens another research requirement, i.e., the effect of magnetic fields on man. High and low magnetic field studies are now in progress and we hope to have some information on these effects in the near future.

The atmosphere versus the manned interplanetary mission is priority II, and the problem is similar to the lunar base, where exposure time is 1 year or more, whereby they must have the proper protection against meteoroides. The internal atmosphere must be compatible to sustain man for extremely long durations.

At this time, we would be inclined to give man an air equivalent to Earth's surface atmosphere. However, atmospheric requirements are being studied to determine the most desirable atmospheric gas combination to prevent oxygen toxicity and bends in case of accidental decompression. We find zero g and subgravity could affect the performance of life support systems. The systems require the use of gases, the thermochemical and physical properties of multiphase systems are greatly affected by reduced gravity, e.g., the separation of gases from liquids. Biotechnology flight experiments, directed toward the determination of effects of reduced gravity on the transport properties of multiphase systems will define requirements for life support systems and will permit the definite selection of the optimum type. In the cases of space radiations with adequate shielding, there should be no real problem in the operation of the physical-chemical support system. If biological systems are ever utilized for life support, the III priority may change to I priority, if the space radiations cause mutations in the various plant or algae systems.

RESEARCH PRIORITIES

Figures 258 and 259 summarize various priority areas. Although these priority areas are not in the order of their significance, they are all top priority items as identified by the system analysis.

PRIORITY AREAS

1 PSYCHO-PHYSIOLOGY OF PROLONGED EXPOSURE TO ZERO OR SUB-GRAVITY (i.e., PERIODS OF 1 MONTH TO SEVERAL YEARS).

2 EFFECTS ON HUMANS AND DESIGN IMPLICATIONS OF SPACE AND MAN-MADE RADIATIONS.

3 ADVANCE INTEGRATED LIFE SUPPORT SYSTEMS DESIGNED FOR ONE MONTH TO SEVERAL YEARS OF OPERATION.

4 ADVANCED INTRA-AND EXTRA-VEHICULAR PROTECTIVE AND LOCOMOTIVE SYSTEMS FOR FREE SPACE, LUNAR AND PLANETARY SURFACE OPERATIONS.

FIGURE 258

PRIORITY AREAS (Cont.)

5 ADVANCES IN BIOENGINEERING ARE NEEDED IN BIONICS, BIOINSTRUMENTATION (ESPECIALLY BODY SENSORS), MAN-MACHINE INFORMATION HANDLING, DISPLAY AND CONTROLS FOR PSYCHO-PHYSIOLOGICAL MONITORING AND FOR ALL-WEATHER MANNED AEROSPACE FLIGHT.

6 ADVANCED DYNAMIC GROUND AND FLIGHT SIMULATION TECHNIQUES AND THE DEVEOPMENT OF HUMAN AKALOGS.

7 FLIGHT, GROUND SUPPORT AND SPACE RESEARCH PERSONNEL SELECTION AND TRAINING REQUIREMENTS AND ADVANCED TECHNIQUES.

FIGURE 259

1. The psychophysiology of prolonged exposure to zero or subgravity: For periods of 1 month to several years. We are concerned both with the mental and physical aspects of man's performance in a zero or subgravity environment. Although we have singled out zero gravity it should be noted we are also concerned with mental and physical aspects of man's performance under other combined stresses such as noise, vibration, temperature, etc.

The problem of developing simulation techniques for studying long-term weightlessness is a serious one. It is considered that an orbital laboratory facility will be required before we can adequately obtain the necessary data.

In conjunction with zero g studies, we are concerned with disorientation and vestibular sickness which occur during certain aspects of aerospace flight. This human research program is also necessary for establishing design criteria for future rotating space stations.

During fiscal year 1963 studies on these problems were conducted through the Department of Defense at the U.S. Naval School of Aviation Medicine.

This contract will be extended to support studies relative to the mechanisms by which force fields produce disorientation and functional disturbances by their effects upon the semicircular canals and otolith organs of the inner ear. Normal and altered vestibular functions are being studied by experiments with animals as well as studies of man with pathological loss of functions of semicircular canals and otoliths. Studies are being conducted on etiology, incidence, symptomatology, prevention of and therapy of vestibular sickness, ocular illusions and disorientation for force factors operative in space flight. This research also includes a study of parameters directly related to the astronaut program to include semicircular canal and otolith function in zero g flights.

2. The effects on humans and design implications of space and manmade radiations: In looking ahead to future NASA requirements in technology, as anticipated one finds considerable association between man and nuclear systems. This most assuredly gives rise to areas of investigation that are new to spacecraft. Shielding, remote maintenance, and radiation effects become commonplace terminology. In biotechnology and human research we become more involved in problems such as biological effects and permissible exposure levels for astronauts, radiation effects in life support subsystems and sensing of radiation exposure, and the maintainability or repairability of space systems and the integration of required shielding into the manned payload complex.

Although all manned spacecraft will be involved to a considerable extent through the interaction of space radiations with the required environment for man, nuclear radiations will be most influential in influencing the design of spacecraft carrying nuclear sources. Design requirements must be established in the areas of shielding and component placement to assure adequate environmental and maintenance conditions.

In this area, NASA is supporting a portion of research on "Aeromedical problems of atomic energy" conducted by the Aerospace Medical Division of the Air Force Systems Command. This research supports the long-term animal experimentation pertinent to the analysis of the effects of various ionizing radiations on biological tissues and the study of methods of diagnosis and therapy in both acute and chronic radiation exposure problems applicable to a man. This work constitutes a substantial contribution to the total national radio-biology program and is specifically germane to future manned space flight and eventual nuclear-powered space systems.

It has been reliably shown by these studies that the Macaca rhesus monkey usefully approximates the human in its normal anatomy and physiology, test performance capabilities, and response to routine laboratory procedures as well as its acute response to ionizing radiation, thus insuring its being an excellent experimental animal for radiation studies.

The School of Aerospace Medicine has initiated and maintained the largest monkey colony in the United States for evaluating and observing delayed effects on radiation exposure. (Some animals are now 10 years or more postexposure.) Since the long-term effects of radiation exposure are of special importance in the ultimate consideration of optimal exposure criteria, and are obviously difficult to ascertain, these animals are providing an extremely valuable and completely unique source of information that cannot be duplicated elsewhere.

Additional radiation studies especially with high energy sources are being conducted under contract with Atomic Energy Commission. Systematic studies are in progress directed both at the fundamental nature of the biomedical effects of heavy ions as well as determination of constraints that will be of practical importance to future space flights.

Research on low and high magnetic fields on humans as related to radiation shielding may indicate some possible physiological effects such as disrupted biological rhythm and space time perceptions. Magnetic fields studies are being conducted by the Navy and are being extended to Atomic Energy Commission and industrial contractors.

The University of Washington is studying the mechanisms by which a.c. and d.c. fields may be utilized in controlling consciousness; i.e., electronarcosis. These studies will be extended relative to current density distribution in the brain as a function of external electrode placement, d.c. potential gradients in the brain and their modification by superimposed d.c. and a.c. fields, the modulation of brain activity by d.c. fields, and, by multielectrode placement, the localization of brain centers or pathways essential for consciousness, and the effect of superimposed electrical fields upon their activity. Pharmaceutical research, relative to therapeutics and prophylaxis, previously limited to radiation protection, will be expanded during the next year to include remedies for counteracting motion sickness and other environmental stress factors.

3. Advanced life support systems: The Manned Spacecraft Center at Houston has been authorized and funded by this office to study the development of life support systems just beyond Apollo, i.e., to 30 days. This was done to make a close tie between the Office of Manned Space Flight and Advanced Research and Technology, so that advanced support and protective systems could be developed concurrently for future approved operational manned projects. This office has recently completed negotiations with the Boeing Co. for a completely integrated 5-man, 30-to-60-day life support system. It includes atmospheric control (super oxide), water, food, and waste management to be demonstrated about June 1963. As part of our program Langley Research Center recently requested proposals from a number of industrial firms for the design, fabrication, and test of a prototype 6-month life support system for four men. In-house studies in progress will determine the design requirements for a 1-year life support system. This advanced system will be contracted in fiscal year 1964. Biological life support concepts have been critically reviewed and a systematic approach by NASA in collaboration with other interested Government agencies will continue. As an example, Ames Research Center is monitoring a contract on a closed ecological system, with a photosynthetic gas exchanger at the University of Minnesota. Biofuel cells (generation of electrochemical power) are being investigated in conjunction with the Office of Propulsion and Power Generation (OAST). Biofuel cells as an adjunct to the life support system, show more promise in the very real and complex problem of fecal and urine waste management. A General Electric contract has been initiated in this area. This major area of life support will continue to receive emphasis for the next several years.

4. Advanced intra- and extra-vehicular protection and locomotive systems for free space, lunar and planetary surface operations: This area involves the establishment of requirements and designs of protective devices which will permit the most efficient utilization of man's capabilities in extraterrestrial environments. The problem of utilising man as an individual in extraterrestrial space is being attacked on a broad front. The Cyborg study being conducted for NASA by the United Aircraft Corp. is studying methods for both the augmentation of man's physiology and for adapting man to extraterrestrial environments. The Bell Aerosystems Corp. is studying mechanical locomotion methods for propelling man and anthropometric and nonanthropometric protective enclosures for maintaining him in a required environment.

5. Advances in bioengineering are needed in bionics, bioinstrumentation, especially body sensors, man-machine information monitoring, and for all weather manned aerospace flight. This is an extremely vital area, since much of the human research depends on the bioinstrumentation that is available. We must increase the state of the art to obtain better sensors, thereby obtaining the more precise information required for the design of our systems. In this area, we have several contracts for specialized bioinstrumentation. As an example (1) United Aircraft is working on bioinstrumentation and the Cyborg study which is research on the equipment for extension of man sensors; (2) Amelco is working on a micro-TV-eye camera to be utilized in human research, especially for the monitoring of performance and body organs during space flight.

Studies are planned with the FAA, to obtain human design requirements for displays and controls for all weather manned aeroflight. A development psychological-physiological monitoring system will be put on competitive bid through our Edwards Flight Research Center in the near future. As a result of this and other work in the bioengineering area, we anticipate that we will have better instrumentation.

6. Advanced dynamic ground and flight simulation and development of human analogs: In conjunction with the bioengineering area, we have been studying the biomedical monitoring of advanced equipment, not only in simulators, but also in the R–4D and X–14 aircraft at Ames, as well as the F100C, and utilizing these advanced systems for a backup in collecting dynamic data in existing aerospace flight projects.

In the simulation area, we have several programs initiated in 1963 which will be continued in fiscal year 1964, aimed principally at improving safety in aircraft. This effort can, and will be, extended to space vehicles. One such program conducted at Ames Research Center is aimed at increasing the pilot's capability in effecting recovery from unusual attitudes and transition from VFR to IFR flight. An additional group of continuing studies are aimed at understanding the role and tasks of the pilot in planetary missions. One such task involves piloted simulations and flight test to determine the proper functions of the human operator in a planetary landing system. Another Ames study is being made, using simulation techniques to determine the role of the pilot in the rendezvous of spacecraft.

A study is underway at the University of Maryland to determine the capability for highly organized task requirements on the performance of humans for extended periods of time. An ex-military officer has been in confinement continually since November 17, 1962. As of March 1, he has completed 15 weeks in a three-room enclosure. He has limited communication with the outside world, but must gain his daily satisfactions from the internal environment.

A series of tasks, ranging from sleep through physical and complex mental exercises are performed as part of the daily routine, in a fixed sequence, but at his own rate of speed and time at each task. Psychological and physiological tests of his performance and physiological well-being are measured.

Information derived from this unique study will provide currently unknown answers to many of the questions concerning the psychological and physiological capabilities of humans to withstand the stresses of long-term flights in space and extraterrestrial journeys.

No time limit has been placed on the period of isolation. The subject can terminate at any time he wishes. However, his morale and motivation are currently very high, so no completion date has been set as of this time.

We are presently studying the human design requirements for an early manned orbital research laboratory.

Integrated aerospace cabin research, using human subjects, advanced life support systems, protective devices, etc., are presently under study to utilize 10 million-cubic-foot and larger balloons as platforms for 30-day flights. The balloon system promises to give us a relatively inexpensive space equivalent platform, where we can obtain data on most of the space environment, except for the weightlessness and the hard vacuum. Flights of this type can be made relatively safely and yet impose psychological stress on the human subjects which cannot be duplicated on the ground.

The majority of these priority areas mentioned above can be studied on the ground and will, in fact, be accomplished that way. There are very specific items such as the prolonged weightlessness, effects of cosmic radiation, the psychological-physiological effects of removing a man from the safe environment on the Earth that cannot, in fact, be measured in a simulator. These then, require flight experiments which will be performed in conjunction with the Office of Manned Space Flight, the Office of Space Sciences within NASA, and with other Government agencies, such as the Air Force and the Navy. As an example, the balloon program mentioned above will be conducted with the Navy. This point will be especially amplified later under flight programs.

7. Flight ground support and space research personnel selection and training requirements and advanced techniques. One of the major areas of concern is research to obtain the requirements for better personnel selection, not only for astronauts and pilots but for research personnel that will perform experiments in aircraft, in space and on various planetary bodies, like the lunar surface. It must be pointed out scientific and engineering personnel will, in all probability, be required for future space missions. The advanced systems which will require personnel of this type must be so designed so these personnel can be safely transported to either the lunar surface or into the space laboratory to perform their research or other designated tasks.

One such study is the "in-flight maintainability study" recently formulated by a NASA and Department of Defense working group to provide information on the performance capabilities of man in space. This program involves testing of subject capabilities to perform taks when in space suits. This research will

be ready for competitive bids in the near future. The project will be monitored through the Marshall Space Flight Center.

The work by the Naval School of Aviation Medicine being conducted for NASA is orientated toward obtaining criteria on disorientation and mental and physical adaptation, for selection and training of astronauts and aerospace crews. This work was mentioned earlier under the psychological-physiological priority area.

RESEARCH CENTERS

The Ames Research Center is the prime research center for human research Other centers are being utilized to undertake specific portions of the program where unique capability exists (fig. 260).

BIOTECHNOLOGY AND HUMAN RESEARCH PROGRAM

		ARC	LANGLEY	FRC	MSC	MARSHALL	LEWIS	DOD
HUMAN RESEARCH	ENVIRONMENTAL PHYSIOLOGY	✓		✓				✓
				✓				
	PSYCHOPHYSIOLOGY	✓						✓
LIFE SUPPORT	ENVIRONMENTAL CONTROL	✓	✓		✓			✓
PROTECTIVE SYSTEMS	SAFETY	✓	✓		✓		✓	✓
MAN-MACHINE	DISPLAYS & CONTROLS	✓		✓				✓
MAN-SYSTEM INTEGRATION	SYSTEMS ANALYSIS	✓						
		✓	✓	✓		✓		
	HUMAN FACTORS							

FIGURE 260

As an example, Langley Research Center is responsible for advanced life support systems of the physical chemical types. Flight Research Center is performing psychophysiological monitoring of pilots in the X–15 aircraft. Marshall Space Flight Center is conducting the inflight maintainability research. The Manned Spacecraft Center at Houston has a unique capability in the protective devices, principally for space pressure suits and survival equipment. They also have operational experience with existing life support systems which can be extended to the next generation of manned space vehicles.

The Department of Defense and Atomic Energy Commission play a vital role in this program. At present, we have significant research projects with the Air Force and the Navy. In addition, a series of proposals are presently being evaluated for work in the critical areas mentioned previously, and it is contemplated that we will increase the DOD funding before the end of this fiscal year. We are presently continuing an evaluation of a number of additional DOD proposals.

In addition to the Department of Defense, we have also major contract activity with the Atomic Energy Commission, and are presently considering possible cooperative work with the Army, Federal Aviation Agency, and other Government agencies.

The majority of our program is being conducted by the Ames Research Center at Moffett Field, Calif. Ames is conducting research in human research, biotechnology, and man-system integration on various aerospace systems, figure 273 (p. 2429). Ames is utilizing ground-based simulators and flight vehicles such as the X–14. It should be noted the Life Sciences Laboratory at Ames Research Center is just acquiring key personnel, equipment, and the facilities necessary to do the special medical research required in biotechnology and human research.

FLIGHT AND GROUND SIMULATION

As mentioned previously, the majority of the program in 1964 will be accomplished with ground-based research facilities. It is recognized that certain critical areas like prolonged weightlessness, space radiations, and duplication of psycho-

physiological stresses cannot be simulated on the ground. Thereby, this required priority research will have to be conducted in flight. Various flight projects are presently under study to accomplish the objectives of the biotechnology and human research program.

These are the utilization of existing aircraft systems, such as the X–14 to study man machine control in V/STOL aircraft. Some of this data will apply to the design requirements for lunar and planetary type landers as well as other aerospace systems. The X–15 and future improved vehicles of this class will continue to be utilized for the physiological monitoring of the pilots. It goes without saying that present supersonic aircraft will also play a role in this program. This data is not only for application to the advanced space systems, but is vitally needed in laying down the design requirements for advanced aeronautical systems. Acoustics (noise) will be a severe problem for supersonic and hypersonic transports, not only on the ground but in flight. We are presently studying lunar and planetary dynamic flight simulators, which will have the characteristics required to formulate landing on planetary bodies with the atmospheres such as Venus and Mars. In atmospheric flight simulators we will require the ability of the human pilot to transition from one mode of operation to glider flight without power, and then possibly to V/STOL operation. These tasks impose severe transition requirements, as well as selection and training requirements on future aerospace pilots.

The balloon has its place in the space age in that it can provide a relatively inexpensive manned aerospace platform at altitudes of 100,000 feet and higher for prolonged periods of time, up to 30 days or more. A project presently under study mentioned previously is to be conducted in conjunction with the Navy; and it is planned that this will lead us to a sealed cabin facility which can be utilized for accomplishing human research, and for the checking out of various equipment such as life support systems, protective devices, bioinstrumentation, and biotelemetry. It is presently contemplated that the balloon system can be made to stay within an area of approximately 150 miles by changing altitudes in the night and day cycle. The large balloons are reliable and are a part of the Navy operational project with launching from aircraft carriers. It is also planned that the balloon platform will be utilized in the Arctic area as soon as more precise information is available on the prevailing winds. From present information, it appears that balloons will travel in a circular path in the polar area and stay confined to a relatively small ground area, thereby making it feasible to establish recovery operations after prolonged flights.

The usefulness of the Arctic flights will provide radiobiological data on the effects of cosmic radiations on animals and humans at these high altitudes. Present data obtained in instrumented balloon flights and U.S. satellites in free space does not indicate that background cosmic radiation is a primary hazard. It seems advisable that before we expose large number of the Earth's population via hypersonic transports to the high altitude, that is, 100,000 feet or higher, flights over the poles will have to be conducted to provide accurate research data as to the effects of this low level radiation. In addition, the balloon offers a fairly good simulation for the mental and physical aspects of space flight without the weightlessness and here again, we can obtain extremely useful data for future supersonic or hypersonic transports. Additional studies are required to determine if passengers require windows in high altitude transports. There are some indications that TV presentations is sufficient to give passengers a sense of orientation, as well as remove any claustrophobic effects. The benefits of such studies could simplify the design requirements for supersonic and hypersonic transports, reducing the engineering problems and eventual cost of development.

Bioflights are being studied in conjunction with the Office of Space Sciences. Although the biotechnology and human research program is man oriented, primates and other animals will be utilized as required to obtain data which we can apply to man. It is presently contemplated that some of our research can be performed by astronauts in existing programs, such as Gemini and Apollo.

Although the above-mentioned flights will solve certain aspects of our program, our real requirement is to have a basic research tool to do prolonged zero gravity studies in the actual space environment. Studies on prolonged zero gravity can only be accomplished with a manned orbiting research laboratory. Such a laboratory is presently being studied in conjunction with the Office of Manned Space Flight. The need for this research tool in accomplishing the necessary human research cannot be overemphasized. We have no methods available to us on the ground to simulate the weightless condition simultaneously with all the other space and environmental factors to determine precisely the effects on the man. This information is required not only for his possible survival, but

also on his performance, since man will continue to be a critical part of the future advanced aerospace systems. The manned orbital laboratory will also be utilized for the biotechnology aspects of our program to check out advanced concepts and advanced prototype systems, such as 6-month and 1-year life support systems, extravehicular suits, and locomotion devices, bioinstrumentation, etc. It should be stressed that the manned orbital laboratory as envisioned to answer the requirements of this program is not a major project, such as the manned space station, which would be a multimanned operational base, and which will take several years to establish. The manned orbital laboratory is essentially a large sealed chamber with the necessary life support and other equipment to permit man to conduct research not only on himself, or his colleagues, but to do physical sciences research and check out various equipment during the prolonged weightlessness, in conjunction with the other space environmental factors.

SUMMARY

What I have attempted to do is indicate that, within the Offices of Advanced Research and Technology, we have defined our overall program, and identified critical tasks by systems analysis. To accomplish this program we are attempting to utilize not only NASA centers but the national capabilities such as the DOD laboratories, AEC, other Government agencies, universities, and industry. I have attempted to indicate the methods by which the research program will be accomplished. These methods include emphasis upon ground research where it can be accomplished and lastly, on the flight programs which are required to study the very difficult problems of weightlessness, human performance under multistresses, etc. I would like to emphasize that through the system analyses approach, we have been able to provide ourselves with a management tool for identifying and controlling our biotechnology and human research program.

We are presently refining our method and techniques and are in the process of coordinating this system matrix within and outside NASA. We feel this method not only identifies work being done but, in fact, points out areas of needed research. We are attempting to generalize this system analysis to provide a method for identifying, classifying, and utilizing all human factors system data irrespective of where accomplished, inside or outside of the United States.

The above program was initiated in fiscal year 1963, and it must be emphasized that it is a continuing program, which is being accelerated to accomplish our program objective to get 10 to 20 years ahead of the present aerospace systems.

This morning we shall try to discuss the newest Office of Advanced Research and Technology, Biotechnology and Human Research. As you may be aware, originally in the NASA, there was an Office of Life Sciences. In 1961, when the new reorganization took place in NASA, the Life Sciences Office was split up and put into the new offices where it could do the most good.

I believe you know about aerospace medicine in the Office of Manned Space Flight with Dr. Roadman in charge. The Office of Space Sciences has basic biology with Dr. Reynolds. We have the center part, if you will, in advanced research and technology for the human.

We are man oriented. We must in some instances do animal research in biomedicine. We do animal research to actually apply it toward the human.

I would like to start then with the statement Dr. Seamans made when this Office was formed in June and I came on board as the Director in July of 1962.

I would like to have the first slide (fig. 261) and I will read the statement.

Mr. KARTH. This Office was authorized by the last Congress. Is that correct?

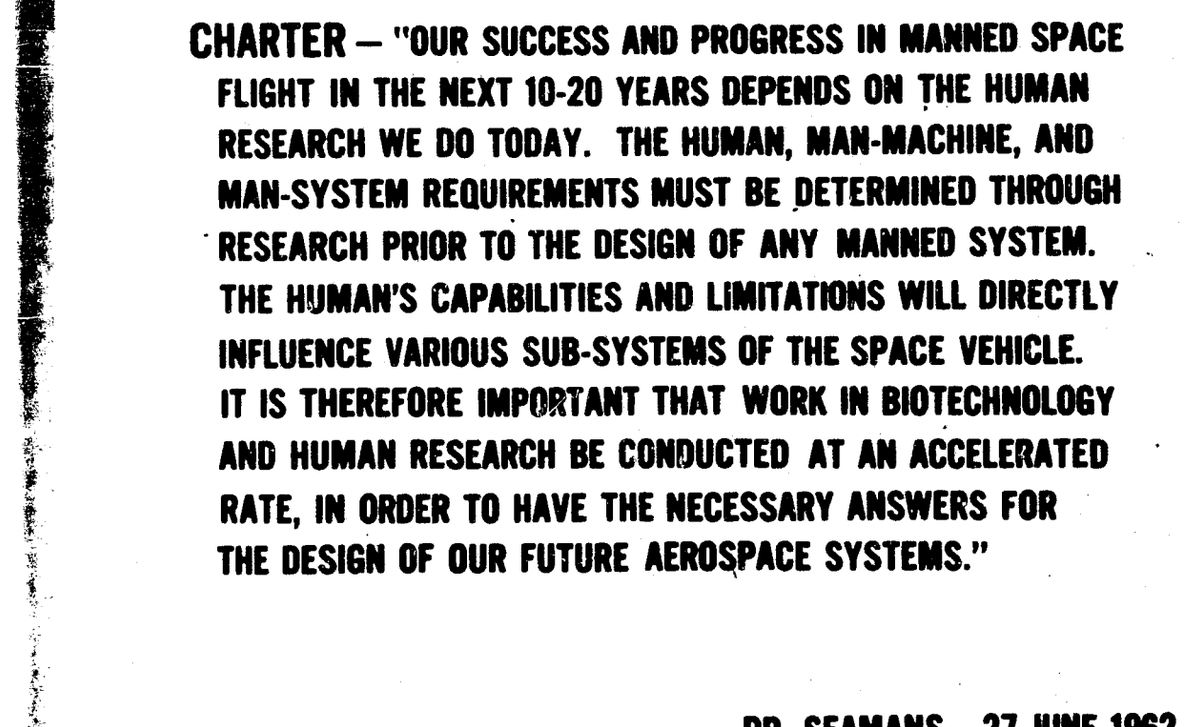


FIGURE 261

Dr. KONECCI. Yes, sir. This is part of the NASA reorganization. (Reading:)

Our success and progress in manned space flight in the next 10 to 20 years depends on the human research we do today. The human, man-machine and man-systems requirements must be determined through research prior to the design of any manned system. The human's capabilities and limitations will directly influence various subsystems of the space vehicle. It is, therefore, important, that work in biotechnology and human research be conducted at an accelerated rate in order to have the necessary answers for the design of our future airspace systems.

What this really says, we must get ahead with the human research several years before Mr. Ames actually starts thinking about doing his designs for advanced vehicles; because, in fact, it is the human requirements that preset what you will do and how you will do it.

In the presentation you will see some slides on life support systems as an example. This is a key item.

If we do not have this information, man will not go into space.

Our model here of the man—actually, we have taken the liberty to try to take and divide man up in an engineering sense. He is composed of various components just like any machine is. We take exception with people that forget they are human and one of the main reasons for doing any of this work is for the human.

They talk about machines versus men. This is erroneous. What we are doing, actually, is taking the man and the machine combined together to give us the best answers.

We, as humans, use machines to give ourselves the answers we need.

When the designer or physical scientist forgets he is a human and separates himself from the experiment and says we are doing this for the physical sciences sake, he has forgotten he is a human.

If I may go to the next slide (fig. 262) and summarize the program objectives by just stating what we really want is a better understanding of man, his capabilities and his capacities.

This simply means we must know more about the human.

In medicine, for years we have studied the pathological side. We haven't really taken cognizance of the fact man has a wide range of capabilities and what we consider normal is really a wide range.

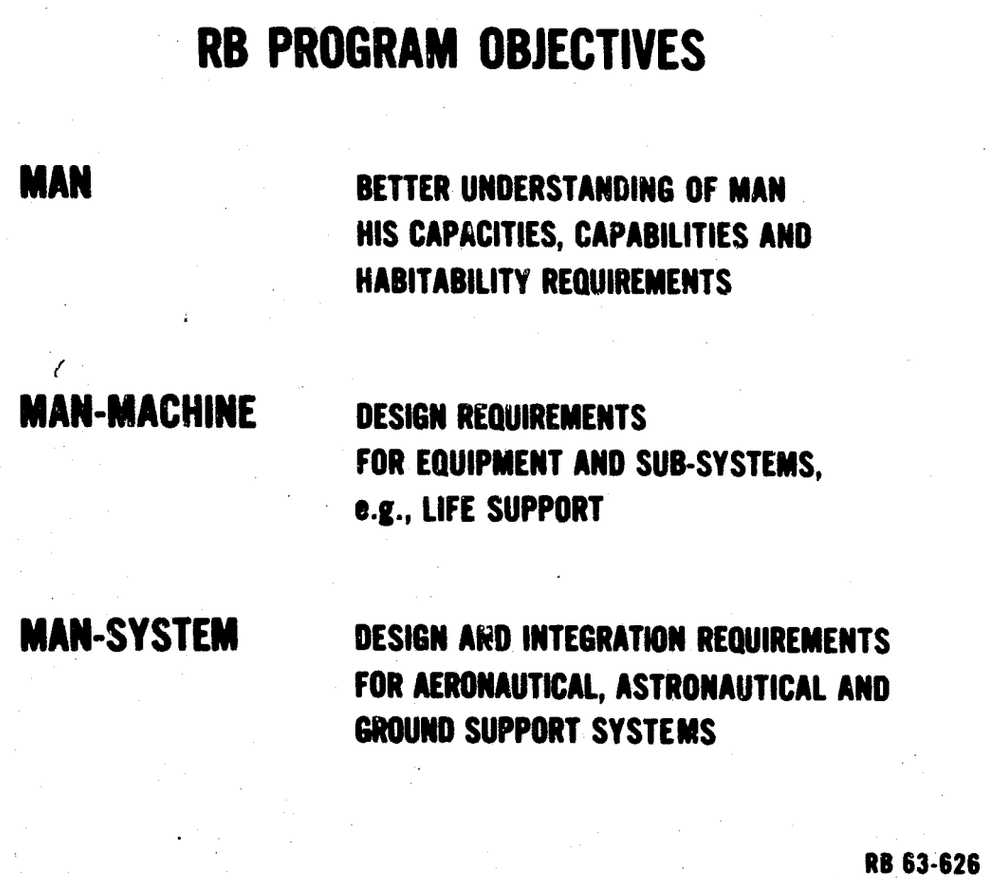


FIGURE 262

In the second area, man machine, we are concerned with the design requirement we must compose in order to obtain the right kind of equipment man will need. Here we give an example of life support.

The next area is man-system integration, and here we are concerned with the man's requirements. We would try to lay them out and, if possible, impose them on a designer.

You heard Mr. Ames say in some cases we cannot impose too high a gravity force on the man when he reenters. This restriction becomes a design requirement.

How did we arrive at this? We arrived at it through research of data on a human.

In this instance we have done work on centrifuges. When we know that a man cannot stand more than several times gravity, this sets a pattern.

If I may be blunt, we have, I think, used entirely too much military aero data with the military having a distinct requirement for their purposes to take man as far as he could go to complete the mission.

Our purpose in the NASA is to develop systems that will then be utilized by everybody. So we must take somewhat the other side and actually look at the normal individual.

It is not always going to be a superhuman astronaut that will fly in space. I think in some cases almost all of us would like to go. I know physical scientists would like to go to the Moon just to mount their telescopes to get better pictures of the planet without the inhibiting atmosphere of the Earth.

So, what we must determine is what is man? What are his best capabilities? How can we use him best in space?

Here I must amplify, we are also concerned with the aeronautics side and, therefore, we get involved with aircraft like supersonic and hypersonic transports. We will try to use the data that does come back from existing flights like Mercury, Apollo, and Gemini and try to use them on the aeronautical side.

Let me give an example. Many years ago when I was with the Inspector General's Office in the Air Force we had quite a few problems in considering the present jet aircraft. We were wondering whether it was ever going to be possible for the normal person in this country to walk up and buy a ticket, without having to take EKG and physical examination, and get on the aircraft. We were concerned with decompression, that is, a window might blow out and passengers would perish.

These things, of course, were unfounded since we found out what our requirements were and laid them down. These requirements then were imposed on the various designers of the various companies.

Today we have had, I don't know the exact number—practically no real decompressions and no fatalities I know of in our commercial airliners. However, during our military aviation we have had many accidental or intentional decompressions of small fighter type airplanes because we were imposing a completely different requirement.

Mr. KARTH. Is not the life sciences research you intend to do, a duplication of what the Air Force now is doing, or can do with the facilities we presently have?

Dr. KONECCI. No, sir; we have taken and have formulated very close coordination with DOD, of which the Air Force is a part.

We are, in fact, as Dr. Bisplinghoff said—already funded this year $1.4 million to get answers for NASA's programs through DOD, of which half of this, roughly, is being performed by the Air Force. Before the end of the fiscal year we will have committed about—roughly, $2 million to the DOD.

We have looked at the DOD capability, sir. We are utilizing them wherever we can and next year we intend to use them even more.

We are talking about the total DOD capability.

Mr. KARTH. This is the argument. Those who feel that it might be duplicative, that is, the research facility you are asking for in this budget.

They say, this is fine. Maybe next year NASA will need to spend $2½ to $4 million getting answers to questions that they have in the life sciences research field, but they do not need to duplicate facilities to get these answers. They can make this payment to the Air Force.

The Air Force maybe would be required to expand their facilities a little bit here and there, but it would be much more economical to do it that way than duplicate facilities.

Dr. KONECCI. Sir, might I state; the facility we are talking about is an actual laboratory to house people, at least, half the people that already exist at Ames.

They are now being housed within buildings that were not meant to be biological laboratories. They do not have the adequate water, gas, vacuum lines—things like this; for the people that are actually doing research on the programs now. This facility then is not the same.

You just don't—if we had an Air Force facility right there at Ames, you could put them in, and use that space, this would be one way of doing it.

However, what we are really talking about is putting the people that are there, to work in a facility, in a laboratory. This is really what is being asked for in the facilities requirement. So, it is not in essence a duplication of a facility.

If we were asking for an equivalent to the Johnsville centrifuge, then we would have done, I think, very detailed studies why we can't use that facility. In fact, we are using the Johnsville centrifuge.

I might state that there was, above my level, detailed coordination on these facilities and the life sciences one was coordinated with DOD, sir.

Mr. KARTH. Let me just say, the reason I bring it up is because there has been considerable speculation in the newspapers, about a report being circulated within the Air Force, a so-called in-house report saying your request in this area is a duplication of existing Air Force facilities and, therefore, should not be allowed.

This is why I ask you the question.

Dr. KONECCI. Yes, sir.

Mr. KARTH. I think if you feel this is not a duplication and can prove it is not, I think you should get the answer in the record.

Dr. KONECCI. In the first place, I think I have read the statement that you are referring to in the New York Times, sir, and I believe Dr. Dryden amply covered that in his questioning. At least, to this article.

The coordination between NASA and DOD was completed; of which the life sciences facilities was one of many that were covered and, in fact, if I may read some words without going into detail.

Upon detailed review of these items it was agreed there was no unwarranted duplication in fiscal year 1964 facility plans—any NASA and DOD; and this life sciences one was one of those, sir.

Mr. KARTH. You know what they refer to when they say "unwarranted duplication?"

Dr. KONECCI. Since we are having—this may be a problem of semantics, sir.

No—I believe they mean——

Mr. KARTH. Means it's duplication but it's warranted? Is that what it means?

Dr. KONECCI. I would not interpret it that way, sir. No.

Mr. RANDALL. Mr. Chairman.

Mr. KARTH. Mr. Randall?

Mr. RANDALL. I was going to suggest we make an effort to determine it and along those lines. I hoped to hear this.

Can't we someway, somehow, within the area of our own subcommittee try to find out first what the Air Force people meant—maybe call some witnesses from the Air Force?

Would that be going beyond the jurisdiction of our committee in the area in which we are inquiring?

Mr. KARTH. I think it would be probably highly irregular to ask one agency of the Government to testify in opposition to another agency's budget request. I'm not sure this has ever been done.

Mr. RANDALL. I would hope it would not be in opposition, but to try to clarify what they meant.

Mr. KARTH. Further than that, I would like to point out, that this is a so-called unofficial document that no one can find or no one will lend credence to, or at least, it's very difficult to locate, if I may say so, or to really find out whether or not the document exists. Some say it does and others say it does not.

Mr. RANDALL. You have just given me a thought. Perhaps our Military Operations Subcommittee of Government Operations might find it out.

That would not involve the legislative committees. Thank you.

Mr. DOWNING. Mr. Chairman.

Mr. KARTH. Mr. Downing?

Mr. DOWNING. If the Air Force is alleging unwarranted duplication and here we are trying to ascertain what is the proper amount and what moneys to give these various agencies in the space program; wouldn't it be proper to call the Air Force up and ask them what is the credibility of this report and if it is duplication?

If they say, "yes" then we'll bring the various heads of the Space Agency back to the counter.

Mr. KARTH. I might say to the gentleman, we are exploring this. Mr. Morris is making inquiry as a member of the committee in line with some action that was taken by the committee last week, I don't remember the specific day. So, we intend to find out whether or not there is such a document and, if so, are the newspaper reports accurate.

We are making every effort we can without violating appropriate legislative practice by calling one agency of the Government before a committee to testify in opposition to another agency's budget request.

Mr. DOWNING. Thank you, sir.

Dr. KONECCI. Sir, may I add, we contacted the Air Force liaison people, General Rittman's people, and we have had communication with Dr. Talbot when this story broke and tried to find out what this document was and had they seen it. They said, "We have not."

Dr. Talbot has been informed of our programs. He attends our meetings and he was aware of this facility request; so I don't know of any document, sir.

Mr. KARTH. Well, I know that the DOD are apparently not aware of this.

I understand, further, that certain officials with the Air Force maintain that there is such a document, but it's an unofficial document and somebody just prepared it, kind of happenstance, and it should not be given credence because of its unofficial content.

But you understand, this committee is responsible for recommending certain budgets to the Congress of the United States and we feel that it's our responsibility to be as accurate as we can.

Dr. KONECCI. Yes, sir.

Mr. KARTH. And that we should avoid unnecessary duplication wherever we can. That is one of the reasons, of course, for our being interested in what we hear via the newspapers, even though it may not be an official report.

Dr. KONECCI. Yes, sir.

Mr. KARTH. I do think it's up to NASA to prove it's not duplication; whether the report is true or not, or whether or not the document is an official document or not.

Dr. KONECCI. Yes, sir.

May I proceed, sir?

Mr. KARTH. Please do, Doctor.

Dr. KONECCI. Can we go with the big slide? We will forget those others (fig. 263).

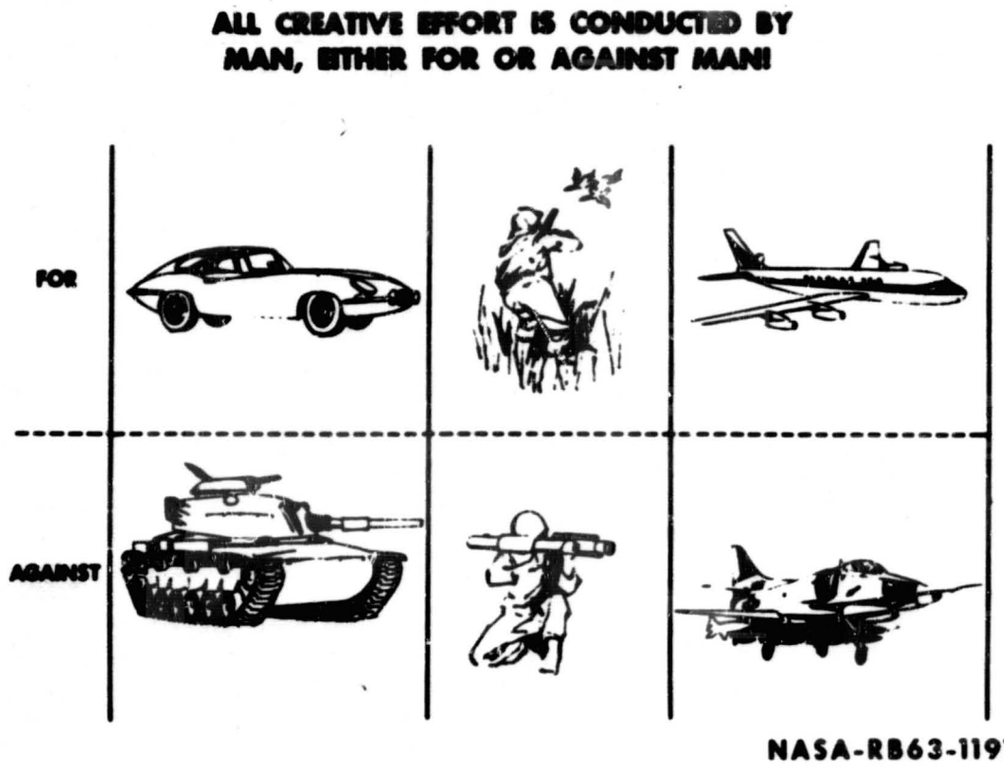


FIGURE 263

In order to set the stage, we would like to point out that everything that's created by man or for man is for or against man and this slide, I think, shows it.

Next slide, please (fig. 264).

We work actually in a framework and even though we are principally concerned with man and his immediate machines and how they fit within the environment of the vehicle, we must also recognize you cannot do basic research on man and his immediate subsystems without actually taking into consideration the overall missions and, in fact, the national objectives of this country.

So we show this as being an overall look.

OFFICE OF ADVANCED RESEARCH & TECHNOLOGY (RB) – 1964

PROGRAM: HUMAN FACTOR SYSTEMS	TOTAL FUNDING HDQS. & CTRS.
06-00 ADVANCED CONCEPTS	(900,000)
06-01 SYSTEM ANALYSES	425,000
06-07 HUMAN ANALOGS	250,000
06-08 BIONICS	225,000
49-00 HUMAN RESEARCH PERFORMANCE	(4,900,000)
49-01 BODY SYSTEMS	650,000
49-02 ENVIRONMENTAL PHYSIOLOGY	2,090,000
49-03 BIOMEDICINE AND PERSONNEL SELECTION	675,000
49-04 PSYCHO-PHYSIOLOGY AND BEHAVIORAL SCIENCES	1,075,000
49-05 HABITABILITY	410,000

NASA-RB63-1198

FIGURE 264

Next slide, please (fig. 265).

Our methodology then is a systems analysis type of methodology. I might mention our people are mixtures of biomedical, engineering, biophysics, nuclear, physicians, and so on.

Here, what we show is a step procedure by which we look at some of the missions and these are broken down into system complexes and so on. We, however, are specifically interested in the specific systems and those can be defined as man, machine, and vehicle, and I will actually take you very quickly now through the step of choosing just man and one of his subsystems and how he breaks down into components.

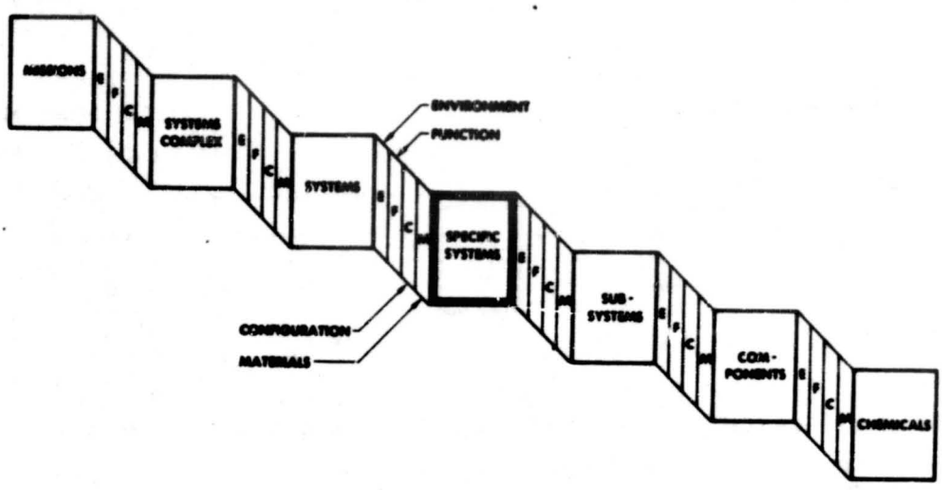
This means we will go from specific systems to subsystems to components and chemicals.

When we learn something in one, we apply it, if we can, to the others (fig. 267).

Here then, is the matrix for the man machine and man system and we find every one of these things is involved with the environment of which we get design requirements and then we go to the bioengineering aspects where we, in fact, get the equipment or research pieces of gear so we can do research on man.

We do the simulation and tests with man. We evaluate it and in many cases we determine there are not sufficient data; there isn't sufficient technology to get our answers. Then we go to advanced concepts.

METHODOLOGY



NASA-RB63-1195

FIGURE 265

D

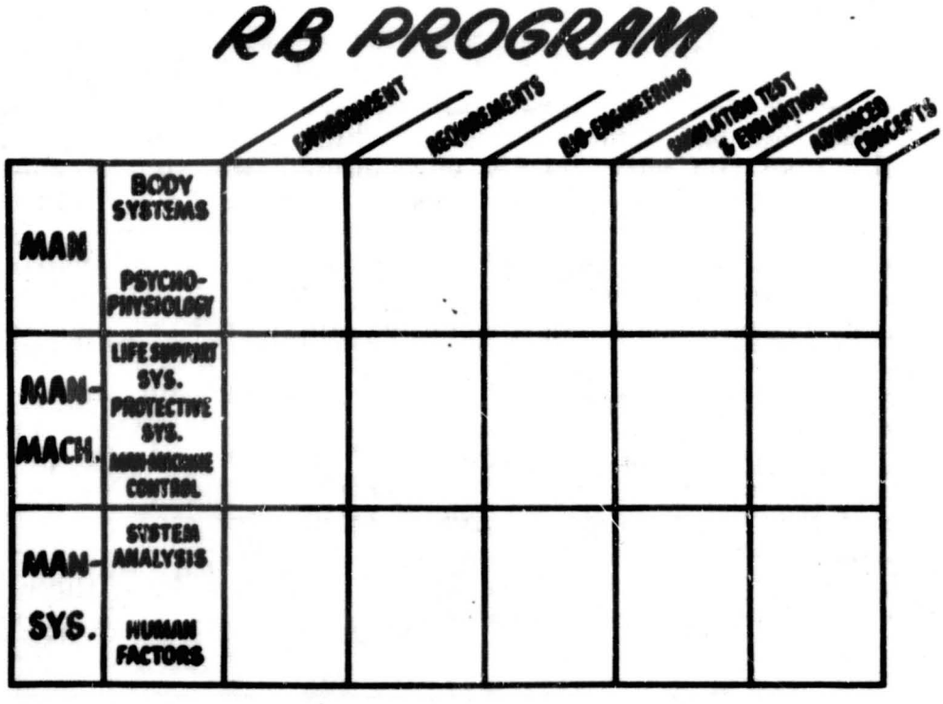


FIGURE 267

In many cases these advanced concepts, like human analogs will assist, actually, the physical sciences.

For example, one nerve cell is now being considered as a computer. It's not a "go no go" algebraic type of thing. It has graded responses.

If we can ever know how it grades from coma on one side to hyperactivity—the physical scientist will have the basic fundamental thinking of the best computers they ever devised (fig. 268).

Let me take you to the "E" level, body systems versus the total environment. We have the integrated body system next, cardiovascular, digestive, excretory, glandular, integurment or skin and so on.

This then shows you we have subsystems within man.

E HUMAN RESEARCH

BODY SYSTEMS \ ENVIRONMENT	ACCELERATION	ATMOSPHERE	RADIATION	THERMAL
INTEGRATED (TOTAL)				
CARDIO-VASCULAR				
DIGESTIVE				
EXCRETORY				
GLANDULAR				
INTEGUMENT (SKIN)				
MUSCULO-SKELETAL				
NERVOUS				
RESPIRATORY				
SENSORY				

FIGURE 268

We have taken one part of the environment alone and this environment breaks down acceleration, atmosphere radiation, thermal and so on up. We have only shown a few. Therefore we must go from this "E" level into the "F" level.

We have here (fig. 269) the integrated total body, including the cardiovascular system versus acceleration. We can see the subsystem of man in this case, the cardiovascular which one breaks into components; heart, coronary artery, peripheral artery, Venous system and so forth.

The acceleration, on the other hand is broken down into a number of subparameters; zero g., subgravity, which becomes very important to us because this is what the lunar surface is—linear g., high g. plus

F

HUMAN RESEARCH

CARDIOVASCULAR SYSTEM / ACCELERATION	ZERO G	SUB G	LINEAR + G	LINEAR − G	VIBRATION	NOISE
HEART						
CORONARY ART.						
PERIPHERAL ART.						
VENOUS SYSTEM						

FIGURE 269

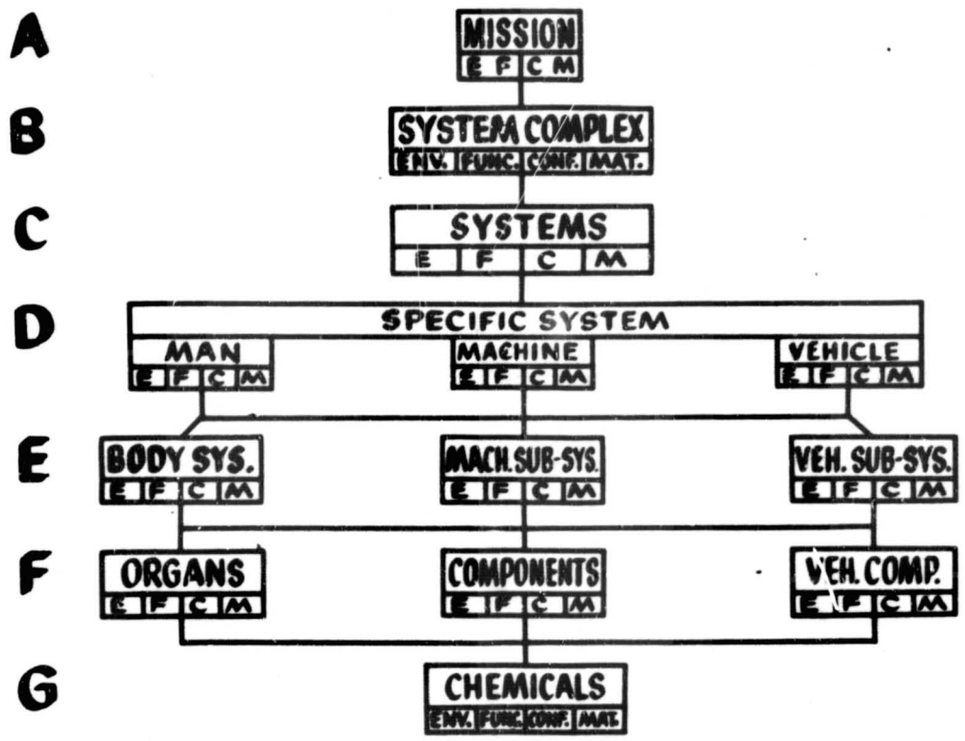
and minus. Here we can go into tumbling and other factors of the vibration and noise which are extremely important.

If the man cannot stand the vibration and the noise then how can you put him into a vehicle, suddenly that has this environment, inherent environment.

Let me take you to the next slide (fig. 270) and when we take these and consider them, just from the "D" level and "F" level and start counting for any one mission and, if you will, on an advanced concept, Mr. Ames mention of the things like the interplanetary flight to Mars—when you start counting the inner section of man, man's equipment and how he inner-acts in the eventual space vehicle, you will come up with the next slide (fig. 271) and you will find there are the levels of the example of the nervous system versus the total radiation spectrum 12,500 task areas that must be looked at. Enormous number.

If you take it one level lower 187,500, approximately, tasks that must be looked at and here we now get a little more specific, the peripheral nerves and the effects of solar flare protons.

We are looking at an enormous amount of research that must be looked at. However, when we take ourselves back to the earlier slide of our framework within the national objectives and so on, we then determine we must set up some priorities.



E=ENVIRONMENT F=FUNCTION C=CONFIGURATION M=MATERIAL

FIGURE 270

MAGNITUDE OF EFFORT

	NUMBER
TASK AREAS EXAMPLE-NERVOUS SYSTEM/ RADIATION SPECTRUM	12,500
TASKS EXAMPLE-PERIPHERAL NERVES/SOLAR FLARE PROTONS	187,500

FIGURE 271

This is what we do. Next slide (fig. 272).

Our priorities, say in the case of Priority I, this is critical.

We must have this knowledge.

II, means it will affect the overall system in its performance, and III means it is not critical, but we still should at least look at it and evaluate it.

Here, for instance, we use some examples of what we meant and did the complete analysis for all these background areas for various future systems and these are not actual NASA missions. We just took examples and we sat down and said in the case of "3" systems, zero gravity of an advanced aeronautical system such as a hypersonical system might fly hyperbolic flight from Los Angeles over the United

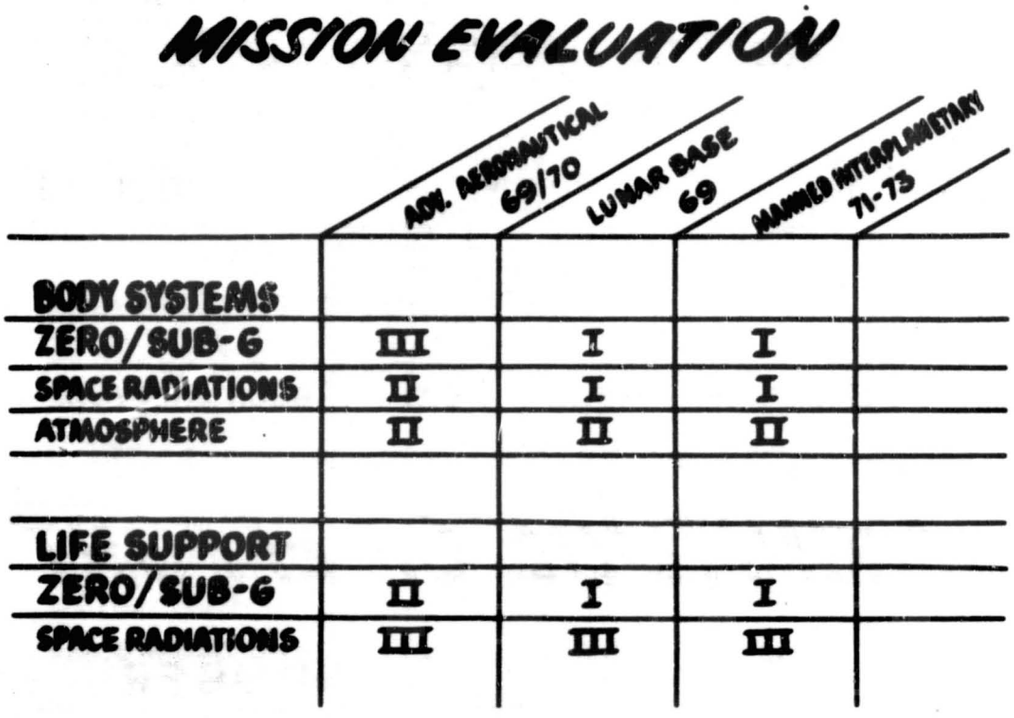


FIGURE 272

States, or to some other section—might be weightless for 30 seconds—30 minutes, pardon me.

We have data from Project Mercury as well as VOSTOK, to know we would not be concerned with that problem in the priority system.

Therefore we have Priority III.

In the case of lunar space, we have Priority I, mainly because Dr. Yuganov, a Soviet member of my bioastronautics committee in the International Astronautic Federation, has done some experimenting in the subgravity field. He has rotated some animals, mice and rats to obtain ⅙–G, equivalent to the lunar surface and found the animals don't coordinate very well, so he has spun them a little faster and determined you must have approximately 0.3–G to have the animals coordinate.

Mr. KARTH. To do what?

Dr. KONECCI. Coordinate properly—to be able to move.

Man is of a higher order and does learn, maybe more rapidly. We have assimulated some experiments on the earth and I'll cover those in a few slides.

Mr. RANDALL. Is there a Russian scientist working with you on your staff?

Dr. KONECCI. No, sir, the Soviet scientist—I am chairman of a bioastronautics committee in the International Astronomic Federation, I.A.F.

Mr. RANDALL. What is his name?

Dr. KONECCI. Yuganov Y-u-g-a-n-o-v.

Mr. RANDALL. Thank you.

Dr. KONECCI. I might take another example in the case of interplanetary flight.

If we fly 1 year plus, depending on whether we get the right kind of power and we are extremely, if you will, propulsion or power conscious—and that's one of the reasons we try to lay down our requirements so the propulsion people will actually be pointing to, say, larger propulsion systems or more efficient ones like the nuclear systems.

Here is zero G then, if a man is to survive for a year or more in a zero gravity field we better know something about the effects on cardiovascular systems which seems to be the main problem.

At least, people are quite concerned about this.

I might point out, maybe the zero gravity problem is not a problem—it's just an unknown area, and a few simple experiments of prolonged nature in near space may help remove that priority I down to priority III which is what we are after.

Life support, I might point out, is also a critical area if we do not give the man the right kind of environment, the oxygen to breathe, the food to eat, the water to drink—and so on—we won't get into these missions (fig. 273).

PROGRAM OF BIOTECHNOLOGY & HUMAN RESEARCH

BODY SYSTEMS	ENVIRONMENTAL PHYSIOLOGY	BIO-MEDICAL DESIGN	BIO-INSTRUMENTATION MONITORING	HUMAN PERFORMANCE	HUMAN CAPABILITIES AND CAPACITIES (CYBERNETICS)
PSYCHO-PHYSIOLOGY	CAPABILITIES AND CAPACITIES HABITABILITY				
LIFE SUPPORT SYSTEMS	ENVIRONMENTAL CONTROL	MAN-MACHINE DESIGN	ECOLOGICAL SUB-SYSTEMS	MAN-EQUIPMENT PERFORMANCE	(BIONICS)
PROTECTIVE SYSTEMS	SAFETY				
MAN-MACHINE CONTROL	INFORMATION DISPLAYS CONTROLS				
SYSTEM ANALYSIS	MISSION FUNCTIONAL PERFORMANCE RELIABILITY CONCEPT	MAN-SYSTEM DESIGN	INTEGRAL ECOLOGICAL SYSTEM	MAN-SYSTEM PERFORMANCE	ADVANCED MANNED AEROSPACE SYSTEMS e.g. HYPERSONIC TRANSPORTATION AND HIGH THRUST NUCLEAR
HUMAN FACTORS	PERSONNEL TASK EQUIPMENT HUMAN ENGINEERING MAINTAINABILITY TRAINING				

RB 63-625

FIGURE 273

I didn't mean to take too much time on this. This is just illustrative. However, when we do this we come up with a program which is, in fact, a matrix showing our primary areas.

The first area is man or human research and we have Dr. Voris who is a naval flight surgeon, a captain on duty with the U.S. Navy. He is not only an M.D., but has background in biotechnology, and works in the area of man-machine.

Dr. Del Duca, formerly of Thompson Ramo-Wooldridge, is a biophysicist but also an engineer.

He formerly worked in NACA at Lewis Laboratory.

On manned system integration we are concerned with what people—here we are primarily concerned laying down the requirements for putting man into these advanced systems. Here we have Mr. Trapp, formerly with Douglas Aircraft, a nuclear engineer and also a design engineer.

The reason a man like that is involved, we should get 10 to 20 years ahead and this will probably be in the nuclear field.

Next slide, please (fig. 274).

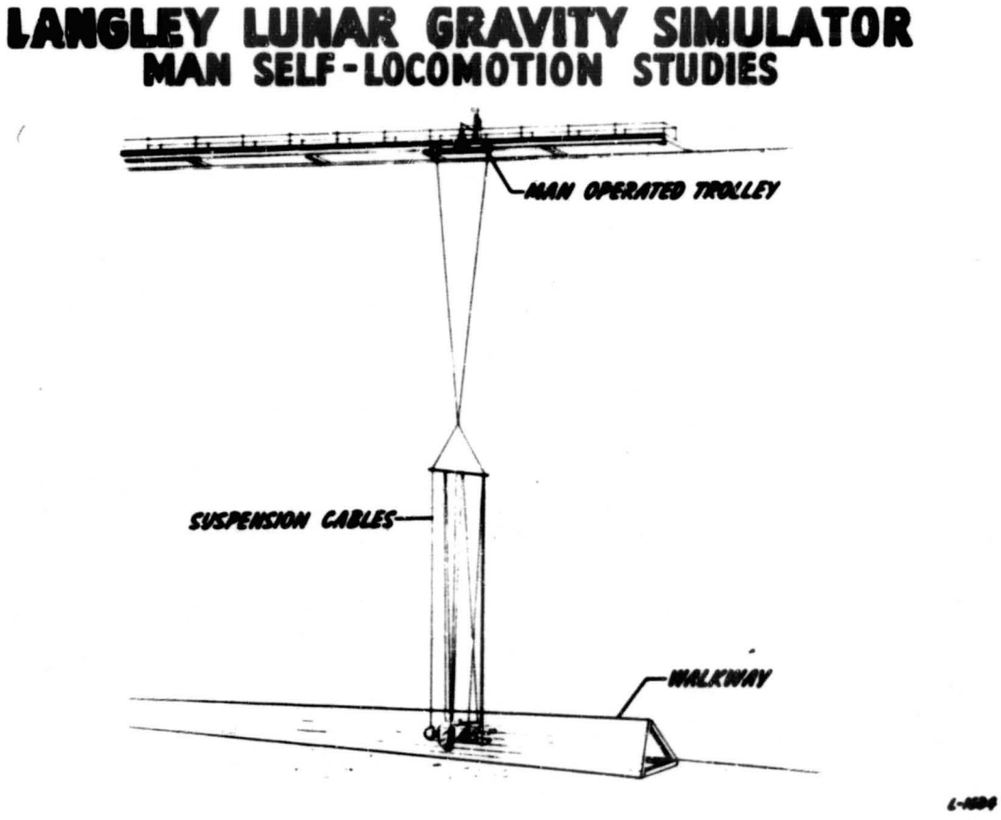


FIGURE 274

Here now is an example of some of the on-the-ground experiments that are being conducted.

This is a lunar gravity simulation where you take the man and put him on the angle and actually then assimilate one-fifth g. by having the components shown on the right as one-sixth.

He then walks on the side of—actually, assimulated condition outside a wall.

Next slide (fig. 275). This will better illustrate. Here is a man on a side walking on a walkway being supported from the top.

He can now make jumps to the side and presumably these excursions and jumps would be equivalent to that in a lunar mission. Another experiment is to take a man in a harness and use filled balloons. We see how he would perform in this situation, one-sixth of his weight. In my case it would be 30 pounds. We see how he could push things and so forth.

These would be of great help. However, I am afraid from the Yuganov experiment we may have greater problems in the lunar surface than we anticipate. One of the ways to do these experiments—trying to get a longer duration in weightless flight. We spin up, say a man, if we could, and try to determine what the one-fifth G would be without, in essence, going into the lunar surface.

Mr. RANDALL. Mr. Chairman, may I inquire where experiments are going forward?

Dr. KONECCI. The balloon experiments at Ames, Langley. Some of the other centers are doing other experiments.

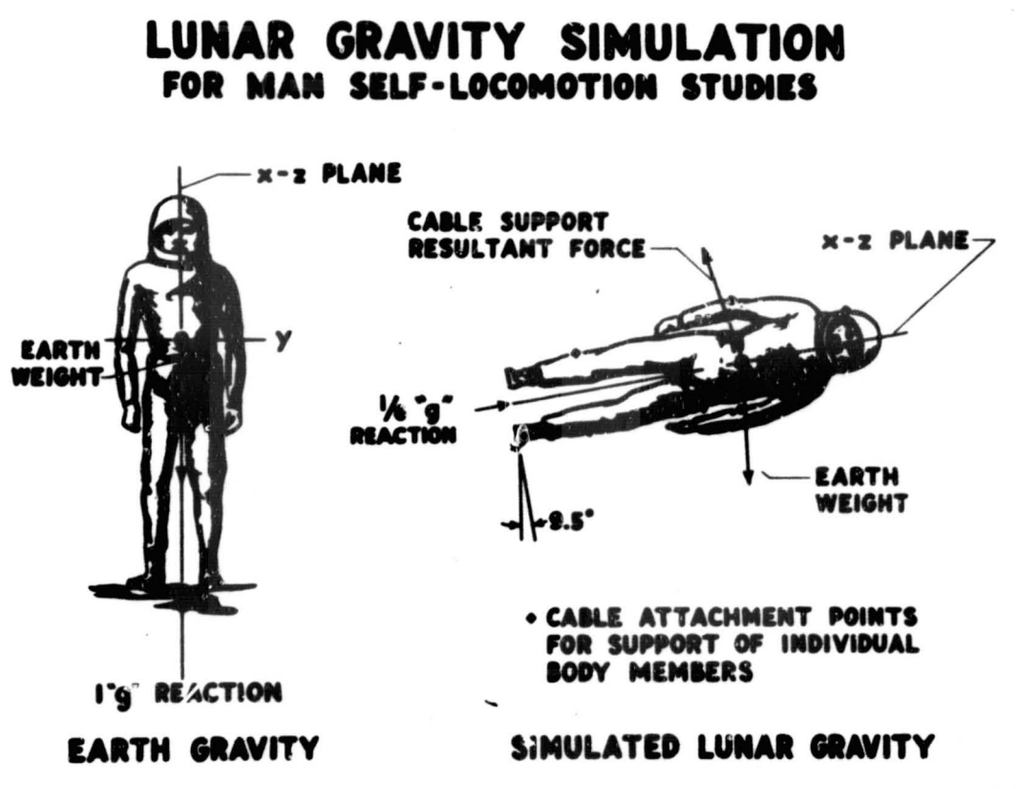


FIGURE 275

Mr. RANDALL. Thank you.

Mr. KARTH. Any requests in these things for laboratories as such?

Dr. KONECCI. What do you mean?

Mr. KARTH. For life sciences.

Dr. KONECCI. That is the facility under question, the laboratory to go at Ames Research Center.

Mr. KARTH. I thought it was more of a housing center, rather than a laboratory.

Dr. KONECCI. That is a laboratory—some space for the scientists, some housing space—but very small.

Mr. KARTH. You do research on the manned lunar landing project?

Dr. KONECCI. Yes, sir. It's just our background bimedical to want to do as much work on the animal to determine these basic fundamental factors before we actually go to man.

We'd have to stop short on man before we ever determined an end point.

Mr. KARTH. Do you have the same kind of animals the Air Force facility has?

Dr. KONECCI. Sir, we are using the animals from Holloman for instance—the chimps in many experiments including—and you'll see a movie on the work we are doing at Maryland.

The chimps at the University of Maryland, actually were procured by NASA from the Air Force and given to the university.

We are using that facility, yes, sir.

May I go to the movie, now?

Mr. KARTH. I think, Doctor, we are going to have to adjourn for the day.

Dr. KONECCI. All right, sir.

Mr. KARTH. I would like to announce at this time, the meeting tomorrow will take place in room 100–A in the Old George Washington Inn.

Now, this is a very small room. I presume only four or five of your staff, Doctor, will be able to get in.

Dr. BISPLINGHOFF. All right.

Mr. KARTH. It's very unfortunate we don't have a larger room to meet in.

All the available committee rooms have been taken up for tomorrow. Rather than cancel the meeting, we felt we would meet in room 100–A which belongs to the Agriculture Committee.

Mr. RANDALL. Mr. Chairman, before we adjourn, I observe Dr. Konecci's brochure is the only one that doesn't have the slides appended to it, at the end.

Dr. KONECCI. They are interwoven in between, sir.

Mr. RANDALL. They are in between? Oh, yes, Thank you.

I was in hopes we could get them, if they weren't there. We could look at them.

Mr. KARTH. Would you be available tomorrow morning, 10 o'clock Doctor?

Dr. KONECCI. Yes, sir.

Mr. KARTH. Fine, the meeting is adjourned.

(Whereupon, at 12:05 p.m. the committee was adjourned until 10 a.m., April 10, 1963.)

1964 NASA AUTHORIZATION

WEDNESDAY, APRIL 10, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SPACE SCIENCES
AND ADVANCED RESEARCH AND TECHNOLOGY,
Washington, D.C.

The subcommittee met, pursuant to adjournment, at 10 a.m., in room 110–A, George Washington Inn, Hon. Joseph E. Karth (chairman of the subcommittee) presiding.

Mr. KARTH. The meeting will be in order. Dr. Konecci, you may proceed in accordance with your prepared testimony. I might, however, make a request of Dr. Bisplinghoff today.

I may have made this request on previous occasions but I don't recall whether I did, and that is, to provide the committee with a compilation of the reprograming of funds under the Office of Advanced Research and Technology, in each one of the divisions.

I think that I've made this request on a couple of occasions but may not have made it for Mr. Ames, yesterday.

I wonder if we could just make a blanket request of you so we have the programs for all those funds.

Dr. BISPLINGHOFF. We will supply that for all the Offices of Advanced Research and Technology, broken down into all these divisions.

(The information requested is as follows:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Reprograming—Office of Advanced Research and Technology programs, fiscal year 1963

[In millions of dollars]

	Fiscal year 1963 budget	Change (plus or minus)	Fiscal year 1963 column of fiscal year 1964 budget (operating plan)
Space vehicle systems	45.885	+0.046	45.931
Supporting research and technology	23.795	+1.482	25.277
Scout reentry	2.500	−1.100	1.400
FIRE	10.000	+2.000	12.000
Scout meteoroid	3.500	−.380	3.120
Small flight projects	6.090	−4.386	1.704
Saturn-launched meteoroid experiments	----------	+2.430	2.430
Electronic systems	20.300	+.396	20.696
Supporting research and technology	19.600	−.754	18.846
Small flight projects	.700	+1.150	1.850

Reprograming—Office of Advanced Research and Technology programs, fiscal year 1963—Continued

[In millions of dollars]

	Fiscal year 1963 budget	Change (plus or minus)	Fiscal year 1963 column of fiscal year 1964 budget (operating plan)
Human factor systems	3.345	+6.715	10.060
Supporting research and technology	3.345	+6.600	9.945
Small flight projects		+.115	.115
Nuclear-electric systems	40.500	+3.031	43.531
Supporting research and technology	13.125	+1.943	15.068
SERT	6.300	−1.130	5.170
SNAP-8 development and flight	14.600	+1.343	15.943
Electric engine development	6.475	−.975	5.500
Small flight projects		+1.850	1.850
Nuclear rockets	82.850	−11.024	71.826
Supporting research and technology	7.850	+5.489	13.339
Kiwi	5.000	−2.600	2.400
NERVA	35.000	+2.021	37.021
Propellants	10.000	−2.134	7.866
RIFT	25.000	−14.300	10.700
NRDS operations		+.500	.500
Chemical propulsion	14.175	+.294	14.469
Supporting research and technology		+.044	14.219
Small flight projects		+.250	.250
Space power	10.250	+.609	10.859
Aeronautics	4.905	+13.173	18.078
Supporting research and technology	3.905	+3.269	7.174
X-15		+5.580	5.580
Supersonic transport	1.000	+3.287	4.287
V/STOL		+1.037	1.037
Total, OART	222.210	+13.240	235.450

Conversion of direct R. & D. funds in fiscal year 1963 budget from fiscal year 1963 headings to fiscal year 1964 headings

1963 budget headings	Current budget headings							
	Space vehicle systems	Electronic systems	Human factor systems	Nuclear electric systems	Nuclear rockets	Chemical propulsion	Space power	Aeronautics
Advanced manned space flight			3,345					
Meteorological satellites		1,000						
Communications satellites		500						
Scientific satellites		1,500						
Lunar and planetary explorations	2,500	10,300						
Spacecraft technology	22,325	6,000						
Launch vehicle technology	19,060							
Launch operations development	2,000							
Electric propulsion				21,000				
Liquid propulsion						8,450		
Solid propulsion						5,725		
Space power technology							10,250	
Nuclear systems technology				19,500	82,850			
Aircraft and missile technology								4,905
Tracking and data acquisition		1,000						
Total	45,885	20,300	3,345	40,500	82,850	14,175	10,250	4,905

Mr. KARTH. Proceed, Dr. Konecci.

FURTHER STATEMENT OF DR. EUGENE B. KONECCI, DIRECTOR, BIOTECHNOLOGY AND HUMAN RESEARCH, OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY, NASA

Dr. KONECCI. Good morning, Mr. Karth, gentlemen.

Yesterday when we left, we were talking about human research and were ready to show you a film. We will show you a film on confinement.

A study is underway at the University of Maryland to determine the capability for highly organized task requirements on the performance of humans for extended periods of time. Since November 17, 1962, a 35-year-old man has lived under a continuous program experimental environment. This experiment is under the direction of Dr. Jack D. Findley and is being conducted at the University of Maryland Research Laboratory, Department of Psychology, College Park, Md.

The subject of the experiment is Whilden P. Breen, Jr., a research assistant in the laboratory. The experiment is being funded by a NASA grant and is a part of advanced research in the life sciences.

I might say, that what we are really trying to do, is to learn something about the basic behavior of man operating in a confined space. At this time we are not trying to simulate space missions. We are trying to learn something about human behavior.

I might also mention we have taken animals, highly trained chimpanzees, and confined them for periods up to 2 years as a part of this university grant and in this area we study their basic behavior patterns. We have now determined a method through this type of experimental research.

The old adage is not true, that animals in zoos die because of confinement. We find we must keep the animals and men occupied. A man who is busy and working will not be depressed. I think, you will see this in the film, Mr. Breen, has been in the confinement since November—this is 5 months now, he has worked very well.

May we start the film. It is a silent film and I'll try to narrate a few things.

This is Mr. Breen as he entered the chamber. He does performance tasks. In other words, we make him work for everything he gets.

This shows a sequencing. He must go through a continued sequencing of tasks before he can actually get any reward at the end.

Here, he performed some tasks. He breathes—and there are some measurements made on his activity.

Here, he goes to the next sequence.

Here, he has to run around the room and shut off lights. As you see, he was not in very good shape when he first started the experiment. Since that time he has firmed himself up beautifully.

Here are some of the exercises. He has the freedom of choosing his various workloads as he pleases. He is given various rewards, like cigarettes, or food in this case. He can eat as quickly as he wants or whatever he wants, if he performs the tasks.

It is quite interesting that his hours were changed to where one time within a matter of several hours he had lived a full day and at other times he went to 36-hour days. He is sort of settling now to about 26 hours.

He is also given rewards such as a hobby.

Those doors will not open unless he performed a task. In other words, these are his rewards.

Here he is doing some art work. He is writing a book and again we are learning very basic things.

Simultaneously with this experiment there are two chimps within a trailer confined for over 2 years.

Here we found at first he was smoking about two packs a day so they made the tasks harder. This cut down the amount of smoking. Then he became very irritable, so they increased his ration by making the tasks easier.

Here he is communicating with the outside world through a microphone. He is being monitored continuously on TV.

Here the design of these rooms was intended to continue and make more room for additional experiments.

While we have the film on I'd like to go into the next step and talk to you a little about "Space maintainability," that is, men working in pressure suits.

It's going to be very difficult for a man to operate in a fully pressurized garment. You see, when the suit is pressurized he has a very difficult time of putting nuts on bolts, in their proper form. The pressurized gloves just weren't designed for this kind of task.

Here, he's trying to take out electronic components. This subject becomes a very critical factor in thinking about men, arbitrarily flying around in space with flying belts and presumably assembling packages.

We have to give quite a bit of thought to human engineering of not only the suit, but the tools this man will have to use.

I don't mean, there are no solutions to these problems. I mean to imply, with the conventional concepts we would have trouble.

As you see, he's having problems trying to pick up a screw. These things are being studied. We have a working group of which the Air Force, various centers in NASA, are coordinated through our office.

We have put out a competitive bid contract for maintainability in space from Marshall.

Here you see a man in a gimbled affair simulating weightlessness. As he moves he will be turning and spinning as he would in space. It is very difficult to orient oneself, as you can see, in the blackness of space and he will eventually have to hook himself onto the package of work.

Here you see he will spin around and attach himself to the object. Now if he implants enough force, the tank or whatever he's working on—in case, say a motor unit—would also move.

So, we get into complex tasks. That ends the film strip. [End of film.]

With that I'd like to lead very quickly, into a series of slides, to show you some additional work we are doing in human research and in biotechnology.

In the case of human research, we are cooperating, as we are in the other areas, with various agencies of the Government.

We do not make a distinction in DOD. We work with the Air Force and the Navy. We have cooperative programs in radiation with the AEC. We are also coordinating with FAA.

First slide, please (fig. 276).

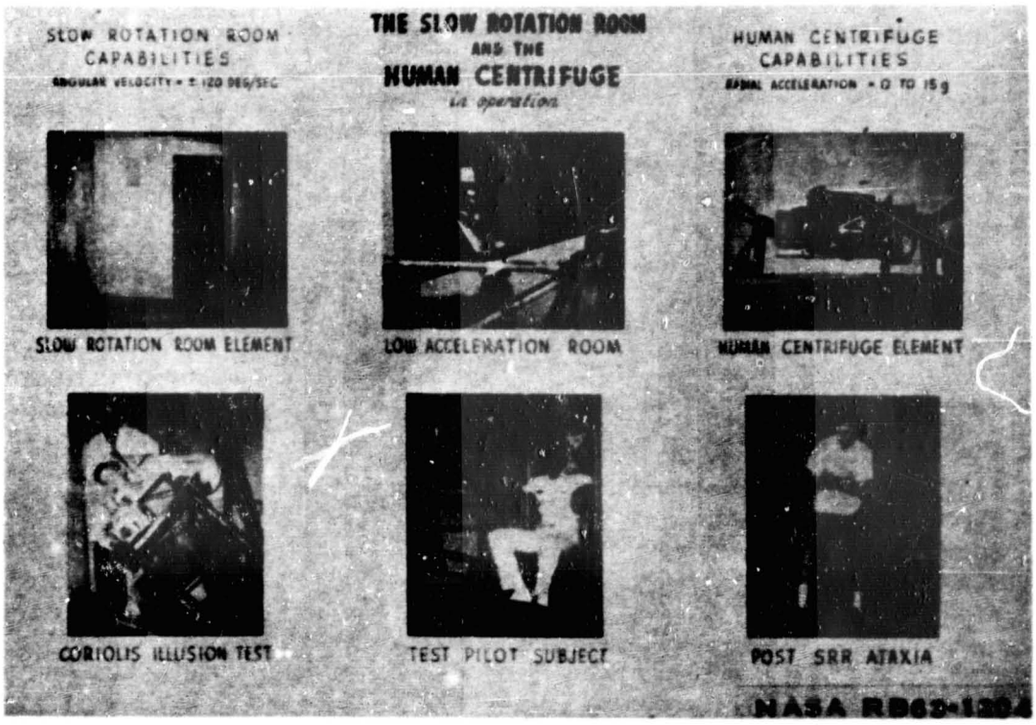


FIGURE 276

In this case, we see the cooperative venture between the Navy and NASA, work that was started, by the old Office of Life Sciences.

Here we are concerned with slow rotation and the human centrifuge since there are problems of orienting a man in space and making sure he does not get sick in space from being in the weightless state.

The experiments that were performed by the Soviets, primarily on Titov, stimulated additional work in this country, principally by Dr. Graybiel.

Next slide (fig. 277).

This, then, leads to the facility NASA has at the Naval School of Aviation Medicine. In other words, we are using their capability in this area. Dr. Graybiel is the world authority on motion sickness. This slide shows the importance of the coriolis effect.

The facility will be finished June this year. It will be transferred from the Office of Manned Spaceflight because it was intended for research, to this Office. We will manage this work.

Here you see men rotated around a room at continuous rates.

We find this has application not only to our space program but also to aeronautics as well, and to motion sickness in general. They will also be working with drugs in trying to alleviate these problems.

Next slide.

Mr. KARTH. Are there any machines other than thic one in existence which we might be able to use?

Dr. KONECCI. No, sir, not of that type. I might mention, the Nike-Zeus radar revolving room has limited capability. I have brought this to the attention of Dr. Graybiel. This is a contractor facility in the Army Nike-Zeus program in New Mexico at White Sands. The complete room actually revolves.

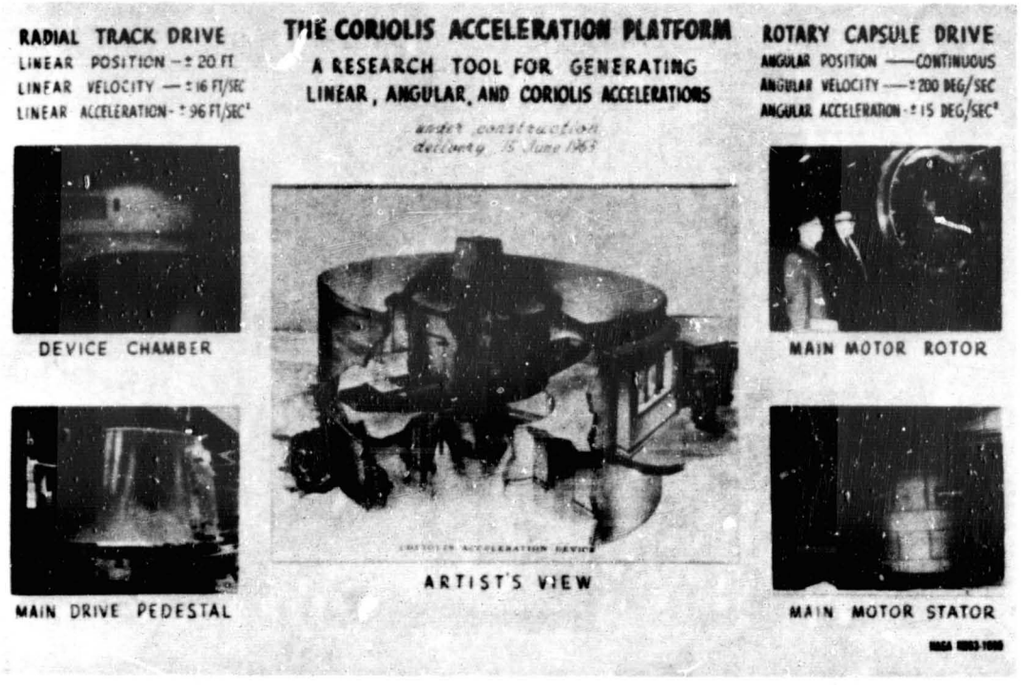


FIGURE 277

This was to be the Nike-Zeus radar missile facility where they could see how all the targets, by having the room spin simultaneously with the radar. They found somehow a miscalculation was made as to what man could really take while rotated and they had to stop revolving the room.

I notified Dr. Graybiel about the possibility of using it for research. The room revolves at 6 r.p.m. and, generally, we get into trouble at 4 r.p.m., depending on the distance from the center.

Mr. KARTH. Could that acceleration facility be changed?

Dr. KONECCI. I believe it would be quite a major rework except Dr. Graybiel does want to work in the 6-r.p.m. range. It might be useful as it is; that is, become immediately useful to our program, sir.

Mr. KARTH. This machine already has been constructed?

Dr. KONECCI. It is being finished now, sir, and will be put in operation August of this year.

Mr. KARTH. What is it going to cost?

Dr. KONECCI. I'm not sure what the actual facility cost is in detail. I can get you those numbers.

The total program so far through the Office of Life Sciences for the last 2 years has been about $1.4 million.

Next slide, please (fig. 278).

There is quite a bit of interest in the area of magnetic shielding, using magnetic shielding to protect man in space. This brings up the problem, what do the magnetic fields do to man. Here we have taken the challenge and started two programs, one in cooperation in the Navy and another with AEC to determine, in fact, what magnetic fields then do to man.

Simultaneously some animal experiments are being done.

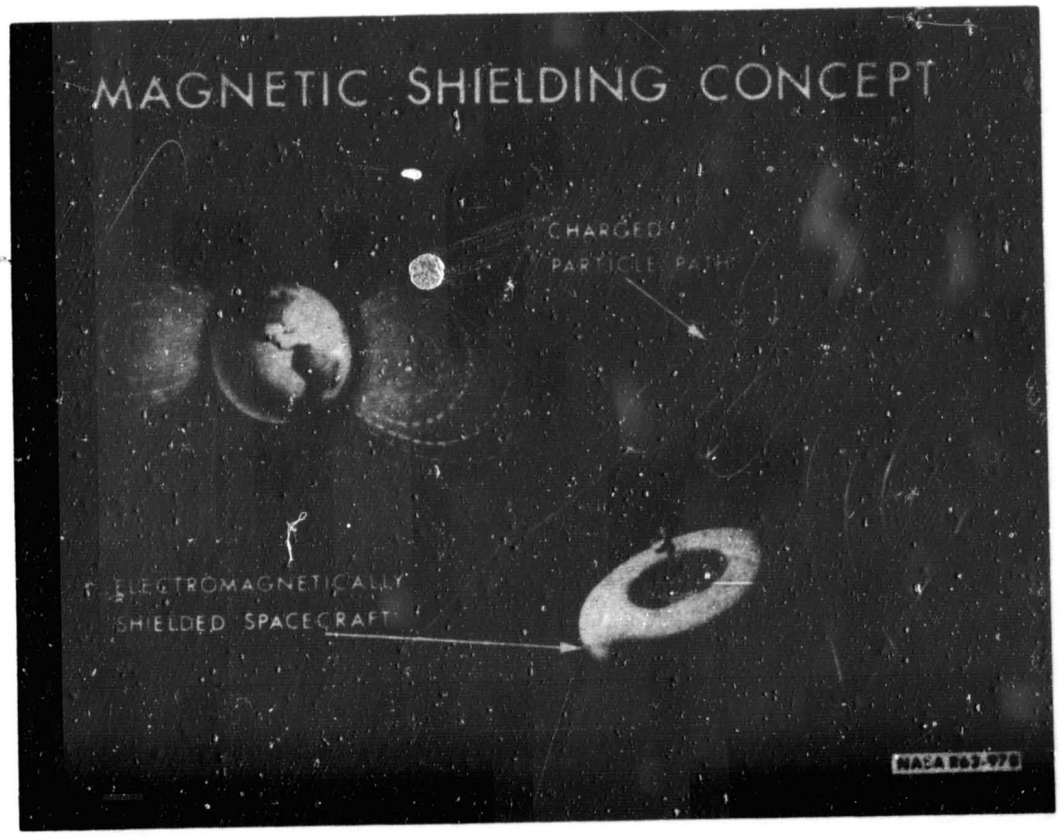


FIGURE 278

I might just say we find so far no magnetic field appear to cause quite a bit of disturbance. We live on Earth in a magnetic field. Our bodies are really electrical and magnetic bodies and when we put a man in a nul-magnetic field he becomes a little nauseous and disturbed by this environment.

We again must determine more about this on Earth.

Next slide (fig. 279).

In the life support area which is at this moment our prime area, we are trying to develop concepts, new concepts, as well as models, if you will, working models, breadboards of advance life support systems.

At the MSC, or Houston, we are working with the people that are presently on the Apollo program. However, we are trying to get the next step. They are working on systems up to 30 days.

We have a contract with Boeing Aircraft for a five-man 30-day total integrated life support system; environmental control, food, and waste disposal which will be demonstrated on the ground in July of this year, sir. Of the five people that will go in—one, will be an Air Force man, some people from Boeing and some from Ames research, will be put into the chamber 1 solid month. We will also be checking the Gemini diet during this period of time, giving useful data to apply to other programs.

Mr. KARTH. Who did the basic research on this concept?

Dr. KONECCI. The basic research was done and must be credited to Boeing Co., on their own money.

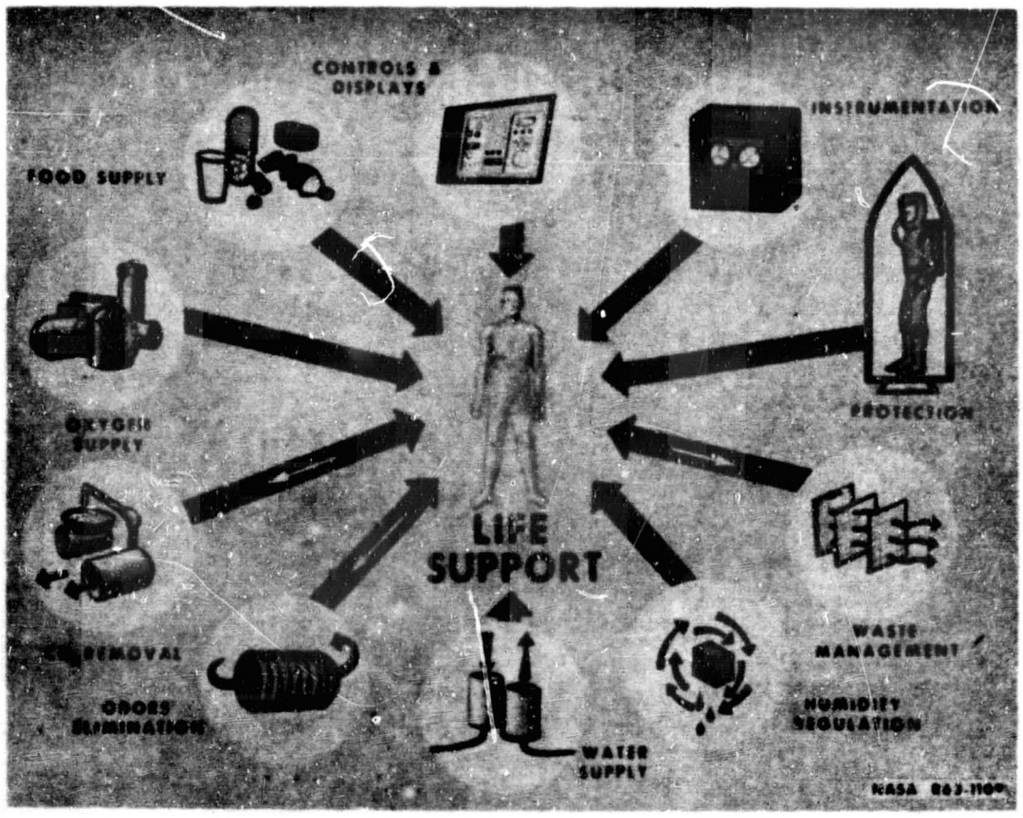


FIGURE 279

NASA picked up this work in an advanced stage. This life support system is a superoxide system comparable to what the Soviets are using in Vostok.

Mr. KARTH. In all probability, it is a duplication of what we have been doing in-house.

Dr. KONECCI. No, sir; we have not been doing superoxide work in NASA at all.

Mr. KARTH. Well, it's a life support system.

Dr. KONECCI. The primary work has been done on the life support system, out-of-house on contract.

Mr. KARTH. This you find to be unsatisfactory?

Dr. KONECCI. No, sir; the industry in the last 2 years, has risen to the challenge and has done an amazing amount of work. As we have found out, in the competition which came out of Langley just recently. We are in the process of evaluating the proposals for a four-man 90-day to 6-month life support system.

Mr. KARTH. Then why the request for additional funds for additional in-house capability?

Dr. KONECCI. In the life support area, sir?

Mr. KARTH. Yes.

Dr. KONECCI. Because, there must be work done to integrate the—the advance concept is not, in fact, the total system.

There are other factors that have to be put into it besides just aspects of what we are working with.

We are talking about——

Mr. KARTH. You are asking for funds to work in areas in which private industry is not working?

Is that what you are saying?

Dr. KONECCI. Yes, sir. Exactly.

We are quite cognizant of any attempts of duplication. We are trying to eliminate that completely. We are informing industry of everything we do in-house, and vice versa.

If industry does anything for NASA we are going to inform the rest of industry as well as in-house, of these efforts.

Mr. KARTH. This is not a very difficult task for one to keep the other informed?

Dr. KONECCI. No, sir, we have not found it true.

Mr. KARTH. Because it has not been done on such a widespread basis as, for example, as electronic research?

Dr. KONECCI. This is very true.

Mr. KARTH. You find this to be true.

Dr. KONECCI. We have a community of people concerned principally in life support.

If you have a meeting, you can call them together and you may get a few hundred people that are the most prominant in the country and it is not very difficult to keep them informed.

Dr. WEAVER. Again on this matter; yesterday it came up, I was wondering whether there was duplication of facilities for this research with the Air Force.

I wasn't clear in my mind whether this has been discussed by you with the Air Force or with the Army or other people in this field, or not.

Has this been discussed back and forth between NASA and the Air Force as to what the research programs are and what the facility needs are, what facilities are desirable?

Dr. KONECCI. Yes, sir.

Dr. WEAVER. Has that been by you with the Air Force personally?

Dr. KONECCI. We have a committee and a working group from DOD, the Air Force people, Navy people, and Army people, and they meet with my office periodically.

This facility, which is really a laboratory at Ames to house the people who are already there, was discussed with them. They know about it.

Dr. WEAVER. Do they have a comparable facility in which you think this experiment could be conducted, under your supervision, using these facilities?

Dr. KONECCI. This has already been done.

The Navy and the Air Force have competence. We have accepted their proposals where they could help NASA; working on a cooperative basis or funding them to do this work for us.

Dr. WEAVER. Could this be done in lieu of this new facility you are asking for?

Dr. KONECCI. No, sir.

Dr. WEAVER. You do not feel you could?

Dr. KONECCI. No.

Dr. WEAVER. Do you have available—maybe it would be more proper to ask the Air Force, giving the existing facilities they are using for their experiments and how they are used, 100 percent of the time, 50 percent of the time, total or partially.

Mr. KARTH. I think this can be done, Dr. Weaver, yes, sir.

Dr. WEAVER. I wonder if you have it if we could get it from you; or would you ask the Air Force to present that material?

Mr. KARTH. I think it would be more appropriate if we asked Dr. Konecci to make available this information to the committee; that is the findings of their Committee, the ultimate findings. They must have been written by the Study Committee.

If they studied this and didn't come to any conclusions, I'd be surprised, but if they did, as I assume they did, we should be advised of what this conclusion was.

Dr. WEAVER. Would that be possible?

Dr. KONECCI. Yes.

Mr. KARTH. The facts on which the recommendations were made, which, I assume, is all the information Dr. Weaver is interested in.

Dr. KONECCI. The NASA has a requirement, from a management standpoint, for staffing an organization with a capability of managing on a day to day basis activities in the life sciences area in support of NASA missions, and in addition must provide this staff with the necessary laboratories to maintain their scientific competence. A management decision was made to locate this organization at the Ames Research Center in 1961. A cadre of well-qualified personnel are on board and have assumed these responsibilities. The primary reason for requesting the proposed Life Sciences Laboratory is for the purpose of providing housing and laboratory resources for personnel needed to carry out assigned responsibilities.

I think, the fact this laboratory was an established entity, 2 years ago at Ames, is, I think a pertinent point, that NASA has been building up their competence to have an in-house capability in the life sciences and Ames was chosen as the center.

Dr. WEAVER. By NASA?

Dr. KONECCI. Yes, sir, and I believe, what should be said, is that this is a laboratory to house the people that are there, physically; presently working in various buildings that are not their own areas.

They are just using available space; and this facility, the life sciences facilities is one of the overall facilities coordinated through DOD.

Dr. WEAVER. DOD?

Dr. KONECCI. Yes, sir.

Dr. WEAVER. This is the $4.8 million?

Dr. KONECCI. Yes, $4.8 million.

Dr. WEAVER. And you do have constant intercommunication then between your office and the DOD as to the type of experiments you are conducting as related to them and industry?

Dr. KONECCI. Yes, sir, even more so, as a matter of fact, a few months ago I called in the DOD, plus key people from the Surgeon General's Office in the Air Force, key people from the Navy.

They were in my office, and we discussed our proposed 5-year program with them, so there would be knowledge passed to them so they'd know exactly what we intend to do and, in fact, assist us to perform this work.

This was the real purpose.

Dr. WEAVER. Do you feel this research you are doing would be as necessary or as let's say "crash," then?

Would it be as necessary to do this if we were not going to have a manned lunar landing and interested only in the domination of space

and the exploration of space itself, or do you feel this is all related—you'd have to have the same type of program whether we landed on the Moon or not?

Dr. KONECCI. Personally, sir, I feel we are in urgent need of as somebody once said, "filling the inkwell of knowledge."

This country was ahead in the life sciences, or aviation medicine until 1953. We were way ahead of the Soviets. Basically then their program started.

After the flights on Aero-Bee and V–2, where we got the first weightless data, this country essentially then became stagnant in the area; except for paper studies. But, actual experimentation was essentially pretty low.

The Soviets continued to do flights with dogs. Perfected their equipment for man, and ended up then in the position in 1961 to put the first man around the Earth.

However, it was, really, the animal experiment of Laika that still stands out today, performed in 1957, to be the best physiological data anyone has in the world. The Soviets have made that available to us in their publications. I can bring them up to you, sir.

They were basing their design of the vehicle on actual laboratory experimentation being done in space. They had the physiological data on the animals.

Dr. WEAVER. Do we have the physiological data on the manned space flight?

Dr. KONECCI. Yes, sir, they turned over two books. One on bio-experiment and the other on Gagarin and Titov, published by the Academy of Soviet Sciences, are now made available.

We have them translated and being passed out to the scientific community.

Dr. WEAVER. In the abbreviated forms I have read, it appeared to me the Russian astronauts were avoiding questions about their actual life in space and avoiding giving information to us on information they gained on that journey.

Was that just the astronauts, or were the scientists the same way?

Dr. KONECCI. No, the scientists have been communicating with us in the past few years. Actually, in the life sciences we had more exchange and communication than any other field—with the safety of man at stake there are no real restrictions.

They are just as conscious of keeping a man alive as we are and they have been rather free in exchanging information.

The main reason we didn't get more detailed technical data, curves, and numbers on Titov was as Professor Yazdowsky told me there were 7½ kilometers of physiological tape on Titov that had to be processed. This takes time.

They finished this last summer and made the data available as a book in November to essentially the scientific community.

Dr. WEAVER. Have we gained from this knowledge from them?

Do you feel it has helped you in your preparation for new experiments in the field?

Dr. KONECCI. Yes, sir.

Dr. WEAVER. You feel they have been free in exchanging that with you?

Dr. KONECCI. Yes, sir.

Dr. WEAVER. Their techniques and scientific procedures and all, have been open and aboveboard as far as you are concerned?

Dr. KONECCI. Yes, sir, so far as I am concerned the technical data put into their reports and scientific literature is of high quality.

I think we go into more finesse in our experimentation and the results we are getting, have a much broader base on which we can build probably better in the future. However, for isolated things they want to do, they have concentrated their efforts on manned spaceflight.

They said this was their main objective.

Dr. WEAVER. You have any indication, they only told us what they want us to know in this field and are withholding further information.

Dr. KONECCI. I think on technical hardware this is always true.

Dr. WEAVER. In the physiological aspects you don't feel there is, but there is on technical aspects?

Dr. KONECCI. On details of the life support system, in other words, how it is constructed they have not told us this.

They have told us the methods, superoxide, and how they generate water and these are perfectly straightforward methods.

In other words, we know how they are doing it.

As a matter of fact if you are interested I have a couple of slides that are on the Vostok to give you some feeling for the amount of data we have been able to get in this exchange. How the man is oriented and so forth. They have told us this—chest to back acceleration. I have an article I'd be pleased to insert in the record if you're interested.

Dr. WEAVER. I would be personally interested in seeing this some time.

Dr. KONECCI. Yes, sir.

(The article referred to is as follows:)

BIOASTRONAUTICS

(By Eugene B. Konecci, Biotechnology and human research, NASA headquarters; chairman, ARS Bioastronautics Committee)

The main space life sciences efforts in the U.S. are centered in the National Aeronautics and Space Administration. However, in addition to the bioastronautics capabilities in NASA and the Department of Defense, the third IAF Bioastronautics Committee meeting held at UCLA last February revealed a surprisingly extensive, well-organized, and well-trained bioastronautics capability in industry. Most of the major companies have life sciences organizations, deriving a great deal of support from company funds. Let us document this talent.

NASA has recently taken necessary steps to strengthen its life sciences capability. In addition to aerospace medicine under Charles Roadman in the Office of Manned Space Flight (OMSF) and biosciences programs under Orr Reynolds in the Office of Space Sciences (OSS), NASA announced the newly created directorate of Biotechnology and Human Research in the Office of Advanced Research and Technology (OART). In making the announcement, Robert C. Seamans, Jr., said "our success and progress in manned space flight for the next 10 to 20 years depends on the human research we do today. The human, manned-machine and manned-system requirements must be determined prior to design of any manned system. The human's capabilities and limitations will directly influence various subsystems of the space vehicle. It is, therefore, important that work in biotechnology and human research be conducted at an accelerated rate in order to have enough answers for the design of aerospace vehicles." The author was appointed director of this new office, which completed the life sciences program offices in the National Aeronautics and Space Administration headquarters.

The programs and aims of aerospace medicine and biosciences were announced last year—the former primarily concerned with manned space flight in the three

existing projects—Mercury, Gemini, and Apollo—the latter concerned with basic biology and the study of extraterrestrial life.

Before we begin to discuss the Biotechnology and Human Research Program, it seems appropriate to mention the responsibilities of the Office of Advanced Research and Technology (OART). NASA Advanced Research and Technology stems from the statement of the purpose of the Astronautic and Space Act of 1958: That one of our missions is to conduct research into the problems of flight within and outside the earth's atmosphere, with a view for their practical solution; to discover new ideas, materials, methods, and devices for space exploration and aeronutronics utilization; to develop and find ability and limitations of promising ideas; and to improve quality and performance of components and systems for space and aeronautical use.

Advanced Research and Technology (ART) is divided into two parts, that is, project and program oriented ART. The first project-oriented ART is advanced technical development necessary to accomplish a single project that has been approved in a "Project Developed Plan" (PDP), and is managed by a headquarters program (mission) office. The second is programmatic—an ART that is directed toward future requirements and/or toward several projects. Program ART is managed by OART. The Biotechnology and Human Research Program falls within the second category, while aerospace medicine in the first. Like OART, Biotechnology and Human Research has four principal methods of carrying out its programs: (1) in-house, (2) outside, (3) place and monitor outside contracts from headquarters, and (4) authorize other program offices (OSS, OMSF, etc.) to get it done.

BIOTECHNOLOGY AND HUMAN RESEARCH PROGRAM

	Area	Environment	Requirements	Bio-engineering	Simulation, test, and evaluation	Advanced concepts
MAN	Body systems Phycho-physiology	Environmental physiology Capabilities and capacities	Personnel selection Habitability	Bio-instrumentation monitoring	Human performance	Human analogs (cybernetics)
MAN MACHINE	Life support systems Protective systems Man-machine control	Environmental, H_2O, food, waste control Safety Information displays, controls	Man-machine design	Ecological subsystems	Man equipment performance	Bionics
MAN SYSTEM	System analysis Human factors	Mission functional performance reliability concept Personnel task equipment, human engineering, maintainability, training	Man-system design	Integral ecological system	Man-system performance	Advanced manned aerospace systems (e.g., hypersonic, transportation, high thrust nuclear)

FIGURE 280

The systems approach was utilized to arrive at a Biotechnology and Human Research Program. This is outlined in the diagram above (fig. 280). The interactions of man, man-machine, man-system with the environment, the requirements, engineering, and simulation, flight test, and finally evaluation, are shown in the diagram.

Human research involves the study of man under normal and unusual conditions in order to determine the functions of man's subsystems—musculo-skeletal, cardiovascular, digestive, nervous, endocrine, respiratory, sensory, and excretory—against the various environmental conditions, such as astmosphere, acceleration, radiation, electrostatic, magnetic, and thermal.

The psychophysiological and behavioral sciences study man's capabilities and limitations under normal conditions, individual stress conditions, and combined stress conditions. Research of this nature will reveal the habitability requirements. The basic requirements of man lead to the development of equipment and instrumentation for research. The data obtained therefrom lead to design criteria for life-support systems, personal equipment, protective systems, and man-machine control, which include information handling, displays, and controls.

A representation of the broad-based NASA Life Sciences Program is given in the following table. A review of several government and company funded life sciences programs follows:

NASA life sciences representative research tasks

SUBJECTS	INSTITUTIONS
Continued research on photosynethetic gas exchanger for spacecraft—extends period of performance.	General Dynamics.
Determination of optimal environment and shielding against meteorites.	Ling-Temco-Vought.
Application and instrumentation of visual perception for space exploration.	Sylvania Electric Products.
Establish human-factors criteria and control-navigation display-system requirements for spacecraft missions.	Dunlap and Associates.
Investigation of control-display problems occurring in accelerative flight phases of high-performance vehicles.	Douglas Aircraft.
Conversion of carbon dioxide for use in closed cabin atmosphere by a single-step method, utilizing the carbon dioxide expired by man and water recovered from normal physiological processes.	MSA Research Corp.
Investigation of variation of electro-neuro-physiological correlates and task performance under conditions of controlled stimuli.	Henry Ford Hospital.
Determine feasibility of regenerating carbohydrates from carbon dioxide and water by physico-chemical techniques.	FMC Corp.
Recovery of oxygen by catalytic disassociation of carbon dioxide at low pressure.	General Electric.
Design, contact, and deliver tactual sensing system.	Stanford Research Institute.
Physiological and psychological responses to force environments generated by rotational motions occurring in operation of aircraft and space vehicles.	Navy Bureau of Medicine.
Cardiovascular—respiratory system reactions of man to accelerations of various directions and durations.	AF Systems Command.
Experimental studies to determine tolerance and effects of vibration on human subjects.	AF Systems Command.
Study of radiation instrumentation, shielding, and biological effects; and determine design criteria of shielding required on manned space vehicles.	Aerospace Medical Center.
Extends period of performance techniques for continuous measurement of blood flow through intact vessels of animals in space vehicles.	Columbia Univ. (L. O'Neill).
Performance research or techniques and instrumentation for measurement of physiological variables in primates under space conditions.	Univ. of California.
Behavioral research and experimental analysis of complex behavioral repertories under full environmental control.	University of Maryland.
Research in cerebral neurophysiology and its application to monitoring. Physiological states of subhumans and humans in space flight conditions.	UCLA.
Biological and physiological studies of Perognathus (pocket mice) to determine their usefulness as experimental animals for space research.	Northrop Corp.
Conduct research directed toward development of biopacks and experiments for use in space.	AEC.
Investigation of hypothermia for mechanism by which it injures living cells.	Navy Bureau Medicine.
Research on closed chemical systems for reduction of carbon dioxide to oxygen and carbon.	Isomet Corp.

NASA life sciences representative research tasks—Continued

SUBJECTS	INSTITUTIONS
Spaceborne gas chromatograph atmosphere analyser.	Beckman Instrument, Inc.
Development of extravehicular suit	Industry.
Extravehicular suit maneuvering device	Industry.
Development of restraint and body support systems.	WADD.
Investigation of waste control methods	General Electric.
Food in manned spaceflight	Industry-DOD.
Design and initiation of prototype hard suit	Industry.
Radiobiological research	DOD–SAM.
Pulmonary function and acceleration	DOD.
Study of human tolerance to impact and landing accelerations.	WADD.
Effect of prolonged exposure to pure oxygen atmospheres on human performance.	Republic Aviation.
Biochemical activities of terrestrial micro-organisms in simulated planetary environments.	University of California.
Investigation of the effects of ionizing radiation on selected biological processes and systems.	Oak Ridge National Laboratory-AEC.
Life under exotic conditions	Navy School of Aviation Medicine.
Radioisotopic biochemical probe for extraterrestrial life.	Resources Research, Inc.
Sterilization of space probes	Wilmot Castle Corp.

Spacelabs, Inc., has been conducting studies of biotelemetry and animal instrumentation. Its Model 130 Impedance Pneumograph, using two EKG electrodes, measures respiratory rate and tidal volume. During respiration, an impedance change produces an output wave form from which respiration rate and tidal volume can be determined. Spacelabs, Inc., has also been evaluating pulse-wave velocity concerning the cardiovascular system. Results look promising, not in presenting blood pressure, but for flow measurement of cardiovascular dynamics.

Hughes Aircraft has devised a 12-channel miniaturized physiological data telemetry system. Twelve signals from sensors and transducers are inverted into FM signals impressed on carriers ranging from 960 cps to 3 kc. With the present power system utilizing batteries, eight hours of operation can be obtained. However, using the EKG system alone, for example, gives about 40 hours' operation.

Basic research activities are being conducted to complement studies on bacteria and low pressures on the order of 10 to −8 mm Hg. Lower pressures are contemplated, if such reductions can be measured accurately.

Northrop Corp. has a life sciences section with four laboratories—bioengineering, behavioral sciences, biodynamics, and bioastronautics. Northrop designed the Manned Rotation Simulator for the School of Aerospace Medicine at Brooks AFB. It consists of a 10-ft. diam. sphere of fiberglass—honeydome structure—that floats on an air pedestal about 6 ft. in diam. Inside the sphere, three inertial rings mounted in a pitch and yaw axis are activated by battery-driven electric motors. At the sphere's center is an adjustable seat which helps place the axis of rotation either through the vestibular area of the brain or the center of gravity, or any place in between. The device rotates between 50 to 70 r.p.m. It could prove a very useful laboratory tool.

Martin Co. is continuing its algae studies on closed ecological systems. In conjunction with this research, plant material studies are also underway.

AiResearch Div., Garrett Corp., has developed 7500 p.s.i. oxygen bottles for the Mercury program. These have proved reliable, and are about 3.2 lb/lb. of useful oxygen for SAE 4340SG; and a little for C120 AV Ti. These bottles and continued development of lightweight molded high-pressure oxygen tanks will find many uses in aerospace systems. AiResearch prefers the two gaseous (N_2+O_2) system and is developing zero-g cryogenic supercritical storage systems for weight reduction. The Division is considering the combined utilization of subsystems, such as the use of water from hydrogen-oxygen fuel cells. At AiResearch a new Cryobiology department has been established to develop hypothermic techniques, which maintain organs or parts of organs down to 200 deg. for possible organ transplant or food storage.

Douglas Aircraft has conducted life sciences experiments in a variety of areas. They are conducting simulated sealed cabin studies in a lox tank of a Thor missile. This is an excellent research tool inasmuch as it constitutes a flight-tested piece

of hardware about 7 ft. in diam. and 20 ft. long. The completely sealed tank was maintained in this mode for a couple of months, and provided valuable information and experience in leak detection and sealing techniques. This experimental work points up the feasibility of utilizing expended and recoverable large tanks of vehicles in orbit, and also opens up the possibility of utilizing large tanks, such as the Saturn S–4 stage, for early space stations or space shelters in emergency. Advanced display and control systems will be placed in the tank and connected to a three-dimensional analog simulator so that human performance studies can be accomplished. The sealed tank is also useful as an excellent test bed for a variety of advanced life-support systems.

In its study of subgravity, Douglas performed human experiments with an integrated harness and helium-filled balloons. Preliminary data revealed significant information. In order to study the combined psychophysiological effects and problems of motion sickness, disorientation, and equilibrium, and to obtain design requirements for rotating space systems, a crazy room was constructed and mounted on a vehicle. Test subjects were placed on horizontal and vertical tilt tables within the room as the truck was driven in 50 ft. plus diameter circles at various revolutions per minute. These preliminary experiments were extremely interesting and highlight the design problems which will probably confront us if we insist on rotating space vehicles with a shortarm radius.

A new approach had to be devised in order to construct the room with proper aerodynamic controls, place it on the end of the large crane and, with the available control, spin the room in the air at various radii and revolutions per minute. This device should be completed and tested in the near future.

Beckman Instruments has directed its efforts in the last several years toward atmospheric analysis, both in the monitoring and process control of atmospheres. Other studies include the development of oxygen and CO_2 sensors as well as the development and testing of a gas chromatograph. Such prototype instruments were developed for JPL during lunar missions and for analysis of closed atmospheres. This final flight unit is housed in an 8 by 8 by 10 in. package weighing 12 lb. and uses 10 w. of power. It will measure 28 complements from lunar dust.

Recently, Boeing completed a successful three-man 7-day sealed-capsule experiment in its altitude chambers. This was an integrated man and hardware test. A sodium superoxide system was used. The three subjects drank purified water, ate frozen food, collected their waste, and performed 11 tasks. Longer duration tests are planned.

Spacesuits.—A review of U.S. and U.S.S.R. spacesuit development reveals some similarities, but differences in objectives and design philosophies. American progress is well-known and need not be covered here, except to say that significant progress in suit pressurization and mobility have been achieved. One of the American groups specializing in protective systems is concentrated at the NASA Manned Spacecraft Center under Stanley White. The United States has developed a variety of configurations and designs for a number of intra- and extravehicular missions. The American philosophy goes beyond the mere survival aspect of the spacesuit. Comfort and performance under pressure are considered vital to the completion of the mission. Under certain conditions the spacesuit could be used as the primary life-support system (fig. 281).

Soviet spacesuit development has a long and not too well appreciated history. It appears that their prime objective has always been to use pressure suits as backup systems for emergency purposes only.

During discussions with Vladamir Yazdovsky last year, while he was examining the NASA Mercury spacesuit, he stated the pressure used in the Soviet spacesuit was ½ atm. or 7½ psia. When confronted with "but you will immobilize the man," he noted that the Vostok was very reliable and the suit was used for emergency purposes, not for calisthenics.

Spacesuit development in the Soviet Union goes back many years. It is important to note that on Jan. 12, 1949, a book entitled "Pressure Suits and Oxygen in Life-Preserving Equipment for High-Altitude Flights" ("Skafandry I. Kislorodno—Spasa Telnama Apparatura Dlia Vysothykh Poletov") by A. I. Khromushkin and edited by M. N. Rabinovich, Lt. Col., Eng., was published there. It dealt with theory and design of oxygen life-preserving equipment and pressure suits intended for use by flight-test and aviation section engineers, pilots, technicians, and all other workers in the field of high-altitude flying. The physiological factors concerned with design were considered indispensable.

The most significant factor about this book is that as early as 1948 the Soviets had an operating regenerative pressure suit. The book described in detail three designs—blower-type, regenerative jet, and lox-type—and indicates a preference

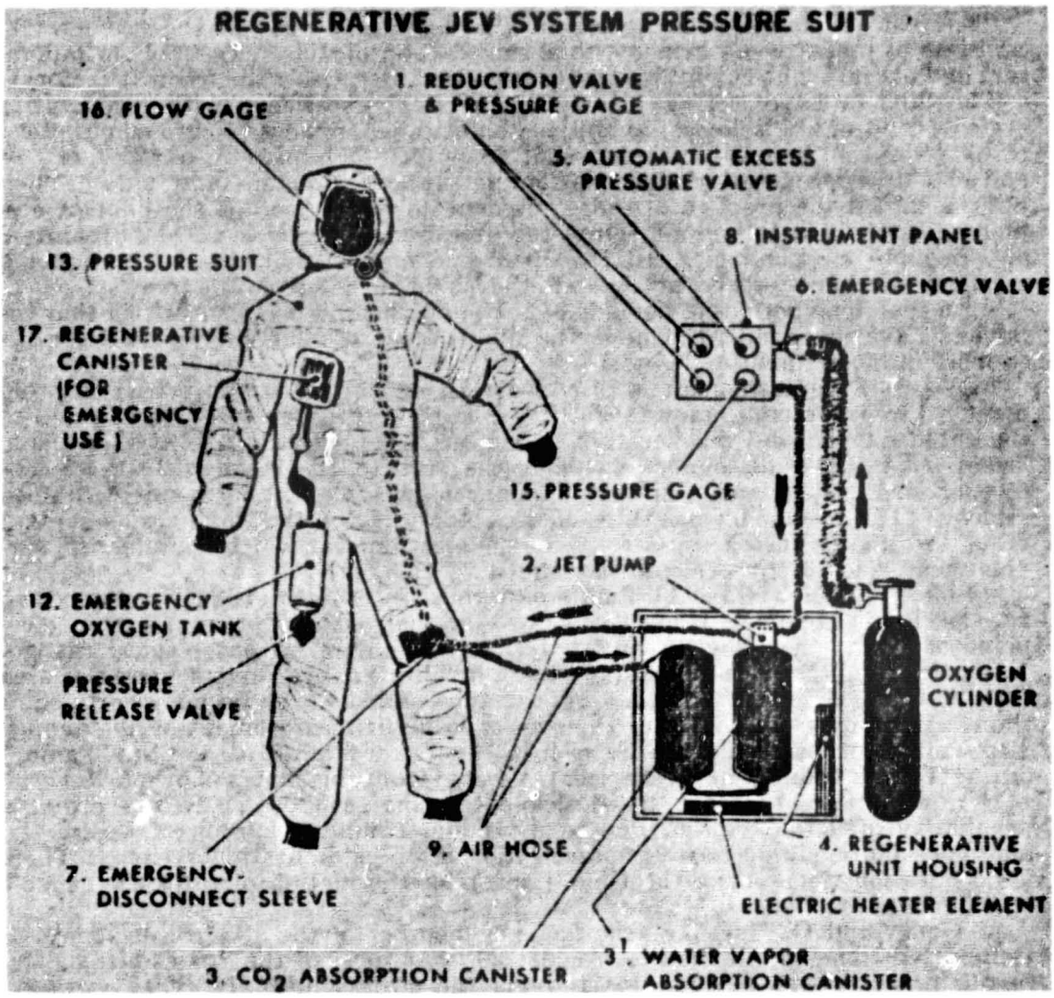


FIGURE 281

for the so-called regenerative jet system. In this design, "oxygen from the cylinder passes through a canister and enters the jet at a pressure of 6 a.t.m. At this pressure the jet of the installation illustrated discharges 2.5 liter per minute The oxygen jet draws the used air from the suit in passing through the canisters and the air is cleaned of carbon dioxide and water vapor. The purified air is returned to the suit with 2.5 liters of oxygen per minute added to it. Hence, while the system is in operation the air is continuously purified and enriched with oxygen. Excess air in the suit is exhausted into the atmosphere through an atmospheric valve." The illustration at left shows the early regenerative jet pressure suit system.

At this time let us review the regenerative canisters used in these early suits, since they apparently are the forerunners of the present spacesuit. The absorbent for carbon dioxide used in the canisters of 1948 pressure-suit systems is KhPI (khimicheskii poglotitel izvestkovyi=chemical absorbent, calcareous), an absorbent of the "Cardoxide" type. Silica gel is used to absorb the water vapor. Data regarding these absorbents are documented in the book.

To quote further from the book:

"The main drawback to using lime is that the particles tend to stick together and form a solid mass under the influence of moisture. However, more recently methods have been developed to process calcium hyroxide so that the lime remains in granular form even when completely spent.

"The KhPI absorbent has a number of favorable qualities. It does not liquefy; it liberates comparatively little heat in reacting with CO_2. Because the mixtures ($MnSO_4$, AlFe, etc.) act as both cementing and catalytic agents, the absorbing capability of KhPI under the conditions obtained in regenerative canisters is fairly satisfactory. No caking takes place during operation.

"The calcareous chemical absorbent KhPI is being used in the regenerative canisters of pressure-suit systems to absorb carbon dioxide. Tests under laboratory and actual flight conditions have shown that its performance is satisfactory."

The Soviets have a long history of practical experience with regenerative systems, and it was a logical evolution to go to superoxides. Throughout these many years the Soviets have continued to perfect high-pressure oxygen systems and chemical regenerative methods for life support in cabins and suits. Their work included the problem of quick disconnects, which permit the pilot or cosmonaut in the suit to become completely free from the vehicle and still maintain an adequate environment. In the 1948 regenerative suit, the jet pump and regenerative cannister were attached to the inside of the suit in the front.

With such long periods of development behind them, it is not surprising that the Soviets have managed to achieve the high degree of reliability needed for life support in bioastronautic flights.

In Vostok, the cosmonaut is provided with an equivalent terrestrial environment. From available information it seems that the spacesuit is connected to the cabin oxygen and regenerative system, and is the backup in case of cabin leakage. A quick disconnect switches the suit to the ejection seat oxygen-regenerative system and a similar disconnect switches to the in-suit contained system. The cosmonaut has three choices of landing on the earth after re-entry. (1) in the sealed Vostok capsule, (2) in the ejection seat which contains the survival gear, and (3) by personal parachute.

Vostok.—Vostok III and IV flights performed by Maj. Andrian Nikolayev and Lt. Col. Pavel Popovich, respectively, are extremely significant from a biomedical point of view. The Soviets reported that there were no pathological changes discovered, and there was no nystagmus, or involuntary eye movements associated with motion sickness or vertigo. Photographs of Nikolayev do not clearly show the electrode over the corner of the eye for in-flight measurement of nystagmus. The white-spot electrodes can be seen in the Titov film, "To the Stars Again," during Titov's training in the device. A frame from this film is shown below.

It now appears that the space sickness experienced by Titov was either a peculiarity of Titov himself, due to a random tumbling motion of Vostok II, and/or oscillations due to overcompensation of the stabilization system. There is no question that during the time Titov took the motion pictures the capsule stability was excellent.

A. Genin and O. Gazenko (the latter a member of the IAF Bioastronautics Committee) reported in Pravda, August 20, that most of the Soviet medical research program was devoted to studying the cosmonauts' ability to work by comparing conditions, volume, and quality of the way they performed in space. Nikolayev and Popovich deliberately made rapid head movements like those by astronauts John Glenn and Scott Carpenter. It now appears that the serious effects anticipated as a result of prolonged weightlessness, at least for periods of 3 to 4 days, did not develop. However, we cannot say for sure what will happen after a 10- or 14-day mission in the weightless condition.

However, the Soviet results look promising. At the press conference of Nikolayev and Popovich, Professor Yazdovsky (another member of the IAF Bioastronautics Committee) summarized biological findings. Also, R. M. Bayevskiy explained that placing of silver electrodes on the corners of the eyes of Nikolayev was for the purpose of measuring nystagmus, while Popovich was apparently the control subject. It has been proposed by many that long-term zero-g flights would upset the vestibular apparatus; and since the eyes are an indicator of these changes, the stagmus would occur and could be measured quantitatively. As we now know, both Nikolayev and Popovich indicated that they experienced no nausea of vestibular effects.

It seems that the Soviet measurements included electrocardiograms (EKG), respiratory rate, body temperature, galvanic skin reflex (ankles), and the nystagmus experiment. Brain waves (EEGs) also were measured. One of the released photographs of Nikolayev shows a little skullcap underneath the leather helmet which could be used for surface EEG electrodes.

The Vostok capsule remains a mystery to the Western World. If the Vostok-II model in the Titov film is an accurate replica, then the in-orbit capsule configuration is cylindrical with a rounded nose section that contains the porthole on the right side, the ejection-seat escape hatch on the top, two triangular-shaped stubby wings (or fins) on the sides, and an annular propulsion ring. Numerous whip and loop antennas are also visible. The cosmonaut is located in the nose section; however, his exact position is not known. There are many possibilities, but side and front facing appear most likely.

Photograph of Titov clearly shows the electrode over the corner of his eye for the measurement of nystagmus during training exercise in simulator.

FIGURE 282

In early dog flights we know that the capsule was put in sideways. A film has shown Gagarin positioned sideways in a Vostok-type couch being subjected to lateral acceleration forces on the centrifuge. Evidence supports the front-facing configuration. Both Professors Parin and Yazdovsky stated that Titov experienced "chest-to-back" accelerations on launch and reentry. The Titov film shows various shots of the capsule and escape hatch which indicate the forward positioning. The following illustrations show the possible sequence of events in the Vostok launch: 180-degee turnaround in orbit, retrofiring, reentry and separation (or burning up) of the annular ring, capsule ejection seat, and personal parachutes.

The launch configuration illustrated shows the long protective nose covering which gets shed in space. For an abort situation depending on the problem, velocity, direction, and altitude, the capsule could be separated by firing the rockets on the annular ring or by blowing the hatch and firing the ejection seat at 30-deg inclination. The Vostok orbital and entry sequence seems to be similar to Mercury.

The Titov film shows the periscope drift meter reverse 180 deg in orbit, indicating tail-first positioning for reentry retrofiring. Retrorockets are located in the annular ring or behind the capsule's ablation shield. The taper of the two stubby wings also indicates re-entry rearwards, that is, chest-to-back g on the cosmonaut. It is doubtful that the wings serve any purpose during re-entry. These could be useful at low altitudes during seat ejection.

Some feel that the Vostok parachute is located in the nose section. The other possibility is shown in the sketch above. By placing the parachute on top, the capsule can be landed horizontally and the cosmonaut ejected upwards. The reason for the triple parachute sequence is not clear. Reduction of capsule weight by several hundred pounds, after cosmonaut and seat ejection, may ease the problem of parachute recovery of the capsule.

Current information indicates that the Vostok-type vehicle in its present form is a one-man system. It appears that Vostok can be enlarged for multi-crew operations by adding a constant section behind the cosmonaut. In this way, the one-man capsule can be made into a two- or three-man in-tandem vehicle. This arrangement would be similar to the three-man crew tandem positioning in the B–58 jet. The escape procedure could also be similar since each cosmonaut

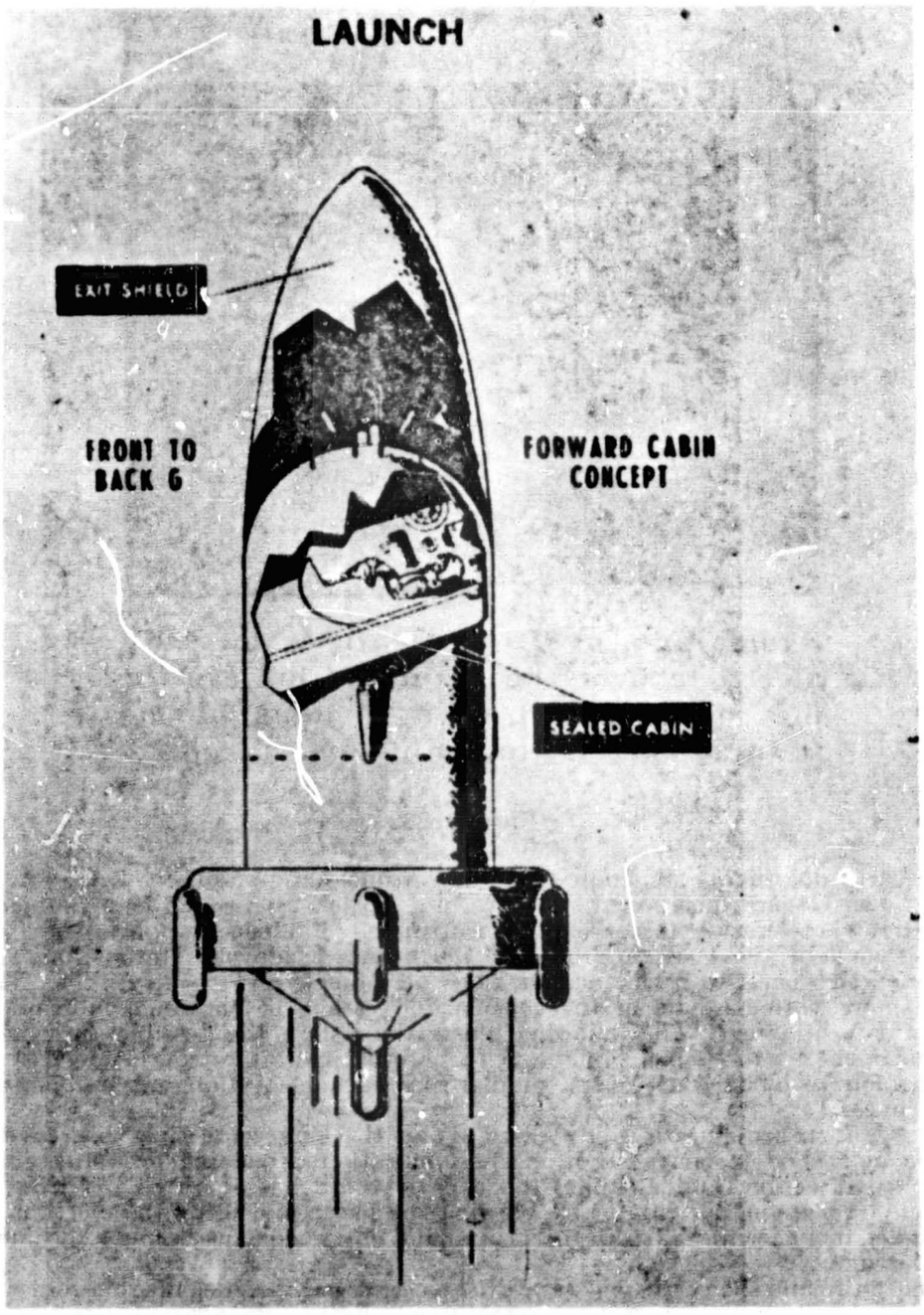


FIGURE 283

would have his own escape hatch, thus permitting multiple ejections in a predetermined sequence. The proper construction of an airlock hatch could lead to the mating of two Vostoks in a rendezvous maneuver and form a small earth-orbited space station.

Conclusion.—At this time bioastronautic activities are confined to the United States and U.S.S.R. space programs. However, international interest in bioastronautics is growing. The increasing activities by China, France, Czechoslovakia, Great Britain, Italy, Japan, Poland, Scandinavia, Switzerland, West Germany, and other countries in the related fields of biology, aeromedicine, biophysics, radiobiology, submarine, medicine, etc., are becoming more and more evident. Some of these countries can be expected to make significant contributions to basic biology and biotechnology in the years ahead and actually contribute their specialized talents to future bioflight programs.

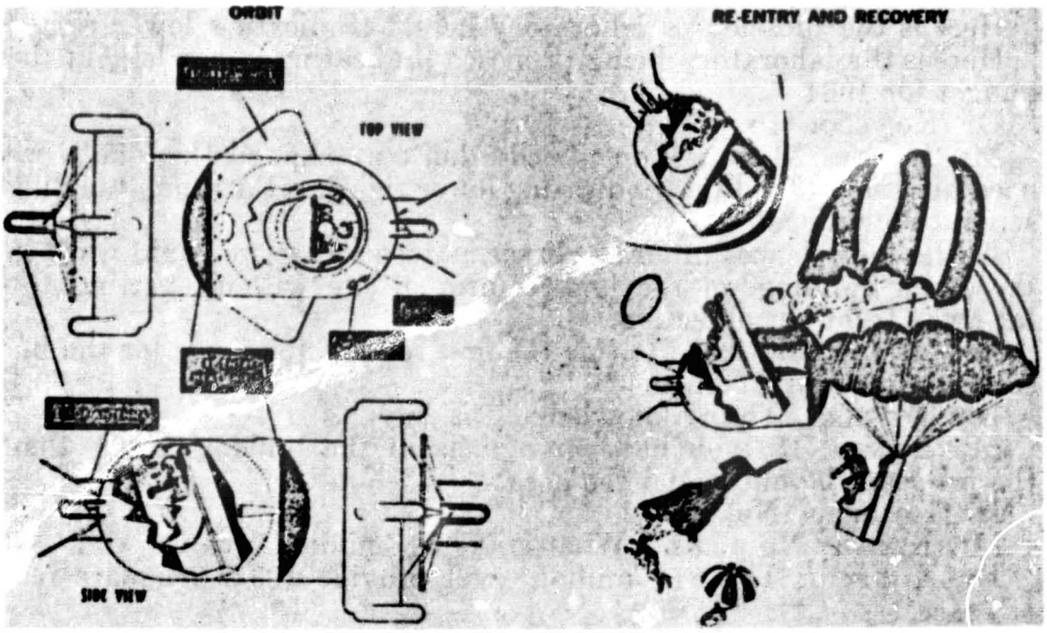


FIGURE 284

It is again important to stress the need for the exchange of scientific information on bioastronautics on an international basis. Some exchange has been accomplished. At this writing, it is anticipated this open exchange will continue during the IAF International Academy of Astronautics meeting to be held in Paris at the end of October.

Mr. KARTH. What is the biosciences laboratory doing under the OSS?

Dr. KONECCI. The biosciences laboratory is responsbile for exobiology and space biology on organisms of a lower form. They attempt to determine if there is life in space and if so how it evolved to help the scientific community to essentially answer the problem of how did life begin.

So they are basically or scientifically oriented.

We are oriented in the manned area, using animals for applied experiments with our objective to get design data to design manned aerospace vehicles.

Mr. KARTH. You mean your office uses a higher form of life than does the biosciences laboratory. Is that what you are saying?

Dr. KONECCI. Yes, sir.

Mr. KARTH. Would it be more economical and more efficient to have one laboratory and let them do both researches in the laboratory?

Why do we have to build two different buildings?

Dr. KONECCI. Sir, actually in the laboratory that's proposed, the exobiology does have a wing of the building, sir.

We will occupy three-quarters of it and they will have 21,000 square feet.

Mr. KARTH. I am only looking at the backup book and this gives us a schematic picture of the Ames Research Center and I see that—might want to turn to this page. It is ARC–5.

Mr. HAMMILL. Volume 1.

Mr. KARTH. Volume 1.

You will notice—I might just hold this up so the committee members can see it.

Here is the biosciences laboratory here. [Indicating lower right.]
Here is the laboratory being proposed [indicating upper left] in the budget for 1964.

Dr. KONECCI. I see.

Mr. KARTH. My question is, why don't we expand this one if we need additional facilities [indicating lower right], rather than building separate buildings.

In the life sciences program, it seems to me that we could work in the same building on the higher form of life without getting too far away from our objective.

Let me ask you this. Is this the first request for funds for the life sciences research laboratory?

Dr. KONECCI. To my knowledge it is, sir.

Mr. KARTH. Do you have any plans of the building other than the proposed layout that I see here?

Dr. KONECCI. No, sir.

Mr. KARTH. No plans. What is the $4½ million for?

Dr. KONECCI. The $4½ million—will provide 106,000 square feet of space.

Mr. KARTH. This for A. & E.?

Dr. KONECCI. Laboratory. The building, principally.

Mr. KARTH. You going to build a building for $4½ million?

Dr. KONECCI. Yes, sir.

Mr. KARTH. It's also going to cover architecture and engineering—or has it already been done? That's what I'm attempting to ask. Where are we? Have any funds been assigned to this building in previous fiscal years for A. & E. work?

Dr. KONECCI. I don't believe, in previous years there were—not to my knowledge, sir.

Mr. KARTH. You are asking for $4½ million to build a building, you must have the design of it, don't you? You have some kind of plans?

Dr. KONECCI. Yes, sir, the Ames Research Center does.

I thought you asked me, specifically, if we have them here.

Mr. KARTH. No, I'm asking do we have them at all.

Dr. KONECCI. Yes, we do. They have them broken down into what the facilities are, what the cost is—the cost breakdown.

Mr. KARTH. How about the electronic research laboratory, Dr. Bisplinghoff.

Can we have this kind of information on that laboratory request also?

Dr. BISPLINGHOFF. For this year, the request that we have made is for land acquisition and initial engineering studies relating to the land acquisition.

We have no breakdown related to the building complexes.

Mr. KARTH. Well, then am I to understand that we have previously funded for this kind of work for the life sciences research laboratory?

Dr. BISPLINGHOFF. Insofar as I know, the sum of money we are asking for here is the first sum of money we have requested and it will include everything—A. & E.—engineering as well as construction.

Mr. KARTH. We have some plans in this instance whereas we have no plans in the other instance.

Dr. BISPLINGHOFF. There is an A. & E. plan for this.

Mr. KARTH. How long has this project been under consideration? This has been in the planning stage for a couple of years hasn't it?

Dr. KONECCI. It's been under consideration since I joined NASA, sir. That's 9 months ago.

Mr. KARTH. Is it your general practice to have at least this much of a plan prior to the request for funds for construction or architect and engineering work?

Dr. BISPLINGHOFF. We very frequently do engineering studies with funds that are already available to us before we make such requests.

Mr. KARTH. Well, how are these funds available to you, Doctor?

Dr. BISPLINGHOFF. We have design and engineering funds that we can use.

These are small amounts of funds that we are able to use for preliminary studies of things of this kind.

Mr. KARTH. But, insofar as the electronics research laboratory is concerned, this has not been done in that case, has it?

Dr. BISPLINGHOFF. No.

Mr. RANDALL. Mr. Chairman, has it been brought out how much has been spent on preliminary design? This is the Ames Laboratory you are speaking of?

Dr. KONECCI. Yes.

Mr. KARTH. How much has been spent?

Mr. RANDALL. Yes, already for design and engineering.

Mr. KARTH. No.

Mr. RANDALL. Could you tell us?

Dr. KONECCI. I don't know the answer to the question.

Dr. BISPLINGHOFF. To my knowledge, nothing.

Mr. KARTH. Dr. Bisplinghoff's testimony has been up to this point this is kind of a general fund they use for doing predesign work and I guess this is rather generally done.

Dr. BISPLINGHOFF. Yes, there is a sum of some $8 million in last year's budget for this purpose across the whole agency.

Mr. KARTH. Yes. So whatever design work was done, was done as a result of a portion of those funds being made available.

Mr. MYERS. I think for the record, Mr. Chairman, $240,000 was transferred to Ames on February 11 of this year for this purpose going into detail design.

Mr. KARTH. February of 1963?

Mr. MYERS. Yes.

Mr. MOSHER. Mr. Chairman, was there an answer to your question—you asked when you had the map in your hands—regarding the two buildings that are widely separated?

I didn't really get the answers to whether the work down in this lower right-hand corner would be transferred to the new building or what.

Dr. KONECCI. No, sir.

Mr. MOSHER. These would be separate buildings?

Dr. KONECCI. Yes, sir.

Mr. MOSHER. I see.

Dr. KONECCI. One of the reasons for having the life sciences located where it is now, the 4.88 is to have it in the proximity of the flight simulator and I believe the land was available.

Mr. MOSHER. Mr. Chairman, could I ask another question?

Mr. KARTH. Mr. Mosher.

Mr. MOSHER. Going back to something you said 10 or 15 minutes ago, Dr. Konecci; you referred to an occasion when you had in your office, I believe, other people involved in the same type of work in DOD.

Dr. KONECCI. Yes, sir.

Mr. MOSHER. Including the Air Force people, I judge.

Dr. KONECCI. Yes, sir.

Mr. MOSHER. You explained to them your 5-year program that you are proposing?

DR. KONECCI. Yes.

Mr. MOSHER. Did you find that there was a duplication in what they have been proposing?

As a result of this conference did either of you weed out and do away with potential duplications?

Did you find they were thinking along the same line as you, so it was decided you would do it instead of they, or vice versa?

Dr. KONECCI. No, sir, in this case we were talking about the NASA program, our mission, and their capability to actually assist us with their facilities if they had the personnel. So, they have been coming to us in the last 9 months with proposals to do specific studies that they did have a capability in.

We have already funded $1.4 million and we will have about $2 million with DOD and I'm not differentiating between Navy and Air Force. Although these are the principal agencies and they have roughly half and half.

Mr. MOSHER. You think you have an efficient mechanism here by which duplicate efforts are weeded out?

Dr. KONECCI. Yes, sir.

Colonel Talbot is on assignment with General Ritland in NASA. He visits my office at least twice a week.

We have constant deliberations and he contacts the field laboratory immediately if there are any questions about any problems.

We also have Dr. Voris on my staff who is a captain in the Navy and Dr. Pollard communicates directly with us on the Navy side.

Colonel Frese is in DOD. He is an Air Force officer, but in charge of coordination of the life sciences area and he has been a frequent visitor with his staff.

Captain Pruett who is from the Navy who was just transferred into this DOD office.

Mr. STAEBLER. Mr. Chairman. May I ask you a few questions?

At the present level of information available to us in the life sciences field, what is the longest manned flight which we can safely take and in defining "safety"—let me say "with assurance"; what do we know that we can take?

Dr. KONECCI. Based on the information from Laika and the Soviet Union, I'm sure we can probably go several days, meaning 7 days.

The project Gemini is designed so we can in essence, as in the "X" airplanes, creep up on the things.

We have recall capability, so if anything happens you can come back.

The Gemini program is designed for 14 days.

We feel, however, we need data beyond this time period; that is, way beyond 30 days and as quickly as possible, so we can give this information to the designers now. I would say that within the coming

years we should have information up into the years of weightlessness because——

Mr. STAEBLER. But at the moment, 7 days or 14 days is the order of magnitude?

Dr. KONECCI. Yes, sir.

Mr. STAEBLER. Within which our present information gives us assurance we can travel.

Dr. KONECCI. Yes, sir. I think this would be a safe statement to make.

Mr. STAEBLER. Yes.

Let me ask a totally different question.

The wife of the junior Senator from my State is an aviatrix and has been deeply interested in the question of women in space travel.

Have you, as yet, encountered any information that would discourage the consideration of women as astronauts?

Dr. KONECCI. I think the answer to your question is, sir, that our purpose is to design and hope to design future systems for everybody to travel—women, children, as well as men.

I think after the initial exploration is over, we will find we do not need the highly qualified individual just to go into space.

One that could withstand the stresses and rigors of selection exercise, psychology, and so on.

In essence, what we are trying to do is determine these factors so everybody will be able to go into space.

The answer to your question is there is nothing peculiar about a woman not being able to go into space. However, we understand at the moment Mr. Webb has a policy to use qualified test pilots, as astronauts. This does not include women.

Mr. STAEBLER. This is rather a matter of convenience and priority. Simplification of the program.

Dr. KONECCI. Nothing to do with the women not being able to perform tasks.

Mr. STAEBLER. I see.

Mr. MOSHER. Equal pay with equal work.

Mr. KARTH. Proceed, Doctor.

Dr. KONECCI. Sir, actually I have one more slide (see fig. 273, p. 2429).

This was just to summarize our man system integration.

Here is where we try to apply the human factor into various advanced systems.

Actually with this slide then I would like to close.

Thank you very much.

I would just like to close it there, sir, because I think we can go into a lot of detail.

I will make these publications available to any—to yourself or any of the members of the committee.

Mr. KARTH. What publication is that, Doctor?

Dr. KONECCI. Sir, the two Soviet translations of two books, biological space biology program as well as their manned space program.

Mr. KARTH. Are there any questions.?

Mr. RANDALL. On the publications, Mr. Chairman—where do these come from? How were they made available?

Dr. KONECCI. We had an international symposium with the Soviets last November and they made the Soviet books available to us and we've had them translated.

Mr. RANDALL. Fine.

Mr. KARTH. Dr. Weaver?

Dr. WEAVER. Dr. Konecci you have the aerospace budget?

Dr. KONECCI. No, we have the human factors. That is, Dr. Roadman's.

Dr. WEAVER. All right, I'll save that question.

But your experiments, don't they come under this?

Dr. KONECCI. We are on the basic side of this and they try to apply them for specific missions.

Dr. WEAVER. I see. Thank you.

Mr. KARTH. I'd like to go off the record for a minute.

(Off the record.)

Mr. KARTH. Doctor, back on the record. I think then, we will adjourn until 10 o'clock tomorrow morning.

I'm not sure what meeting facilities we are going to have, but the staff will notify you.

Dr. BISPLINGHOFF. All right, sir.

Mr. KARTH. They will contact you sometime this afternoon. Thank you very much. The meeting is adjourned.

(Whereupon at 11:05 a.m. the committee was adjourned until April 11, 1963, at 10 a.m.)

1964 NASA AUTHORIZATION

THURSDAY, APRIL 11, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SPACE SCIENCES
AND ADVANCED RESEARCH AND TECHNOLOGY,
Washington, D.C.

The subcommittee met at 10 a.m., Hon. Joseph E. Karth (chairman of the subcommittee) presiding, in room 214–B, Longworth House Office Building.

Mr. KARTH. The meeting will be in order. Mr. Finger, I wonder if I could ask that you proceed in the same manner as the witnesses that preceded you; that is, to summarize the prepared statement that you have and use whatever visual aid you think would help tell your story.

STATEMENT OF HAROLD B. FINGER, DIRECTOR, NUCLEAR SYSTEMS OFFICE, NASA

Mr. Chairman and members of the subcommittee, the early development of nuclear energy systems and their early application in space missions is a major goal of NASA's research and development program. The space nuclear systems program involves large amounts of funds, manpower, and facilities in NASA's program and, in addition, involves substantial effort on the part of the Atomic Energy Commission. We are convinced that the high-performance potential of these systems for space propulsion and electric power generation justifies the substantial effort that we are devoting toward the early development of such systems. It is clear that if we are to perform extensive space exploration missions beyond our first manned lunar landings, it will be necessary to have available to us nuclear propulsion systems and if we are to establish large space laboratories, lunar bases, and are to travel to distant planets, we will have to rely on the availability of large nuclear electric power generating systems.

The approach that we have adopted in carrying forward this program is indicated on the first figure (R63–809). Essentially, we utilize the closest available technology in order to provide early hardware developments which are aimed at determining the feasibility of systems and at evaluating the flight problems that we will encounter when we start operating nuclear systems in the flight environment. These early developments are so designed that they will provide a growth capability for early application in operational missions. NERVA, RIFT, and SNAP–8 are projects that fall within this early development category. While we proceed with this early development program, we consider that a major and essential part of the program is a parallel and continuing advanced research and technology effort. This effort will provide the technology to support the early development program and to lead to advanced systems. It will also evaluate the feasibility of new ideas that are proposed.

Our nuclear systems program is composed of two major parts, nuclear rocket systems and nuclear electric power and propulsion systems. A large portion of these programs is a combined effort between the AEC and NASA. Responsibility for providing the required reactor research and development rests with the AEC. NASA is responsible for the nonnuclear component research and development programs as well as for the integration and application of the overall systems.

96-504 O—63—pt. 3b——26

PROGRAM PHILOSOPHY

- EARLY DEVELOPMENT
  - * USE CLOSEST AVAILABLE TECHNOLOGY
  - * DETERMINE FEASIBILITY
  - * EVALUATE FLIGHT PROBLEMS
  - * PROVIDE EARLY APPLICATION OF CONCEPTS
- ADVANCED RESEARCH AND TECHNOLOGY
  - * PROVIDE TECHNOLOGY FOR ADVANCED SYSTEMS
  - * EVALUATE FEASIBILITY OF NEW CONCEPTS
  - * SOLVE DEVELOPMENT PROBLEMS

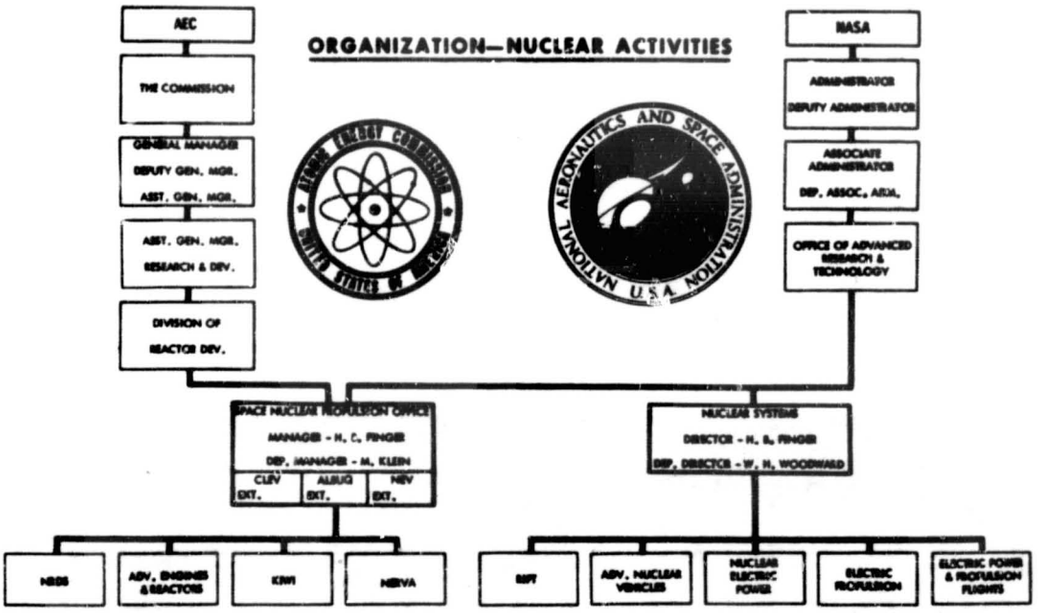
NASA R63-809

ORGANIZATION

The management organization is shown on the next figure (R63-810) and consists of two main organizational segments, the AEC NASA Space Nuclear Propulsion Office located at AEC headquarters, and the NASA Office of Nuclear Systems at NASA headquarters. It is designed to insure a single channel of coordination from NASA to the AEC on all developments of nuclear systems for space propulsion and power.

The development of nuclear rocket propulsion systems is under the management of the Space Nuclear Propulsion Office. The SNPO reports to both the AEC and NASA, is staffed by both agencies, and is considered a field office in both agencies operating with its own budget, accounting functions, technical direction, procurement authority, etc. The detailed day-to-day technical direction and contract-administration functions are handled through the three extensions of SNPO in Albuquerque, Cleveland, and Nevada. For example, the Cleveland extension directs the NERVA contract. Various phases of the work in the nuclear rocket propulsion program are conducted by Los Alamos Scientific Laboratory, Argonne National Laboratory, Aerojet-General, Westinghouse, Lewis Research Center, and other Government and industrial groups under SNPO management and direction.

The Office of Nuclear Systems operates differently from the SNPO in that it is exclusively a NASA headquarters staff organization. It is responsible for overall program planning and review, establishment of program objectives, preparation of budgets, and the review of technical decisions, configurations, contracts, and



NASA R63-810

policies established by the field center responsible for program execution. Responsibility for detailed technical direction, contract administration, procurement, etc., is carried out by the NASA Research and Space Flight Centers. For example, the Marshall Space Flight Center directs the RIFT development and the Lewis Research Center directs almost all of the work on nuclear electric power and electric propulsion. In addition to directing contract work, the responsible Center conducts an in-house research and technology effort in related areas to properly support and guide the contract project activities.

NUCLEAR ROCKETS

I would like now to discuss the status and plans of several elements of our nuclear rocket and nuclear electric power and electric propulsion programs, as well as some of the important results that have been obtained during the past year. I will start with our nuclear rocket program.

Nuclear rocket applications

Recent studies of advanced space missions have confirmed and reemphasized the importance of nuclear rocket propulsion in post-Apollo space flight. The studies have analyzed the objectives and requirements of many missions, principal among which are: (1) post-Apollo lunar logistics and personnel transport; (2) unmanned planetary and deep-space probes; and, (3) manned planetary expeditions.

The earliest impact of nuclear rocket capability is to increase the performance and useful life of the Saturn V launch vehicle. (Shown in fig. 89, p. 1904.) Dr. Bisplinghoff, in his previous testimony, has illustrated a manned Venus flyby and unmanned Mars orbit and Jupiter probe missions, which could be accomplished with this nuclear Saturn V using a NERVA-powered, RIFT-type third stage on the first two stages of the Saturn V. If a nuclear rocket is not available for these applications, we must either hasten the development of a new all-chemical launch vehicle, resort to orbital rendezvous, or cancel the missions. The early Venus flyby mentioned by Dr. Bisplinghoff would require more than one Saturn V launch if only chemical rocket stages were used.

Studies continue to indicate that the nuclear Saturn V can make a valuable contribution in the area of lunar logistics. By increasing the lunar payload by 60 to 100 percent, the nuclear Saturn V significantly reduces the number of Earth launches required to support a lunar station. It may also permit large payload items to be transported in one piece, thereby eliminating the expense and weight penalty associated with breaking the payload into small units. As a result, the usefulness of the Saturn V vehicle and its launch facilities could be extended and made adequate to carry out extensive lunar station activity.

In a manned Mars landing expedition, such as the one I have discussed at previous hearings (shown on the next figure RN63–738), there is a requirement for a high-power nuclear rocket engine (or cluster of medium-power nuclear engines) to propel the spacecraft out of Earth orbit. Later in the flight, when approaching and leaving Mars, a low power nuclear engine of the NERVA type would be desired. Mars landing expeditions require so much energy that nuclear propulsion is essential to the accomplishment of even moderately fast round trips of 400 to 450 days. For such missions, the nuclear spacecraft will weigh between one-fifth and one-tenth the weight of a chemical spacecraft.

The important conclusion to be drawn from this discussion is that there are many missions for which nuclear rockets are desirable and have such substantial, potential advantages over chemical rockets that they are necessary. I am convinced they will be used extensively as soon as they can be made available.

Nuclear rocket program elements

The nuclear rocket program is composed of several major hardware elements. The relationship of three of these elements, Kiwi, NERVA and RIFT, has been described by Dr. Bisplinghoff and is shown again in the next figure (fig. 92, p. 1906). Kiwi reactor technology will be used in the development of the NERVA reactor and engine, which will be flight tested in the RIFT stage.

Kiwi-NERVA

During 1962, two "hot" reactor experiments, Kiwi B1B and Kiwi B4A, plus a series of cold-flow reactor experiments preceding and following the Kiwi B1B tests, were run at the Nuclear Rocket Development Station in Nevada. The cold-flow experiments were conducted to gain experience in the operation of liquid-hydrogen systems at test cell A, but even more important, to obtain data necessary to establish operating conditions during startup for the hot-reactor tests. All of these tests were conducted by the Los Alamos Scientific Laboratory as part of its responsibility for the Kiwi work.

The Kiwi B1B reactor, shown on the next figure (fig. 289, p. 2483), was tested on September 1, 1962, using liquid hydrogen for the first time in any power test. The basic findings were discussed by Dr. Norris Bradbury, the Director of the Los Alamos Scientific Laboratory, in his testimony before the Subcommittee on

Research, Development, and Radiation of the Joint Committee on Atomic Energy on September 13, 1962. In summary, the two principal results were: (1) Kiwi reactors can be started up on liquid hydrogen without difficulty from a neutronic and controllability point of view; and, (2) portions of the fuel elements in Kiwi B1B were broken and ejected from the reactor at about 60 percent of the power objective set for that test. The conclusion arrived at from the test, one which was largely anticipated prior to the test based on previous test experience, was that the Kiwi B1 core design is not a promising design for application in a nuclear rocket reactor. I must add, however, that we still do not completely understand the failures observed in the Kiwi B1B test. Efforts are continuing toward explaining the results more completely since an understanding of all results is, I believe, essential in the development of such a new technology.

The Kiwi B4 reactor power test was conducted on November 30, 1962. The next figure (fig. 290, p. 2483) illustrates the test setup. Although this reactor looks very similar to the Kiwi B1B reactor shown on the previous figure, the internal design is substantially different. This Kiwi B4 design has been and still is favored for early NERVA application. This November test was intended primarily to examine this design and to provide additional data on liquid hydrogen startup. The test was cut short when flashes were observed in the exhaust jet with increasing frequency.

The following short film clip taken during the test in real time will indicate what we mean by the occurrence of these flashes. [Movie.] Even though the reactor continued to operate and control room diagnostics indicated no obvious problems, it was felt that an orderly shutdown and examination of the reactor would reveal information about the core design and operation that might otherwise be lost.

Data now available from that test tend to confirm previous information that the reactor system can be started up on liquid hydrogen; however, detailed post-mortem examination has shown extensive damage to the reactor core with most of the fuel elements broken. It appears that this damage was the result of mechanical vibration within the reactor. Although the source and mechanism of vibration can only be hypothesized at this time, the problem appears to be associated with engineering design matters that should be susceptible to solution and do not constitute a question of basic fundamental feasibility.

In arriving at a solution to problems that have been encountered, the Los Alamos Scientific Laboratory and the NERVA contractors, Westinghouse Astronuclear Laboratory and Aerojet-General are working closely together on design corrections. In addition, I have directed that a thorough program of design analysis and experimental evaluation be conducted before further reactor power tests are conducted. This design evaluation will take the form of extensive materials, component, subassembly, and full reactor tests under various simulated flow, temperature, stress, and vibration conditions. I am convinced that only through an extremely thorough evaluation and test program of this type can a successful reactor system be developed. In such a program, integral reactor power tests become a logical part of the development aimed at evaluating the design and operating characteristics of the reactor under conditions that cannot be fully simulated in other types of tests.

Although much has been learned in the integral reactor power tests that have been run to date, it is apparent that a much more thorough design and test program is required to develop this extremely complicated mechanical equipment with sufficient reliability to assure that the system can be used in flight systems. Only through such a comprehensive program will a true understanding of nuclear rocket reactors and their range of operating parameters be fully developed. Westinghouse and Los Alamos are, therefore, conducting the necessary redesign work and initiating the necessary test effort to arrive at a system that is as well evaluated as possible and, therefore, ready for power testing.

In addition to our Kiwi B4 and NERVA reactor design and test work, we are considering alternate graphite reactor designs to serve as back-ups in the event the Kiwi B4 type of design does not work out as well as is now hoped. I will discuss under our advanced research and technology program, work we are also conducting aimed at the development of the technology of metallic reactor systems in the event the graphite systems have an inherent fault which is not now apparent.

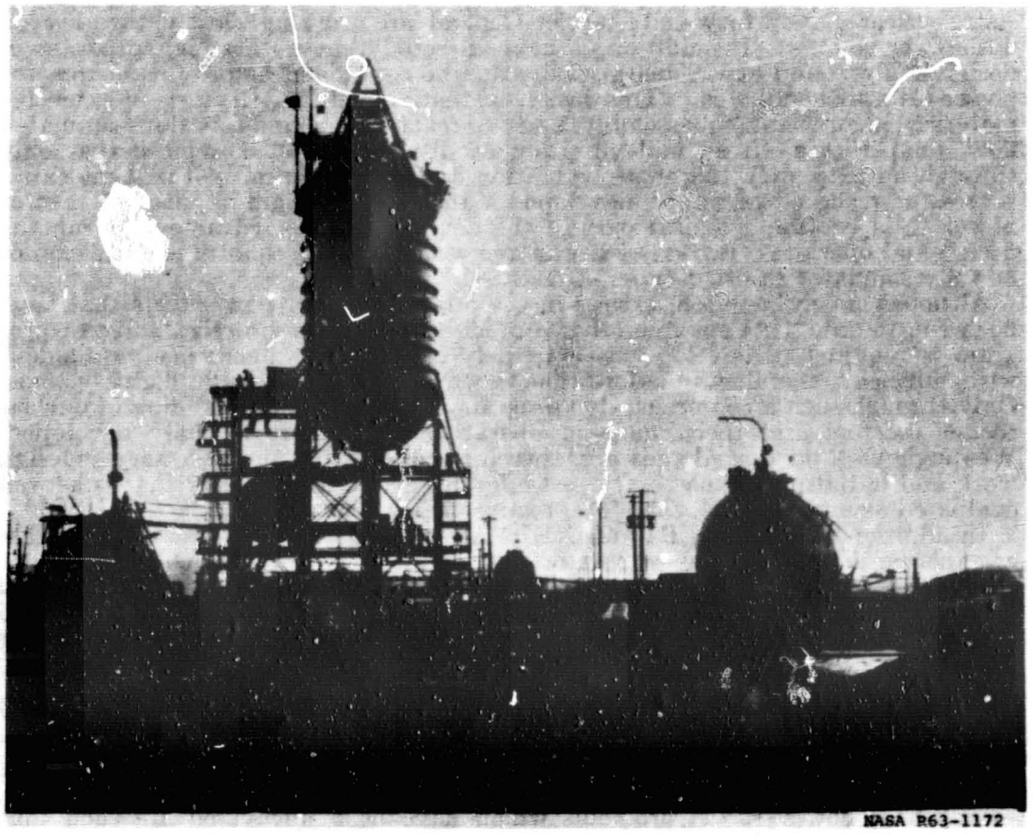
The Kiwi reactor tests were intended to establish the fundamental feasibility of nuclear rockets based on graphite fuel elements and graphite core components and to establish a basic reactor design susceptible to flight engineering development by the NERVA industrial team. The feasibility has been, in general, established; however, the problems which have been uncovered are such that

heavy effort in engineering disciplines available to us within the industrial team is essential. This effort is of the type I have just described. Westinghouse Astronuclear Laboratory, the principal subcontractor to our NERVA engine contractor, Aerojet-General Corp., has been directed to proceed with the necessary engineering effort to fulfill this need. Although the groundwork was already laid in the NERVA contract, the Westinghouse and Aerojet-General efforts are being expanded along these lines. Los Alamos will continue to work on Kiwi B4 through the next Kiwi power testing in the early part of next year. The laboratory will then continue to provide research support and information to NERVA and it will proceed with its pioneering work aimed at more advanced systems.

Prior to the Kiwi-B4A test, several power tests of Kiwi-B4 type reactors had been planned during the first half of 1963. Because of the results of that test, no such power tests will be conducted in that period. It will take at least that long before a reactor can be made ready with design modifications indicated by that test and subsequent analyses, including the necessary prerequisite design support experiments. Component tests and cold-flow integral reactor tests will, however, be conducted during this time as part of our expanded design evaluation program. The new schedule has not as of this date been firmly set, but it is clear that the next power tests will not occur until late this year, at the earliest. It is possible, however, that our component and subassembly testing will reveal problems that will result in a delay of power testing into next year.

Although, as Dr. Seamans and Dr. Bisplinghoff have already pointed out, we are not undertaking the heavy procurement and development of major hardware until we have demonstrated that we are well along toward establishment of a reactor suitable for NERVA engine application, we are conducting research and technological development in those critical areas of the NERVA and RIFT programs that require long leadtimes and that may have major effects on the design and operation of nuclear rocket systems. We have been operating the program under such a guideline during the past year. Our fiscal year 1964 budget request is planned on that same basis.

In the NERVA program, for example, we are conducting overall engine design and systems analysis based on the results of testing of individual components. Much of this work is being done at the Aerojet-General Liquid Rocket Plant in Sacramento in the facilities shown on the next figure (R63-1172). Aerojet-

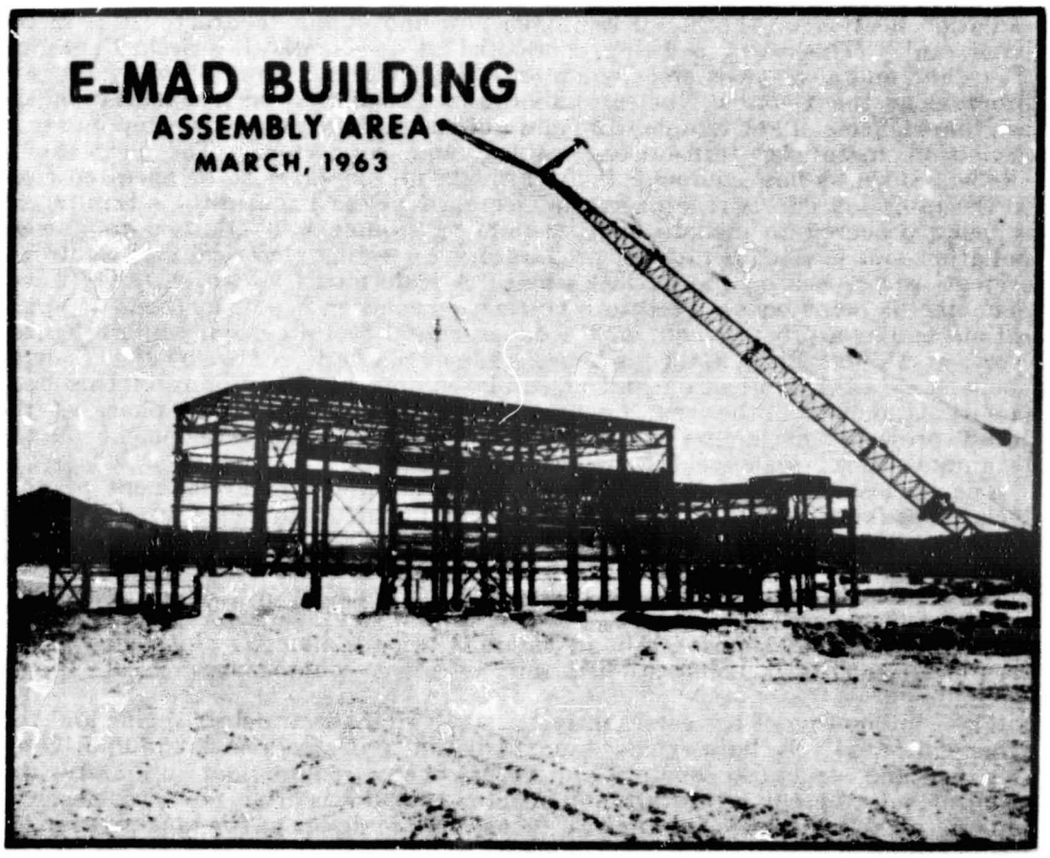


NASA R63-1172

General has conducted several tests in these facilities and additional hardware and tests are now being prepared for a cold-flow development test system which will incorporate the major engine components including a simulated reactor core to evaluate the control requirements during the crucial startup phase of a nuclear rocket engine.

In addition to controls, the effects of radiation on the nonnuclear components of an engine and vehicle system provides a new environmental condition that must must be sustained by these components. We have reached an agreement with the Air Force under which the Space Nuclear Propulsion Office will utilize the Fort Worth nuclear aerospace research facilities, operated by General Dynamics, to develop components under the radiation conditions that would be experienced in a NERVA engine. Testing is already underway in this facility and we will, during this year, design and construct additions and modifications to this facility to allow for simulation of engine conditions on major flow components, such as the turbopump.

Reactor testing, simulator testing, and component testing are, of course, all parts of the development program culminating in operation of integrated engine systems at the Nuclear Rocket Development Station in Nevada. Our first engine test stand shown in the next figure (fig. 292, p. —) is well along in construction. The instrumentation and control system is being designed. Development is still being conducted on a major portion of that stand—the exhaust duct system required to carry the exhaust gases leaving the engine nozzle away from the test stand. After power tests in Nevada, when the engine is radioactive, disassembly, examination, and maintenance will have to be done remotely in our Engine Maintenance Assembly and Disassembly Building (E–Mad), the construction status of which is shown on the next figure (R63–530). The steel framing shown here is for the assembly area in which radioactively clean engines would be assembled. The disassembly area will be located in the foreground, with delivery of hot engines to the disassembly area being accomplished by remotely controlled railroad cars. This hot disassembly area will have 6-foot thick concrete walls to provide adequate shielding for personnel operating the remote manipu-



lator equipment. Additional facilities are requested in the budget before the committee to satisfy NERVA requirements at the Nuclear Rocket Development Station.

RIFT

As mentioned previously, the primary purpose of the RIFT project is to flight test the NERVA propulsion system in a configuration that would lead logically to its eventual development to operational status as a third stage on the Saturn V vehicle. This project is being conducted by the Lockheed Missiles & Space Co. under the direction of the Marshall Space Flight Center.

Our concept of the RIFT stage is shown on the next figure (fig. 294, p. 2501). It will be 33 feet in diameter, the same diameter as the Saturn V vehicle. From the interstage separation plane to the top of the stage, it will stand approximately 80 feet tall. With the required flight nose cone added, the total height of the stage will be in excess of 125 feet.

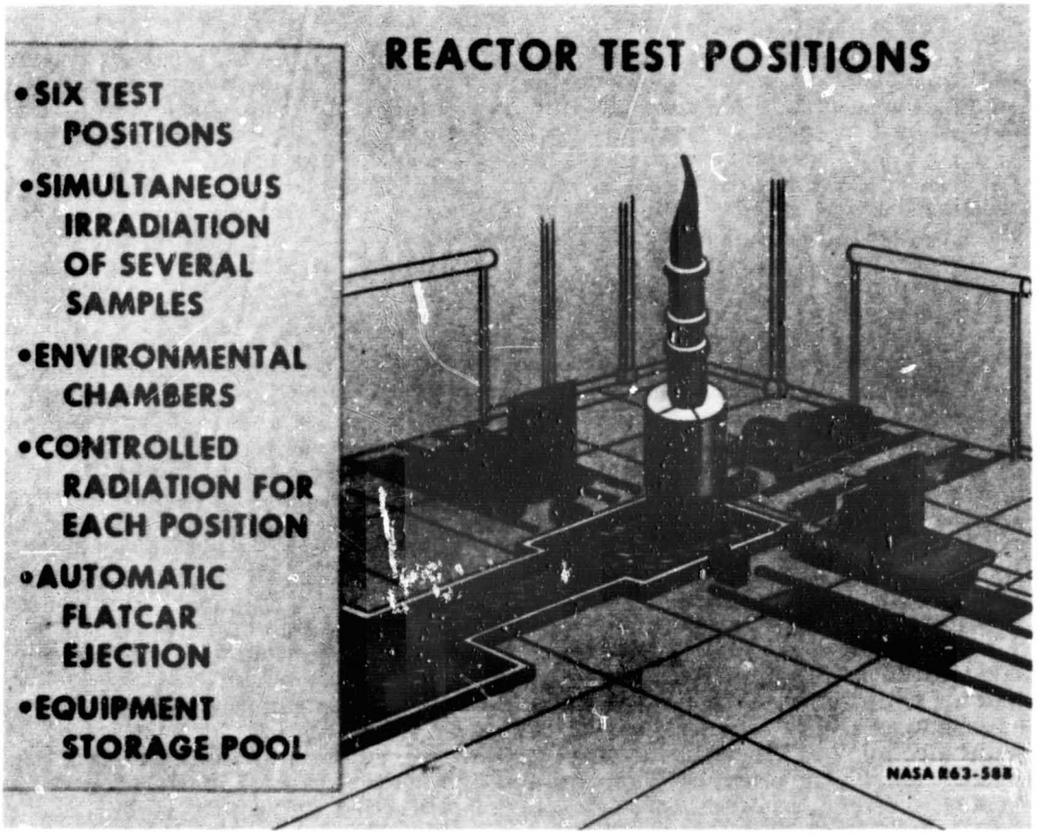
Flight tests will be conducted utilizing the Saturn V launch complex at the Atlantic Missile Range in a trajectory similar to the one shown on the next figure (fig. 295, p. 2502). The flights will be conducted with the RIFT stage mounted on top of the Saturn V first stage using a dummy S–II second stage to obtain the proper acceleration conditions. The flights will be over a carefully controlled, limited range, lob trajectory having a range of about 1,300 miles.

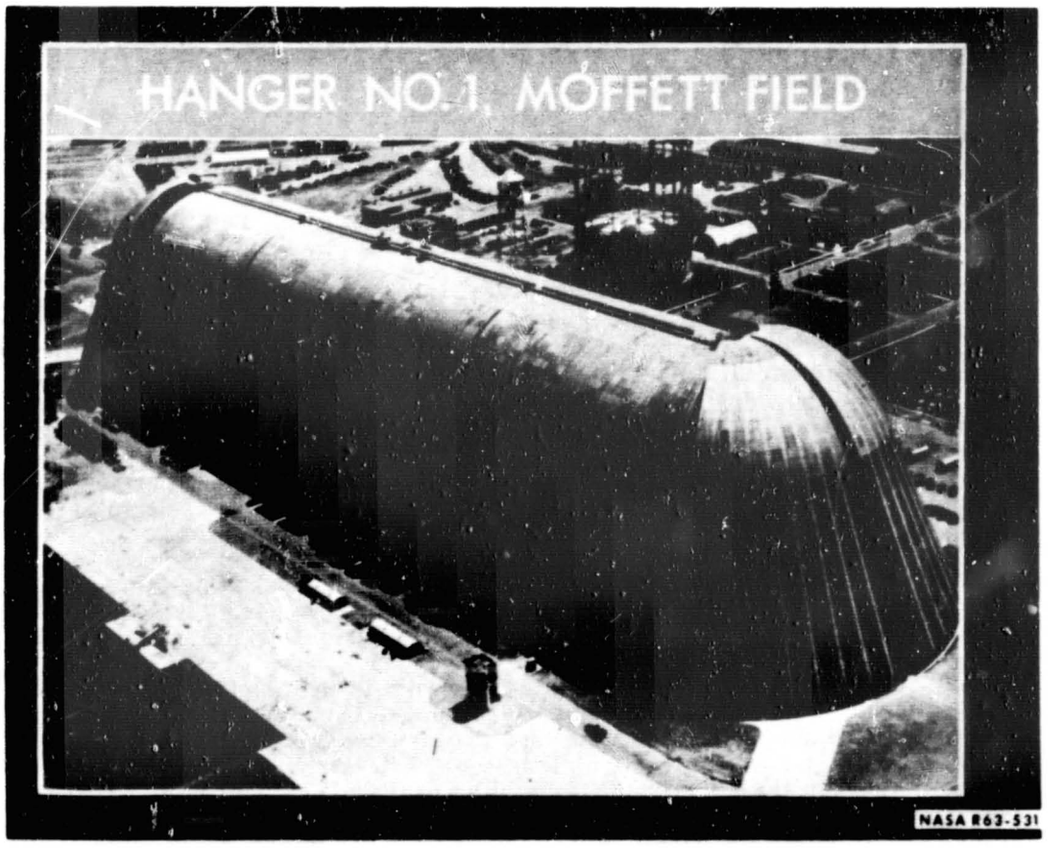
The implementation of the hardware aspects of the RIFT project is paced by the Kiwi and NERVA programs. At this time, therefore, we are concentrating on a research and technology program that will provide the data required for solution of many of the technical problems associated with RIFT and nuclear rocket vehicles, in general.

There exist numerous areas that require concentrated research effort if solutions are to be available for nuclear vehicles. The RIFT stage will require one of the largest flight tanks ever constructed for liquid hydrogen. The combined effects of low temperatures resulting from the use of liquid hydrogen, and the nuclear radiation generated by the reactor in the NERVA engine on the materials, structures, insulations, propellants, etc., represent problem areas where research is now underway. Research effort is also concentrated on determining the effect of radiation heating on the liquid hydrogen flow and storage characteristics in the large tank. This work is being conducted at the Lewis Research Center in Cleveland and also at General Dynamics in Fort Worth. In addition, work is in progress at the Georgia Nuclear Laboratory (Lockheed) near Atlanta on the combined effects of low temperature and nuclear radiation on such components as insulation materials, transducers, cables, and connectors. The next figure (R63–588) shows how components are brought up on dollies to be operated close to the radiation effects reactor at the Georgia Nuclear Laboratory. Equipment is being procured to include high vacuum environment in addition to nuclear radiation and low temperatures, preparatory to testing electrical and electronic systems to be used on the nuclear stage. A scale model hydrogen tank (9 feet diameter) is being constructed to investigate insulation types, methods of application, and as a proof vehicle for the experimental tool program. Blimp hangar No. 1 at Moffett Field, Calif., is being made available to NASA by the Navy to house stage tank fabrication and assembly equipment. A picture of this huge facility is shown in the next figure (R63–531). In the current phase of the RIFT project, this facility will be used for research and development on the techniques of full-scale welding, inspection, and testing.

The nuclear flight safety requirements will require the development of new techniques for checkout, launch operations and destruct systems in addition to those that are already provided for range and flight safety in nonnuclear applications. The special talents of 27 Government laboratories, industrial companies, and educational institutions are utilized in solving the anticipated problems. These problems exist not only in the area of launch and flight, but also are a factor during shipment and during ground handling prior to launch. Identification of credible accidents is being studied and effective countermeasures are being devised.

The combination of the comparatively heavy gimballed nuclear engine and the large, but relatively lightweight, tank of liquid hydrogen present unique aerodynamic and structural loadings and thrust vector requirements. Finally, the requirements for engine restart and reactor cool down after power cycles will impose additional factors that must be considered in design of the tank pressurization, venting, and particularly the guidance and control.


REACTOR TEST POSITIONS
•SIX TEST POSITIONS
•SIMULTANEOUS IRRADIATION OF SEVERAL SAMPLES
•ENVIRONMENTAL CHAMBERS
•CONTROLLED RADIATION FOR EACH POSITION
•AUTOMATIC FLATCAR EJECTION
•EQUIPMENT STORAGE POOL
NASA R63-588


HANGER NO. 1, MOFFETT FIELD
NASA R62-531

Summary of Kiwi-NERVA-RIFT

The next figure (fig. 296, p. 2503) summarizes the Kiwi-NERVA-RIFT timing and phasing. Six reactor power experiments have been conducted in the Kiwi program by the Los Alamos Scientific Laboratory. Information from all of the Los Alamos reactor experiment and laboratory work on materials, neutronics, heat transfer has been transmitted through reports and close working relations to the NERVA contractors. Work at Los Alamos aimed at correcting the deficiencies of the Kiwi B4 design will be continued through the next power test. At that time, the Kiwi program will phase out and Los Alamos will take on increasing emphasis on research and technological development aimed at supporting and advancing the NERVA effort and aimed at advanced nuclear rocket reactor systems based principally on graphite.

The NERVA contractors have been directed to proceed to design, procurement, and test effort aimed at the development of NERVA reactors based on the Kiwi B4 design and utilizing information already available at Los Alamos as well as additional information that will be developed by the NERVA contractors and Los Alamos. Our preliminary planning has indicated the possibility of a NERVA reactor test late this year at the very earliest. Kiwi power testing will not be accomplished until early next year. It is, of course, important to point out that the extensive component and subassembly as well as integral test work that will be done on these reactors as part of our extensive design evaluation effort may reveal new problems that will require solution before power tests may be conducted. In effect, we have established parallel, but closely coordinated reactor development programs, one being conducted by Los Alamos through the next Kiwi B4 test, and the other being conducted by Westinghouse and Aerojet-General as a continuing program aimed at the development of the NERVA reactor and engine. When a reactor is available and engine tests have indicated sufficient reliability that stage power testing may be initiated, the NERVA engine will be coupled with the RIFT stage to start the program of stage static testing in Nevada. Our program planning and more importantly our reactor design evaluation, redesign, and test effort has not proceeded sufficiently at this time to be able to estimate confidently or even reasonably the timing of first flights of the RIFT vehicle.

Advanced research and technology

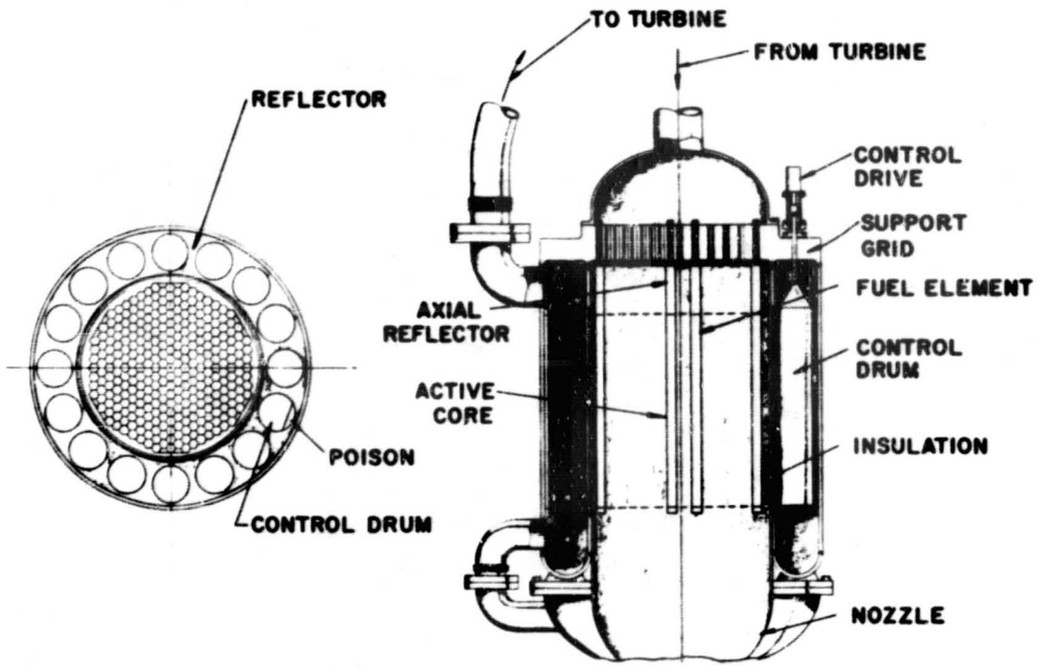
As I indicated at the outset, in addition to our early development projects such as NERVA and RIFT, we consider it essential to conduct an active advanced research and technology effort, paralleling the development effort. This is especially important because the nuclear rocket program is a long-term effort leading to the evolution of operational propulsion systems for all types of future space missions. In addition to the development of a particular system, our program must provide for this new technology and for this whole new field of rocketry a base of research information to permit us to satisfy future requirements when they are stated.

I will discuss four areas in our advanced research and technology program: (1) The follow-on graphite reactor program, commonly called Phoebus; (2) the metallic-reactor program; (3) nonnuclear engine component and systems work; and, (4) the investigation of advanced concepts, such as the gaseous-core reactor, which have the potential of large increases in performance.

The basis for the Phoebus reactor program is the clear need for higher power propulsion systems in manned interplanetary flight. The program will be directed by the Los Alamos Scientific Laboratory toward the design of graphite reactors many times higher in power than Kiwi and NERVA. The target power level has not been set, but is an object of mission studies and investigations of the feasibility of clustering nuclear rocket engines. The Phoebus program will consist of an intensive series of basic material and neutronic analyses, component and subassembly tests, leading eventually to full reactor power tests. New or modified ground test facilities will be required for the high power reactor tests and we are now, under the AEC part of our program, starting conceptual studies of such reactor facilities.

In addition to the graphite-reactor program, work is also underway to establish the technology of metallic fuel element reactors. The objective is to achieve reactors of long life and possibly improved restart capability. Both the Argonne National Laboratory of the AEC and the Lewis Research Center of NASA are engaged in analytical and experimental studies of promising concepts. Although tungsten is the preferred metal for the fuel elements, two basic types of reactors are under consideration. One is a fast reactor which requires no moderator in the core; the other is a thermal reactor using water as the moderating material.

The next figure (296a) illustrates the configuration of a fast reactor for nuclear rocket application. The core consists of a bundle of fuel elements made of a high-temperature metal loaded with fissionable material. A reflector surrounds the core and contains the control drums. The hydrogen flow path is similar to that in a graphite reactor—the hydrogen cools the nozzle and reflector, drives the turbine in the propellant feed system, and, finally, passes through the core where it is heated to a high temperature. A principal feature of the fast reactor is that the core consists solely of fuel elements.



FAST REACTOR CONCEPT

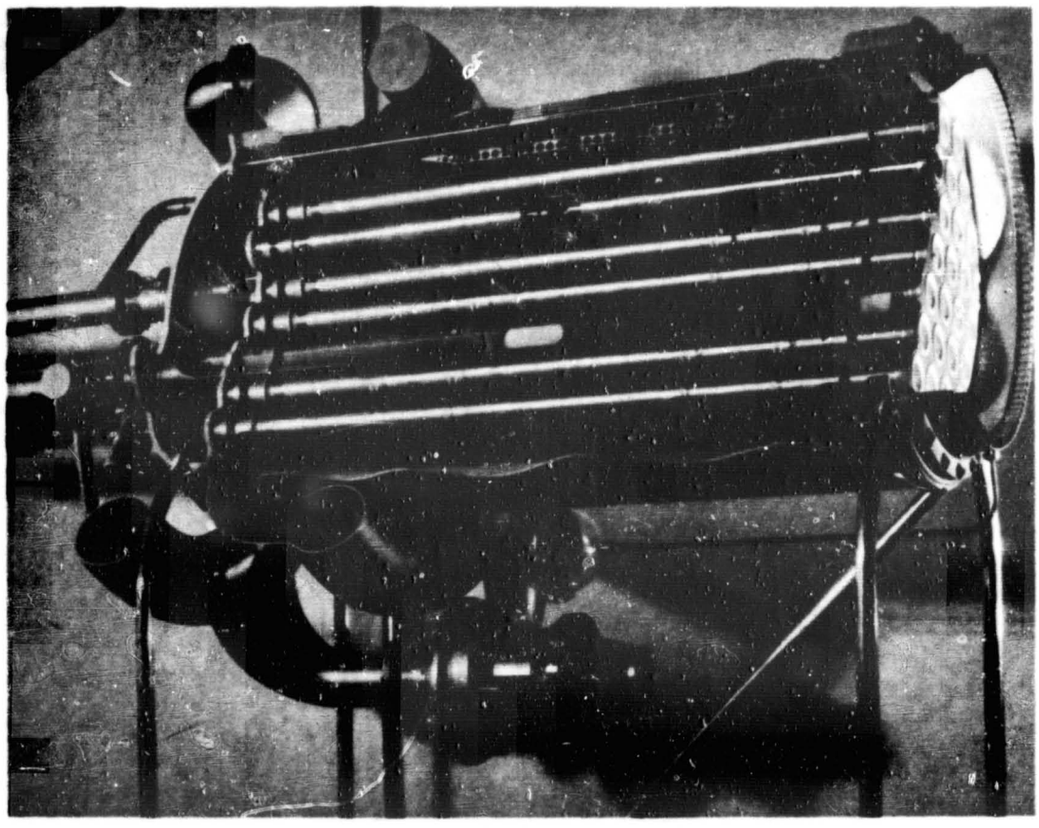
FIGURE 296a

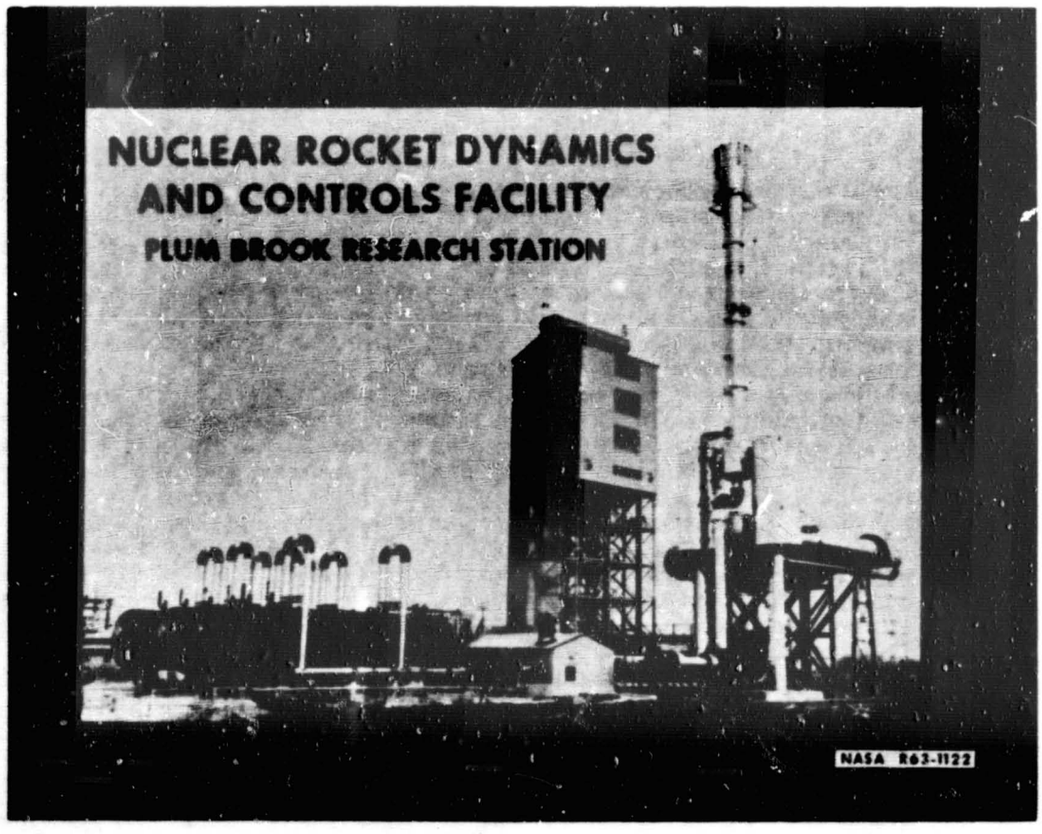
The thermal reactor concept, illustrated by the model shown in the next figure (CS–24889), has a core composed of individual fuel-element assemblies dispersed in a tank of water. The hydrogen flow path is the same as that described for the fast reactor except that a heat exchanger is located in the reflector region to transfer heat from the water moderator to the cold hydrogen. By means of this heat exchanger and a judicious use of insulation, the moderator and core structure can theoretically be maintained at low temperature while the adjacent fuel elements operate at extremely high temperatures.

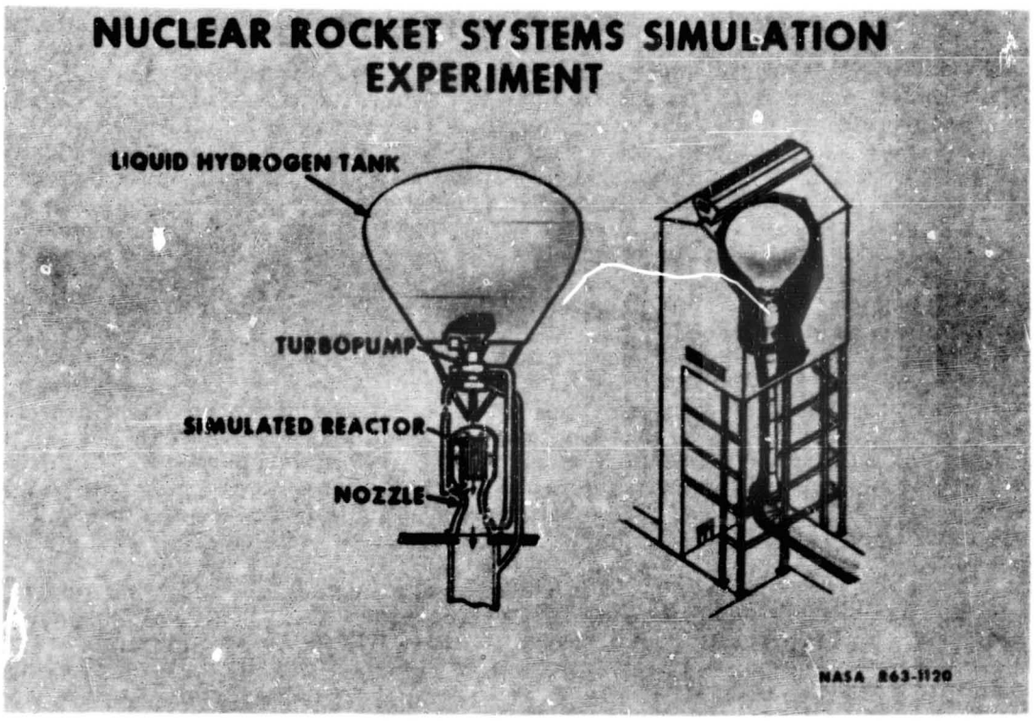
The metallic-reactor program will concentrate first on establishing the basic technology of metallic fuel elements and reactors of the proposed types. Later detailed design and reactor-test efforts will depend upon the results of the preliminary investigations aimed at solving major questions and accumulating necessary design information.

Advanced work on non-nuclear engine components is being conducted primarily in the experimental facilities of the Lewis Research Center. Two engine stands, such as the one shown on the next figure (R63–1122), will investigate system dynamics and controls. A schematic description of the equipment in this facility is shown on the next figure (R63–1120). Tests of simulated reactors in an engine configuration will give important engine systems understanding that will help us in the NERVA program and, because the first tests will be with a Kiwi B1 simulated reactor, we may be able to get some understanding of the reasons for failure in that reactor that I discussed earlier.

Experiments in the Plum Brook reactor facility will determine the radiation effects on control actuators and materials at cryogenic temperatures. The materials test setup was started sometime ago and is now being installed in the reactor. The hot-hydrogen test stand, approved in last year's budget, at Plum Brook will




NUCLEAR ROCKET DYNAMICS
AND CONTROLS FACILITY
PLUM BROOK RESEARCH STATION
NASA R63-1122



be used to study the cooling and performance of nuclear rocket nozzles. Work is also underway on nozzles made of refractory materials, seeking satisfactory manufacturing methods and knowledge of cooling characteristics. Problems of bearings in the combined space and nuclear environment are another part of the program. Investigations of radiation heating in the liquid hydrogen propellant tank are being made both in-house and at General Dynamics in Fort Worth. Another important, continuing project is the determination of hydrogen properties, being handled by the National Bureau of Standards at Boulder, Colo.

The fourth category of the advanced technology program is concerned with new concepts of nuclear rocket propulsion, chief among which is the gaseous-core reactor. Several schemes appear to have potential for containing fissioning uranium gas in a cavity reactor while transferring heat to a flow of hydrogen propellant. The goal for the gaseous-core reactor is to combine high specific impulse and high thrust without excessive loss of uranium. Many complex research problems in the areas of fluid flow and heat transfer are occupying the efforts of the investigators in this field. One concept is under study at the Lewis Research Center; another is being analyzed at the Jet Propulsion Laboratory. We are also watching closely the Air Force sponsored project at the United Aircraft Research Laboratories. The hope is that some such device will eventually prove successful and lead to a large improvement in our capabilities for space travel.

It is apparent, I believe, that the effort on nuclear rockets is a substantial one, justified by the potential performance capability and wide applicability of these systems for difficult space missions. We believe that the program we are pursuing is a logical one and includes the sort of work that is essential in assuring that this technology is available at the earliest possible time. Our emphasis continues to be on the solution of reactor problems and on work aimed at establishing a base needed to perform development of alternate reactor ideas. In addition, work is being done in important nonnuclear areas required in these systems to assure that the technology will be available.

NUCLEAR ELECTRIC POWER AND ELECTRIC PROPULSION

I would like now to proceed with a discussion of our nuclear electric power and electric propulsion programs. The NASA nuclear electric system program is composed of two major segments, the electric power generation program which is aimed at converting nuclear energy into electric power for space applications, and the electric rocket engine program which is aimed at converting electric power into thrust. Both programs include system development as well as research and technology projects.

A typical nuclear electric power generation system is composed of a reactor and its associated equipment; e.g., shielding, and a power conversion system for converting the thermal energy producing in the reactor into electrical power. Anticipated power levels range from the few kilowatts or less needed to operate spacecraft life support systems, communications systems and instrumentation systems; etc., to the megawatts we calculate we will need to power large electric rocket engines in electrically propelled spacecraft. In general, power levels in the range below 1 kilowatt can be furnished by radioisotope sources. In the range above tens of kilowatts, reactor powered systems offer advantages over other power sources and for megawatts of power appear to be the only feasible space systems.

A typical electric rocket engine is composed of a thrust chamber (or accelerator), propellant storage and feed system and a power conditioning and control system. Anticipated applications for electric rocket engines include spacecraft attitude control, station keeping, and primary propulsion in space. These applications cover a range of size from very small (0.01 pound of thrust) units suitable for attitude control systems to the very large (30 pounds of thrust) engines suitable for propelling manned interplanetary spacecraft. While the spacecraft propulsion system engines are dependent upon nuclear energy as the only practical source of electrical power, the attitude control engines mentioned above require only a few hundred watts and can be driven by solar-powered electrical generation systems.

The next figure (fig. 297, p. 2505) lists the technical goals and major elements of the nuclear electric power and electric engine programs. I have already mentioned the power program goal of watts to megawatts to meet potential or anticipated needs. The power program goal of 10 pounds of weight for each electrical kilowatt produced is specified primarily by electric rocket engine requirements. Such low weights are necessary to permit electrically propelled spacecraft to deliver high payloads in short-trip times. While such a low specific weight is extremely desirable, it is not a prerequisite to practical utilization for onboard power applications such as communications, data acquisition, life support, etc. For example, low power systems such as the 50-watt isotope system being considered for the NASA interplanetary monitoring probe (IMP) and the 3-watt systems now operating in the Transit 4A and 4B satellites, have specific weights in excess of 1,000 pounds per kilowatt. For comparison, the current SNAP–8 reactor-powered, electric generation system under development by NASA and the AEC has a specific weight in excess of 100 pounds per kilowatt. However, this specific weight, together with its higher power, 30 kilowatts or more, will probably make it most attractive for use in large vehicles such as a 200,000-pound manned orbiting laboratory, where it would be a small part of the total spacecraft weight, thereby permitting some compromises in specific weight in the interest of availability and reliability.

The need for a power program goal of long life is readily apparent and we speak in terms of years for this goal. It is important to note that we mean a maintenance-free life of years, since it will be difficult, if not impossible, to perform maintenance or repair operations of a major nature on nuclear equipment in space. This requirement for reliable operation over periods of years without maintenance has not existed for any other kind of system and, in itself, will require long, thorough, and possibly unique approaches to development not yet fully available.

The goals of the electric thrust engine program are high efficiency, long life, and a wide range of thrust. The goal of high efficiency results from the fact that for a given thrust and impulse, engine efficiency determines the amount of electric power needed and, hence, the weight of the power generation system. Since the power generation system weight is many times that of an electric rocket engine, engine efficiency turns out to be of great importance. The goal of long life is again expressed in terms of years and is specified primarily by the low thrust-to-weight ratios (10^{-4} to 10^{-5}) developed by electric rocket propulsion systems. These low thrust-to-weight ratios result in low vehicle accelerations. Therefore, long operating times are needed to reach the required vehicle mission velocity. Typically, a Mars round-trip mission may take 2 years. For most of this time, the electric rocket engine will be in operation. The need for engines developing a wide range of thrust is specified by anticipated requirements ranging from the low-thrust attitude control engines to high-thrust engines for interplanetary spacecraft propulsion.

ELECTRIC POWER GENERATION PROGRAM

I would like now to discuss each of the program elements which are shown in this figure (fig. 297, p. 2505). The power program is composed of the SNAP–8 development project, the SNAP–8 flight evaluation project, an advanced research and technology project, and a liquid metal, zero-gravity flight project (MECA). Here again, is the program philosophy that I discussed earlier. SNAP–8 represents our early development effort. Paralleling that development, we have the advanced research and technology effort aimed at supporting SNAP–8 and paving the way for development of advanced systems that cannot now be undertaken because of a lack of knowledge and technology.

SNAP–8 development project

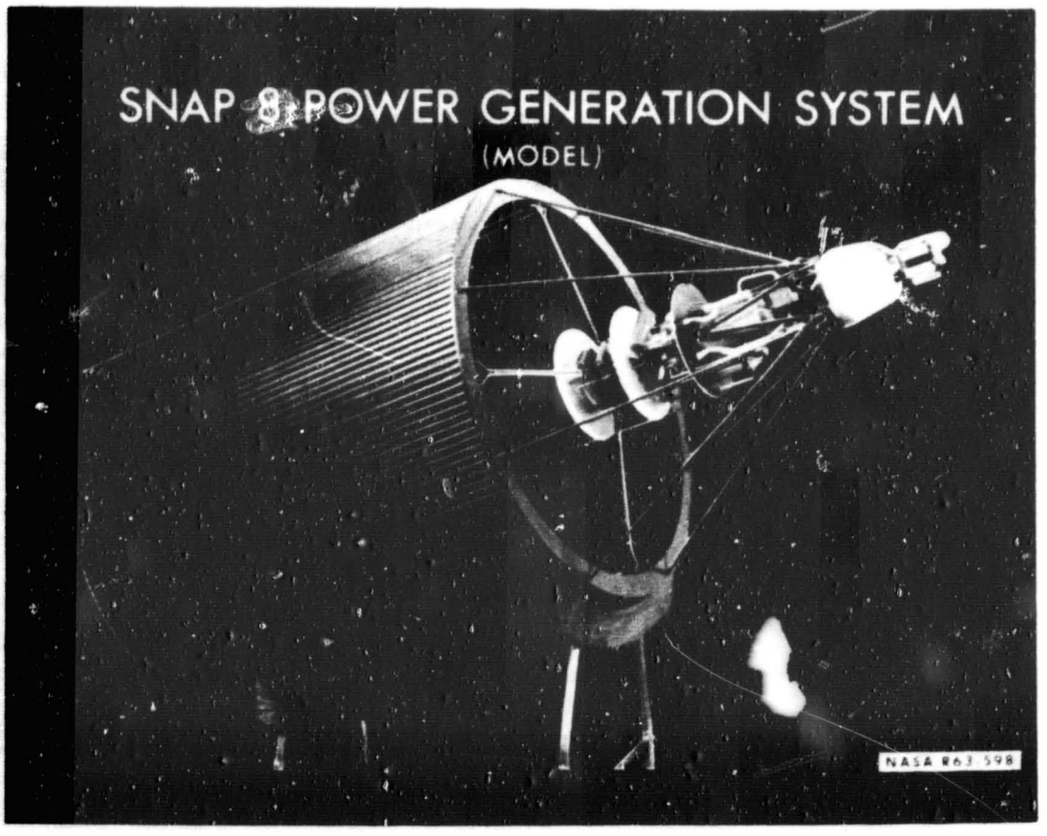
The SNAP–8 electric power generation system is a 30-kilowatt, reactor-powered system for space applications. Development was initiated by NASA in 1960 at the Aerojet-General Corp. The reactor for SNAP–8 is being developed by Atomics International under AEC contract. The SNAP–8 system design made use of as much common SNAP–2 and SNAP–10A technology as possible in the interests of time and economy. For example, much of the reactor technology is common to all three systems. The SNAP–2 and SNAP–8 use mercury as the working fluid, and the SNAP–2 and SNAP–8 turbine shaft bearings were of the same type. During last year, it became apparent that the slightly higher operating temperatures and higher power levels of the SNAP–8 system, over the SNAP–2, were posing problems that might not be readily solved. For example, serious difficulties were being experienced in developing suitable means for protecting the generator windings against attack by the mercury working fluid. Difficulties were also being encountered in the design and test of liquid metal lubricated sleeve bearings.

A detailed design review was therefore initiated by the Lewis Research Center in its role as technical director of the project. The contractor personnel and Lewis Research Center personnel participated in the design review. By December 1962, a redesign had been outlined and approved in principle. The final design has now been agreed upon and Aerojet-General is proceeding with its development.

The next figure (fig. 101, p. 1926) is a schematic diagram of the present SNAP–8 design. As mentioned earlier by Dr. Bisplinghoff, it consists of a nuclear subsystem and a power conversion subsystem. The nuclear subsystem generates heat. The power subsystem converts this heat to electrical power. Heat energy generated in the reactor is transferred to the boiler by circulating a mixture of sodium and potassium (NaK) in the first loop. Mercury vapor formed in the boiler passes through a turbine which extracts sufficient energy to drive the generator. The mercury vapor is then condensed in a compact condenser and the liquefied mercury is pumped back to the boiler to repeat the cycle. The energy released by the liquefaction of the mercury in the condenser is removed by a cooling fluid in this third loop, and radiated to space by the radiator.

The changes in system design include: (1) The addition of a third loop to permit the use of the more stable, compact condenser and a single-phase (all liquid) radiator; (2) the use of available antifriction bearings instead of undeveloped hydrodynamic or sleeve bearings for all rotating shafts; (3) the selection of a more corrosion resistant alloy for the mercury-containing pipes; and, (4) the provision of a fourth low temperature (250° F.) loop (not shown in the figure) to provide cooling for the alternator and the organic fluid used to lubricate the antifriction bearings. Wherever possible we have adapted the ground rules of making the system easier to develop in order that we may have a better chance of obtaining the desired reliability and life (fig. 299, p. 2507). We recognize and accept the fact that in following this philosophy the system will be heavier than originally planned.

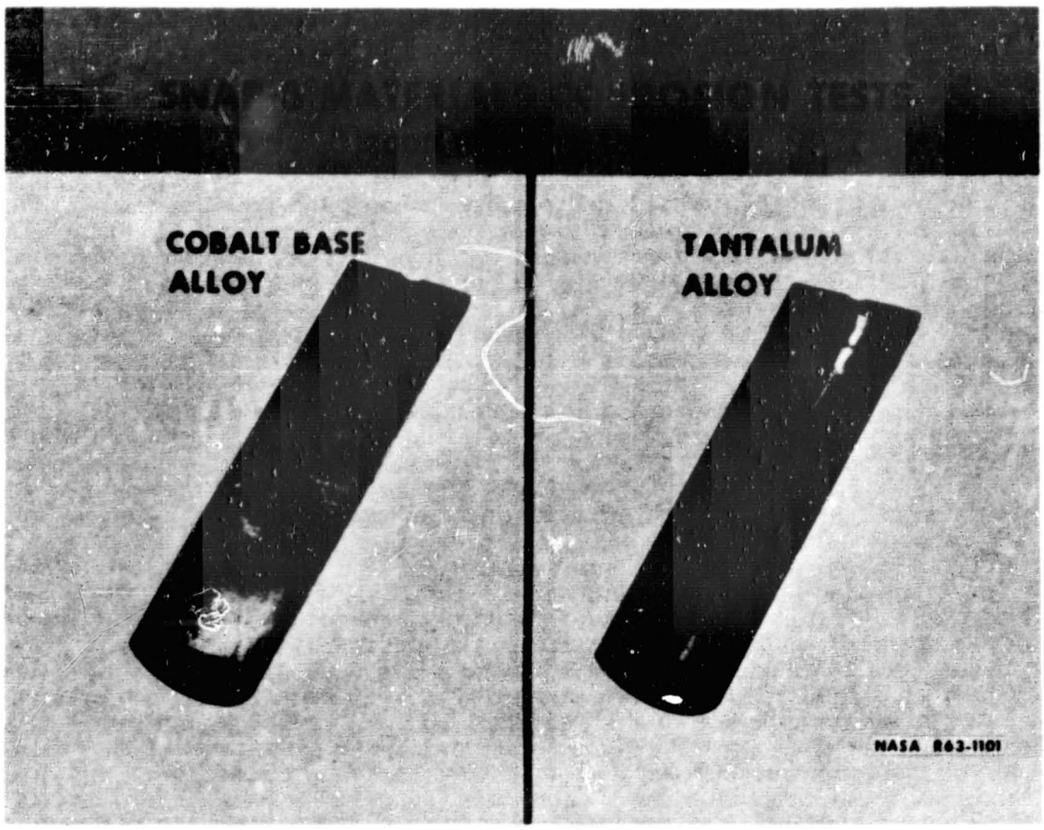
A scale model of the SNAP–8 design is shown in the next figure (R63–598). It will be approximately 50 feet long overall and 20 feet in diameter. From right to left on the model are shown the reactor, nuclear radiation shield, power conversion system and the radiator. Note the large size of the radiator in comparison with the rest of the system. Depending upon the thickness of armor needed to prevent micrometeoroid penetration, the radiator may be two or three times as heavy as the rest of the system. The original radiator design was considerably smaller and therefore lighter due principally to the higher operating temperatures in the bearings, generator, and other electrical equipment as described above.



The selection of an alloy having improved resistance to mercury attack at SNAP–8 life (10,000 hours and more) and temperature (1,300° F.) conditions is a good example of the difficulties we are facing. HS–25, a cobalt-base alloy, was originally selected on the basis of an extrapolation of available data to SNAP–8 conditions. It is important to note that there was no data available for the SNAP–8 condition since these conditions have never been required in past systems design. Recent tests have shown that HS–25 will be attacked by mercury at a rate that is unacceptable for a 10,000-hour system. The problem is one of flow restriction and possible flow blockage due to corrosion product deposition rather than purely one of corroding a hole in a pipe.

The next figure (fig. 300, p. 2508) shows the results of corrosion tests of HS–25 and two alternate materials under conditions more nearly representative of the SNAP–8 design. Shown are cutaway views of three sections of tubing or capsules after exposure to mercury liquid and vapor at 1,200° F. for 1,000 hours. Each of these tube sections was filled approximately one-third full of mercury, evacuated, and sealed. The mercury at the bottom of the capsule was boiled and the resulting vapor corroded the capsule's upper walls. The resulting corrosion products were desposited at the liquid-vapor interface in the central portion of the capsule as shown on the figure. In general, the heavier the deposit the more severe was the corrosion. Below each capsule is a microphotograph of the corroded section. As you can see from the amount of corrosion product deposition and the microphotographs, the HS–25 alloy shows the most corrosion. A stainless steel, AISI 304, shows less corrosion and a silicon-chromium, molybdenum steel, Sicromo 9M, shows the least corrosion of the three. While results of these and other Sicromo 9M corrosion tests appear encouraging, we have not yet conducted a full 10,000-hour test and, therefore, cannot be certain that the alloy will be fully suitable for our purpose. Consequently, we are investigating another class of material that shows little or no attack by mercury which is the refractory alloys of columbium and tantalum.

The next figure (R63–1101) shows the results of a slightly more severe capsule test of tantalum. Similar results are obtained with columbium. An HS–25 alloy capsule is shown on the left side of the figure for comparison. Unfortunately, these refractory alloys are subject to rapid oxidation at SNAP–8 temperatures, so that means must be found to keep the air away from the system during ground



development testing. This will require vacuum facilities or the development of protective coatings such as stainless steel cladding.

As a result of the above investigations, we will use Sicromo 9M for early development testing. We will continue to try to solve the problems of protecting columbium alloy from oxidation by cladding with the objective of utilizing it in the SNAP–8 design.

As I stated previously, the above changes in materials, component design, and operating temperatures will make the system easier to develop at the expense of added weight. However, the advantages of the heavier system, including the increased flexibility made possible by the redesign, far outweigh the weight factor for the auxiliary power applications we anticipate for SNAP–8.

The requirement to achieve long operating life in the SNAP–8 system will be satisfied by over 60,000 hours of test time including full nuclear system tests in the space propulsion facility that will be built at our Plum Brook installation near Sandusky, Ohio. Such full system tests are, we believe, a necessity in achieving a reliable, proven system.

SNAP–8 flight evaluation project

The SNAP–8 flight evaluation project has the objective of evaluating the problems of starting and operating a SNAP–8 power generation system in the space environment. As stated earlier by Dr. Bisplinghoff, no major hardware commitments are planned in this project until SNAP–8 development progress warrants such action. There are, however, unexplored research and technology problems caused by the requirement for spacecraft subsystems to operate for 10,000 hours or more in a nuclear reactor radiation environment that must be investigated. The information developed in this field by other programs such as the lower powered SNAP–2 and SNAP–10A systems, RIFT, and applicable non-space projects will be reviewed and utilized wherever possible. In addition, a systematic study of various vehicle configurations to define special factors requiring further effort is underway. Programs aimed at exploring and defining these problems will be initiated with fiscal year 1963 funds and continued in fiscal year 1964. It is important to note that these programs will provide a sound foundation for the development of future nuclear electric space systems as well as for the SNAP–8 design. The design of the spacecraft eventually to be used in

the flight tests will be such that it is a logical step in the development of the spacecraft for early operational use.

Advanced research and technology project

The advanced research and technology project is aimed at acquiring the technology on which to base the development of future systems such as those shown on the next two figures required to develop megawatts of electric power in extremely lightweight systems. The Rankine cycle, turboelectric system shown on the next figure (fig. 301, p. 2510) utilizes lithium and potassium as working fluids and a segmented radiator to minimize radiator weight, while assuring adequate protection against puncture by micrometeoroids. To achieve 10 pounds per kilowatt, this system must operate at fluid temperatures of 2,000° F. and higher, giving reactor temperatures up to 2,500° F. It must, in addition operate reliably for years. Turbines and electrical equipment and bearings, as well as all containment materials, must withstand higher temperatures with metal fluids than we have previously experienced.

The thermionic direct conversion system shown on the next figure (fig. 302, p. 2510) appears to be a simpler system than the Rankine cycle system in that it has fewer moving parts. However, it requires a maximum temperature of approximately 3,000° F. to achieve 10 pounds per kilowatt. Both systems are technologically far beyond current ground based power generating devices and beyond our available space technology.

The uncertain micrometeoroid environment, and the lack of both basic and engineering knowledge on materials, heat transfer, flow processes, component design and operation; etc., pose serious obstacles to be overcome before hardware development of such advanced systems can intelligently be undertaken. We, therefore, attach much importance to this area and, under the technical direction of the Lewis Research Center, are conducting a vigorous program with approximately 25 industrial, research, and university contractors as well as within NASA to provide the necessary data. This program includes such items as the experimental evaluation of electrical equipment; the viscosity, specific heats, thermal conductivity, etc., of liquid metal and metal vapors of interest; the emissivity of radiator materials over a wide range of temperatures for space use; the boiling heat transfer coefficients of the metalworking fluids at the high temperatures required; and, the compatibility of the metalworking fluids with the containment materials and the components used in the system. This area of work also includes analysis and experiments on such system components as bearings, turbines, generators, pumps, thermionic emitters, etc. We believe that the establishment of such a base of research and technology must pace full system development.

Our work on micrometeoroid protection for radiators is an example of one area of our advanced research and technology effort. I stated in regard to SNAP–8, the radiator can be the largest single part of a power generation system totaling 40 to 50 percent of the system weight. The armor protection needed to prevent puncture of the radiator by micrometeoroids may constitute over 75 percent of the radiator weight. Several different armor designs are under study as well as studies of different armor materials. Two of the design concepts are shown on the top of the next figure (fig. R63–1288), a double plate "bumper" concept on the left and a single, solid plate of the same overall thickness on the right. The damage shown was due to the impact of a single aluminum pellet moving at velocities of 18,500 feet per second. As shown on the upper left, the "bumper" plate was penetrated, but apparently broke up the projectile, thereby reducing the damage to the second plate. Contrast this with the damage shown on the upper right. Even though penetration did not occur in either case material was spalled or chipped off the back side of the plate, as shown in the bottom half of the figure. Spalled material in radiator tubes or other narrow passages can be just as serious as a puncture.

Meca project

The Meca project is aimed at determining the effects of relatively longtime zero-gravity exposure on liquid metal boiling and condensing heat transfer. The 8 or 10 minutes of zero gravity exposure needed to establish equilibrium conditions will be obtained in freely falling vehicles at high altitudes. Experiments weighing up to 1,000 pounds will be launched by small (26,000 pounds of thrust) solid rocket-powered vehicles shown in the next figure (fig. 303, p. 2512). Composed of available motors, vehicles will be launched from Wallops Island, Va., at a rate of two to three per year. The first experiments are in direct support of SNAP–8 and will utilize mercury fluid and SNAP–8 boiler and condenser component configurations. Data will be both telemetered to the ground and recorded on film.

The camera package will be recovered using techniques already developed by the Lewis Research Center. The total cost of each shot is on the order of $250,000 to $300,000 and is, we believe, a good means of getting zero gravity data before major and expensive flight tests of large systems.

ELECTRIC PROPULSION

Referring again to the right-hand column of a previous figure (fig. 297, p. 2505), the propulsion subprogram is composed of an advanced research and technology project, an engine development project, and a flight evaluation project called Sert.

Advanced research and technology project

With regard to the advanced research and technology project, our efforts are directed toward providing the basic information necessary for the development of any engine that may ultimately be required. The next figure (fig. 304, p. 2513) lists the three main types of electric rocket engine: The arc jet, the ion engine, and the plasma jet. The arc jet develops thrust by electrically heating a fluid such as hydrogen or ammonia and expanding it through a nozzle. The ion engine depends upon electrostatic forces and reactions to accelerate a working fluid such as cesium or mercury ions, thereby developing thrust. The plasma engine utilizes electromagnetic forces to accelerate plasmas, thereby developing thrust. As you can see in the left-hand column of the figure, the arc jet has a specific impulse range of 700–1,500 pounds of thrust per pound per second of propellent flow. The ion engine develops impulses in the 3,500–10,000 seconds range. The plasma jet offers the potential of covering the whole range of the other two. The right-hand column of the figure lists the major problem areas for each engine type.

The major problems remaining to be solved in the arc jet engine pertain to dissociation losses, which materially affect engine efficiency, and electrode erosion which has a significant effect on engine life. Efficiencies obtained to date range from 40 to 50 percent, while endurances of hundreds of hours have been demonstrated in ground facilities with 30 kw. systems.

Ion engines are sufficiently well along for us to plan flight tests to evaluate current solutions for problems which cannot be fully evaluated in ground facilities such as ion beam neutralization, and to determine the effects of long-time

exposure to the space environment. As you may recall, the amount of thrust developed by an ion engine is strongly dependent on the degree of ion beam neutralization. For example, if no beam neutralization is achieved, the ions that have been accelerated by the engine's electrostatic field, will be attracted back to the vehicle and no thrust will be developed. Ground tests in vacuum facilities do not give conclusive proof of the degree of neutralization achieved because the tanks cannot accurately simulate the space environment. Therefore, flight tests in the actual space environment are needed. I will discuss these flight investigations in more detail under the Sert project. The other two problem areas, propellant ionization and acceleration, are under vigorous investigation by industry and at the Lewis Research Center.

The plasma jet technology program is still in its very early phases. As indicated earlier, the plasma jets offer the potential of good performance over a broad range of specific impulse. However, a good understanding of the many engine concepts and their limitations and problems is needed before we can concentrate our efforts on one or two main approaches.

Although not shown on this figure, another advanced research and technology area that until now has been deferred in favor of work on thrustors is the power conditioning and control system. A program in these areas will be initiated in fiscal year 1964.

Approximately 26 industrial and university contractors are involved in the various portions of the engine advanced research and technology project.

Engine development project

The engine development project consists of a number of development contracts for arc jet and ion engines aimed at providing hardware for ground and flight test purposes. The engines developed as a part of this project will be suitable for early anticipated applications. An example of this philosophy is the 3 kw. ion engine module, under development by the Hughes Aircraft Co., and the concept of clustering the basic 3 kw. unit into multikilowatt- and megawatt-size systems, as described earlier by Dr. Bisplinghoff and shown on the next two figures (fig. 94, p. 1916 and fig. 95, p. 1917). A summary of the various engine systems we have under development or study, together with typical performance characteristics, is shown in the next figure (R63–1092). The engines included in the engine development project are shown under the first part of the figure. The remaining items, the MHD and high power accelerators, are being investigated as advanced research and technology efforts since they are not as advanced in development as the ion and arc engines listed on the upper half of the figure.

ELECTRIC ROCKET ENGINE SYSTEMS
CURRENT STATUS

PROGRAM OBJECTIVE	CURRENT PERFORMANCE			
	POWER KW	Isp SECS.	EFF. %	TEST TIME HRS.
1. FEASIBILTY DEMONSTRATION				
LOW POWER SYSTEMS				
ARC	1	1,000	30	50
ION	1	7,500	70	50
INTERMEDIATE POWER SYSTEMS				
ARC	30	1,500	55	100
ION	1	8,900	60	200
	3	8,700	86	200
	30	UNDER DEVELOPMENT		
2. ADVANCED RESEARCH & TECHNOLOGY				
M H D	7	6,000	35	90
	30	5,500	30	6
HIGH POWER SYSTEMS	500-1,000			

NASA R63-1092

Sert project (space electric rocket test)

The Sert project is composed of a series of electric rocket engine tests that, in general, cannot be performed meaningfully in ground facilities alone. By comparing flight test results with data obtained in ground facilities, we will determine the limitations and accuracy of our ground tests. Because we can never expect to simulate the space environment completely, flight tests such as these are also necessary to prove or qualify specific engine developments for future mission applications. Flight test engines and components for the Sert project are furnished by the engine development project. There are three categories of Sert flights:

1. Those flights required in support of the advanced research and technology project; e.g., beam neutralization tests (Sert I);
2. The flights required in the development of large engines for primary propulsion applications (Sert II); and,
3. Those flights required in the development of small engines for such applications as attitude control systems (Sert III).

The first Sert flight will consist of a battery-powered ion beam neutralization experiment and is scheduled for launch within the next 6 months. A 350-pound, spin-stabilized capsule, built for us by RCA, will be launched from Wallops Island, Va., by a Scout launch vehicle to an altitude of 2,500 miles, as shown on the next figure (fig. 307, p. 2514). This trafectory will give up to 55 minutes of free fall above the Earth's atmosphere. During this time, two experimental ion engines will be operated in such a manner as to change the capsule spin rate, as illustrated in the next figure (fig. 308, p. 2515). The amount of change in spin rate will be a measure of the thrust developed, which in turn is a measure of the degree of beam neutralization achieved. The last figure (fig. 309, p. 2516) shows the completed capsule installed in an altitude simulation tank at the Lewis Research Center. We are, in this program, following our basic philosophy that the full spacecraft must be operated on the ground under environmental conditions that simulate the space flight environment as closely as possible in order to give the greatest possible chance of successful flight. These vacuum tank tests have already uncovered problems that would have caused a flight test to be unsuccessful.

The Sert II and III orbital flights are scheduled for launch in the 1965–66 time period. Solar cells will be used to provide the necessary power (100 to 200 watts for Sert III and up to 3 kilowatts for Sert II) for the desired 6-month flight duration. Thor-Agena (Sert II) and Thor-Delta (Sert III) launch vehicles will be utilized in launchings from AMR or PMR, depending upon the orbit desired.

In summary, I want to emphasize that our major goal is the early and practical utilization of nuclear energy in space. We are convinced that a substantial effort is justified by the potential performance advantages in these systems for difficult space missions. Rather than only developing specific pieces of hardware, we are conducting the program so entirely new areas of rocket and power technology and equipment will be available in the long-term space program which will inevitably lead to important missions beyond our first lunar landings.

Mr. FINGER. Thank you, Mr. Chairman, and members of the committee.

I have gone through my prepared statement, and I will excerpt and summarize some of the major items in it.

It is clear to us in our NASA program that if we are to perform extensive space explorations beyond the first manned lunar landing mission, it will be necessary for us to have available nuclear propulsion systems, and, if we are to establish large space laboratories, lunar stations, and carry on communications from deep-space objectives in our long-term and continuing space program, we will need large nuclear electric power supplies. It is for that reason that we have a very substantial program of development in this area of nuclear systems, as you can see by the budget line item, including the effort in manpower and facilities that we are devoting to the program.

Our nuclear systems program is broken into two main areas, one being nuclear rockets, the other one, the development of nuclear electric systems.

A large portion of this program is obviously a joint effort between the Atomic Energy Commission and NASA. Responsibility for the

development of reactors, of course, is that of the Atomic Energy Commission and NASA is responsible for the development of the nonnuclear components of the system as well as for the integration and application of the reactor with the other components into the operational system.

The development of the nuclear rocket propulsion system is handled as a single program, even though there is a responsibility in both agencies, AEC and NASA. The work on nuclear rocket propulsion is handled as a single program under the management of the Space Nuclear Propulsion Office, which I head. This Office is considered, essentially, a field office by both agencies. We have our own technical direction responsibilities, budgetary responsibilities. The Office is staffed by both agencies in about equal numbers.

The Office of Nuclear Systems, which I also head, is exclusively a NASA Office. It is within that Office that we handle the NASA portions of nuclear electric power generating systems and electric propulsion. The responsibility for detailed technical direction and contract administration in those areas is handled by the NASA Research and Space Flight Centers. For example, the Lewis Research Center does most of the technical direction and monitoring work as well as the contract administration work on our nuclear electric systems and electric propulsion programs.

I would like now to discuss very briefly the status and the plans of several elements of our nuclear rocket and nuclear electric power and electric propulsion programs starting with the nuclear rocket program.

To refresh your memory, the nuclear rocket propulsion system is illustrated on this first slide (fig. 286). It consists of a large tank

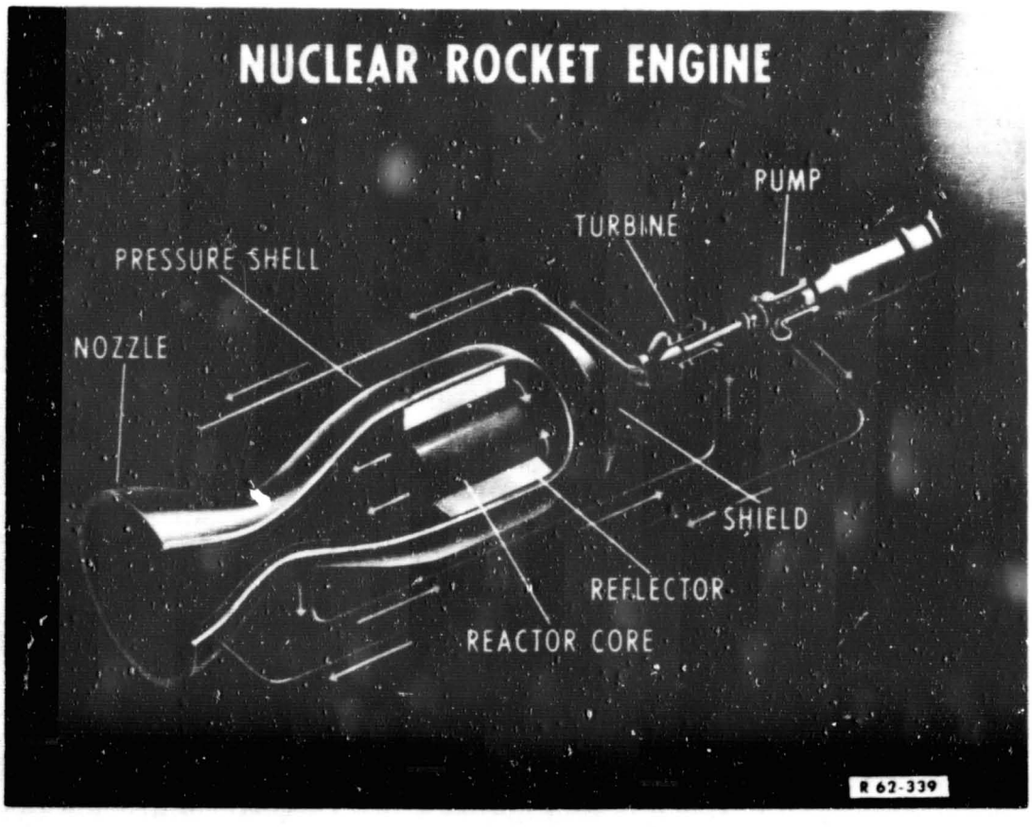


FIGURE 286

loaded with liquid hydrogen shown on the right of the slide, in the upper right corner. Hydrogen is pumped out of this tank by the pump that is shown and the hydrogen is then passed down to the nozzle on the lower left part of the slide. The liquid hydrogen which is at a temperature of 420° or 430° below zero is then used to cool the nozzle and the hydrogen then passes up through the reflector and is heated in the nuclear reactor. The reactor replaces the combustion chamber of the chemical rocket systems. Some gas is drawn off to drive the turbine which in turn drives the pump in the system.

The real advantage of this nuclear rocket system is that, because we use hydrogen alone which has a very low molecular weight, the specific impulse that we can generate is two or three times the value we can get in chemical rocket systems. We can get, say, 800 to 900 seconds of impulse compared with somewhere between 250 and 450 seconds in chemical propulsion systems.

Mr. KARTH. What is the weight-to-payload ratio in comparison with the chemical systems?

Mr. FINGER. It depends on the mission. What happens with specific impulse essentially is we get a large thrust for every pound of flow that goes through the system, and this means for any mission we have to store less hydrogen.

Mr. KARTH. Your reactor and everything else amounts to quite a bit of weight.

Mr. FINGER. Yes, it is heavier. For near Earth missions we can expect to get up to twice the payload of chemical rockets. For example, in earth-orbit systems we can expect up to twice the payload. If we go to a Mars landing mission we can expect up to 5 to 10 times the payload for nuclear systems for equivalent spacecraft weight. I think that in most cases we would tend to use smaller rocket systems or lower gross weight rocket systems to deliver the required payload and to do a given mission if we used nuclear rockets. It is really this very substantial improvement in specific impulse with the very substantial improvement in payload that we can get, that is the justification for our large program in this area and our interest in developing these nuclear rocket systems.

Dr. Bisplinghoff has already indicated the relationships among some of the elements in this nuclear rocket program that are shown on the next slide. I am sorry this is one that I omitted; this is the nuclear Saturn V (fig. 89, p. 1904). Our earliest mission capabilities with nuclear rockets appear to be an outgrowth of the Saturn V vehicle. If we applied a nuclear stage as a third stage on that vehicle we could deliver approximately twice the payload in the Earth orbit. We could also accomplish the manned Venus flyby mission that Dr. Bisplinghoff mentioned, as well as various unmanned missions to Mars and Jupiter probes.

It is with this vehicle that we anticipate we would have our earliest applicability with nuclear rockets, and then go on from there to much more advanced manned missions to the planets.

Mr. KARTH. What time do you have in mind for this engine applied to the Saturn V concept?

Mr. FINGER. We still believe that we can fly this kind of a system in this decade. I will get into some of the technical problems that we have come up against in the reactor portion of the program which really paces the whole development. Until we have a reactor we cannot really predict schedules. I will get into that shortly.

Now, the elements of the program are shown in the next slide (fig. 92, p. 1906). This is a slide that Dr. Bisplinghoff mentioned earlier. The Kiwi reactor program is being conducted at Los Alamos Scientific Laboratory under contract with the Atomic Energy Commission to provide us with a reactor that could then be developed through an engineering development effort to flight status. It essentially sets the basic groundwork for our reactor development. It had been intended that the Kiwi reactor would then, in basic design concept, be used in our NERVA engine which is being developed by Aerojet General with Westinghouse as a principal subcontractor; Westinghouse being responsible for the engineering development of the reactor for flight application and Aerojet for the entire engine system as well as the nonnuclear components. The NERVA engine would fit into the RIFT reactor in-flight test stage which is under the technical direction of Marshall Space Flight Center. The RIFT technology work is being done by Lockheed Missiles and Space Co.

The RIFT stage would then be used as a third stage on the Saturn V; that is, it would first be test flown on a Saturn V configuration, but it would have the capability to be developed eventually to an operational status as the third nuclear stage that I showed in my second slide.

During 1962, two power reactor tests were run, hot reactor tests, as part of the Kiwi program. These tests were run by the Los Alamos Scientific Laboratory at our Nuclear Rocket Development Station in Nevada. This station, you will recall, is managed by the joint Space Nuclear Propulsion Office for both NASA and AEC.

All of these reactor tests have been run by the Los Alamos Scientific Laboratory. The first of these was run in September of 1962 and is called the Kiwi B1B reactor shown on the next slide (fig. 289). This was the first reactor run with liquid hydrogen as the coolant. The use of liquid hydrogen is an area which concerned us greatly because there was a control question involved with it. This test run was run in September of last year. The two principal results that we got from this test were, first that we could in fact operate a reactor with liquid hydrogen and control it satisfactorily. Essentially, the analysis indicated this, but it was comforting to have experimental verification of it.

We did, however, get into structural problems in the reactor in that at about 60 percent of the desired power, reactor damage occurred. We had cracking of these fuel elements in the reactor. The conclusion we arrived at was that this reactor design was not suitable for flight application; although we have not yet explained the causes of that cracking and we still have work proceeding in order to explain it. It is my feeling in a new technology like this that we better understand every aspect of every analysis and experimental result in order to really try to understand the system and be sure we don't run into similar problems later. We, therefore, do still have work going to explain the cracking in this Kiwi B1B reactor in order to apply that information to future reactor designs.

The next reactor test we ran is shown on the next slide (fig. 290). It is the Kiwi B4A reactor run last November, November 30. It is this reactor that has been the principal hope of our program in that we had been directing our major attention to this reactor design because it looked as if it was the most promising of the designs we were exploring.

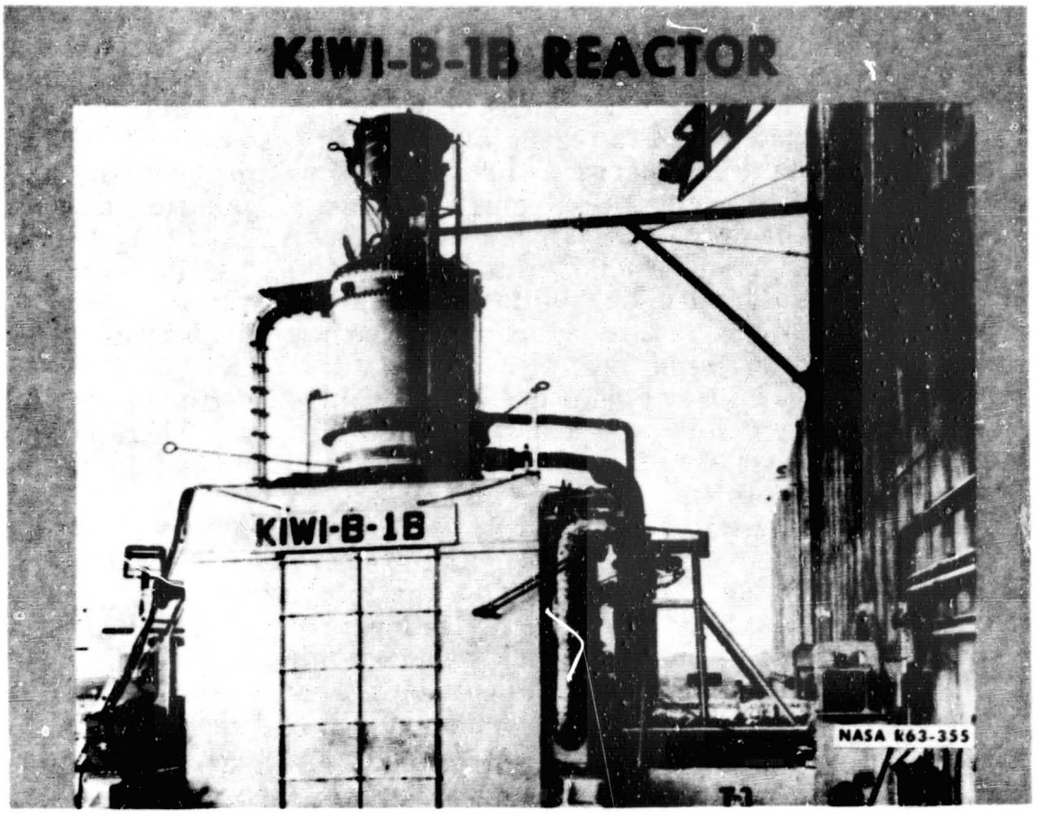


FIGURE 289

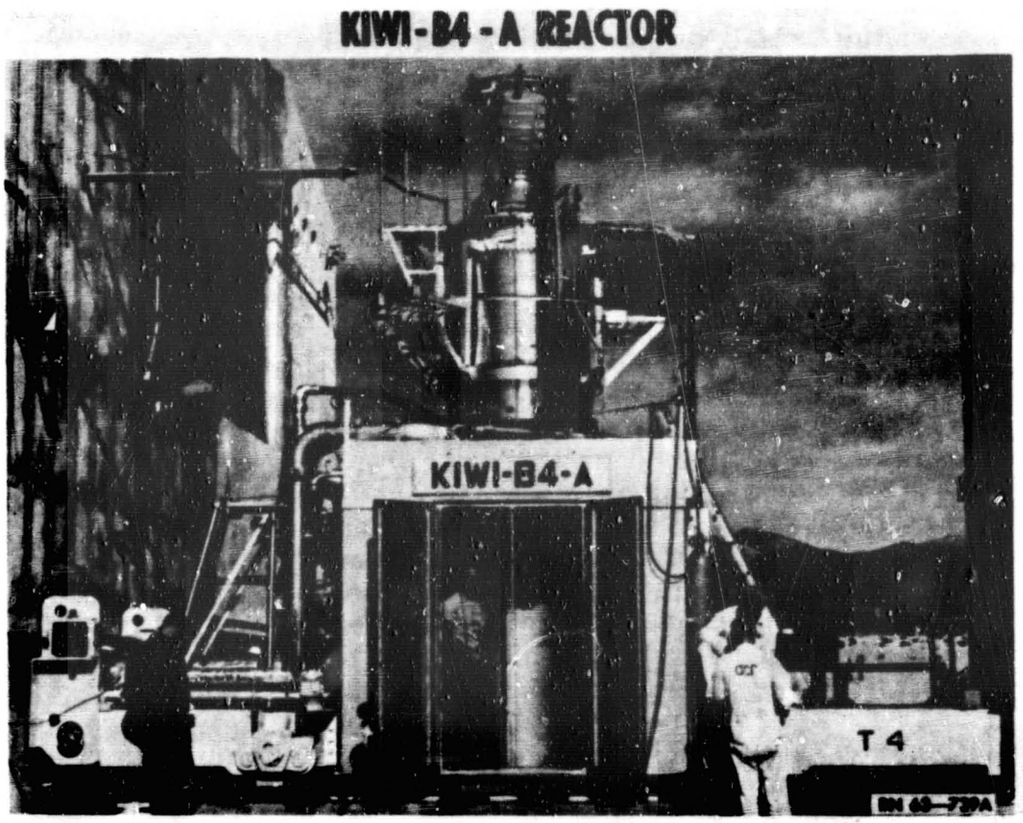


FIGURE 290

You can see that the reactor looks very much like the B1B externally, but internally it is a very different design. Hydrogen enters through the jet nozzle at the top of the reactor, and passes down through the tubes that make up this nozzle so liquid hydrogen is used to cool the nozzle and it is a regenerative cooled system. The hydrogen passes through the reflector as I showed on the first slide, and back up through the core and out through the nozzle, pointing upward. The area down below the reactor is called the privy. It is a shielded area that is used as an instrumentation interconnect section and also our control actuators are located down in that privy area.

Mr. KARTH. What radiation problems are we encountering when these things are test fired, if any?

Mr. FINGER. The test operations are all controlled from a location at a test location a mile and a half to 2 miles away. There is very little, if any, release of radioactive products during the test operation, so we can move into the area very quickly after a test.

During these tests where parts have been ejected, and there has been some cracking, there has been more release of radiation, radioactive fission products, than would be the case in a reactor that remained integral and didn't have any failures, but even in this case we have been able to move in quickly and examine the area.

The reactor, however, when the test is finished is always handled remotely, it is removed from the cell remotely and disassembled remotely from behind heavy concrete walls, so it does have to be handled in a remote manner.

Mr. KARTH. Is there any possibility that a nuclear propulsion system could form the basic booster system of a deep spacecraft?

Mr. FINGER. There is that possibility, however, as we see it, there are great advantages to using it as an upper stage, either a second stage, or third stage, or orbital start stage.

Mr. KARTH. There are greater advantages for upper stages?

Mr. FINGER. Yes, sir. The power levels that are required are less and the problems of launching and launch site problems are very much eased by using it as an upper stage.

The other point is, of course, we will have very large boosters available, so we will be able to use these first chemical stages that are available. I do see for a long time, a very long time, that we would use these nuclear stages in combination with chemical stages.

Mr. HAMMILL. May I ask a question.

Mr. Finger, why is it that we have what appears to be a flight type nozzle on this reactor test? Is this necessary, or is it desirable?

Mr. FINGER. It turns out that there are certain components that you really cannot make boilerplate or heavy. These nozzles must be cooled. In order to cool them and use available materials you have to make the walls very thin, and the problem, therefore, is that we automatically get into a flight type design just by virtue of requiring a system that will operate satisfactorily. In this case we must use very thin wall tubing in order to have a material temperature that won't be too high and won't exceed temperature limits, so we are essentially building flight type hardware in that component.

That is not the case in some of the other components. For example, a turbopump can be built very heavy structurally in order to provide hydrogen for a reactor test. It can also be built fairly heavy even for early engine tests and later on we would thin it down and pare it

down to a lightweight, flightweight pump. There are components that have to be made flight weight because their performance demands it, even in ground tests.

Mr. HAMMILL. My real point is this: did the flight type nozzle cause any problem in the reactor test? Would it have been better to test the reactor without a flight type nozzle at this early stage of the development?

Mr. FINGER. I see the point you are making. There has been some consideration of the possibility of vibrations in the nozzle that feed back into the reactor. We are not discounting any possibilities, although all of our data tend to indicate that the problem we have had is a vibration that occurred within the reactor, itself.

Now, the one thing that might not be necessary in this design, and I think if we were starting from scratch and not trying to develop flight technology at the same time we were trying to develop hardware for reactor test, is this fairly large nozzle area ratio. We might cut back the area ratio of the nozzle; that is, we might have a shorter expanding section than what is here, although this is not very high. This is a 12 to 1 area ratio, and is not really excessive. We might cut it back to 4 to 1 or 5 to 1—something like that; but I really don't believe that had an effect on the performance of the reactor, itself, nor that it caused the vibration that we have encountered. None of our data substantiates that possibility.

Now, during this test we had intended to examine the particular mechanical design we were working with, and also we wanted to get additional verification of this liquid hydrogen start data that we got in our earlier test. The test was cut short when we observed flashes in the nozzle discharge, and these flashes kept increasing in frequency and, finally, got to a point where we felt we would be better off shutting down and examining the reactor in order to get data on what caused the flashes rather than trying to barrel ahead to go to the full-power conditions.

I have a short film strip of these flashes. I think we can probably hold it until later, near the end of the session, and show it. We have talked about the flashes a great deal, and I thought people might want to see what these really looked like. They really do look like light flashes.

Mr. KARTH. If you wish we can do it now.

Mr. FINGER. I think we can do it later and continue on in this sequence.

Now, even though the reactor continued to operate satisfactorily and the control-room diagnostics indicated no problem, it was felt that some material was leaving the reactor, so we did shut it down and examined it.

Mr. KARTH. What did you find out after you shut it down?

Mr. FINGER, I was getting to that. We removed the reactor to the disassembly area, and tore it down and examined it very carefully. Although initially it looked as if only some fuel elements were cracked, as we went deeper into the reactor it was apparent that most of the fuel elements were cracked. It appears to us, and there are data to indicate it, that there was a vibration within the reactor, induced by reactor flow conditions and that it was this vibration within the core and the graphite within the reactor that caused the cracking.

Mr. KARTH. Is this a major technical job?

Mr. FINGER. This, to us, is a mechanical engineering design problem. We know what the materials can take, and it is a matter of designing around those material properties. We don't believe that it is a fundamental problem that will block the development of a graphite reactor of the type we are using. We do believe that we can design around this difficulty.

Now, what we have done——

Mr. KARTH. Have you made any new designs?

Mr. FINGER. We have several designs that are being checked out. I might go into the approach we are using.

Mr. MOSHER. Just to get a definition of terms, what do you mean by fuel elements?

Mr. FINGER. The fuel elements in a reactor are those portions of the reactor that are loaded with uranium. They are a structural material that has been impregnated with uranium. The fissions that occur within a reactor, the generation of energy, comes from these fuel elements. There is then a separate section in thermal reactors called a moderator, in which the neutrons are slowed down so that they can fission again and get back into the fuel, into the uranium, and fission again.

Mr. KARTH. These fuel elements make up the core, do they not?

Mr. FINGER. Yes; that is correct. They make up the reactor core.

The approach we are taking is that we have Westinghouse and Los Alamos working on redesigns of this reactor, of this basic reactor design. We had originally intended that Los Alamos develop a Kiwi design that could then be handed to Aerojet and Westinghouse to develop into the NERVA engine. It is apparent to us that the difficulties in this design are significant mechanical engineering difficulties and the major mechanical engineering capabilities exist in greatest depth with our industrial contractors so we have told our industrial contractors to go ahead and redesign the reactor, start procuring parts, start conducting a detailed test program leading to the test of full, integral, power reactors.

Mr. KARTH. Up to this time where has most of this work been done?

Mr. FINGER. Almost all of this has been at the Los Alamos Scientific Laboratory. The entire Kiwi program has been a responsibility of Los Alamos Scientific Laboratory.

Mr. KARTH. Very little of it has been done out of house; right?

Mr. FINGER. Los Alamos has used industrial contractors working with them to hep them. For example, American Car & Foundry has been working with them and Air Products has been doing some cryogenic design analysis for them through various contractors.

What we have done is give to our NERVA contractors a real responsibility to do engineering design, test, and development on these reactors.

Mr. KARTH. Who has previously done the design work?

Mr. FINGER. Los Alamos.

Mr. KARTH. So the design work was done in-house?

Mr. FINGER. That is correct. There was design work done by ACFI but that was design work related to the pressure shell and in the components that were not critical to the reactor core itself.

Mr. KARTH. Now, we are thinking about doing some of it out of house; right?

Mr. FINGER. Not thinking about it; we are going ahead and doing it. We have instructed our NERVA contractors to go ahead and do this work.

Mr. KARTH. What caused us to make that decision?

Mr. FINGER. The recognition that we really needed a greater engineering talent brought to bear on these problems. I think the situation we are in is that the Los Alamos Scientific Laboratory has, with comparatively few men, most of whom are scientifically oriented, done a very excellent job in materials work and materials fabrication, the physics of the problem, the chemistry of it, but that we do need greater engineering depth than exists in a national laboratory. It is that determination that has caused us to assign this responsibility to the NERVA contractors.

Mr. KARTH. What if this graphite core doesn't work, what have we as backup program?

Mr. FINGER. We have a technology effort in metallic reactors. I was planning on discussing that with regard to our advanced research and technology program in this area. I should mention that our program is really broken down into two main parts.

Mr. KARTH. How far behind the development of the graphite core is this new technology you are talking about?

Mr. FINGER. I think there is a requirement that we establish first a base of information on the materials and the physics associated with these reactors.

Mr. KARTH. So it is a very basic thing and it is years behind the development of graphite?

Mr. FINGER. I would say it is several years behind. We must recognize that this graphite work started in 1955, and it has been going, therefore, for 8 years in establishing the basic background of information and in doing the detail design work. Full reactor tests started in 1959, so there have been 4 years of reactor tests as well. It is certainly advanced over any of the metallic reactor work. We are, however, supporting work on the metallic reactors at Argonne National Laboratory and the Lewis Research Center. In addition, the AEC has a materials program in process with General Electric, in metallic reactors.

Mr. MOSHER. Mr. Chairman, this engineering design work which has been inadequate, do you feel there is a probability that it would have been of quite a different nature and of better quality had it been done by contract to industry out of house earlier? Do you wish that you had gone out of house earlier?

Mr. FINGER. Well, I think we would have been better off if we had a stronger support capability in engineering brought into the program earlier; a support capability that had a responsibility to do engineering design on the rector core itself.

I think, though, we must recognize there has been up to recently, up to the past year or two, a requirement to establish a basic background of design data which required emphasis on the more basic aspects of materials; properties evaluation; evaluation of methods of fabricating fuel elements, of mixing fuel with the basic structure of the material in the fuel elements, and producing fuel elements; establishing the basic physics data and neutronics of the system. That work is done best, I believe, by a laboratory like Los Alamos.

Mr. MOSHER. You are going to Westinghouse and what?

Mr. FINGER. Aerojet is the prime contractor, and Westinghouse is the principal subcontractor responsible for the reactor, so Westinghouse is taking the primary load.

Mr. MOSHER. There is some new engineering design from industry. I realize this has to be speculation, but is there a probability Kiwi would have been further advanced had you done this 2 years ago, say?

Mr. FINGER. I believe if we brought the stronger engineering support into the program earlier we would be further ahead toward having a developed reactor. It is a little difficult to judge. I say this because I am convinced we can develop this reactor, and what it takes is a really sound engineering organization. A thorough engineering analysis and development procedure, I believe, would, therefore, have helped it.

Mr. MOSHER. Did you lack funds to do this 2 years ago?

Mr. FINGER. One of the problems, of course, was that we brought the NERVA contractors on board in June of 1961, I believe it was. It took them time to build up. It takes time to accumulate the basic information that is available and to staff up an organization that can handle the work.

I don't know how long ago they really could have taken on the job. I don't believe we were prepared to take on a contractor before June of 1961. Not only from a funding point of view, but just that the basic data weren't available to go ahead and design with a strong engineering organization, a contractor organization. We did last summer, make the selection of this Kiwi B4A as our basic design. We did, then, tell Westinghouse to go ahead and start designing this reactor and start planning on doing tests of this reactor late this year. That is still the case. So we gave them a large part of the go-ahead last summer, and expanded the component work that we were doing, early this year.

Mr. KARTH. When was some of this work finally let to private industry?

Mr. FINGER. The industrial contractors were brought on board in June of 1961. It was at that time that we had some reactor tests, and we felt we would gain by bringing industrial engineering capability into the program for the reactor as well as the nonnuclear component.

Mr. KARTH. I am not sure I understand your testimony. In one instance it seems to me you said you are not sure we could have gone any other route prior to June of 1961, and in the other instance it seems to me you said we could have advanced further if we had done this sooner. Which is it?

Mr. FINGER. What I defined was if we had engineering support for Los Alamos we could have moved ahead faster. I don't believe we could have given full responsibility to an industrial contractor to do the engineering design, as we have now done, much earlier than we have.

Mr. MOSHER. As I understand the testimony, Mr. Chairman, he is saying that on the basis of hindsight it might have been good to do what they are starting to do now 2 years ago; is that correct?

Mr. FINGER. What I am saying is we should have had a reactor engineering support organization working closely with Los Alamos a year and a half ago. What we have done now is given a full responsibility to Westinghouse to design, test, and build reactors, and this is,

essentially, an effort that proceeds parallel to, but is not governed by, the Los Alamos effort. I think if we had a collaboration between the engineering capability and the scientific organization early, we would have been advanced over where we are now.

It is really in reference to the degree of responsibility we give to the engineering organization that I am saying we could not have given him a full responsibility 2 years ago. There had to be basic data accumulated and we were not in a position to give an industrial contractor that kind of a responsibility then.

Mr. KARTH. You are not giving him full responsibility now?

Mr. FINGER. Yes, sir; we are giving him full responsibility within the direction that we in the Government provide him.

Mr. KARTH. And you are working with Los Alamos, I assume, to some degree?

Mr. FINGER. The work that they are doing with Los Alamos is an interchange of design ideas but the Los Alamos scientific laboratory doesn't determine the NERVA design nor make the judgment on the design. That is a technical direction responsibility that we provide.

Mr. KARTH. Who has the authority to make the decision or who is responsible for not making it if it is not made?

Mr. FINGER. I believe I am. I made the decision this time. It was supported, I am sure, by both agencies. The fact that it was not made before, I would say, is also my responsibility.

Mr. KARTH. Had you recommended it before?

Mr. FINGER. Not really strongly, no, sir.

Mr. KARTH. Had you recommended it weakly?

Mr. FINGER. I started moving in this direction last summer by having Westinghouse start doing design work on the reactor, detailed design work and start procuring parts so they would be ready for reactor testing and it was at that time I recommended it first.

Mr. KARTH. What time was that?

Mr. FINGER. It was at that time that I recommended it first and started initiating it.

Mr. KARTH. Could you identify that time with dates?

Mr. FINGER. I believe I can. It was approximately last summer. I don't know exactly when last summer. I can look at that but we did give direction to the contractor to proceed with engineering design and test planning. I should further mention that when we initially let the NERVA contract it was then anticipated that when we felt that the reactor technology was well enough in hand we would give the responsibility for engineering design to the industrial contractors. So this was the anticipated approach at that time. The time we instituted it is something that, yes, I had control over it.

Mr. KARTH. And despite the fact that the graphite core is causing many problems, you feel that the time has arrived now when this thing should be given over to industry?

Mr. FINGER. Yes, sir, I do. I believe that we understand the problems quite well and that we can develop the system. It does take their design effort to do it. We have also given the contractors a responsibility to look at various alternate designs, using graphite, rather than being pinned entirely to the general Kiwi B4 type of design and they are proceeding to do this work as well so that if we run into further problems that we feel are difficult to resolve in this kind of a reactor, in this general type of reactor design, we will have alternates

that are coming along, that are not limited in any way by the availability of fuel elements, fuel element materials and so on.

Mr. MOSHER. In your backup work on alternates, in case graphite eventually doesn't pan out, do I remember that Lewis is involved?

Mr. FINGER. Yes, sir, we are supporting Lewis in metallic reactor technology work using a thermal reactor design concept.

Mr. MOSHER. This is all in-house work?

Mr. FINGER. Yes, sir, although there is funding in this budget for an increased effort out of house in order to provide for sample materials and buildup of certain equipment that has to be used as part of their program.

Mr. HAMMILL. Regarding your statement that if engineering know-how had been introduced at an earlier time that the program would be advanced over what it is today, let me ask you, has the Los Alamos lab opposed the introduction of this kind of engineering help in any way?

Mr. FINGER. I think Los Alamos feels they have an obligation and have been given a responsibility to develop a reactor at least to the point of demonstrating that it can be taken over and made suitable for flight by the industrial people. They have been driving to go ahead with this approach. They would like to finish that job. Now what we have agreed to is that——

Mr. KARTH. They really haven't finished it yet?

Mr. FINGER. No, sir, they have not finished that job.

Mr. KARTH. So if they had their way, the industrial contractors would not yet be involved in a program, is that what you are saying?

Mr. FINGER. They have no objection. We have discussed this and they have no objection to the approach we are taking to start the industrial contractors off on the full reactor development effort.

Mr. KARTH. If they had to make the decision, this decision would not have been made, would it?

Mr. FINGER. It might not. I don't know. I have made that decision and discussed it with them. I find no basic disagreement on the need for that decision. We have agreed, however, that they will continue working on this B–4 design and redesign it and they will go through a component test program just as we have indicated is needed for the industrial contractor and then run another power test. At that point I expect that the Kiwi effort as it requires developing a reactor that may feed into a NERVA engine would phase out and Los Alamos would go on to look at more advanced reactor systems of higher power as well as providing supporting technology for the NERVA reactor effort.

Mr. HAMMILL. Have they taken any steps toward development of higher power reactors?

Mr. FINGER. There is initial technology work in process. As they phase out of the Kiwi program that part of the program will expand. Now, we are talking there, too, about starting the program with a greater engineering support than was available here, still leaving the responsibility, however, with Los Alamos.

Mr. HAMMILL. But very little has been done, is that correct?

Mr. FINGER. That is correct. It is primarily in the materials area they have been looking at this, as well as in some materials fabrication work and design studies.

Mr. KARTH. If I recall correctly, AEC and NASA were negotiating and disagreeing or whatever you want to call it for quite a considerable

period of time on this program or similar ones, were they not? Wasn't there considerable differences of opinion—at least it seems to me as I read the newspapers for some reason or other we couldn't get agreement between these two agencies of Government on this or some other program is that correct?

Mr. FINGER. Not on this one. I think since we have established this joint office we have really worked very well together. I think this arrangement of putting the two agency responsibilities into one office and running the effort as a single program even though it has divided agency responsibilities is a very effective way of working and it has worked well.

Mr. KARTH. Are you familiar with any other difficulty that NASA and AEC have had in trying to reach agreement on how they shoud proceed on a particular program?

Mr. FINGER. I believe that the recent publicity—recent, meaning within the past year—that you are mentioning is probably with regard to the nuclear electric power system development at high powers, the Snap–50 program. There was considerable discussion about how that program should be operated. There was an agreement reached among NASA, the DOD, and AEC establishing an office within the AEC to direct that program, with a NASA and an Air Force deputy assigned to the office to provide appropriate liaison among the programs in the three agencies.

Mr. KARTH. And this discussion that finally resulted in an agreement is caused because we had two independent programs, did we not, SNAP–50 and SPUR?

Mr. FINGER. It started that way in that the Air Force had a program proceeding called SPUR and the AEC had a program proceeding called SNAP–50. It was apparent also that NASA was interested.

Mr. KARTH. SNAP–50 was funded by NASA?

Mr. FINGER. No, sir, it was funded by the AEC. It was a reactor development effort.

Mr. KARTH. Where did NASA come in?

Mr. FINGER. NASA had, all along, a technology effort on high powered electric systems which is still an important program item in our budget. We are interested in power going up into the megawatts of power and it is this technology effort that is being coordinated with the AEC and Air Force program through our deputy assigned to that SNAP–50 office.

Mr. KARTH. Do you have any idea whether or not this inability to reach agreement caused a delay in the program?

Mr. FINGER. I don't believe it did. I know it didn't alter our program. We proceeded with our technology effort in the same way and I——

Mr. KARTH. You don't think it speeded it up?

Mr. FINGER. No, sir. The funds were available. I think all of the agencies proceeded with their part of the program in the way they had planned to proceed. It was the management structure that was in question, not the program itself, not the basic elements of the program.

Mr. KARTH. When you have the management structures disagreeing, it seems to me something happens.

Mr. FINGER. We are in a very——

Mr. KARTH. Either your independent programs are slowed down or they take a devious course or it is speeded up but certainly it doesn't, in my opinion, go down the same road that it would have gone down had nothing happened in the way of disagreement.

Mr. FINGER. I think the timing of the program really plays a very important part in the judgment of whether it slowed down or not. It was obviously not speeded up. By timing I mean this; that we are now in a position where we are trying to develop the materials data, corrosion data, heat transfer coefficients, very basic elements of the technology and research information. This is information that can proceed without need to integrate it closely into a particular system concept, so that at this point, I would say those elements of the program did proceed as they were planned. We certainly proceeded as we had planned and still are; I know that.

Mr. MOSHER. Mr. Chairman, Mr. Finger says that the various agencies involved proceeded with their work involving management procedures. Was there any duplication of effort between the agencies as they proceeded?

Mr. FINGER. No, sir. The AEC was handling the reactor portion of the program and neither, as I understand it, neither the Air Force in Spur nor, certainly, the NASA were doing reactor work. The Air Force had some study work being done by Aerojet Nucleonics which was transmitted to the AEC on a continuing basis. All of that information was available to the Atomic Energy Commission.

Mr. MOSHER. So you say there was no particular waste or inefficiency resulting from this?

Mr. FINGER. No, sir. On the NASA and Air Force side we both worked in the nonnuclear aspects of high power system programs and there we had very close liaison on the working levels as well as meetings I had with Air Force representatives to insure our program elements were contributing to each other. There were, for example, total areas in which the Air Force did no work because we had a program going in that area. So that these individual research elements were being coordinated and they didn't rely for their execution on having a single management structure at that time. As time goes on and specific systems are to be developed, the management structure becomes extremely important because you have to integrate all of this work. Our technology effort is, however, not a direct part of the SNAP-50 project but it does provide important research and technological information.

Mr. KARTH. It is even very important when you are beginning a program, isn't it?

Mr. FINGER. You must certainly know that you don't duplicate any of the work unnecessarily. I think there is a point to be made——

Mr. KARTH. Good, strong central management is very important, regardless of the time frame within the program.

Mr. FINGER. Yes, sir; I agree with that. I agree with that.

Mr. HAMMILL. How long were the SNAP–50 and SPUR programs independent?

Mr. FINGER. Well, the SNAP–50 program was a fairly new one, as I understand it. I don't remember when it was started exactly. The initial work is an outgrowth of the nuclear-powered airplane work at Pratt-Whitney. The SPUR program was started in a study way back in 1959, and when it was started NASA and the Air Force sat together

and discussed it and discussed the work statement that the Air Force issued. The AEC, I believe participated in the selection of the contractors for SPUR from the reactor point of view. So there was coordination right from the start of it.

Mr. HAMMILL. The only question relates to the fact that they were independent programs for a year or two or more, but recently they were combined. Why did they remain independent as long as they did? If it is wise to combine them as a single effort, as has been done, why wasn't it wise to do that early in the game?

Mr. FINGER. I think there was just no feeling that it was essential at that time to coordinate the research efforts, that the managements of the separate agency efforts could be coordinated in such a way that there would be no undesirable duplication.

Mr. HAMMILL. This is now under your office?

Mr. FINGER. No, it isn't. The SNAP–50 program is being managed in the AEC, with a NASA deputy assigned to that office and an Air Force deputy assigned to that office.

Mr. HAMMILL. You have nothing to do with that, is that correct?

Mr. FINGER. The NASA deputy, assigned to the office, reports into the Electric Power Systems Branch of my NASA office.

Mr. KARTH. Are any of NASA's moneys going into that?

Mr. FINGER. Into SNAP–50 office itself? No, sir. We do have, in NASA, a technology program which does provide technology which I am convinced will be very useful in a SNAP–50 system, and it is that information that will be carried into that office by our man assigned to it. Our technology effort is a broad gage effort that will permit us to go to megawatts of power.

Mr. KARTH. This technology is being carried on in various centers such as Lewis; right?

Mr. FINGER. Lewis, as well as on contract.

Mr. KARTH. Might it be duplicating what is done at AEC?

Mr. FINGER. No, sir; I know it is not. We have a man there that knows the AEC SNAP–50 program in detail, and he also knows our program in detail.

Mr. KARTH. How much money is your office asking in the 1964 budget?

Mr. FINGER. In the nuclear electric systems?

Mr. KARTH. Yes.

Mr. FINGER. We have $13 million for the "Advanced research and technology," $15.1 million, I think, for SNAP–8 system, or our portion of the SNAP–8 system, $9 million for the development of SNAP–8 flight technology. I think it is $1.4 million for flight tests to evaluate zero gravity effects in these systems.

Mr. KARTH. Zero gravity effects are the same, no matter what system they are in, whether a nuclear system or chemical system?

Mr. FINGER. The difference is primarily in the configuration and the fluids you work with. The fluids we are interested in are liquid metals, molten metals, used as our working fluids, as well as metal vapors.

Mr. KARTH. You are talking about the reaction of fuels under zero gravity conditions?

Mr. FINGER. We are talking about the boiling and condensing of these metals in zero gravity. I think most of zero gravity work you have heard of so far has been related to the propellant systems, hydro-

gen, oxygen systems. That is not the work we are doing. We are relating our zero gravity work specifically to the SNAP–8 system and these electric-powered systems, using liquid metals and metal vapors.

Mr. KARTH. What is the difference between SNAP–8 and SNAP–50?

Mr. FINGER. Power level and technology. The SNAP–8 technology——

Mr. KARTH. Should we be traveling down both roads?

Mr. FINGER. SNAP–8 is only a 30-kilowatt system and the SNAP–50 that is being carried on by the AEC will deliver 300 to 1,000 kilowatts of power. The exact value is not yet determined, but it will approach the megawatt range.

Mr. KARTH. Why are we doing work on a 30-kilowatt system?

Mr. FINGER. As we see it, there are strong potential uses for this kind of a power level. It was started, as you recall, originally to serve both auxiliary power requirements and early electric propulsion. Essentially our chemical vehicles have grown so large that the SNAP–8 system doesn't serve very well as an electric propulsion system; it is intended for on-board power to serve auxiliary power requirements, but it might also be used for orbit stabilization. Our interest is largely for providing power for large space laboratories, for lunar stations, and for deep-space communications. We will need high powers for those applications, 30 kilowatts of power.

Mr. KARTH. Is the technology for a larger producer of power different from the technology used for a relatively small producer of power?

Mr. FINGER. The main reason for that is the result of the application. A SNAP–8 system being used for auxiliary power can be fairly heavy. We would like to make it as light as possible, but it can be fairly heavy and we do intend to use it for auxiliary power in these space laboratories, and so on.

Mr. KARTH. My question was a large producer of power——

Mr. FINGER. It must be different technology.

Mr. KARTH. It calls for a different technology than the development of a power system of the lower kilowatt range?

Mr. FINGER. Yes, sir, the main reason being that the weight of the system would be too large if we used the same technology.

Mr. KARTH. I know there would be differences in the whole vehicle, but is the technology different?

Mr. FINGER. In order to maintain a reasonable weight you must go to high temperatures in a higher power system. For example, if we use the SNAP–8 technology in a thousand-kilowatt system we would have a system that weighed 100,000 pounds, because the SNAP–8 will weigh 100 pounds per kilowatt. In order to have a system at a megawatt that is of reasonable weight to put on any of our vehicles, we must go to higher temperatures, and this involves the development of a new technology. The system would just be too heavy if we used SNAP–8 technology.

Mr. KARTH. You feel that we will have future uses for a lower kilowatt nuclear power source?

Mr. FINGER. Yes, sir, I do. In addition to that, we——

Mr. KARTH. At the moment we don't have any specific use for it, do we?

Mr. FINGER. No, sir, and I think that is a very important point to make for most of the areas that I am talking about here. The systems we are developing here are aimed at establishing for us the technology

and the kind of systems that we will want to use for missions beyond those that are currently planned and for which firm time requirements are established. Essentially, we want to be sure that when we get to a point of doing these missions beyond the first lunar landings we are, in fact, in a position to do so.

Mr. KARTH. If the question is asked on the floor of the Congress or by the full committee or the subcommittee what portion of your budget is directly applicable to the manned lunar landing program, we can say that insofar as the nuclear systems office, none of it is, couldn't we?

Mr. FINGER. Not to the first manned lunar landing. We had earlier hoped we could be a backup approach on the first manned lunar landing system with a nuclear rocket, but our timing is not right.

Mr. KARTH. I am talking about the $20 billion program.

Mr. FINGER. That is correct.

Mr. KARTH. Our answer could be "None," right?

Mr. FINGER. That is correct. We are part of the program aimed at developing systems to provide this country with a capability to do the missions beyond that first manned lunar landing. For example, lunar logistics, where we establish a station on the Moon and have to supply it with manpower and flight cargo, as well as with power; planetary missions where we carry men out to the planets, either to land or simply to fly by, for both communications and the propulsion capability. These are systems that are, essentially, laying the groundwork to provide us with a capability to go beyond this first really large mission that we are talking about.

And they are the missions that I think many of us believe are inevitably the ones that will be coming along to follow on beyond the manned lunar landing mission.

Mr. MOSHER. Mr. Finger, this is just a matter of curiosity: Do you have any specific information which leads you to believe that the Russians are as deeply involved already and as deeply committed as we are to work looking to missions beyond the lunar landing? Are they as involved as we already are in it?

Mr. FINGER. I don't have any information on that. There may be information in the Agency on it, but I don't know.

Mr. MOSHER. We have to assume they probably are.

Mr. FINGER. I believe so. This is a very large effort for them, too, and it must lead on to something on a continuing basis, I would think. It isn't the kind of a program that I would think could be cut off drastically here or there.

Mr. MOSHER. In other words, the lunar landing itself doesn't make any sense unless you go beyond?

Mr. FINGER. I think it must lay the groundwork for a continuing effort of exploration in space.

Mr. KARTH. Our whole policy of preeminence in space goes well beyond the manned lunar landing?

Mr. FINGER. Yes, sir. I believe that is the point. This is the first of the missions that we believe that we can do that will clearly establish a preeminence, but obviously, in my mind anyway, we must continue this program and do the advanced missions and missions of interest to us scientifically and technologically.

Mr. MOSHER. We have to assume this is the same philosophy the Russians have.

Mr. FINGER. I would think so. They have been using it up to now.

Dr. BISPLINGHOFF. Could I add something? We do know that the Russians are active in the area of electric thruster development. Mr. Finger is going to discuss this in a little while, the work we are doing in electric engines, and this would be an indication that they are working in missions beyond the lunar landing, since this is not a device which would ever be used for that purpose.

Mr. MOSHER. Our electric thrust development is largely being done in Lewis?

Dr. BISPLINGHOFF. A great deal of it, yes.

Mr. KARTH. Doctor, did you say the Soviets are working with this electric thruster system?

Dr. BISPLINGHOFF. Yes.

Mr. FINGER. Yes, I neglected to mention that. We do know they have worked in this area.

Mr. KARTH. That is rather important, isn't it?

Mr. FINGER. Yes, it is.

Mr. KARTH. What we are talking about right now as the pacing item. For example, this electric thruster system the Doctor just mentioned, you can't have that without first having developed power supply systems. So might that imply that they are ahead of us?

Certainly it implies they are doing a lot of work in it.

Mr. FINGER. It might very well. There is the possibility they are ahead of us in power levels and the kind of systems they are working with. They are interested in it. Incidentally, in terms of direct conversion, it is very clear that they are working actively on methods of converting electrical energy from heat to electric power by direct means, without any turbo machinery, and that is an area, too, in which we are working. I don't know the detailed status of their work in either of these areas.

Mr. MOSHER. Are they publishing anything?

Mr. FINGER. They have published some information, and it is on the basis of some of that information that we make these conclusions that they are quite interested in these areas.

Mr. MOSHER. How freely and completely do we publish?

Mr. FINGER. In these areas, generally, we publish most of our information. We do hold back some of the techniques we use in instrumentation and the technology of these systems, but generally we publish our data quite freely.

Mr. KARTH. You don't see much data published by the Soviets on this?

Mr. FINGER. I don't see very much of it; no.

Mr. KARTH. If they publish, would you see it?

Mr. FINGER. I believe it would be in our office and I would see it; yes.

To go back to the Kiwi-NERVA–RIFT program a bit, Dr. Seamans and Dr. Bisplinghoff in earlier testimony have already pointed out we are not undertaking the heavy procurement and development of nonnuclear components of these systems until we have demonstration of successful reactor operation. We think this is a logical approach, but we are not, by this guideline, eliminating the work on these components entirely. There are certain long leadtime development items that are required, certain technology developments that are required, and there are certain items that will really establish or have a real

impact on the design of the reactors as well as on the design of overall systems, so we are proceeding with those things in this program. But we are not proceeding with a major full blown development effort on NERVA and RIFT until we have a reactor that has indicated successful operation.

A mockup of the NERVA engine is shown on the next slide (fig. 291). This engine stands 22 feet tall. The reactor is in the central portion of the engine, the thrust structure at the top and the thrust structure bolts up into the liquid hydrogen propellant tank. The nozzle is at the bottom. One of the factors we are looking at is the effect of nuclear radiation on all of the components of the system

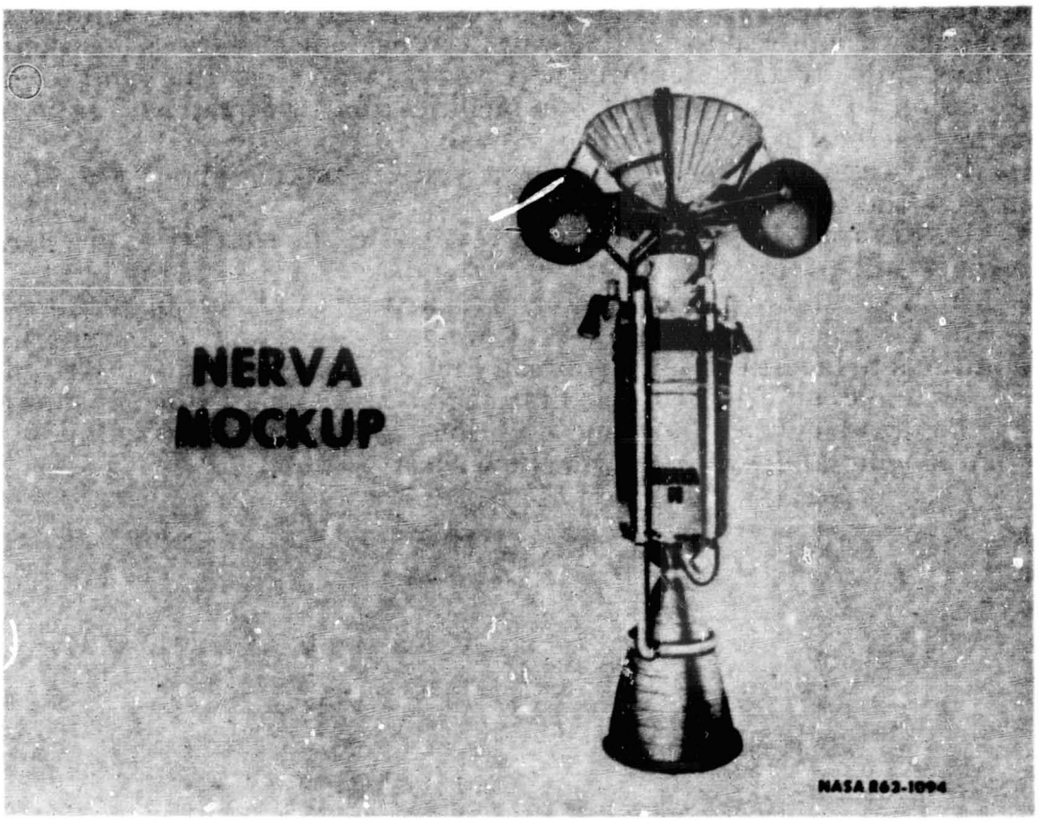


FIGURE 291

We have reached an agreement with the Air Force by which the Space Nuclear Propulsion Office would use the nuclear aerospace research facilities at Fort Worth, operated by Convair for the Air Force, to evaluate these radiation effects.

There is a test reactor down there we are proposing to use in this program. In addition, we will run the actuators that you see at the top to control the reactor in our Plum Brook Reactor Facility.

We are also doing radiation effects work on the RIFT components, components related to the vehicle, in a test reactor that is located at Dawsonville, Ga., operated by Lockheed. This also was an Air Force facility and there are negotiations underway now to determine how to proceed with operation in that facility. Reactor tests such as the KIWI and the test——

Mr. KARTH. May I interrupt? Do you have any request for funds for facilities in this area?

Mr. FINGER. We have a request for twenty and a half million dollars in funds for the nuclear rocket program at NRDS, the Nuclear Rocket Development Station, which are related to the test stands that are located out there and support facilities for that site.

Mr. KARTH. Do you have any of these facilities any place else in this country in private industry or Government?

Mr. FINGER. No, sir. I think this is a unique thing about the nuclear rocket program, in that all of the facilities involved with power testing of reactors in the nuclear rocket program are located in Nevada at this one location. There are no other facilities like these. The testing of the nonnuclear components in simulated systems without reactors—that work can be done at various locations. But in order to test at power with reactors we need this kind of an exclusion situation, so all of our facilities that are planned for tests using reactors are located out in Nevada.

Mr. KARTH. The facilities request you are talking about, will that involve the testing of a reactor?

Mr. FINGER. That does involve test stands in which reactors and engines will be tested; yes, sir.

Mr. KARTH. Is this just a downpayment or total cost of facilities?

Mr. FINGER. The facilities that we are requesting are primarily additions to facilities that are already under construction or in design. For example, additions to our first engine test stand, which is shown on the next slide (fig. 292) and additions to the disassembly building that is being built, which I will show shortly——

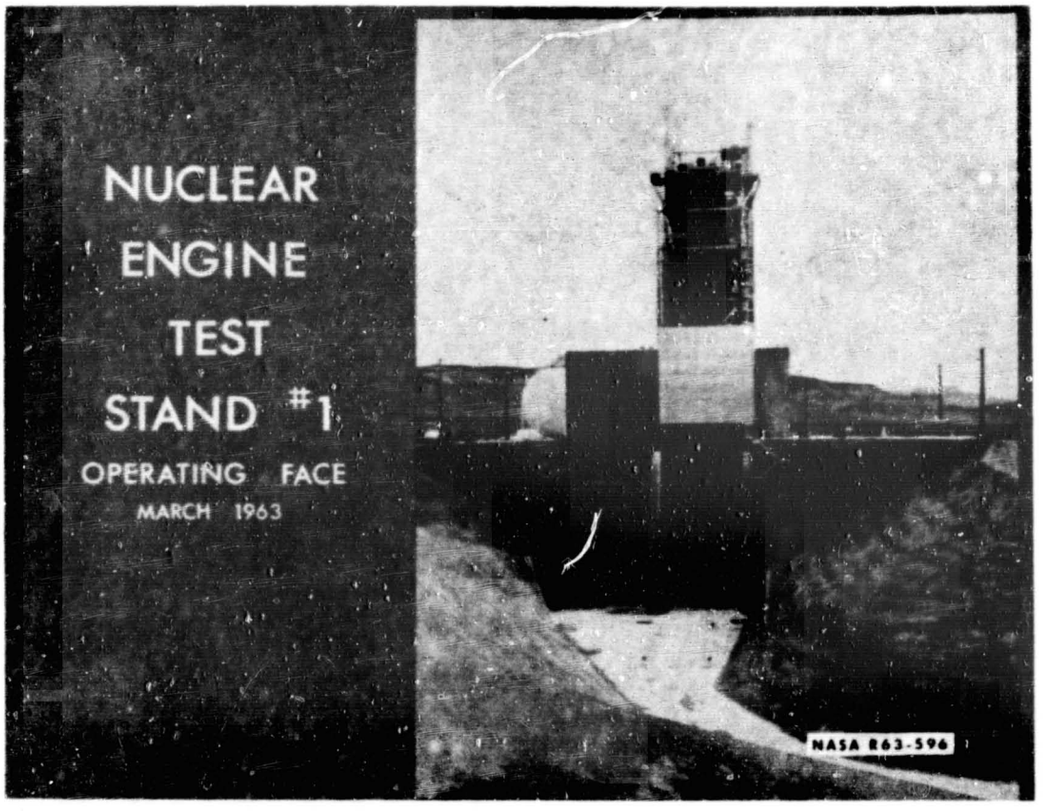


FIGURE 292

Mr. KARTH. This $20 million will pay for all of the additions that you presently have in mind?

Mr. FINGER. There will be need for additional funds out in Nevada if that is the question that you are really asking. These funds don't provide for any vehicle test stands, and there will have to be vehicle test stands out in Nevada. There will also have to be an additional engine stand which can be used either for engines or vehicles, in order to integrate these systems so there will be additional facility requirements in Nevada not included in this present budget. This doesn't complete our installation.

Mr. KARTH. When will you have use for that engine test stand you just referred to?

Mr. FINGER. The first engine test stand would be available the early part of 1965. This one that is under construction——

Mr. KARTH. Have you already funded for that?

Mr. FINGER. This is the test stand. There is still quite a bit of work required to get it ready. I think this is the main reason we asked for funds in the engine area. The test stand takes so long to build and we have such long leadtimes that we must anticipate our needs in some of these facility areas. It is not the kind of an area in which we can catch up. We can do some catching up in a research part of the program but it just takes a certain number of long years to build the facility. These take three years to build, three to three and a half years to get them operational. So we have a go-ahead on two engine stands, this one and another one now in design, and additions are included in this budget for those facilities.

Mr. KARTH. Why does it take three and a half years to build an engine test stand? It takes about 7 years to get to the Moon, and it takes us half that long to build a test stand.

Mr. FINGER. It takes that long to design, build, and activate the test stand. There is a complicating factor in these nuclear test stands in that they must be built of materials that will not become radioactivated during operation. They have high-temperature gases and high-heat transfer situations associated with them. There must be proper exclusion or separation of the control point from the test stand and tunnels are involved. It is a more complicated test installation than is the case with many of our chemical rocket systems, although they take 2 years to 2½ years to activate generally.

Mr. KARTH. Will the test stands be built with the possibility of expansion so that they may be utilized to test larger or different engines in the future?

Mr. FINGER. Yes, sir. They have a growth capability in them. We do have to limit that growth capability by the funds available and technical design considerations, but we have built, into all of these stands, some growth margin. In fact, they can grow several times.

Mr. MOSHER. Mr. Chairman.

Is the 8-hour day, 5-day-per-week schedule very much involved in the fact that it takes 3½ years to build these test stands? Is that a major element in the time? Could they be built a lot faster on the basis of overtime and double time and all that sort of thing?

Mr. FINGER. They could be built faster with this kind of an arrangement. We have, in certain critical items where we have felt we had a large gain to make in time by going to overtime, done that.

That hasn't been done very much because of the premium pay involved. But we could gain some time. I don't think it would be very substantial time that could be gained. In fact, as an example, I might mention that out here in the Nevada desert some of the pouring of concrete must be done in early evenings or very early mornings in order to avoid doing the work during the high heat of the day and to be sure we get a proper setting of concrete; so we are frequently, out here, limited to when we can do some of the work involved. It is in particular with regard to some concrete work that we have had some overtime requirements.

Mr. MOSHER. The time lapse actually has quite a little to do with the construction, itself, rather than the amount of time it takes to design?

Mr. FINGER. Yes. Design time, of course, can be done pretty rapidly, although even that is longer than a normal chemical rocket test stand, because of the added factors that have to be considered. We have also found another problem we have is that there are development items right within the test stand. For example, the exhaust duct that deflects the exhaust gases from the engine in this test stand involves high heat fluxes of the high temperature hydrogen gas and in order to try to simulate altitude conditions in the system we have a problem in designing an ejector to try to get to low pressures; so there are technology items involved just in building the test stands in these systems, as well as in building the engines and the reactors. This is another reason that we have had long times in building many of these stands. Incidentally, I might mention, the structure of this entire stand is aluminum in order to try to keep the radioactivity down in the stand.

On the next slide (fig. 293) you see the status of our disassembly building and assembly building (E–MAD). After an engine is tested it is radioactively hot and must be moved remotely and disassembled remotely. This is the steelwork on our assembly bay of this disassembly building. The engine will be brought on a railroad car, remotely controlled, along these railroad tracks into the disassembly area which will be a 6-foot-thick concrete structure. The walls will be 6 feet thick and all operation on the reactor will then be done using remote manipulators operated from behind the 6-foot concrete walls. There is in this budget an addition on this building, the engine disassembly building, as well.

In addition to the development of NERVA, we have indicated that the RIFT stage will be used to flight test the NERVA engine and that that is its primary objective, but it is also being designed in such a way it could lead to an operational third stage on Saturn, on the Saturn V. Our present concept of the RIFT stage is shown in the next slide (fig. 294). You can see here the total height of the stage is about 126 feet, the diameter is 33 feet, which is the same diameter as the Saturn V diameter. The NERVA engine is shown at the left of that chart. It is interesting to point out that this stage will have almost the largest hydrogen tank of any vehicle now being developed. The next slide (fig. 295) indicates the kind of a trajectory we are talking about using in flight testing this stage. Next slide.

We will essentially have a lob shot from the cape with the RIFT stage set down on the S–IC of the Saturn V vehicle, with a dummy second stage, and there will be a ballistic firing over a limited range

FIGURE 293

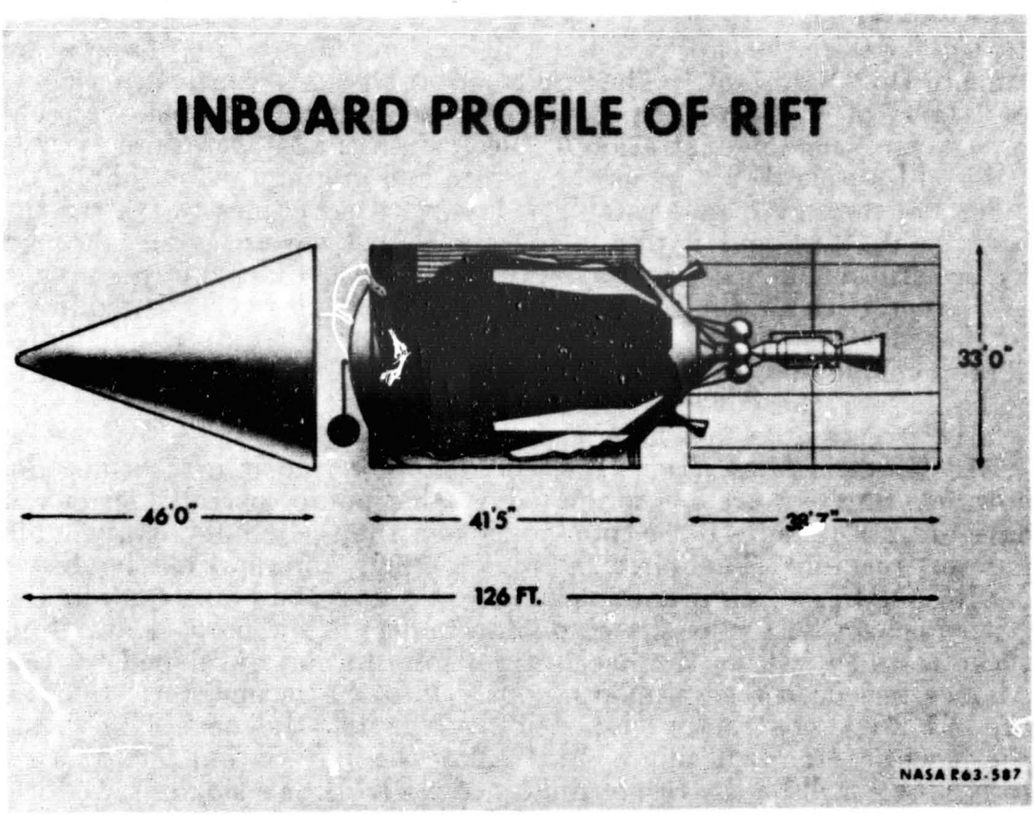


FIGURE 294

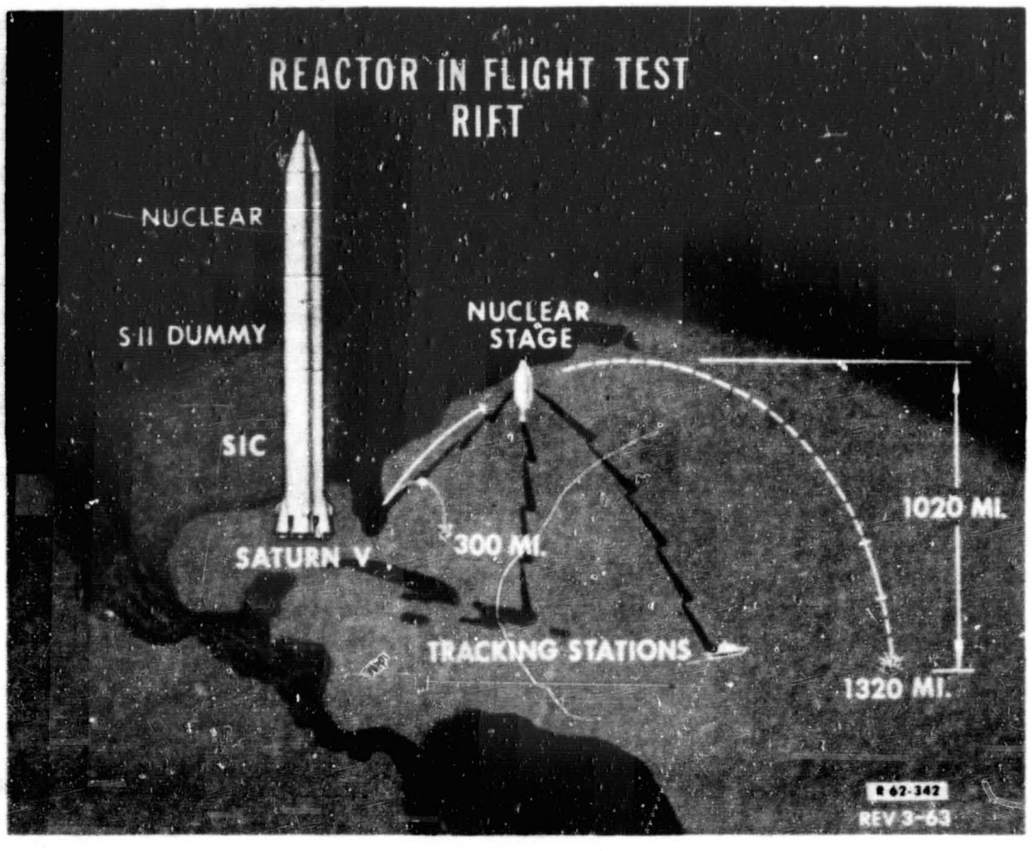


FIGURE 295

trajectory from the cape. There will be about 20 minutes of operating time in this flight test. The implementation of the hardware aspects of RIFT, of course, depends on the availability of the reactor technology and the demonstration of successful reactor operation.

Mr. MOSHER. What general date are you aiming for for that?

Mr. FINGER. We had established various schedules but after the last reactor test and with the redesign effort we are going through we are still in the process of looking at what schedules are reasonable. We haven't fully established the program schedules yet. In addition to that, because of the technical status, the flight date is indefinite. The development of the RIFT and NERVA systems depend on the technology of the Kiwi or NERVA reactor.

Mr. MOSHER. Is this some years away?

Mr. FINGER. Yes, it is. We would hope to do it in this decade, however, but we are not prepared at this point to really specify a date on it. It depends so much on when the technology is available for the reactor. The next figure (fig. 296) summarizes the Kiwi-NERVA-RIFT timing and phasing. We have had six tests on the Kiwi reactors so far as shown on the upper yellow bar. Data from those tests as well as the background information developed by Los Alamos has been feeding continuously into the second bar, which is the NERVA contractor responsibility. After the next Kiwi test, the Kiwi program will phase out. All of the information then related to NERVA will be the responsibility of NERVA as a single-line effort. We have already given the NERVA contractors responsibility to

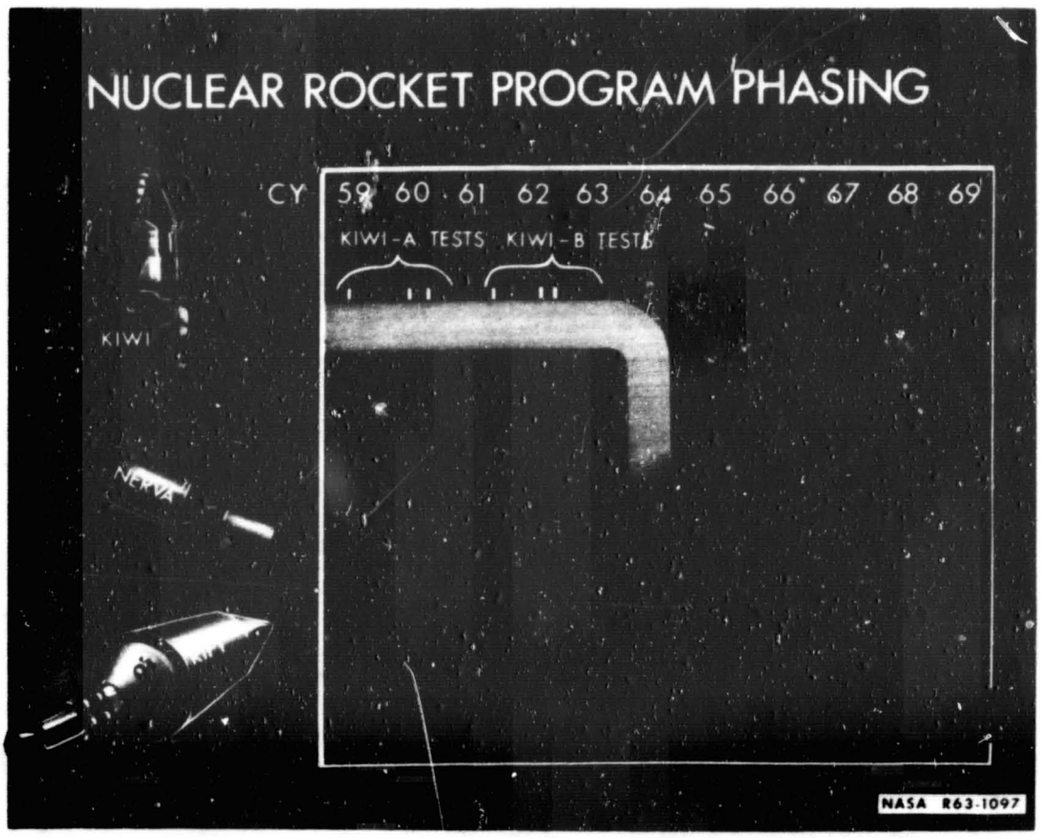


FIGURE 296

proceed with the reactor required for NERVA, designing and building reactors for NERVA and reactor components. That work will continue on to the development of a fully operational and reliable NERVA engine.

When the NERVA engine gets to a point where we have sufficient confidence in its reliability and operability, it will be mated with a RIFT vehicle which is the bottom bar and we will start our program of static testing out in Nevada of the entire stage. We will continue that on through the development of the stages that will be flight tested and, I am convinced, on to the development of an operational stage to be applied to the Saturn V. In addition to what I term early development projects, such as RIFT and NERVA, we consider it essential to conduct an active advanced research and technology program paralleling the development effort. This is, I believe, especially important in an area like this one where it isn't only the single system that we are trying to develop but we are trying to develop a whole new area of rocketry that will permit us greater freedom and flexibility for traveling throughout space. The advanced technology phase of this program is a very essential part, both in supporting the development and also leading to more advanced ideas and advanced systems. Our work in this area includes such items as work on advanced, higher power graphite reactors. This part of our program has usually been called Phoebus. It is the work that will be done primarily by Los Alamos with engineering support. It includes work on the metallic-reactor technology, work on nonnuclear engine com-

ponents aimed at higher powers and greater performance capability and improved design concepts and it also includes the investigation of advanced reactor concepts such as the gaseous core reactors that offer promise of very high specific impulse, much higher than we can get out of the solid fuel element reactors.

Much of this work on the nonnuclear engine components in our ART program is conducted at our Plum Brook installation and there has been funding in past years to provide facilities for our controls and nuclear systems studies at Plum Brook. We will also use the Plum Brook reactor for some of the radiation effects work in this program. There is greater detail in this section on our advanced research and technology effort in my formal statement but I think for the sake of time I would just summarize it by the comments I have just made.

It is apparent, I believe, that the effort on nuclear rockets is a substantial one. It is justified, we are convinced, by the potential performance advantages and capability and wide applicability of these systems for these space missions. We believe that the program we are pursuing is a logical one and includes the sort of work essential in insuring that this technology will be available at the earliest possible time. Our emphasis continues to be on the solution of reactor problems and development of a reactor design suitable for flight application. We are confident that this kind of a reactor can be developed. In addition we are doing work in important nonnuclear areas that are required to assure that this technology can be available.

I would like now to go into the discussion of our nuclear electric power and electric propulsion programs. The single line item in our budget called nuclear electric system programs is composed of two major segments: One, the development of systems for generating electric power using nuclear energy sources, and the second one is a use of the electric energy to develop thrust in an electric-thrust engine. I would like first to discuss the nuclear electric power programs and our technical goals in that program as well as the electric propulsion program as shown on the next slide (fig. 297).

The power program goals include trying to get as light a system as we can. We are trying to get a weight of 10 pounds per kilowatt in these power generating systems. As I mentioned earlier, this is necessary for electric propulsion. It is desirable but not necessary for auxiliary power. In addition we want a wide range of power capability. We think of isotope systems to provide powers up to 1 kilowatt or in the watts of powers. We think of the reactor systems for providing powers into the megawatt range. In addition for all of these systems we need long life and it is really for long-life applications that the nuclear systems hold promise. They must therefore be developed for operating life without maintenance of at least a year and going up into several years for some of the applications that we have studied.

In regard to the electric engine program, one of our major goals is high efficiency. The higher the efficiency the lower the power that is needed out of the power supply and therefore the lower the weight of the power supply; so we do want to get high efficiency in these engines. In addition the requirement for long life still exists there. Now, we also have a broad range of thrust that is required but you will notice that the thrust levels are very low. These systems with electrical

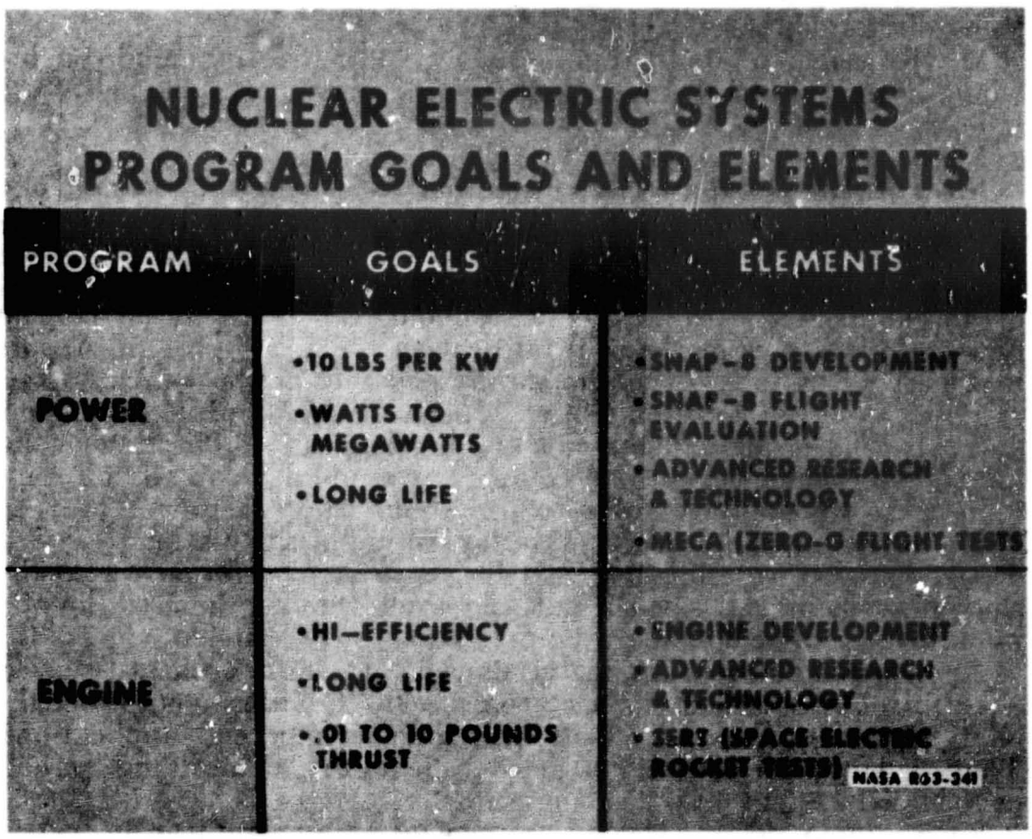


FIGURE 297

acceleration are just not capable of developing high thrust and they must, therefore, be used as space engines, not at all as booster-type engines. They can only propel us once we are out in space.

Mr. KARTH. Mr. Finger, just as a matter of curiosity, if we put this much effort into the development of a nuclear engine for the purpose of powering automobiles, could we develop one?

Mr. FINGER. There really wouldn't be anything to gain as I see it in that kind of application. There would be a problem in shielding, in safe operation, but the important thing is that we have gas stations located all over the country and we can stop to refuel wherever we want. I think if we had way stations all the way out to Mars so we could stop and refuel chemical rockets we would do that too, generally. The problem in space missions is that we must carry the propellant with us right from the start or else try to refuel and rendezvous at various locations in space in order to provide us with a capability to go far. On the Earth we don't quite need this. We have a capability to travel far.

Mr. KARTH. What you are saying is that all of the research and technology that goes into the development of these engines do not have a commercial or a consumer application in any sense of the word?

Mr. FINGER. Not in the case you have illustrated. I think that there is the strong probability that some of the technology we develop may have impact on various of the reactor programs that are being investigated from the point of improving analytical methods,

for materials properties, and so on, but not specifically as the systems being directly applied.

Mr. KARTH. You don't think a nuclear-powered automobile engine would be any better than the reciprocating-piston-type engine we use today?

Mr. FINGER. No, sir; I don't, and I like nuclear energy.

Mr. KARTH. Do you foresee any other areas where this technology may have some future consumer use, where it might find its way into the economic stream of this country?

Mr. FINGER. I think the real possibilities in this area are by virtue of development of certain of the technological items, by developing new materials, new methods of fabricating them. High temperature is something we look for in almost any compact power source.

Mr. KARTH. If you don't have a need of this kind of an engine, and this kind of an engine is not applicable to any domestic or commercial economic use, then, of course, you could develop all you want to because we are only going to use about three or four a year, so you really do nothing for the material section of the Nation.

Mr. FINGER. My comment in relation to your question was really that this system as it exists is not something that can be used directly in any kind of a commercial application but I am convinced the technology we develop, the materials work, the data on heat transfer, the control system, and the electronic gear, the instrumentation, the analytical methods, and so on, will have commercial applications. They will provide us with a greater flexibility in building various commercial systems and products.

For example, central station powerplants may significantly benefit by some of these systems, or process gas systems will, I believe, benefit from the kind of technology we are developing here, but the system, as such, doesn't have a general applicability, I don't believe. The system as we are developing it is really a space flight system, but certainly the materials we develop and the technology we develop will find its way into the general industrial and technical competence of the country.

Mr. KARTH. Other than in materials, can you think of any other areas where it might find its way into the general consumer type economic stream?

Mr. FINGER. Well, we may develop materials that are radiation resistant, and these could be used in bearings or turbines and pumps, and so on, in various kinds of power application, but it is in the area of components and basic information rather than in the full system and I think there we will in fact find great use of these systems.

I would like to go very quickly through each of the program elements indicated on the right, starting with the SNAP–8 system, the SNAP–8 flight evaluation, the advanced research and technology effort, and the MECA.

Mr. KARTH. I wonder if you would just amplify the SNAP–8 flight evaluation and advanced research and technology. Why do we separate advance research and technology from the two SNAP programs? They are all research and technology, aren't they?

Mr. FINGER. But they are much closer to available technology and we have started them, in fact, as full development efforts. We have hardware being developed for those, whereas in the advanced research and technology program we have some 27 different groups working

with us. Part of the work is done in house, a large part is done outside through industrial universities and various research institutes.

The next slide (fig. 101, p. 1926) indicates the SNAP–8 system which is a hardware development effort. It consists of two main systems, a nucelar subsystem and a nonnuclear or power conversion subsystem. The nuclear reactor, itself, is being developed for the Atomic Energy Commission by Atomics International. The rest of the system is being developed by Aerojet General for NASA and the integration of these is also the responsibility of NASA. We have gone through a review and a redesign of this system. This is the redesigned version and the next slide (fig. 299) indicates the results of redesign.

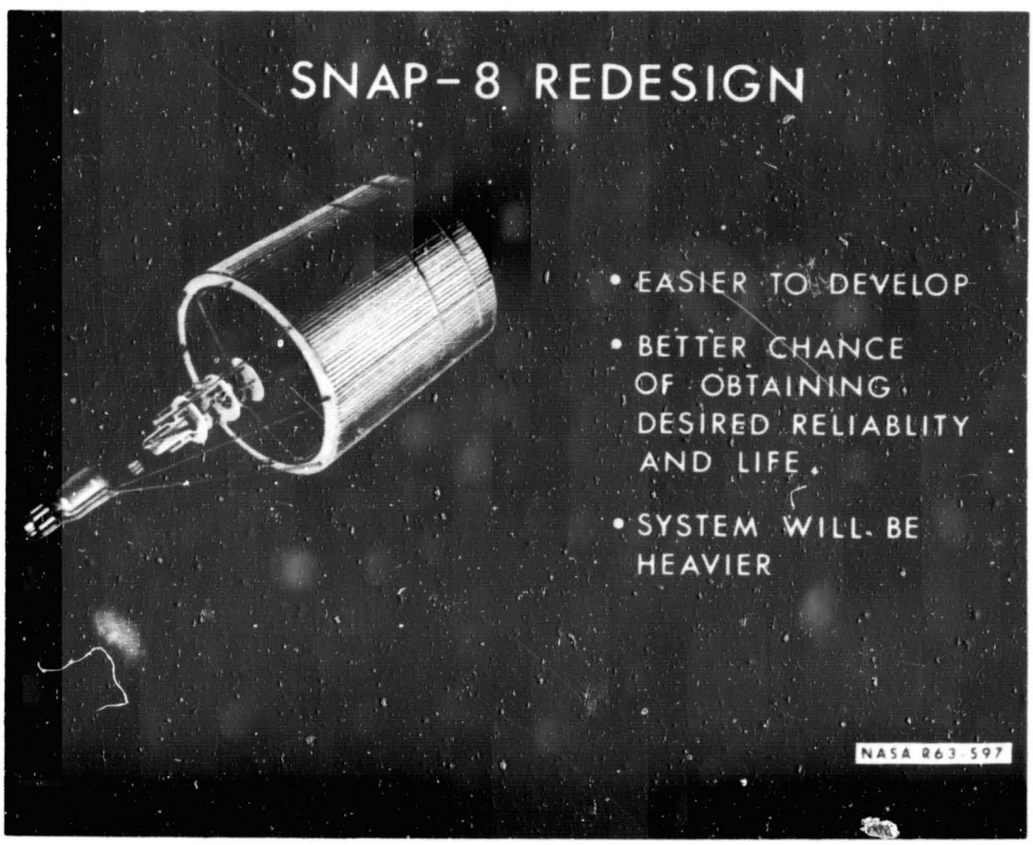


FIGURE 299

Essentially, we believe we have gotten a system that is easier to develop than our original design. We believe it has a better chance of getting high reliability and the long life we want. It will be heavier, but we are willing to take this sacrifice because we intend to use the system for onboard power and consider it a very important part of our program from that point of view. It will in addition be a much more versatile system in that we will be able to apply it easily to many different kinds of vehicles.

Some of the problems that we have encountered are materials problems, and the next slide (fig. 300) indicates a result of some of our materials testing. One of our problems is that we use mercury in this SNAP–8 system as a turbine drive fluid and mercury is quite

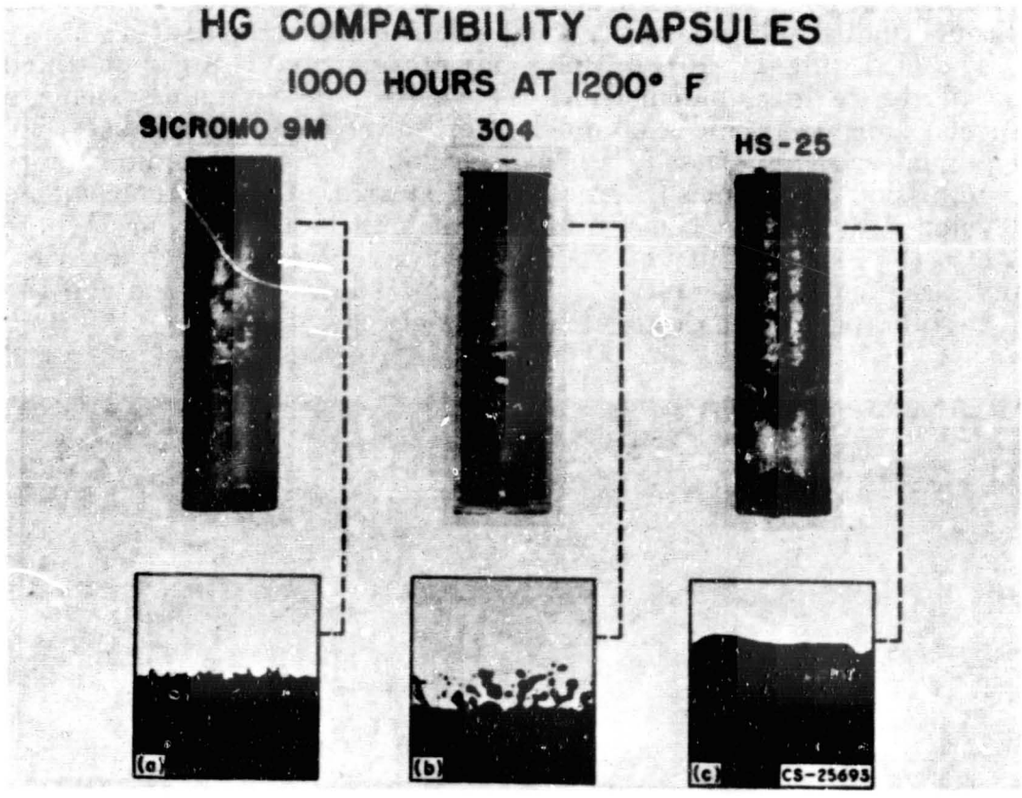


FIGURE 300

a corrosive fluid. This slide shows you three capsules, small sealed metallic capsules. Mercury is filled up to about a third of the height of each of the capsules, and it is then boiled. The mercury vaporizes and coats the walls and is then condensed back to a liquid. You can see the corrosion that has occurred in each of these capsules after a thousand hours of operation at 1,200° F. The SNAP–8 mercury system must operate at 1,200° F., and we are in the process of trying to select a material or develop a material that will give us the long life we need—a year of operation, which is about 9,000 or 10,000 hours of operation, compared to the 1,000 hours shown here. We are tentatively using this Sicromo material which shows the lowest corrosion.

This indicates a new technology that may in fact have real applicability in powerplants for various applications.

With regard to the flight testing of this system, as has been indicated before, we are holding off on hardware development on this system, on the test flight spacecraft, until we see how the development effort on the SNAP–8 system itself proceeds, until we get further along in the development program.

Mr. KARTH. Is most of this work being done in-house?

Mr. FINGER. The SNAP–8 work is almost entirely outside contract with Aerojet General.

It happens this capsule work you see was done in-house at the Lewis Research Center. They also are the technical director on the SNAP–8 program, so they conduct, and this is essentially the way NASA operates throughout its programs, they conduct a strong in-house

effort in areas related to those projects for which they have technical direction responsibility. This is, therefore, work done inhouse in support of the SNAP–8 program.

Mr. KARTH. I assume that the Navy and Air Force, and possibly other agencies of Government, are doing research work in this electrical propulsion system field. I wonder how do you coordinate the activities of the various agencies of Government that have companies under contract doing research in this area, so that you don't have a considerable amount of duplication?

Mr. FINGER. There are really very few groups that do work in this area. We have a strong program in electric propulsion, specifically. The Air Force has a program out of Wright Field in this area, and also they are going to be running some flight tests. The AEC work is in the area of power supplies, power systems, so there are principally the three agencies. The happy situation in this case is that we can go to specific groups and they have the full responsibility for the program in their respective agencies.

Mr. KARTH. Duplication here is much easier to keep tabs on than for example the electronic systems?

Mr. FINGER. I am really not familiar with the electronic system coordination problems. I am familiar with this program and I think, partially because there are relatively few groups in it, the groups can work together and exchange their requests for proposals, meet together, and there is a full exchange of data. All of the groups get all of the reports generated, and we frequently meet in formal sessions to discuss very specific topics—for example, corrosion, heat transfer, and such subjects. All of the people involved get together to discuss this and reports are issued on those meetings as well.

Mr. KARTH. Thank you.

Mr. FINGER. Now, with regard to the flight test, there will be work done, supported by the budget that we have requested, on technology in this area in order to insure that we have flight components and information available, so that when we can define a clear mission we can build a spacecraft that would lead to the development of a mission type spacecraft.

In the next slide (fig. 301) is shown one of the advanced systems that is of interest to us. This is very much like SNAP–8 except the temperatures at which it operates are much higher than SNAP–8. SNAP–8 operates at 1,300° to 1,200° F. This system operates in the neighborhood of 2,000° F., and as a result it requires different materials and different working fluids, and is a technology that is not readily at hand. It does use a turbine drive system.

The next slide (fig. 302) shows another advanced system that we are interested in. This is the thermionic direction conversion system in which a fuel element in a reactor is operating at a temperature of about 3,000° F. It is made of a material that emits electrons which are then collected on the anode. The anode must be cooled, and it is cooled by a radiator. This system generates electric power that can be drawn off into any kind of a power application. What you see here are very high temperatures in the neighborhood of 3,000° F.

Both of these advanced systems are systems of great interest for the development of megawatts of electric power for use in the electric propulsion systems, and if we are to have electric propulsion we must have power generating systems that give megawatts of power with

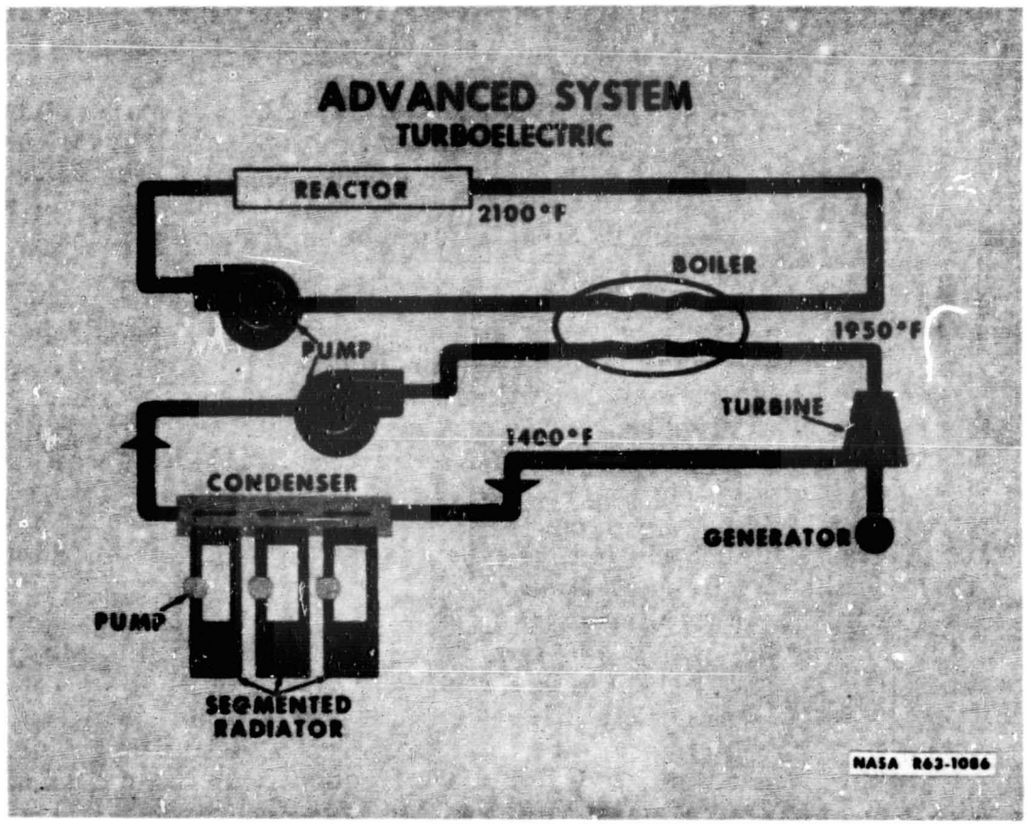


FIGURE 301

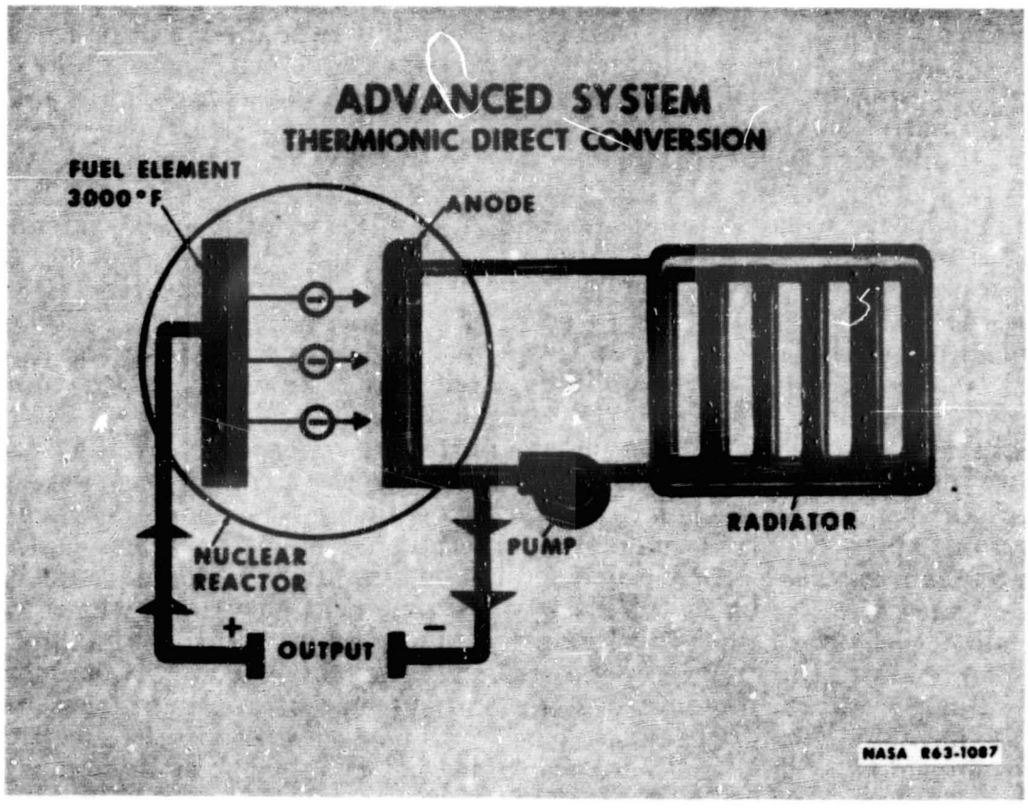


FIGURE 302

very light weight. Neither one of these systems is close at hand. We are working actively in trying to develop the technology for such systems. The electric propulsion application for distant planetary missions is paced by the development of these power systems and the technology required. For that reason we have a very active program in this advanced area working on both of these systems, since we are not really sure at this point which one of these systems would be most promising. This thermionic system looks simpler because it has no moving parts. However, it operates at a higher temperature than the turbogenerator system, and the material problems may be more severe, so we believe that there is no clear choice to be made at this time. There must be a great deal of basic work done before we can make such a choice.

Mr. KARTH. You have a pump there.

Mr. FINGER. That is an electromagnetic pump at least in one concept, so it is nonmovable. There are some people that believe we would need a mechanical pump. The choice isn't clear at this point, either. There may be further developments on electromagnetic pumps that could be applied to this one. In any case, even if it is movable it is still one component compared to turbine alternator, and several pumps in the turbogenerator system.

Mr. KARTH. What is your budget request for fiscal year 1964 in this area?

Mr. FINGER. The direct research request in the advanced research and technology effort is approximately $13 million. This is for in-house——

Mr. KARTH. Is this the advanced system?

Mr. FINGER. Advanced system area. This is not in thermionic direct conversion alone, but it is in the whole area. In thermionics—it is distributed in the thermionics, if I can total it rapidly——

Mr. KARTH. That is all right. What was budgeted last year for fiscal year 1963?

Mr. FINGER. Approximately $10 million, I believe, in this area. There is a small increase related to the electric power system area in the supporting research area.

Mr. KARTH. Did you gain or lose funds during the year?

Mr. FINGER. In the nuclear electric system area we gained $3 million, and in the nuclear rocket area we lost $11 million. I shouldn't say "lost" because that was a decision that we made in that we decided not to commit as much to the RIFT program, the flight-test program on nuclear rockets, until we had successful reactor operation. In view of the fact that such operation didn't occur, we cut funds out of that program. That was the main change that occurred in that program.

Mr. KARTH. A loss of about $8 million?

Mr. FINGER. It was an overall loss of about $8 million, yes. We gained $3 million I believe in the electric power, nuclear electric programs, and lost $11 million.

Mr. KARTH. Your problems still haven't been solved in the reactor field. Why do you need more money this year than last year?

Mr. FINGER. I believe you are addressing your attention to the nuclear rocket program, we haven't increased that RIFT program very much at all over what we ended up with last year. We had $10.7 million in RIFT in 1963 that was used, and we are asking for $12

million now for fiscal year 1964, so we have essentially said we will continue on this pace until we have a reactor that shows promise, and presumably we would come in and ask for additional funds when we had a successful reactor we could point to.

Mr. FINGER. The increase that I mentioned from $10 to $13 million was in the nuclear electric systems area for advanced research and technology.

Mr. KARTH. Your overall increase in the nuclear systems office, what is that?

Mr. FINGER. There is increase in the technology for SNAP–8 flight systems; there is an increase in the supporting research and technology for nuclear electric systems, and there is an increase in the electric propulsion part of the system, electric engines.

In the nuclear rocket area the increase is primarily in the NERVA program related to doing some of this components work that I mentioned earlier, which was necessary—the long leadtime component work—but very little in any other areas, and an increase in the supporting research and technology effort in the nuclear rocket program.

Now, if I may refer to the next slide (fig. 303). This is the vehicle, solid propellant vehicle, that would be used to evaluate the zero gravity effects in these nuclear electric systems. The vehicle is made up of stages that were available and were assembled together. The system will be launched from Wallops Island, and will provide in the

FIGURE 303

neighborhood of 8 minutes of zero gravity operation in a ballistic trajectory.

It is a two-stage vehicle. The payload is being designed and built by Lewis Research Center, and will include a condensing section out of one of the mercury condenser systems included in SNAP–8. We will telemeter data and, in addition, we will photograph, through a transparent tube, the conditions in the condenser, and then recover the package in accordance with methods already used in the zero gravity program.

If I can go to the next slide (fig. 297, p. 2505), I would like to quickly go through the elements on the electric engine program.

We have the engine development and advanced research and technology efforts, and Sert which is our space electric rocket test program.

The next slide (fig. 304) indicates the various kinds of engines on which we are working. These are the arc-jet, the ion, and the plasma jet system. I don't believe you can read it but the arc-jet is capable of giving impulses from 700 to 1,500 seconds, the ion 3,500 to 10,000 seconds, and the plasma jet 700 to 10,000 seconds. The plasma jet could cover the entire range of operating capability of these other two systems. Unfortunately, it is further off in that there are many concepts available but it is very difficult to determine which ones to concentrate on. The arc-jet and ion engine are fairly well advanced. We have had hundreds of hours of operation on these systems.

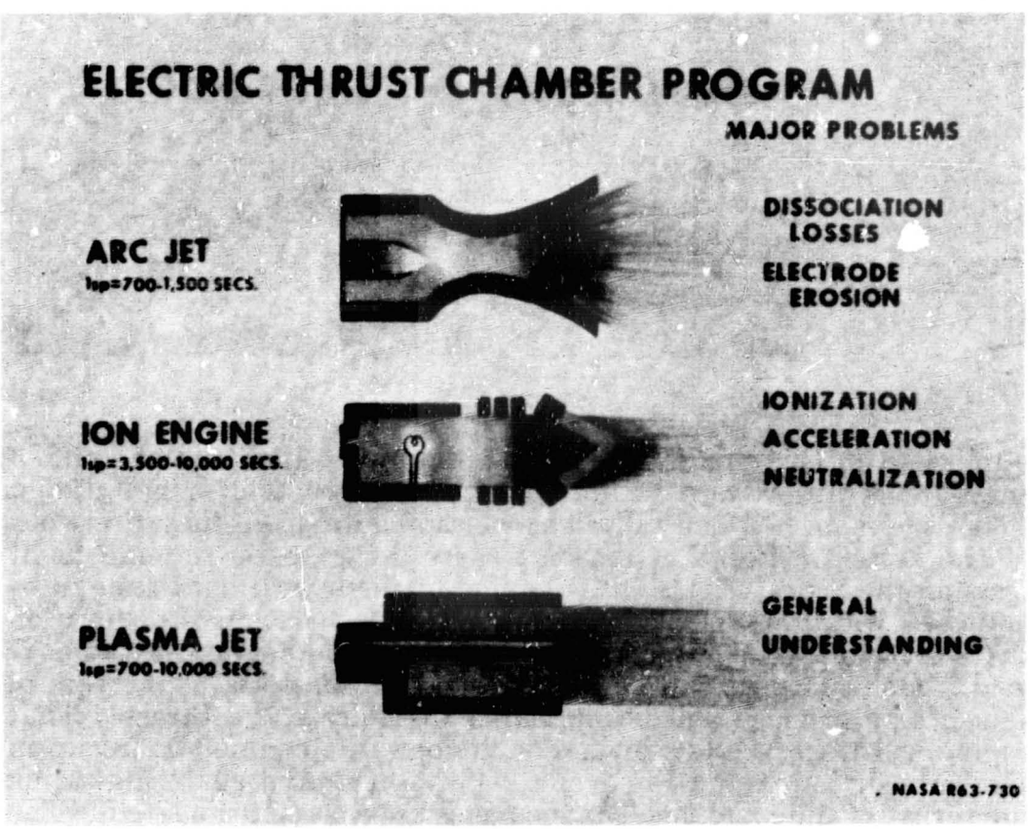


FIGURE 304

Next slide, please (fig. 94, p. 1916).

One of our ion engines has been shown by Dr. Bisplinghoff. This is a single module capable of delivering thrust powered by a 3-kilowatt system and the next slide (fig. 95, p. 1917) indicates how we would cluster this into much larger systems. By developing a module we believe we can develop our capability to go to high powers as well as providing us with a research tool and an engine for low-power systems. The next slide (fig. 307) indicates the kind of a trajectory we will follow with our space electric rocket test. There are some things that we, at this point, are not sure are fully duplicated in our ground laboratory; some things associated with space flight that we are not sure are

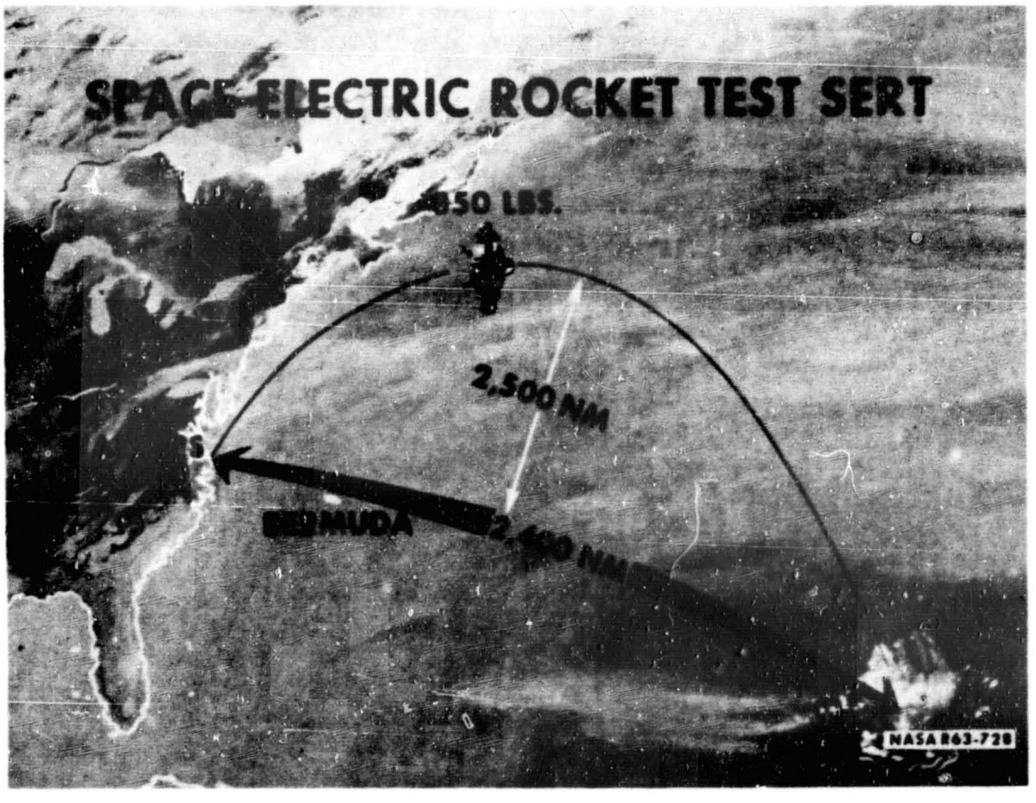


FIGURE 307

duplicated in our ground vacuum laboratories. For example, one of these items with regard to the ion engines is whether or not the jet that issues is in fact neutralized so we can continue getting thrust out of the system. For that reason we are going to be running flight tests on the Scout vehicle with the first of these Sert flight tests to be launched within 6 months from now. The test package is shown on the next slide (fig. 308). It will contain two ion engines in the payload. One of them will be fired up and the increase in the rate of spin of the package will be measured to indicate the thrust. That engine will then be shut down and the opposite engine started up in a reverse direction and the despin will be measured again indicating the thrust of the system. These engines are well instrumented. The entire package is being developed by RCA. One of the engines is a

FIGURE 308

Hughes engine developed by Hughes under contract with NASA and the other one is an engine developed by the Lewis Research Center.

The next slide (fig. 309) shows the payload undergoing test in a vacuum chamber at the Lewis Research Center. I believe this system test demonstrates the importance of doing as much as is possible in ground test facilities, trying to simulate all or as many of the space flight conditions as we possibly can in ground test facilities. We have already uncovered problems in this spacecraft in the ground test facility which, if they had not been found here, would have caused failure of the flight and, therefore, the wasting of the Scout vehicle. The facility was one available to us at Lewis, a large vacuum chamber built specifically for electric engine testing. It was during the operation of this system that we encountered shorting in the power supply and we are working on trying to correct that problem. It would, as I said, have caused a failure if we had gone ahead with the flight test without such an integral experiment in a vacuum tank simulating the space flight environment. We believe that this kind of a testing is essential to successful flight operations and that it is necessary that we devote great effort to simulating these environments in our ground facilities.

In summary I want to emphasize that our major goal is the early and practical utilization of nuclear energy in space. We are convinced a substantial effort is justified by the potential performance advantages in these systems for difficult space missions. Rather than only developing specific pieces of hardware, we are conducting

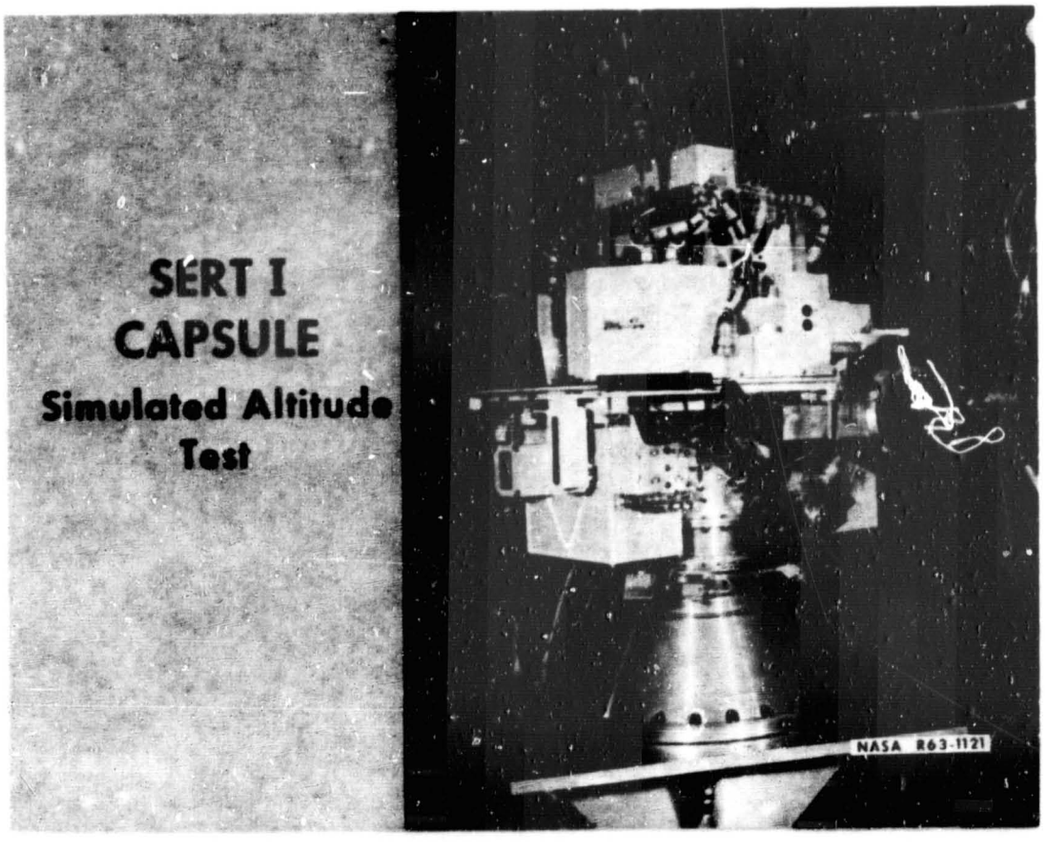


FIGURE 309

the program so that we can develop entirely new areas of rocket and power technology and equipment that will be available in the long-term space program when requirements are specified for missions that will inevitably follow our first lunar landings. This completes the presentation I had.

If you would like, Mr. Chairman, we can, I believe, show that short movie on the test of the Kiwi B4A reactor.

Mr. KARTH. Fine. Please proceed.

Are there any questions at this point?

Mr. FINGER. This film was taken of the Kiwi B4A reactor. I showed a still picture of that reactor earlier. The jet leaves the nozzle pointing upward and you will notice that the jet of hydrogen is ignited by a torch so you will see a yellow flame issuing from the nozzle. This is the reactor as I showed it earlier. This is early in the run. This is liquid hydrogen at this point. You can see the flashes there at the top of the figure. Those flashes increased in frequency and at a certain point we determined that it would be wiser to shut down although there was nothing visible actually leaving the reactor. It was just those flashes that indicated damage.

Mr. MOSHER. That was part of the uranium element itself?

Mr. FINGER. We believe that the pieces we saw here, or the flashes, were caused by nonuranium components, by thermal insulation components that surrounded the core. These were plain graphite components. None of the fuel elements left except a few on the outside,

but when we got into the reactor we did find most of the fuel elements were cracked.

Mr. KARTH. The fuel elements on the outside that did leave, where did they go?

Mr. FINGER. Out around the test site. They were picked up later.

Mr. KARTH. You found them all?

Mr. FINGER. Yes. They were not very active and we believe this was due to a vibration.

Thank you very much.

Mr. KARTH. Thank you very much, Mr. Finger.

That concludes what the subcommittee had in mind today and we want to thank you, and Dr. Bisplinghoff, for your patience and your tremendous help to the subcommittee. It may be that we will be in touch with you so that we can coordinate our schedules.

Dr. BISPLINGHOFF. Fine. We will stand by until we hear from you.

Mr. KARTH. Thank you very much, sir. The committee meeting is adjourned.

(Whereupon, at 11:55 a.m., the subcommittee was recessed.)

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1964 NASA AUTHORIZATION

WEDNESDAY, APRIL 24, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SPACE SCIENCES AND
ADVANCED RESEARCH AND TECHNOLOGY,
Washington, D.C.

The subcommittee met at 10 a.m., Hon. Joseph E. Karth (chairman of the subcommittee) presiding, in room 304, Cannon Building.

Mr. KARTH. The meeting will be in order. Dr. Bisplinghoff and Dr. Newell, I think you are aware of the purpose of meeting this morning.

STATEMENT OF DR. RAYMOND L. BISPLINGHOFF, DIRECTOR, OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY, NASA; ACCOMPANIED BY DR. HOMER E. NEWELL, DIRECTOR, OFFICE OF SPACE SCIENCES; MILTON B. AMES, JR., DIRECTOR, SPACE VEHICLES, OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY; DR. EUGENE B. KONECCI, DIRECTOR, BIOTECHNOLOGY AND HUMAN RESEARCH; AND WALTER C. SCOTT, CHIEF, SPACE POWER TECHNOLOGY, PROPULSION AND POWER GENERATION

Dr. BISPLINGHOFF. Yes, sir.

Mr. KARTH. And I understand that the staff has furnished you with a copy of the memo that I had prepared, where it appeared that duplication might exist between the Office of Space Sciences and the Office of Advanced Research and Technology.

If such duplication does not exist, we would be interested in the explanation for the fact that items appear in the budget which seem to be duplicative.

So, if you have no objections, and knowing the purpose of the meeting, and the specifics in which we are interested, and for which we would like to get answers, maybe you would want to proceed and go down the itemized list that we have prepared for your consideration, beginning with meteorites and micrometeorites.

I might say that as you are explaining to the committee the reason, or reasons, for these items appearing in various parts of the budget, you might also explain why they are distributed as so many different small pieces, obviously directed by many people, rather than being consolidated under one head. Even though it may be necessary for the Office of Space Sciences, and the Office of Advanced Research and Technology, to have similar programs, or programs that appear to be similar, it is hard to understand the way they appear in the budget books.

Dr. BISPLINGHOFF. Yes.

Mr. KARTH. So, I wonder if you might proceed. From time to time there may be questions in the minds of the committee members which they would like to address to either one of you gentlemen.

Dr. BISPLINGHOFF. May I suggest, Mr. Karth, that we take the items in the order in which they are given on your memo, and perhaps each of us could speak to the item with regard to our particular office, and in this way I hope that the meanings will become clear as we go along.

Mr. KARTH. The first one is the Office of Space Sciences, Dr. Newell, and it appears under "Geophysics and astronomy," I think you will find that item on page No. 26 of your backup books, under meteorites and micrometeorites. Would you just care to explain that $800,000 item?

Dr. NEWELL. Thank you, Mr. Chairman.

In approaching this item, with your permission, I would like to make a few general remarks first.

There will be found a general difference between the Space Sciences items in your list, and those of the Office of Advanced Research and Technology, and generally the difference is the following:

We, in the Office of Space Sciences, will be concerned with the investigation into the fundamental questions in space science, such as the origin of the solar system, the influences on the Earth of the happenings on the Sun, or the galactic and solar problems.

Therefore, our supporting research and technology will be directed toward that mission. It will not be directed primarily toward the advancement of general technology.

It will be aimed at specific flights or specific scientific problems. By that, I mean it will be aimed at the solution of major questions that scientists have with regard to these various areas. A good example is to be found in the micrometeorite investigations. I might explain this further by saying that in the Office of Space Sciences we are concerned with the distribution of matter throughout the universe, and more closely at home, the distribution of matter throughout the solar system. As you may know, in our galaxy, there is as much unseen matter as there is seen matter. The gases and dust in our galactic system equal the mass of material that is seen in the stars and nebulae, that we can witness in the galaxy.

We know this to be true because the material has a gravitational attraction, just as the assembled material such as stars and other objects have gravitational attraction.

This gravitational effect is seen in the mechanics of the galaxy, and we can compute that there must be this amount of material in between the stars and the planets. If we go beyond the galaxy, the problem becomes even more startling. It is estimated that there is a factor of 10 more material in the whole universe than is seen in the external galaxies.

One of our major problems in the study of the solar system is to investigate the cosmic dust, the micrometeorites, the stones and rocks, and meteors and such, that exist in the solar system.

It is believed, as we told the committee earlier in our testimony, that the Sun and the planets may have been formed from an accumulation of dust and rocks and cold gas, into the bodies that we now know as the Sun and the planets.

It is also believed by some that some planets may have existed previously and been disintegrated into dust and particles.

Our motivation here, then, is to study the origin of the solar system and the history of the solar system.

In the case of "Geophysics and astronomy meteorites and micrometeorites," the $800,000 figure to which you refer, Mr. Chairman, the G. & A. people in the Office of Space Sciences are interested in cosmic dust as an extrapolation of their interest in planetary atmospheres, building up from the molecular constituents of the Earth's atmosphere to the particles that impact on the atmosphere and that may be distributed through the solar system.

We also know from ground-based research, there appears to be a direct relationship between the dust particles that impact on the Earth's atmosphere and rain effects on the Earth.

We also know from ground-based observations, that the Moon seems to have a shielding effect on these particles, and there is a relationship between the streams of particles hitting the Earth, and the rain, and the streams of particles that perhaps might hit the Earth if it were not for the shielding effect of the Moon.

This becomes an intricate and very interesting and important scientific problem.

With regard to the lunar and planetary program item, meteorites and tektites, the $1,090,000 item, this is under the Lunar and Planetary Office of OSS. The Lunar and Planetary people derive their interest by moving downward from their interest in the large bodies like the Moon and the planets, to the big rocks and stones, which is somewhat different from the geophysics and astronomy interest. They are interested in the composition of these particles, and the possibility that some of them may come from the Moon, or that these may be particles that went into the creation of the Earth and the Moon, in its original form.

Thus, you can see within OSS there is a difference in interest, and there must be a difference in approach here, because one group is concerned with very tiny particles, and the other with bigger rock-sized or gigantic boulder-sized particles.

Between OSS and the Office of Advanced Research and Technology, there is also a difference which I am sure Dr. Bisplinghoff will speak to in a moment, but I might mention it right here, to open up the subject and point up the difference.

OART is concerned with what these particles do to the things that we want to send out into space, the pitting effect, their penetration capabilities, and so on. Their experiments are directed largely toward the examination of these matters, in order to have engineering data available for the design of large structures in space, such as antennas, radiator systems, and so on.

The combination of the OART measurements and the OSS measurements put us in a position to do many things that we want to do in space. With the collection of data from the space sciences observations, showing the distribution of particles throughout the solar system, and the OART measurements showing what they do to various structures and equipment, one has at hand, then, important engineering data.

Mr. KARTH. Dr. Bisplinghoff?

Dr. BISPLINGHOFF. Mr. Chairman, I think I can now discuss the OART side of this.

This comes down to the third item, "Meteoroid environment and impact hazard," and I would like to preface my remarks here by amplifying what Dr. Newell has mentioned already concerning the OART interest in this matter.

Our interest is entirely one of the development of the technology that is needed to design space vehicles.

At the present time we realize that the meteoroid environment and hazard is one of the most severe design conditions that we have to meet.

Mr. KARTH. May I interrupt to ask a question at this time?

Dr. BISPLINGHOFF. Yes, sir.

Mr. KARTH. Who designed the space vehicles that OSS is now using to conduct their experiments?

Dr. BISPLINGHOFF. These were designed by contractors operating under the Office of Space Sciences.

Mr. KARTH. They were not designed and developed or engineered by OART, then, were they?

Dr. BISPLINGHOFF. Our purpose is to provide design criteria, which may be used by the designers to carry out such designs, Mr. Chairman, but we have no direct connection with the designing.

Mr. KARTH. Did you provide such information for the design and construction of these vehicles that OSS is now using in their experiments?

Dr. BISPLINGHOFF. There may very well have been some information provided directly from our Centers, to these contractors. I would not be able to answer that definitely, but our own meteoroid program has just started and we have not obtained very much information.

Most of the design, so far, has been pretty much on a hit or miss basis, and such designs are all right, as long as we don't spend too much time in space, with large areas exposed.

We need much more accurate information than we now have, if we want to design with precision for large time in space, and with fairly large areas exposed.

Mr. KARTH. Dr. Newell, would you care to add to what Dr. Bisplinghoff has said on this?

Dr. NEWELL. Yes, sir.

I would like to say that OSS has received from Advanced Research and Technology, information in this area which we have taken into consideration in our vehicles. This information comes from their ground-based observations on impact phenomena, because the OART program in flight, as you know, has just gotten underway recently.

They have given us data on some of the effects of high-speed particles.

It should be recognized, however, that these are much lower speed particles than you get in the meteor field, by a factor of seven, or so, and therefore, we need more information to go on with the things that we want to do in the future.

Up to now we have not done very much in the use of very light structures for antennas or radiators, but we will want to make use of such structures in the future, and we will need this information in the years to come.

Mr. KARTH. Dr. Bisplinghoff, are we not really cutting this pretty fine and pretty thin, when we say that the Office of Space Sciences is strictly interested in the scientific information we can get on the composition, or the origin of the meteorites, et cetera, and the Office of Advanced Research and Technology is just interested in ascertaining the amount of the damage that might be done to a vehicle, as a result of the meteorites, or micrometeorites hitting them?

I am sure you are conducting other experiments, too, but are we not cutting this kind of thin by saying that this unique little set of questions must be answered by the Office of Space Sciences over here, and the unique set of little questions are to be answered by the Office of Advanced Research and Technology, over there.

Really, aren't we cutting this pretty thin, when we make this kind of differentiation?

Dr. BISPLINGHOFF. I think that this is a natural division, and I would like to explain why I think so, by going on with my description of what we are doing.

Mr. KARTH. Very well.

Dr. BISPLINGHOFF. We need really a twofold approach to providing this design criteria for space vehicles. One, we need an accurate statistical sampling of the meteoroid environment, and by this I mean frequency of occurrence, the velocity of the particles, and the mass of the particles.

This kind of information can only be gotten from flight experiments——

Mr. KARTH. Well, if I may just interrupt you there, Doctor, could this information not be gotten from Dr. Newell's experiments, too. It could, could it not?

Dr. NEWELL. Yes, but in our case our observations will be extended out to the lunar and planetary distances, and to the asteroid belts, as well as in the Earth's vicinity.

Mr. KARTH. Yes, but regardless of where they are, they will be gaining some of the information that you need, is that not so?

Dr. NEWELL. Except for our purpose, we are more interested in the general distribution of these particles in the solar system.

Mr. KARTH. Well, let me ask Dr. Bisplinghoff if these experiments are not designed to get information additional to what Dr. Newell has set forth this morning?

Dr. BISPLINGHOFF. Our experiments are designed to get more data, specific information, more specific than his are. Generally, his sensors are microphones which do not give us the detailed statistical data that we need for design.

Mr. KARTH. But your experiments are designed to give the information, in addition to the mass and the number and the frequency, and so forth, that you need to know about, are they not?

Dr. BISPLINGHOFF. Yes. But I think perhaps an interesting analog to this would be the kind of things which the meteorologists might do to study the behavior of the atmosphere, and the kinds of things that we did for so many years in the NACA, to get gust information for the design of aircraft. I think this, perhaps, is the best analogy we can make here. The factors needed to design aircraft, covered data on the frequency of the occurrence of gusts, and this had to be rather detailed information; the kind of information that would fit into design criteria for aircraft.

The meteorologist, on the other hand, didn't get that kind of detailed information that was needed and necessary for gust data.

This, I think, is the best analogy that we can make of Dr. Newell's interest, and my own interest.

Mr. KARTH. I think the question that normally arises, however, is that inasmuch as your experiments are apparently more exhaustive and more detailed——

Dr. BISPLINGHOFF. Yes.

Mr. KARTH. Cannot we derive from your experiments, the more limited information that Dr. Newell needs?

Dr. BISPLINGHOFF. Except that our experiments are done in the Earth's vicinity.

We have concentrated our flight experiments in the Earth's vicinity.

Mr. KARTH. Well, all right, then let us just talk about those experiments that are designed to be conducted in the vicinity of the Earth.

I assume that some of the meteorite and micrometeorite experiments done by OSS would be done in the vicinity of the Earth, so my question would be:

Could not one or the other of the two offices conduct all of the experiments in that vicinity, rather than having some of them conducted by OSS, and some of them conducted by OART?

Dr. BISPLINGHOFF. I would like to defer to Dr. Newell, to talk about the flight experiments of this kind. But I would point out, however, that in the case of observations from the ground, notably radar meteor studies, which are under contract with the Smithsonian Astrophysical Laboratory, we are concerned with combined findings and combined interests on the part of Dr. Newell's office and my office.

We are interested in these, because they will provide us with data on rather large particles that we will not be able to get with the satellites that we now have, and Dr. Newell's interest is more in the scientific direction.

Here is an example where we have attempted to team together on the ground observational studies of meteoroids.

With respect to their flight program, I would rather defer to Dr. Newell.

Dr. NEWELL. I think there is a subtle question here, Mr. Chairman

Mr. KARTH. I didn't mean to make it subtle. [Laughter.]

Dr. NEWELL. I think we might like to develop it: The flat answer to your question is "yes"—it could be done in one office or the other, but if OSS were to do it we would then have to staff up with different people to do the part of the job that OART is working on, namely, a group of engineering investigators and applied researchers, to look into the impact phenomena, the effects of these particles, as well as people to measure velocities, distribution, and so forth.

If OART were to do it, with its researchers, then they would have to add geophysicists, astronomers, and lunar scientists to their complement to make a proper tie-in on the problems that we are trying to solve.

So there seems to be little to gain by having a little island of engineers doing applied research over at OSS, simply to have this all done in one office.

Likewise, there is little advantage, managementwise, in having a little island of space science activity over at OART. It is not a clean break, as one might imagine. Those researches that are being done

primarily to determine the engineering problems we face in building space structures of the future should be done in close association with the ground-based researches on high-velocity impact, and the effects on materials, should be done at OART. But, on the other hand, when these researches are tied to space science activities, they should be in a space science context, where space science is done, that is in OSS.

I think it is important to note that for OSS interests, it is sufficient to have very little detectors, tiny things, either microphones, or little wound wire drums, that will register a signal when impacted by these particles.

These instruments can be very easily put on the satellites, or deep space probes, without displacing a lot of equipment, in order to get statistical data that Dr. Bisplinghoff referred to. He, however, has to have very large sized areas, and make observations over very long periods of time.

Therefore, it is common, in that case, for an entire satellite to be devoted to the micrometeorite penetration and hazard problem, as has been done in the OART program. Otherwise, you would not need to do that for our OSS purposes.

Mr. KARTH. Except that in the OART, we have quite a number of these meteoroid experiments, do we not? In volume 5, I notice on page 50, the Scout launched meteorite satellite, and this just follows the list that I gave you, we also have a Saturn launched meteoroid experiment, or experiments.

Then, on page 51 we have meteor simulation, and I don't quite know what that means, and on page 51 we have meteoroid penetration probe.

Now, you see we have penetration probes specifically spelled out.

Dr. NEWELL. Yes, sir.

Mr. KARTH. And this is what you have both been addressing yourselves to in differentiating the interests in the two offices. But we do have this meteoroid simulation, and we have the meteoroid experiments, and it would seem to me that this is pretty all inclusive, and there is a $4.2 million item for the Saturn launched meteoroid experiments, which is quite a sum of money.

Dr. NEWELL. Yes.

Mr. KARTH. And then the meteoroid satellites are just under $1 million.

Now, I am sorry to have interrupted you. Why don't you just go ahead and explain to us what the difference is, as between these experiments I have listed in OART, and why this could not be done by OSS, or should not be done by OSS. Perhaps I should not have stopped you.

Dr. NEWELL. Well, I think Dr. Bisplinghoff would like to continue on that, sir.

Dr. BISPLINGHOFF. Yes, Mr. Chairman.

In continuing the remarks that I made before that we need a two-fold approach to the development and design criteria: The first is the statistical population of the space environment—the frequency of occurrence, velocity, and mass; and then there is the second problem of a criterion for determination of the penetration phenomena that should be used for design.

Supposing one knows that one has a meteoroid of a certain mass and a certain velocity, what will the penetration be?

This is a very difficult question, because meteoroids, as you probably know, travel at very high speeds, at much higher speeds than we are able to simulate in the laboratory.

The light gas guns enable us to reach velocities of something of the order of 35,000 feet per second in the laboratory. However, many of these meteoroids, travel at 100,000 to 200,000 feet per second. So we are a long way from developing a ground simulation.

This is the twofold approach that we are following in OART, and the item numbered "OART, SR AND T, Space vehicle systems—meteoroid environment and impact hazard" is concerned with several areas. One is detector development. In this area we are attempting to develop improvements in detectors that we will need to put on the meteoroid satellites, to measure the kind of information that we must have for design purposes.

There is another item, namely, particle accelerators. Here we are attempting to develop in the laboratory, devices which will propel particles at higher and higher speeds. We realize that we have got to do better than 35,000 feet per second, if we are going to understand, in a theoretical way, with some confidence, what these particles do, even if we are going to be able to run ad hoc tests of the vehicles in their design and development stages.

Part of this study is on particle accelerators, with which we study impact and penetration effects. This is the employment of these particle accelerators in studying the influence of different kinds of materials and the influence of such devices of meteoroid bumpers, and other things of this kind.

We also have theoretical studies that we need to develop our theory on impact, along with the experimental tools.

This area of theory is a very difficult one. The physicist who works in the solid state, finds that the kind of theory that is needed in the impacting process is beyond his capabilities.

For example, when the particles hit at these very high speeds, they behave as though they were a liquid. In fact, the whole area in the vicinity of where the particle strikes is liquefied, and there is actually a splashing action that takes place.

We are attempting to understand in a theoretical way, how this works. I personally consider the theory very important, because, if it turns out that we cannot develop experimental devices that can reach the velocities of meteoroid impact, then we are going to have to rely on the theories, as a means of extending our knowledge.

Also, in this area, we are, together with the Office of Space Sciences, and the Office of Manned Space Flight, funding observational studies, using radar techniques.

In connection with these techniques, Smithsonian Astrophysical Laboratory has a series of radar stations which follow the ionized trail that is produced by meteoroids entering the atmosphere and, by this technique, they are able to determine many things.

They have determined, for example, the frequency of occurrence of fairly large meteoroids, which enter the atmosphere, and they can actually measure the deceleration and thereby get an idea of what their mass may have been, or what their velocities may have been on entering the atmosphere.

This kind of technique is very useful. Particularly is this so with the rather large meteoroids—the smaller ones, of course, can't be seen in this way, but our flight programs lend themselves to studies of the rather small ones. So we are looking at this kind of technique as a means of improving and amplifying our knowledge in the area of fairly large meteorites.

Turning now to our flight program relating to meteoroid satellites, the first one that is listed at $950,000 concerns two Scout-launched meteoroid satellites, and I would like to remark that one of these was launched last December.

Mr. RANDALL. What page is that on. I do not follow you.

Dr. BISPLINGHOFF. This is the memorandum which Mr. Karth gave us, and it is on the first page of the memorandum, fourth item down.

Mr. RANDALL. I see. Thank you.

Dr. BISPLINGHOFF. The flight programs and space vehicle systems. The first item is Scout-launched meteoroid satellites. The first of these was launched last December from Wallops Island, with a small vehicle of about 25 square feet of area. The satellite weighed about 200 pounds.

We expect to get a lifetime of 1 year from this satellite in the Earth environment.

I believe the apogee is about 700 miles, and the perigee about 400 miles.

This satellite is bringing to us the first real satellite information that we have gotten, as yet, in the space program, on the meteoroid environment. Because of its small area, and its 1-year lifetime, however, we cannot expect more than about 100 penetrations during the year—something of this order of magnitude.

The thickness of the skins that we are investigating are from about one- to five-thousandths of an inch thickness.

Mr. MORRIS. What do you mean by that—the skin of what?

Dr. BISPLINGHOFF. The satellite. The satellite sensors. As Dr. Newell mentioned, in order to get as large a statistical sampling as possible, we plaster the whole area of the the satellite with sensors.

Mr. MORRIS. I understand.

Dr. BISPLINGHOFF. The sensor that is used primarily on this satellite is a pressurized can. We have a number of these pressurized cans spread over the surface, and when these pressurized cans are punctured the pressure sensors give us signal to the ground.

We expect to launch the second of these Scout satellites this spring, and this will give us, we feel, a good start on the kind of statistical data that we need for design.

However, these are rather small satellites, and we cannot expect, with such a small area, and at a time of 1 year, to encounter fairly large particles. So we have taken the advantage of using these Saturn launch vehicles, SA–8 and SA–9, as a means of carrying the much larger meteoroid satellite aloft, next March.

Mr. MORRIS. May I interrupt to ask one question:

Why can't this be covered in the launching of the Scout vehicle. I understand that this item is $950,000—now does that cover all of the development of the payload, and the launching, or is this just for one launching, or two, or how many? Is it just the payload, or does this include the launch vehicle?

Dr. BISPLINGHOFF. This is the payload and the launch vehicle.
Mr. AMES. No, no launch vehicle.
Dr. BISPLINGHOFF. This is just the payload?
Mr. AMES. This is two payloads, S–55 C and D.
Mr. MORRIS. Oh, it does not include the vehicle?
Mr. AMES. No.
Mr. KARTH. Are you riding piggyback then, on someone else's experiment?
Mr. AMES. No, sir.
Mr. KARTH. Who is paying for the launching?
Mr. AMES. In this particular case, we in OART are doing it with a Scout launch vehicle—we have purchased through Dr. Newell's office. The primary part of the $950,000 is to pay for the two spacecraft. S–55C and S–55D, which are the same general type as the Explorer XVI, launched last December. As Dr. Bisplinghoff mentioned, the significant difference is in the experimentation on each of these spacecraft, which would expand our knowledge of meteoroid penetration probabilities.
Mr. KARTH. Well, I can appreciate that, but I would just like to understand that so that the record may be straight. But I would like to point out that in your backup book on page 50, it very specifically states: "Spacecraft and satellite services, $450,000, launch vehicle very specifically is shown as $500,000." For a total of $950,000.
Mr. AMES. Well, sir, there may be some launch vehicle money in here, as I believe I indicated, but each Scout launch vehicle costs a million dollars, so that you would have $2 million for the two launch vehicles required.
The statement that you read indicates that we have already paid $1½ million on two launch vehicles, but we must now complete paying for the second launch vehicle and buy the payloads and support the experiments in 1964.
Mr. KARTH. So, in answer to the question from the gentleman from New Mexico, it is a part of this payment, then, a downpayment on the launch vehicles necessary, while the launch vehicles must be funded by OART to carry out these experiments.
Mr. AMES. $1½ million has been spent on two launch vehicles in the 1963 budget, Mr. Chairman, and that, I see, is shown on page 50.
Mr. KARTH. And these are some launch vehicles in addition?
Mr. AMES. The other $500,000 to make up the $2 million for the launch vehicles is included in the 1964 funding on page 50.
Mr. KARTH. Oh I see.
So, OART is totally funded for the two launch vehicles to fly the two experiments that we are talking about, which involve the last payment of $450,000, is that correct?
Dr. BISPLINGHOFF. The last payment of $500,000 for launch vehicle, and $450,000 for payload development.
Mr. KARTH. Well, if I understand the backup book, we started funding for these two experiments in 1962?
Mr. AMES. There will be three experiments, sir.
Mr. KARTH. I see. Three experiments?
Mr. AMES. Yes. S–55–B, which is now called Explorer 16, and S–55–C and S–55–D, which are to follow.
There are three launch vehicles, three spacecraft, and a backup spacecraft.

Mr. KARTH. And how much money do you feel that you must have to complete these three experiments in fiscal year 1965, for example, or is this the end of this program?

Mr. AMES. This would finish that program.

Mr. MORRIS. The problem with the Scout-launched payload is the area that you can cover?

Dr. BISPLINGHOFF. Yes, sir; yes.

Mr. MORRIS. I would just assume, from looking at the figures, that the Saturn vehicle would be able to cover a greater area for you?

Dr. BISPLINGHOFF. Yes.

Mr. MORRIS. Is that so.

Dr. BISPLINGHOFF. Yes. The Scout payload limits the area to about 25 square feet of area, and the Saturn will give us about 2,000 square feet of area.

Mr. MORRIS. You would get a 25-square-foot area——

Dr. BISPLINGHOFF. With the Scout.

Mr. MORRIS. Versus what?

Dr. BISPLINGHOFF. 2,000-square-foot area.

Mr. MORRIS. You might explain this, Doctor:

How many experiments does this $4,250,000 take care of, and does it include the launch vehicles and the payload?

Dr. BISPLINGHOFF. This is the cost of the payload, and here we are very fortunate, because we observed earlier in the game that the early Saturn launch developments involved carrying aloft water ballast.

Mr. MORRIS. I think many other people have observed or wondered if there was not something else that you could carry up besides water?

Dr. BISPLINGHOFF. Yes, sir; and this provided us with an opportunity to ride piggyback on the launch development program, and to avoid the cost of separate launch vehicles.

So that this $4.2 million that you see here is payload development for two payloads.

Mr. MORRIS. For two spacecraft, two payloads?

Dr. BISPLINGHOFF. Yes, sir.

Mr. MORRIS. And who is the contractor?

Dr. BISPLINGHOFF. Fairchild.

The payloads are identical.

Mr. MORRIS. And that is completely finished as of the year 1965—is this the downpayment and does that complete it?

Dr. BISPLINGHOFF. This, as far as we know, completes it.

Mr. AMES. May I correct that, Mr. Chairman.

I am afraid there was some money in 1963, $2.4 million, to start paying for this spacecraft to get it on schedule with the SA–8 and the SA–9 launchings of the Saturn vehicles, and in 1964 there is $4.25 million to complete the purchasing of the spacecraft.

We will have some data handling costs and some finishing up items which will be relatively minor in the 1965 budget.

I indicated to you in my earlier testimony that we anticipated that a program of this magnitude would run somewhere in the order of between $6½ and $7½ million—that is for the two 2,000-square-foot spacecraft, including all the data handling.

Mr. MORRIS. Why do you think it is necessary to have such a large area of coverage? Can't you interpolate from the area that you have covered already through the Scout launch vehicle?

Dr. BISPLINGHOFF. We can extrapolate but we can't interpolate from there.

Many of the longtime space vehicles that we have in mind for the future will certainly be affected by the fairly large particles.

Now the statistical probability of our getting data on a reasonably large particle in 1 year with 25 square feet is quite small. In fact, it is unlikely that we will encounter any particles, or at most only a very few particles, that will enter or penetrate skins of over five-thousandths of an inch thick. If we have 2,000 square feet up there, there is a very good chance we will get penetration sufficient to get a statistical indication of how many there are up there. It is simply very important for us to have as much area as we can get.

Mr. MORRIS. This investigation, Dr. Bisplinghoff, is it involved in the goal that we have at the present time of putting a man on the Moon and returning him to Earth safely, or does this study of meteorites involve other deeper and longer space aims?

Dr. BISPLINGHOFF. I think it will have some value to the Apollo program and it also is very fundamental to anything that we do in space from now on—very fundamentally valuable.

Mr. MORRIS. Do I understand correctly that what our national policy is at this time, is to put a man on the Moon and return him safely to Earth and to get as much scientific information as possible?

Dr. BISPLINGHOFF. As I understand our national policy, it is preeminence in space and one of the elements of this preeminence is the program of the lunar mission.

Mr. MORRIS. So you feel that this is only a part of it?

Dr. BISPLINGHOFF. Yes, sir.

Mr. MORRIS. That is your felling.

Dr. BISPLINGHOFF. Yes, sir.

Mr. RANDALL. We started this investigation, now, into meteorites and particles and dust and so forth, previously, did we not?

In other words, is this just starting now or is this something that has been going on before? Here we are talking about S–55–B and reference was made that it was the same as the Explorer 16. That means there have been 16 Explorers, this was the 16th. Has there not been some experimentation going on that would give us some of the information on penetration and pressure cans and that sort of thing, or are we just starting that?

Don't you have some of it now?

Dr. BISPLINGHOFF. No, sir.

Mr. RANDALL. In other words, my question is: Do we not have some backlog of information already?

Dr. BISPLINGHOFF. We have no backlog of the kind of information that we need for this design, that is correct.

Mr. KARTH. Now, what design do you mean there?

Dr. BISPLINGHOFF. For the design of space vehicles.

Mr. KARTH. Which space vehicles?

Dr. BISPLINGHOFF. Any space vehicle that will operate in this environment.

Mr. KARTH. You are flying them by some design now, aren't you?

Dr. BISPLINGHOFF. We fly them much heavier than they need to be.

Mr. KARTH. You are kind of flying them by the seat of your pants; is that what you are saying?

They are not as good as they could be?

Dr. BISPLINGHOFF. Yes. We have theories which we have been given by the astronomers, but there are major uncertainties in terms of the frequency of occurrence and size of meteorites and effects of impact, and so on, and this means in my opinion that if we don't get this information our space vehicles will be much heavier than they need to be, perhaps by a factor of some 20 to 50 in the skins of the space vehicles.

Mr. KARTH. Well what have all the Explorers been doing in connection with this experimentation? I thought that the Explorers were doing a good deal of this work.

Dr. NEWELL. I wonder if I could use this little graph here, Mr. Chairman, to illustrate the background of this problem (fig. 310).

Mr. KARTH. Yes.

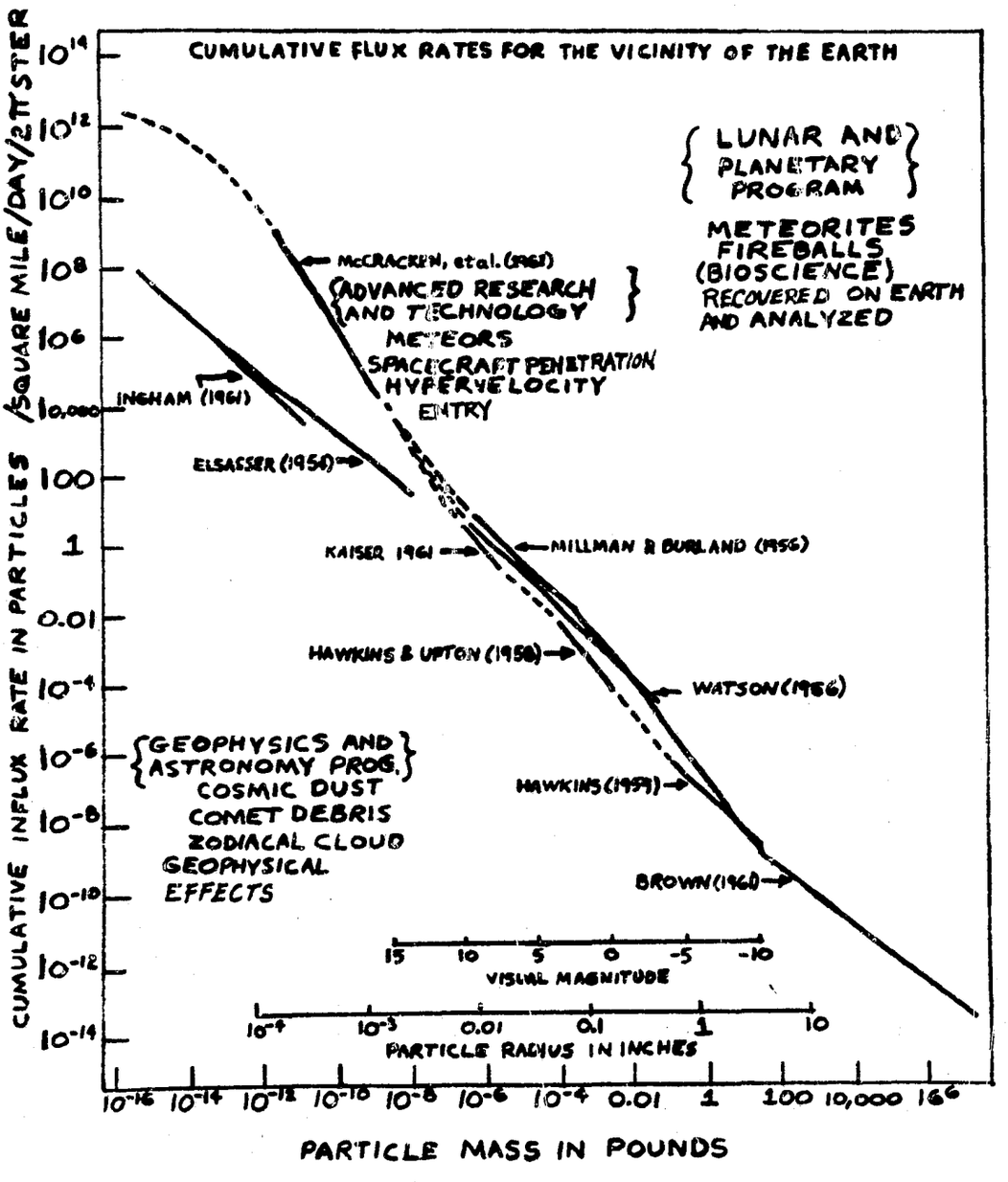

FIGURE 310

Dr. NEWELL. Along the vertical axis is the number of particles involved, and I should remind you that this is a logarithmic scale. In other words, the units are factors of 10—so it would be 1, 10, 100, and 1,000, rather than, 1, 2, 3, 4, and so forth. Looking along the horizontal axis are the sizes of the particles, with the boulders at the right, and the grains in the middle, and the dust on the left, meaning particles of some thousandths of an inch, or so in diameter.

Mr. KARTH. Do we have to worry about those too much, since we are taking care of the grains and the boulders?

Dr. NEWELL. Well, this is part of the story that I would like to present here.

Mr. KARTH. All right.

Dr. NEWELL. Here is the present estimated curve of distribution of these particles, and you get up into very great numbers in the cosmic dust region. Down in the boulder region, there are very few. If you collect throughout the entire Earth's atmosphere, you only get a few, per year, of the boulder size, and you get, maybe, some tens or hundreds in the stone size. When you get down to the grain region, then you get much more in number.

When you get down to the dust, of course, you are going to get a very much larger number, and it is estimated that the dust size particles are collected by the Earth at the rate of 1 to 10,000 tons per year.

Mr. KARTH. May I question you right there.

These dust particles won't penetrate anything; will they?

Dr. NEWELL. No—well, they will penetrate something, but the point at which the penetration hazard exists, is in the grain area.

Mr. KARTH. Right.

Dr. NEWELL. You are not so much worried about the boulders because there are not enough of them to worry about.

Mr. KARTH. And you couldn't design against them anyway; could you, Dr. Newell?

Dr. NEWELL. You couldn't. If you got hit by one of the boulders, that would be that.

In the grain area you can design against the hazard.

An interesting thing is that in the grain area the measurements made on the Explorers have indicated that there are enough to be concerned about, particularly, when you want to fly equipment that must stay up for a long time, or expose sensitive surfaces that must remain unchanged for a long time.

Furthermore, investigations of OART in the laboratory, have shown that the penetration physics of these particles is so much different from the penetration physics of the lower energy particles, that new techniques are required in studying these.

It has been found that the low energy particles make a crater that is about the size of the particle, but when you get up to these very high-speed particles, a particle striking a surface will gouge out a crater that is many, many times as large, perhaps 10 or 100 times the size of the particle.

So, in our interest in geophysics and astronomy, we are concerned with the nearby region of the solar system, and we are looking at this area of dust, and are using primarily counting techniques.

As I have mentioned previously, we can use very small counters, and just put them on any vehicle that happens to be going up.

In connection with the interests of OART, in the grain area, the techniques have to be entirely different. And, as Dr. Bisplinghoff mentioned, you have to use the penetration physics approach in your spacecraft, plus the meteoriod physics approach of radio and radar studies from the ground.

They are entirely different techniques, and whether it is done in OSS or OART, you will have different groups of people doing them.

Mr. KARTH. You could not conduct both kinds of experiments in the same spacecraft, could you?

Dr. NEWELL. Well, you could, and OART will be collecting information we will be interested in in their spacecraft.

But, in the space science area, we do not find it necessary, or of interest, to devote a whole experimental spacecraft to this problem.

On the other hand, when we get to the point where we want to extend our surveys for our radioastronomy work, or for using large power supplies, we are going to want to have data from OART in this area, for engineering purposes.

Mr. KARTH. You are talking about the $4¼ million spacecraft, or two spacecraft costing $2 million odd each.

Are there any of these areas where you could ride piggyback in relation to some of your experiments? If you could, I would assume that it would be very advantageous—at least, to the taxpayer.

Dr. NEWELL. Oh, on the $4¼ million, that is the total $6 to $7 million—that is required to do this job right, and if we did it we would have to pay out the same amount of money in OSS.

Mr. KARTH. Yes, but my point is that I wonder why we could not fly some OSS experiments on the $4¼ million vehicles that OART is launching. That is my question.

In other words, rather than building, let us say, a $1 million space vehicle of your own to conduct your own experiments, why can't we merge these two areas of interest to a finer degree so that we can ride piggyback on each other's satellite, so to speak, and get about the same kind of information as we could by launching two satellites?

Dr. NEWELL. Well, OART experiments, as Dr. Bisplinghoff mentioned, in this case, are piggyback experiments on the Saturn vehicle.

Mr. KARTH. Well, they are piggyback on the launching vehicle.

Dr. NEWELL. Yes.

Mr. KARTH. But the $4¼ million is to conduct their own experiments; is it not?

Dr. BISPLINGHOFF. That's correct.

Mr. KARTH. It is a spacecraft, is it not?

Dr. BISPLINGHOFF. Yes, sir, it is a spacecraft.

They will put sensors in to give us data in the region that Mr. Newell has just discussed.

Mr. KARTH. And we could not build Dr. Newell's experiment into this spacecraft—can't we do that, this is my question, sir.

Dr. NEWELL. Sure.

Mr. KARTH. That is what I want to have clear.

Dr. NEWELL. But I think I should make it clear that we almost always piggyback these small dust experiments on every flight that we can put one on. It is almost like pasting a postage stamp on, and I understand that you have some of the dust experiments on your satellite?

Dr. BISPLINGHOFF. Yes.

Mr. RANDALL. I have three or four questions but I would like to see the chart, and see what we are talking about.

Dr. NEWELL. Geophysics and astronomy interests are in the dust, and the technological interest is in the grains that penetrate, and the lunar and planetary interest is in the boulder area—where one wants to recover material from out in space to get some idea of what the Earth was originally formed from or perhaps what the Moon is made of.

Mr. RANDALL. All right, now. I would like to know what we have been getting from all of the other efforts in the other areas that have been made—either piggyback or otherwise. Couldn't we get some of this information that you and Dr. Bisplinghoff need?

Dr. BISPLINGHOFF. The kind of experiment that I need for statistical purposes, or the kind of statistical data that I need for design in this region, has not been going on and in connection with the other experiments, as Dr. Newell, pointed out, the microphone data have been gotten from many other flights.

Mr. RANDALL. Well you used the word "design." Design what—spacecraft of some kind in particular?

Dr. BISPLINGHOFF. The design of any spacecraft in the future. We are trying to determine what criteria we need for the design of spacecraft in the future.

Mr. RANDALL. Any and all types?

Dr. BISPLINGHOFF. Any and all types, yes. How thick the walls should be and so on.

Mr. RANDALL. Well this piggyback concept seems to me to be one worthy of study. I think some of this is familiar to some of us, and I know that some of us went down to Cape Canaveral and we know there have been other Saturn shots and that there will be several more.

Now, is there anything in the works for piggyback rides on them?

Mr. AMES. These two experiments.

Dr. BISPLINGHOFF. Saturns 8 and 9 will be employed for that purpose.

Mr. KARTH. All right, and the ones which have gone heretofore—would it have been possible to attach any piggyback there?

Dr. NEWELL. We did.

Mr. RANDALL. You did—I thought you were just starting. Then we do have a backlog of information—some?

Dr. NEWELL. Piggyback experiments with the proposed Saturn were to use this water ballast not for micrometeorite studies, but for other studies. We felt that if we were going to carry water we might as well do something with it, and release it in the upper atmosphere to see what would happen.

We have done this on two occasions and there have been some very interesting data on the mechanics of what happens when you release liquid in a virtual vacuum.

Mr. KARTH. What did happen—this is very interesting, to digress for just a moment.

Dr. NEWELL. Well, there was quite a wide range of predictions as to what would happen and how fast it would happen.

Some of these predictions were that there would be a marked area of contamination in the upper atmosphere for a long period of time. Others were that the cloud would disperse very rapidly and disappear

in a very short period of time and, of course, the dispersal would create lightning storms and snowflakes and so forth.

This latter is what did happen; there was a snowstorm which was followed by radar for a long period of time thereafter and there were lightning discharges created by the charging due to friction of the particles as they dispersed, very rapidly, in the vacuum.

Mr. RANDALL. That was on one of these Saturn shots, was it?

Dr. NEWELL. Yes.

Dr. BISPLINGHOFF. I might mention, Mr. Randall, that several of the Saturn shots were suborbital shots and we were unable to get any meteorite information.

Mr. RANDALL. Of course, this raises a question, if this is suborbital, of when the Saturn shots will be orbital. Have all of the Saturn shots been suborbital up to now?

Dr. BISPLINGHOFF. I believe they have, yes.

Mr. RANDALL. And do you contemplate an orbital shot in the Saturn program?

Dr. BISPLINGHOFF. Yes; SA–8 and SA–9 are orbital.

Mr. RANDALL. Those are orbital?

Dr. BISPLINGHOFF. Yes; and those will be next spring, sir.

Mr. RANDALL. This raises something, Mr. Chairman, that I stumbled on in another committee yesterday in connection with the military communications satellites.

In connection with this piggyback concept they nest a whole group, five, six, or seven, in one and discharge them. Do we have anything in NASA along those lines?

Dr. NEWELL. Yes.

Mr. RANDALL. I was amazed that they had put up as much as half a dozen and they go off in all directions. Are we doing anything along those lines?

Dr. NEWELL. Well, not to the extent of half a dozen but we are putting some satellites together and launching a couple at a time.

Mr. RANDALL. It appears to me that the military has something here that NASA ought to study.

Dr. NEWELL. We will put two packages on a Scout to go up in the near future.

Mr. RANDALL. And this is the first time that we have done anything like this in NASA?

Dr. NEWELL. No.

Mr. RANDALL. Oh—there have been other instances?

Dr. NEWELL. We have done it in a minor way in the past in having beacons separate from the main package. Most of our participation in this has been with DOD.

Mr. RANDALL. So we are in coordination with DOD, and watching this very carefully?

Mr KARTH. I think that ought to be clarified.

Dr. NEWELL. Oh yes, certainly. In fact NASA has been telemetering their information from some of the DOD satellites in these package launchings.

Mr. RANDALL. As I say, I think it should be on the record, and we were impressed yesterday by the techniques they are using and it did occur to me that this is a chance to do a lot of things in one, and maybe NASA has not been doing this as completely as they should?

Dr. NEWELL. No, we have been supporting the Injun State University of Iowa satellite and the NRL satellites in this area—providing them not only some funding for their work, but providing also tracking and telemetering that goes with some of this.

Mr. DOWNING. As a matter of fact, are there not gradations of boulders and are there not powerful boulders that might hit a spacecraft that are perhaps about as big as your fist?

Dr. NEWELL. Oh yes, yes.

Mr. DOWNING. Can you design against them?

Dr. BISPLINGHOFF. As Dr. Newell mentioned, there is a continuous gradation in size, from the asteroids down to the smallest particles of dust.

It would be difficult for me to sit here and say just what we can design against. We obviously cannot design against the very large ones. We have got too heavy pressure, of course, but the probability of hitting will be very small so that the danger would be negligible.

Mr. DOWNING. Say one the size of this water glass.

Dr. BISPLINGHOFF. No; we can't handle those. We can handle them in the order of a gram or so, but that size of particle would penetrate anything that we could design.

Dr. NEWELL. As a matter of fact, it wasn't so many years ago that a very small particle about stone size, struck the engine of a Ford I believe it was, and went right through.

Mr. KARTH. The engine of what?

Dr. NEWELL. A Ford.

The man was driving along and a meteor just went through his engine.

Mr. MORRIS. Do you mean a Ford automobile?

Dr. NEWELL. A Ford automobile.

Mr. MORRIS. Where was that?

Was that Ford up in space?

Dr. NEWELL. It has been so long ago, I am not sure, but hazily I think it was somewhere in one of the Southern States.

Mr. KARTH. Was it in New Mexico?

Dr. NEWELL. No. [Laughter.]

Mr. KARTH. He is wondering what happened to one of his old Fords.

Mr. MORRIS. We don't have that kind of thing happening in New Mexico. [Laughter.]

Dr. NEWELL. But I would like to comment on this package satellite question.

We have for a long time been interested in this approach but our analysis of the economics shows that the cheaper way is to use the large observatory type of approach than the smaller, package type approach.

With the smaller satellites you do make it more comfortable for the individual experimenters because they can take the little package off to their laboratory and work on it, and in effect bring it back to be merged along with the others, but you pay an additional price in dollars for doing it that way.

Mr. RANDALL. In what way, Doctor?

Dr. NEWELL. It just costs more to do.

Mr. RANDALL. Well is not the larger part of the cost—at least from the figures that we have here this morning—the cost of the launch vehicle?

Dr. NEWELL. No, sir.

Mr. RANDALL. I thought that they were $450,000, and $500,000—the spacecraft is the smaller amount, isn't it? I want to be corrected if I am wrong, but that is the way it looks to me.

Dr. NEWELL. In general the spacecraft costs about the same as the launch vehicle.

Mr. RANDALL. Well than I wonder if we should not look at this package idea. Doesn't that have some economy aspects?

Dr. NEWELL. It depends on what you want to do—if your payloads don't require stabilization and accurate pointing, very careful control of temperatures, and so on, then the smaller packages will be cheaper, but if you do require these things, and many of these experiments that we are now doing do require them, then it is more economical to provide for ones that have a whole group of experiments.

Mr. RANDALL. You talked about the observatory types but I did not think we were talking about that—I thought we were talking about the Scout and Saturn shots.

Dr. NEWELL. No; but, in the case of a great number of satellites put together, you are not talking about Scout—you are talking about the Atlas size vehicles.

Mr. RANDALL. Well, it would seem to me that with the package approach you could cut down on the costs, and if I am wrong about that, I want to be corrected, but I just can't get that feeling out of my mind.

Dr. NEWELL. Well, the point is that with the one launch vehicle you can either launch six experiments in six separate packages, or six experiments in one single package.

What I am saying is that one launch with six experiments in one package does it cheaper than six experiments in six packages. This is because you have one power supply, one utility system, one temperature control and so on.

Furthermore, with six packages you have to set up six different ground based operations to provide the telemetering, individual tailor-made treatment for each experiment, whereas, with the observatory type integrated package, one ground based operation will take care of all the data; when you add up all the figures it will come out cheaper.

Mr. RANDALL. But apparently we haven't added up all the figures according to these statements that we have here this morning.

You still show the launch vehicle as the expensive item. In any event, in view of the comments that you have just made, because of the spacecraft capability, you can accomplish what you need to accomplish with the one spacecraft—is that your statement?

Dr. NEWELL. What I am saying is that as a general principle it is cheaper to use an integrated spacecraft approach than to use an individual package for each experiment. I am willing to grant that there are exceptions, and when there are exceptions we make them.

Mr. RANDALL. Then, as I understand it you will have to go to something much heavier than Scout in order to get it all aloft?

Dr. NEWELL. Yes, and DOD does, too.

Mr. KARTH. Of course, I am inclined to agree with you, Doctor, but it is also true, I think, that there are additional costs that we must attribute to this theory that you are now expressing.

For example, we are in the process of developing one or two launch vehicles just to take care of some of these so-called integrated experi-

ments that we have been talking about, so, I think if you take everything into consideration maybe the savings might not be as great as they might appear to be.

Dr. NEWELL. No, my statement is based on amortizing the development costs along with the usage costs, but of course that means that you have to use the observatory over a reasonable length of time to provide an amortization period, but, If you assume that you are going to use both approaches for a number of years, then the cheaper approach is the integrated spacecraft approach.

Mr. KARTH. That is probably true so long as we don't find it necessary to create a brandnew launch vehicle just to do all these things. It gets to be a very expensive proposition.

Dr. NEWELL. Yes.

Mr. KARTH. As I am sure you are aware, this Centaur is not exactly a 25- or 50-cent item.

Dr. NEWELL. No.

Mr. KARTH. It is very, very expensive.

Dr. NEWELL. I agree with you, sir, but we will use Centaur for things that just can't be done in any other way, Mr. Chairman.

Mr. KARTH. May I just get back to this water ballast question one more time.

It seems to me that quite a number of people have thought that we should take some advantage of the first three Saturn shots by attaching some experiments on them other than the water ballast experiment, and I am now just wondering whether there are some experiments on the Saturn 6, or Saturn 7, or Saturn 8 along such lines?

Dr. BISPLINGHOFF. Eight and nine.

Mr. KARTH. Eight and nine? What happens to all the Saturns between Saturn 3 and Saturn 8? Are they just going to fly some more water?

Dr. NEWELL. Well—this Saturn involves the first test of the live upper stages.

Mr. KARTH. So we are not taking any chances on flying anything in place of the water?

Dr. NEWELL. We are not taking any chances.

Mr. KARTH. I see.

Dr. NEWELL. We are going to concentrate on making the engineering experiments a success.

Mr. MORRIS. There will be some water on it?

Dr. NEWELL. There will be some of the water ballast, yes, sir, but much of the area that was used for water ballast will now be live stages with their fuel supplies.

Mr. MORRIS. Well, that is the second stage.

Dr. NEWELL. Yes.

Mr. MORRIS. Yes; I see.

Mr. KARTH. Well, with all of these stages, it seems to me that it might be well worth while to consider—or does the Office of Manned Space Flight object to our giving consideration to carrying experiments aboard the SA–4, SA–5, SA–6, and SA–7?

Dr. NEWELL. There are several points here. The micrometeorite experiments will be on the first orbital shots so, if you are talking about orbital experiments, they begin when they can begin. I am not sure of the scheduling, but I seem to recall that the Apollo people themselves will be flying some boilerplate spacecraft with experiments that they need to do, as sort of prechecks for their spacecraft.

Mr. KARTH. Well, Doctor, insofar as the Saturn shots are concerned, they are just up and down and you really couldn't get too much value out of experiments of that kind, could you?

Is this probably part of the answer as to why this has not been further developed?

Dr. NEWELL. You could do it so much better normally with sounding rockets that that would be the approach rather than trying to introduce some complications on the Saturn vehicle itself.

Mr. KARTH. But OSS and OART have given consideration to the possibility of flying experiments on SA–5, SA–6, SA–7, and so on, if the Office of Manned Space Flight does not object to it?

Dr. NEWELL. We are considering this constantly, and not only that, but we are looking beyond that at Mercury, and the flights of Gemini and Apollo.

In fact, there is a group of people specifically assigned to keep looking at the question of what can be done in the way of experimentation on manned flight missions.

Mr. MORRIS. You don't want to get that spacecraft too loaded down because it won't take off. [Laughter.]

Dr. NEWELL. That is exactly right.

Mr. MORRIS. I can see where we could get very involved, if each one of us has his own pet project on there, then you could get this spacecraft involved in some problems.

Dr. NEWELL. Yes.

Mr. MORRIS. But I just hope you won't load that down too much because it is very marginal, anyway, it seems to me.

Mr. KARTH. I wonder if, just for the benefit of the subcommittee, and so that the particular point in the record might be easier to read when the subcommittee decides to formulate an opinion on this, I might summarize this by saying that as far as the Office of Advanced Research and Technology is concerned, your only interest in the meteorite and micrometeorite field is to design spacecraft that will in fact stand the environment of space insofar as the meteorite and micrometeorite factors are concerned, and in this effort to attempt to get a design and material that is of the lightest possible weight, so that we can get more punch per dollar, so to speak. Would that be right?

Dr. BISPLINGHOFF. Yes, sir.

Mr. KARTH. And that on the other hand, the Office of Space Sciences' interest in the meteorite and micrometeorite phase of NASA's program, is to get all of the scientific data about meteorites and micrometeorites other than what the design of the spacecraft might need to be able to withstand the reaction of space. Is this correct?

Dr. BISPLINGHOFF. This is a correct statement of our objective, yes sir.

Dr. NEWELL. Very good.

Mr. KARTH. Could we then go on to space chemistry?

Dr. NEWELL. Space chemistry is an area of interest in OSS as has been pointed out, and the manned space flight people have a project that they call space chemistry.

We have two areas of OSS activity; one is associated with the Earth's upper atmosphere and related studies. These studies are designed to shed light on the origin and history of the Earth's upper atmosphere.

The geophysics and astronomy people are concerned with this particular project and their investigations go into learning more about processes going on in our upper atmosphere and processes in the chemistry of the comets, which are doubtless bodies that will give us information about the early history of the development of the atmospheres and the processes going on in them.

The lunar and planetary people have a similar interest in space chemistry. However, their attention is directed toward the Moon and the other planets.

I am given to understand that the manned space flight phases of the space chemistry item are for studies of lunar sources of raw materials and what can be done in order to use the materials that we may find on the Moon for providing water, possibly the construction materials, and the other needs of the manned flight program after a landing has been effected.

This is a different project from the OSS space chemistry.

Mr. MORRIS. I am reluctant to ask you to comment on some other office's project, but would it not seem more reasonable to wait to get the material and then figure out what you can do with it?

Dr. NEWELL. It depends on how you want to approach this.

Mr. MORRIS. Yes, but I am asking about whether it is the hard way or the easy way.

Dr. NEWELL. Well, in football, a football player can stand and wait until he gets the football, in which case he can be very sure of catching it, but then if he doesn't have a running start he may be thrown—even for a loss.

Mr. MORRIS. Yes.

Dr. NEWELL. Whereas, if he catches the ball on the run, most of the time he will catch it if he is pretty good about calculating his catch, and he will have a running start and get that much further ahead. Indeed with running start approach his lifetime yardage record will be much better.

In the case of the manned spaceflight, however, I don't know the details of their project of course, but I would assume that what they are doing is looking into the processes and techniques, and assembling information, in order to have a headstart.

Mr. MORRIS. All right; all right. Sorry I asked the question. [Laughter.]

Mr. KARTH. Have you ever counted the people, Dr. Newell, who have become mesmerized by this sort of explanation?

You both do an excellent job.

Mr. MORRIS. If we could go off the record, a moment, Mr. Chairman?

Mr. KARTH. Yes.

(Discussion off the record.)

Mr. KARTH. I think it is good for the subcommittee to be aware of all the reasons, whatever they are, as to why funds have been requested and I hope that you understand that this is the reason why we are asking you to come back here.

There have been a considerable number of questions in the minds of the members of the subcommittee as to why these things have appeared so often throughout the budget books. We also considered the possibility of whether or not it could be a method of confusing those who read the books, if I may be candid about it, and I think

that you have certainly helped me a great deal—both of you—this morning, in formulating an opinion as to the need or the justification of these requests.

Now, thermoelectric power supplies is next. I wonder if we can have either one of you tell us about that. Time seems to skip past us so rapidly here, but we did not cover this and I would like to do so. Back, then, to the meteorites and the micrometeorites, I wonder why we have the Office of Manned Space Flight involved here in this project, too?

I forgot to ask you about this last item that appears in the group. We have got three offices involved in the meteorites and micrometeorites and I wonder what their interest might be that could possibly be different from either one of your interests?

Dr. BISPLINGHOFF. Well, their interest is concerned primarily with the Apollo mission and in bringing in data.

Mr. KARTH. But so is yours.

Dr. BISPLINGHOFF. In bringing in data in the field, and the knowledge which exists on micrometeorites, for application in the design of the Apollo vehicles.

Mr. KARTH. This is not your function, do you say?

Dr. BISPLINGHOFF. Our function is to provide design criteria for this purpose, yes; but it is not our function to actually design the Apollo vehicles.

Mr. KARTH. Yes.

Dr. BISPLINGHOFF. There are problems along these lines in connection with this particular, specific vehicle, that they are designing.

Mr. KARTH. I understand.

It seems to me that it should be not in the meteorite and micrometeorite field, then, because as long as you give them whatever information they have on this subject, I think this is very probably scattering it around a little bit and it doesn't make much sense to me, but this is not our subject and I will call it to the attention of Mr. Teague.

Dr. NEWELL. Dr. Bisplinghoff and I have looked into this, Mr. Chairman, and in this request here, they have a scientific instrument, and we have initiated discussions with manned space flight on it. I think the outcome of this may be that if this experiment goes forward then space sciences will handle it.

Mr. KARTH. Good.

Dr. NEWELL. So we are indebted to you for pointing this out, and we have it in hand.

Mr. RANDALL. May I just ask three or four questions, Mr. Chairman?

Has there been any data brought back or anything of value from any of our Mercury shots on this penetration and meteoroid hazard that they have accumulated up to now? Another instance is the Mariner shot—what did we bet from that? Anything of value?

Dr. NEWELL. Oh yes, yes. Mariner had an instrument on board for micrometeorite studies which showed very interesting effects. When we got beyond the immediate vicinity of the Earth, the counting rate is very low.

In fact, the measurements indicate it is a factor of 10,000 below what you have in the vicinity of the Earth.

Mr. RANDALL. Well we know there are big flights and so on, but I am thinking of Mr. Morris' approach here, and our national or main and immediate objective of getting a man to the Moon.

How many more of these micrometeorite studies are we going to have to make in the foreseeable future? Is this going on for years?

Dr. NEWELL. Well certainly our main objective is to maintain preeminance in space and space science and space technology and, as I pointed out, the OSS is interested here in the importance of this material to scientific questions.

Mr. RANDALL. Well, I don't want to stay the proceedings, so go ahead, Mr. Chairman.

Mr. KARTH. Dr. Bisplinghoff.

Dr. BISPLINGHOFF. In the area of thermoelectric power supplies which is at the bottom of the first page, there are two items in question. One is an item under OART—S.R. & T., on space power entitled "Thermoelectric".

This program is a program which is concerned with materials and devices for converting thermal energy directly to electrical energy. On the research side of this, we are studying all of the various thermoelectric materials that we can investigate and that we envision might have value for this process.

We are also studying the synthesis of materials such as sulphides and selenides, and there are quite a few including titanium, zirconium and hafnium, and others in an attempt to determine which materials should be used for this direct conversion of the thermal energy to electrical energy.

Under this item we also have some research on what kind of surfaces ought to be used to collect solar energy and the kind of surfaces which might be spectrally matched with the materials that we use to convert the heat energy to the electrical energy.

Also, we are doing work on techniques for improving the modules themselves once we have selected the best material and how do we fabricate it into a module?

Here we are looking at very thin films, flat plates, and other kinds of devices for that purpose.

I have also looked into the Office of Applications work and I find that the program which is listed as OA, S.R. & T., communications satellites, isotope thermoelectric power is a paper study with the objective of investigating the problem areas which one would have if we incorporated an isotope thermoelectric power sources in a communications satellite.

It does not involve the research that is needed to select materials for this purpose, or to get the basic information that one might use for design. It is merely a paper study which studies the integration problems that one might have if one had such a system.

Mr. KARTH. Who is doing that?

Dr. BISPLINGHOFF. It is done in the Office of Applications, but I don't know who is actually doing the work.

Apparently it is at Goddard Research Center.

Mr. KARTH. So it is in-house?

Dr. BISPLINGHOFF. It is in-house, yes.

Mr. KARTH. What is the $200,000 item? Is this for salaries, in-house?

Mr. SCOTT. There are quite a number of factors, Mr. Chairman, that have to be studied, including the conditions that you have to

expose yourselves to, and radioisotopes, specific design changes that would be required to the vehicle, prelaunch, the conditions, distribution of heat flow throughout—the reentry problems and other matters. And this has gotten to be more expensive and more complex than we at first had thought.

Mr. KARTH. But my question is: What do we purchase with the $200,000?

Mr. SCOTT. There are a lot of engineering and computer studies and all of those things that are quite expensive.

Dr. BISPLINGHOFF. The computer expense is quite a big item?

Mr. SCOTT. Yes.

Mr. KARTH. Who wants to start on the life support systems? I guess maybe Dr. Bisplinghoff should be the one to take off on that one.

Dr. BISPLINGHOFF. Yes, sir.

This is at the top of the second sheet, and is entitled "OART, S.R. & T. in Human Factors Systems, Life Support and Protective Systems."

The main purpose of this item is to finance the work that is being done by OART in the development of the technology for longtime life support systems.

We are spending this money primarily through the Langley Research Center and the Manned Spacecraft Center and are experimenting with the kind of gases that we might want to use and the kind of regenerative systems that one should use and all of the other parts of the system which might be needed to provide life support for times and numbers of people that are well beyond what is being contemplated for the Apollo mission.

I have also looked at the Office of Manned Space Flight items which follow this on that page, and find that the one entitled "Experimental Studies in Aerospace Medicine Life Support Systems," is being used for the development of hardware associated with Gemini and Apollo.

Mr. KARTH. The development of hardware?

Dr. BISPLINGHOFF. The development of hardware associated with Gemini and Apollo missions.

Mr. RANDALL. You mean that is page 14?

Dr. BISPLINGHOFF. Yes, sir. this is the $2,315,000 item.

The next item is "Crew systems in aerospace medicine" and, according to their descriptions, for the development of equipment and components such as space suit assemblies and environmental control devices, also for Gemini and Apollo missions.

Included in this area are the preflight and inflight checkout of personal support and safety equipment. Again these are directed specifically toward the Gemini and Apollo missions.

Mr. KARTH. And your $6.8 milllons program differs in what respect, briefly?

Dr. BISPLINGHOFF. Well the Gemini and Apollo missions as we see them make use of the present state of the art in the development of the life support systems.

Our whole job is to advance the technology of this area so that we can go well beyond the times and numbers of people that will be involved in the Apollo and Gemini missions. For example, we are looking at a 360 man-day study at Langley, at the present time, which involves really quite a jump in the technology of the life support system.

Mr. KARTH. And what is the extent of this research work that you are doing now? The $6.8 million if I understand it correctly is for fiscal year 1964?

Dr. BISPLINGHOFF. Yes, sir.

Mr. KARTH. How much money do you think we will need to complete the human factor systems study that you are making from the research you are doing in this area? What do you think it will be in 1965 and 1966—or do you think that you might bring this to a conclusion?

Do you look for an expanding program or about the same program or what?

Dr. BISPLINGHOFF. I am quite sure it will continue. It will continue beyond this.

It would be my guess that it would be slightly larger in 1965.

Mr. KARTH. Well is that because of an oncoming program that NASA has, or what might be the reason for this program becoming larger?

Dr. BISPLINGHOFF. Well, it is because of our responsibility to provide and develop the technology for systems that might be designed in a 10- or 15-year period from now.

Mr. KARTH. Except for that, is there some value in having some kind of a program before you—at least before we spend substantial sums of money in doing research for what might or might not become a program?

Dr. BISPLINGHOFF. I believe we have to spend a certain amount of money.

Mr. KARTH. You see, I am not sure that we will ever have 10 men or 100 men or whatever are presumed to be going from here to the Moon, or the planets or whatever, and therefore I am not sure that we should spend too much money in an area like this.

I may be dead wrong, and I am sure I would be dead wrong if NASA had some kind of a plan that they came up with and said: "Well, this is our schedule."

Then I could see the feasibility of going ahead but I am not sure that I have ever heard of any plan that NASA may have which parallels our need for research in this area.

That is what concerns me.

Dr. BISPLINGHOFF. Of course, we have no approved programs which represent this kind of time or this number of people, but I feel that we must spend a certain amount of money in all of these areas to develop the technology and knowledge beyond what it is at the present time.

We will find, if we don't do this, and if we later have programs that involve the design of space vehicles that go well beyond our present state of the art, that we just won't be able to build them, or we will then have to start to build them which will be very expensive because the technology is not there when we are ready to do it.

Mr. KARTH. I appreciate of course, Doctor, that we have got to do some research work that we refer to as "way out" or future research.

Dr. BISPLINGHOFF. Yes.

Mr. KARTH. I am just not sure how concentrated it should be or what importance, or emphasis should be placed on it.

Dr. BISPLINGHOFF. Yes.

Mr. KARTH. I think it is a matter of degree.

Dr. NEWELL. Some of this life support work, Mr. Chairman, gets to be quite fundamental.

It is already known that some of these regenerative systems for example can poison themselves and cease working if they are not handled properly.

Thus, if you are looking forward to flying manned orbital laboratories for long periods of time, or if you are looking toward protecting the men out in space for long periods of time, either in flight or on the moon or on the planets, you will have to solve these problems.

If you want a headstart, right now, Mr. Chairman, is the time to work on the fundamental problems and the applied research problems, so that the development later can go forward.

Dr. BISPLINGHOFF. Mr. Karth, may I ask Dr. Konecci to add to this. This is Dr. Konecci's work and I think he could perhaps help us.

Mr. KARTH. Yes, certainly.

Dr. KONECCI. Mr. Karth, actually we are behind right now in the development of advanced life support systems. There had not been a very large effort in this area, thereby, requiring some of the work that is now being done by the Office of Manned Space Flight to meet the mission requirements of Gemini and Apollo.

So what we are trying to do is to accumulate knowledge in the area so that a large amount of dollars will not have to be spent in the future, trying to catch up.

Life support is the most critical item of getting man into space and we are working hand in glove with the Office of Manned Space Flight. Their mission duration is 14 days for both Gemini and Apollo while we are looking at 30 days, and beyond.

To give you an example, we will be demonstrating a 5-man, 30-day, completely integrated life support system test on the ground, at the Boeing Airplane Co. in approximately July of this year, using various NASA Center people and including two Air Force people.

Mr. KARTH. Well, you can't say that we are not spending much money on it.

Dr. KONECCI. No.

Mr. KARTH. We are spending—what is it, $15 million, and you are requesting $13 million in 1963.

Dr. KONECCI. That's right. But roughly half of that money is, of course, being spent on improving the so-called Mercury-type system that we have for going beyond the presently designed part of Mercury. They are working on it now and hope to improve it beyond Gemini.

Mr. KARTH. Well I hope that they decide very quickly what to do with Mercury. I think that they should go on with other things than Mercury. Now we have Gemini and Apollo, and if we are spending money on Mercury it seems to me we ought to take a good look at that. Is there any money for Mercury in here?

Dr. KONECCI. No, no. This is technology that we are concerned with, sir.

Let me explain that the systems they are working on at the present time with the Gemini and Apollo programs are, a "one gas, 100 percent oxygen, 5 pounds per square inch system" which are integrated—whereas, we are trying to get into the next stage beyond this, with two or more gases; but using air very much like here in this room.

like the conditions here on Earth; in other words, at 14.7 pounds per square inch. This is a completely different state of the art.

The Soviets I might mention are already at the 14.7 pounds per square inch, two gaseous system stage.

Dr. KARTH. How do we know that?

Dr. KONECCI. We have gotten their data, sir.

We have had a very good exchange in this area of aerospace medicine. It is in the book that I made available to you, I think—they have published two volumes of experimental data.

Mr. KARTH. Are we making use of those?

Dr. KONECCI. Yes, sir.

Mr. KARTH. Well it is good to get this sort of thing on the record once in a while, because some people think that we give away all of our information to our enemies and get nothing in return.

Dr. KONECCI. No, sir.

Mr. KARTH. Anything further on this subject?

I think it will be necessary for us to come back on Friday and resume this discussion—and for both of you to return if you can?

Dr. BISPLINGHOFF. Yes, I can be here on Friday.

Dr. NEWELL. I am scheduled, Mr. Chairman, to be out of town but Dr. Clark would be available if this would be acceptable.

Mr. KARTH. Fine, yes; that is certainly acceptable.

The committee has a luncheon engagement at the request of the chairman, so I think we might adjourn at this point and reconvene at 10 o'clock on Friday morning.

Thank you very much.

(Whereupon, at 12 noon, the subcommittee was adjourned to reconvene at 10 o'clock, Friday, April 26, 1963.)

1964 NASA AUTHORIZATION

FRIDAY, APRIL 26, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SPACE SCIENCES AND
ADVANCED RESEARCH AND TECHNOLOGY,
Washington, D.C.

The subcommittee met at 10:15 a.m., Hon. Joseph E. Karth (chairman of the subcommittee) presiding, in room 214–B, Longworth Building.

Mr. KARTH. The meeting will come to order. Dr. Clark, we want to welcome you before the subcommittee.

Dr. CLARK. Thank you, Mr. Karth.

Mr. KARTH. We are happy to see you again. Dr. Bisplinghoff, it is good to have you back with us.

Dr. BISPLINGHOFF. Thank you, sir.

Mr. KARTH. You are kind of the standard fare. You have been with us more times, I guess, than anyone else this year. We think you are doing an extremely good job justifying your program.

As I recall, we were on planetary atmospheres, when we adjourned last, and inasmuch as most of this is under OSS, I wonder, Dr. Clark, if you would care to proceed and attempt to tell us why we find items so many different places in the budget, carrying the same title, such as under "Geophysics and astronomy," as happens in this case?

Dr. CLARK. Yes.

Mr. KARTH. And what is the purpose of the requests in each one of the instances? And why couldn't we put it all together and ask for one lump sum?

STATEMENT OF DR. RAYMOND L. BISPLINGHOFF, DIRECTOR, OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, ACCOMPANIED BY DR. JOHN F. CLARK, ASSOCIATE DIRECTOR AND CHIEF SCIENTIST, OFFICE OF SPACE SCIENCES

Dr. CLARK. Yes, sir. The order given here is a very excellent order, because it is essentially the order in which the job is being done. Starting first with the two associated projects in "Geophysics and astronomy," the supporting research and technology efforts in this area include, as is customary, both laboratory and theoretical studies, and instrumentation which is developed to understand primarily the structure, dynamics, and composition of the earth's upper atmosphere.

This is the home base, the proving grounds in which techniques are developed for use farther away in the solar system when the missions

become much more costly, and in which the penalty for error, for not having done everything possible in a preparatory way, is much more severe.

When we have undertaken adequate background research, laboratory research, development of instrumentation, and theory, we are in a position to conduct flight measurements in the Earth's atmosphere by the use of sounding rockets. This is the bulk of the second item here, "Flight projects" in "Geophysics and astronomy," in which once one has developed successful instrumentation for the sounding rocket work, getting results from this area, essentially graduating the experiments to satellites, and accumulating data over a longer period of time over a much larger fraction of the total volume of the Earth's atmosphere.

Mr. KARTH. The items in question, Doctor, are "Planetary atmospheres." We find, under "Geophysics and astronomy," a request for planetary atmospheres appearing in two different places in the budget.

Dr. CLARK. Yes.

Mr. KARTH. Under "Lunar and planetary programs," in another part of the budget, we find again a $1¼ million request under "Planetary atmospheres." On page 38 of the budget, we find "Spectroscopic studies of planetary atmospheres and surfaces" calling for another million dollars.

What we want to know is, what is the difference between these various planetary atmosphere studies or projects and research programs, whatever they might happen to be? What is the difference between the one that appears on page 26 and the one that appears on pages 32 and 34, 38, and so on? Why do we have this in four different places in the budget, all under the same heading?

Dr. CLARK. Yes. I have described first the item that appears on page 26 on the "Geophysics and astronomy" and supporting technology. We consider that the Earth's atmosphere is a planetary atmosphere and that geophysics is confined totally to it.

The relation to the supporting research and flight pattern is that we do not commit things to flight until they have been well developed on a sound basis of laboratory and theoretical research.

Mr. KARTH. Isn't that OART's job?

Dr. CLARK. The difference between supporting research and technology and advanced research and technology in the flight projects area, space sciences, is a fine one in that there is a sequence through which any flight experiment must go. This requires a closely integrated and coordinated effort on the part of the responsible investigator.

Dr. Van Allen, of the State University of Iowa, is a good example in which the most effective res arch is done, not by separating this into different programs and different investigators, but by having one well-coordinated program of theoretical and laboratory research, and sounding rocket, satellite, and space probe flight research.

We consider this coordinated activity in space sciences as so closely associated with the flight projects and with the flight experiments involved that they are supported by our supporting research and technology program.

Dr. Bisplinghoff's area, in Advanced Research and Technology, has to do——

Mr. KARTH. We agreed that was a misnomer. We agreed earlier in the hearings that it should be Research and Advanced Technology, didn't we, Doctor?

Dr. BISPLINGHOFF. Yes, I think that that is a better phrase with which to describe it.

Dr. CLARK. That is a good way to put it. I think I need add nothing.

Mr. KARTH. Will you go ahead? What I would like to have you do, Doctor, is explain a little further. It might be just because it is a Friday morning, that I did not quite understand the difference between the page 26 planetary atmospheres item and the page 32 planetary atmospheres item.

Dr. CLARK. Page 26 is primarily ground-based theoretical and experimental research. Page 32 is——

Mr. KARTH. Would you call that basic research?

Dr. CLARK. Semantics are very tricky here. As far as Space Sciences is concerned, this is supporting research. Since supporting research must always be in support of something, this is in support of the development of the best available flight experiments at the lowest possible cost. As I think you have heard from Dr. Newell, the difference between basic research and applied research is frequently one of motivation. So far as the men at the universities and our centers who are engaged in this research are concerned, this is basic research. All of space science is basic research in terms of understanding the environment.

This is a different sort of basic research than the sort of research one is talking about when dealing with research in terms, for example, of basic propulsion techniques. We might be more comfortable calling this environmental research, which is a perfectly good term. There is a rather substantial difference between the complex research effort which evolves, from time to time, competent flight experiments through which we can learn a lot about our environment in space at a minimum cost; and the sort of research that is directed to solid state physics, mechanics, and materials.

Mr. KARTH. What is the purpose for the $1½ million item on page 2, under the same title?

Dr. CLARK. These are the flight experiments within the Geophysics and Astronomy area, which involve primarily sounding rocket and satellite experiments. So that again, taking the State University of Iowa as an example, under the item on page 26, they may have a continuing relatively low level of support to maintain a continuity of effort which will occasionally develop proposals to do specific flight experiments.

Mr. KARTH. Is that where a good deal of that work is going to be done?

Dr. CLARK. In universities, yes.

Mr. KARTH. How about the planetary atmospheres item on page 32? Where will that be done? Is this a kind of in-house thing?

Dr. CLARK. No. This is done by the same groups when they have proposed a specific space flight experiment which now starts to involve larger sums of money because of the necessity for the development of flight hardware.

Mr. KARTH. Do we already have some answers on this basic research area so that we can apply some of this knowledge to actual flight experiments as you request on page 32?

Dr. CLARK. Yes. These same people come in with proposals for specific flight experiments which are individually funded, after their selection, for the development of hardware on a schedule which can be integrated with the total flight package; for example, an Orbiting Geophysical Observatory.

Mr. KARTH. How do we determine, Doctor, and this always bothers me, how essential an experiment may be? How do we determine that we have to move forward with this experiment as opposed to some other experiment, or move forward with this experiment as opposed to doing nothing in the area, because whatever the experiment is about, it might be inconsequential, even if we get all the answers we hope to get? How do we determine the need, the essentialness of any experiment?

Who determines this? There is a lot of research that we could do in this field, just fantastic amounts of it, that a scientist, or I as an individual, might be interested in doing. As to its effect on the whole program, however, I am not sure that it would enhance it even to the slightest degree.

How do we determine what is important? What we have to move forward with; what we should spend money on? How do we determine this?

Dr. CLARK. This is always a difficult question because I don't think it has an objective answer. As soon as you say that, then you say the subjective answer which is available is necessarily a matter of opinion, and you must necessarily get the best opinion that is available. So this is where our Space Sciences Steering Committee, with its various scientific subcommittees, comes in. For example, one of the seven subcommittees of the steering committee, deals with planetary atmospheres.

Mr. KARTH. Who is on these committees, Doctor? Are they more scientists?

Dr. CLARK. These committees are composed of scientists. There are generally a somewhat larger number from the university community than from the Government community.

Mr. KARTH. This doesn't get to be a "scratch my back and I will scratch yours" type situation, does it? If you will agree to this experiment then we will be nice to you when yours is considered, something like that?

Dr. CLARK. This is always a danger when you must have well-informed people, because there are not enough well-informed people that are not involved in the program. We accept men who are informed even though they may well be prejudiced and try to balance these prejudices. We have full-time competent headquarters scientists, all Ph. D.'s, chairing the subcommittees; men who are not eligible to have their own flight experiments. These are the men that have to weigh the comments that are made by the members and consultants of these subcommittees and make recommendations as to what should be done. Each year we get from the subcommittees a long-range space sciences thinking document, which contains not only the presently approved program but also two shopping lists: one, those experiments in a rough priority ranking that we would like to carry out when the resources are available, and two, a list of experiments that should be performed when the technology has advanced to such a point where they are feasible at a reasonable cost.

Mr. KARTH. Who first determines that we should do research work in planetary atmospheres at the university level? This is first determined by NASA, isn't it?

Dr. CLARK. This is first determined by NASA specifically in the Steering Committee, chaired by Dr. Newell and has most of the senior——

Mr. KARTH. There are no university people on that Steering Committee?

Dr. CLARK. That is correct. This is entirely in-house NASA.

Mr. KARTH. The first decision on whether or not some basic research should be done in an area is decided by a steering committee and after the basic research is done by universities, if it is, members of the university staff help NASA decide what experiments they should actually perform, is that right?

Dr. CLARK. This is right, in part. The reason why I hesitate here is that we feel that it is both undesirable and impossible to plan a research program for someone to do. No one plans research. One takes advantage of the best minds and then supports them.

Mr. KARTH. I am not questioning the theory used. I am just asking whether or not that is the procedure.

Dr. CLARK. Right. This is the procedure that is used specifically. As various space flight missions are formulated, as, for example, now that one has an orbiting geophysical observatory with known characteristics, known weights, and power, then one does not go out and suggest to the scientific community that certain discrete experiments should be done. Rather, one tells them in as much detail as possible what facilities are available, like the orbiting geophysical observatory, and solicits proposals by the scientists. The subcommittees then review all the proposals that are submitted and categorize them, depending on the scientific competence and feasibility of the proposed experiment, the reputation of the principal investigator, and the technological competence of the team that he has gathered to help carry out the proposed experiment, if it is accepted for flight.

Mr. KARTH. Doctor, isn't this putting the cart before the horse? Isn't it turning it backward? Shouldn't we first have a program? First, shouldn't we decide long before we go to the university for basic research, which then leads up to a flight experiment research effort, shouldn't we first determine that we have need for a program? Shouldn't we first determine a problem? OK, this is a problem area. We have to find the answer to that problem.

Dr. CLARK. That is correct. This is done.

Mr. KARTH. After we have the target, then we go into the research, I don't care whether you call it basic, applied, or anything else, it seems to me the decision has first been made that we have an objective, that we have a target. After that decision has been made then we follow down the line, down the road to see if we can get the answer so that we can reach the target. Really, what you are saying to me is that we have a whole bushel basket full of ideas here and we throw a few of them out to the university and say: Do some basic research, and they do, and after doing the basic research they come to us and say there are problem areas that we should look at and conduct some experiments. I don't think this is the right approach. I could be dead wrong. It doesn't seem to me this makes sense from an objective program standpoint.

Dr. CLARK. If this is the impression I have given you I appreciate your correcting it, because this is not the correct impression. We do lay out a research program in terms of fundamental questions which must be answered before we can send machinery and men into space safely, for example. In order to learn what we need to know about various regions of space so that we can proceed further out into space, we must proceed into other subsidiary areas in order to learn more about the total environment of space. These objectives are, in more general terms, starting with some of the fundamental questions to which we need answers. For example, what is the nature of the control exerted by the Sun over events here on Earth? What is the origin, history, and future behavior of the solar system and the universe? These questions are broken down into the sorts of space flight projects that will be required. One goes from the lowly sounding rocket investigating the physics of the lower Earth's atmosphere to the various types of satellites. Some take measurements of the environment in their immediate vicinity throughout the entire Earth's atmosphere. Finally, we graduate to space probes which are looking at phenomena in the vicinity of the nearby planets, Venus and Mars. Once we have gone through the very necessary exercise of determining the nature of the measurements which should be made, using each of these various vehicles and each of these regions of space, we go back to the scientific community to find out who is in the best position to make the detailed measurements in this area which has already been circumscribed. In this way, we try to get the maximum amount of valid data, within the time and other constraints of the program, at the most reasonable cost. So that what we have been talking about here is a refinement of the area of measurements which has already been outlined in some detail.

Mr. KARTH. I am not sure that I understood everything you said. Let me ask you why it appears in the budget that we are doing this in so many different ways. For example, on page—volume 5, page 27, I find "Atmosphere Explorers and Monitors." I don't know what Atmosphere Explorers and Monitors are all about as well as you do. And I don't know what our planetary atmosphere studies are all about as well as you do either. The only thing I do question is if planetary atmosphere studies are to accomplish what you say they are to accomplish, and if I understood correctly the purpose for the atmosphere Explorers and Monitors on page 27, then, it seems to me, if my recollection serves me correctly at all, that we are really asking for these two different items for the same purpose or essentially the same purpose or purposes. You call them a little bit different. We have them in different places in the budget. They are all for substantial amounts of money. It seems to me they are all supposed to meet the same objective. I am not sure I understand this.

Dr. CLARK. Let me try to put this in perspective——

Mr. KARTH. Do you have volume 5 there, page 27?

Dr. CLARK. Yes.

Mr. RANDALL. What is the page of the atmospheric studies?

Mr. KARTH. Page 2 of the list that we gave you. You will notice on page 26 of the budget the item designated as "Planetary atmospheres" for $2 million and down the list. My question is that this is atmosphere study and it seems to me that the Explorers and the Monitors are conducting the studies that you are attempting to con-

duct, or have in mind conducting, in your planetary atmospheres portion of the budget.

Dr. CLARK. Let me try to put the whole thing in perspective and go through all of these items quickly relating the items on page 27 with the four items which your staff has called out on the staff memorandum. First and perhaps most important, this is all part of the same program. This is one program. The way in which this is conducted is as follows: We first start out in the supporting research and technology area, making sure that we have good instruments and good experiments to be performed. This is relatively cheap to do before we do any of the more costly flight experiments.

The second step comes after the experiments have been developed on sounding rocket flights (this is item 2 in your staff memorandum on page 32). Some of these flight experiments go into these atmospheric Explorers and Monitors. These are prerequisites for the development of the experiments which are broken out specifically on page 27 of volume 5.

Mr. KARTH. Why aren't they listed under experiments on page 27 under "Atmospheric Explorers and Monitors"?

Dr. CLARK. During their development we require that they first be flown successfully in sounding rockets. We don't want to commit them to the relatively expensive satellites until we are sure the instrumentation functions well.

Mr. KARTH. These page 32 items are only going to be flown on sounding rockets?

Dr. CLARK. Correct.

Mr. KARTH. None will be included in the satellite?

Dr. CLARK. The dollars for procuring the experiments which will be flown in satellites are listed on page 27. They will be the same experiments scientifically, but now they will have been checked out. When we select the experiment for satellite use, the experimenter gets a contract to develop qualified satellite hardware according to the schedule required to meet the total satellite project. That is why it is budgeted in that way for tighter control at the stage that the instrumentation has been developed and checked out.

Mr. KARTH. It may be, Doctor, that some of these flight projects on the sounding rockets need never be flown in spacecraft, isn't that true?

Dr. CLARK. Yes. There are some sounding rocket experiments which are designed to explore the altitude region below that readied by satellites. These are never flown in satellites. It is also true that some experiments, which seem very promising from everything that can be determined by trying them on the ground, prove to have difficulties when they are tried in sounding rockets which makes us decide that they are not sufficiently worthwhile to expend the funds necessary to carry them through to a satellite flight. That is the second reason why they might not be so flown.

Mr. KARTH. Can you tell me why we need that $1½ million item there, the $1.4 million for flight experiments? What information do we hope to get that we now don't have and how will that affect our overall space effort?

Dr. CLARK. Information in two areas. These are sounding rocket flights, and they are necessary first to understand this very important transition region between our lower atmosphere, where weather is

normally considered to be formed, and the outer atmosphere which is the region of the satellites. This is the region through which any coupling between the upper and lower atmosphere must take place. We are going to have to understand this region far better before we are able to understand such processes, which may have long-range influences on weather and communications. The second reason is to make sure that no instrument that can be reasonably checked out in a sounding rocket, and this includes most instruments, fails to be checked out on a sounding rocket before it is committed to a far more expensive satellite or space probe flight.

Mr. KARTH. To page 34, planetary atmospheres in the lunar and planetary programs. We have ionosphere requests in the budget on page 27 also I think. Are these experiments, noted on page 34, to be flown in spacecraft? I assume they are not——

Dr. CLARK. Page 34——

Mr. KARTH. They are not sounding rocket experiments?

Dr. CLARK. No, under the lunar and planetary programs, there are two major types of activities under that category. The first of these are the experiments that are conducted in space probes. For example, in the Mariner II flyby of Venus, some of the radiometer work there has to do with determination of characteristics of the Venus ionosphere. This work will, of course, be continued and expanded. This work will, of course, be continued and expanded. The other type of work that goes on here is ground-based observations of the atmospheres of other planets, particularly Mars and Venus, with the development of the special techniques that are required in order to make the best use of spectroscopic techniques for determination of the composition, temperature, and other characteristics of the planetary atmospheres. Some of these experiments are carried aloft in ballons in order to get above some of the obscuration of the Earth's lower atmosphere. This is closely related to the ground-based studies. In other words, all of the techniques for studying the characteristics of other planetary atmospheres are gathered together here from the point of view of the basic physics, dynamics, and chemistry of these other planetary atmospheres. The fourth item is "Biosciences." We can either come to it now in relation to the difference in emphasis between this and the lunar and planetary research, or explore the lunar and planetary area further.

Mr. RANDALL. I can understand the Mariner flyby. You talk about ground-based observations of Mars and Venus. Then you say in the next breath they are going to send them up in balloons. I thought our whole emphasis was to try to get out beyond the atmosphere. What is this ground-based technique? Is it some kind of infrared or some type that the British are using? What is it?

Dr. CLARK. The whole thrust of our program is to do by means of our rocket-propelled vehicles that which we cannot do otherwise. This would offhand seem to exclude anything that does not include rocket-propelled vehicles. But there is a very important consideration here. We certainly do not want to do anything with these very expensive space probes. We don't want to do anything with these means that we can do in any other less expensive way.

There are some things that we can do from the ground. There are some things that we can do from balloons——

Mr. RANDALL. Specifically, what?

Dr. CLARK. Specifically, studies of other planets by telescopic means.

Mr. RANDALL. Innovations in the ordinary means. What specifically on that?

Dr. CLARK. Specifically during the time Mariner II was flying by Venus, the 200-inch telescope at Palomar was being used by a Cal-Tech scientist, Dr. Murray, to scan the surface of Venus, that is the cloud tops, and determine the temperature of the cloud tops by this means. He was able, because of the large telescope, to actually get contours of equal temperature, so-called isotherms, on the cloud cover of Venus. The reason this was important is that it enabled us to get a direct correlation between the measurements that were made from the Mariner II flying by the planet, and the more conventional ground-based techniques, but to a higher degree of resolution for spatial detail than we had ever achieved before, because of the use of this largest available telescope.

Mr. KARTH. Would the gentleman yield?

Mr. RANDALL. Certainly.

Mr. KARTH. How much difference was there between the ground-based observations and Mariner's, as to the temperature at the cloud tops?

Dr. CLARK. The results were in agreement. They gave us assurance that the results we were getting from the ground were valid and that those from Mariner II, were valid. If I could anticipate a question that should be in your mind at this point, why should we do experiments from space probes that we can do on the ground? We shouldn't, we aren't, we haven't.

This was but one of the elements that we could get from Mariner II. You recall we had two infrared bands. The one infrared band was at a window in the Earth's atmosphere and we could observe this by means of the ground-based telescope. The other infrared band was in a region where the Earth's atmosphere is partially opaque, and furthermore, we can achieve even on some of the first crude experiments flying by Venus, better spatial resolution, so that we could see smaller areas of variation on the Venus surface. With these two bands, two wavelength bands, it was possible to determine whether there were holes in the clouds through which we could see lower in the atmosphere. No such holes were observed. This is data that could not be obtained——

Mr. KARTH. You didn't expect any, did you?

Dr. CLARK. It is risky to say what one should expect because some astronomers at times of very good seeing, have thought they have seen some detail. But the fact of the matter is, the instrument did not.

Mr. KARTH. As I understand it, the scientists didn't really expect to see any holes in the clouds. They had a feeling that it had such a dense cover, if they saw any holes, it would be one of the unexpected things, rather than the expected.

Dr. CLARK. I was not surprised that they did not, but I was very much interested in the actual fact.

Mr. KARTH. Let me ask this question—it is digressing a bit. I think it gives the subcommittee a better idea of how important some of these scientific experiments are. What difference was there between the Mariner findings and the estimated temperature theory

with which we have been living for quite a number of years? What was the difference between our ground-based observations, and the temperatures that were reported by Mariner?

Dr. CLARK. If one takes into account all available data, including reasonable assumptions of factors such as the emissivity of the planet's surface which is not yet known precisely, it is fair to say that the ground-based observations are in excellent agreement with the space flight observations, and conversely.

Mr. KARTH. Both observations are in agreement, that it is, about 800°?

Dr. CLARK. That is correct. There is a difference between this 800° derived surface temperature and the 600° brightness temperature. The brightness temperature is the apparent temperature, you see, if it were a perfect black body emitter.

If it has the order of 70 or 80 percent, then you have to correct the brightness temperature, because it is not a perfect black body. The magnitude of that correction is such that the 600° brightness temperature is in agreement with the 800° computed temperature of the surface of the planet. In summary, the measurements are in agreement.

Mr. KARTH. In most instances, then, we could say the recent scientific experiments we have conducted and, in particular, the Mariner, findings merely substantiated data that we already had or conclusions that we had already drawn? In most cases this is true, isn't it?

Dr. CLARK. I would have to say that a substantial——

Mr. KARTH. There are two important areas where this is true?

Dr. CLARK. I would say that, in my view, a substantial minority of the total findings of Mariner II were primarily in substantiation of facts that we already had on a reasonably firm basis, whereas a substantial majority of the facts we obtained from Mariner II were quite new.

Let me cite some of these. The findings on the magnetic field of Venus being less than 5 to 10 percent of that of the Earth, insofar as the dipole moment is concerned, is something which scientists know of no way to determine without going to the planet. The fact that the interplanetary flux of micrometeorites away from the Earth is down by a factor of 10,000 from that near the Earth, is something which I know of no way to pin down to that accuracy, although some observations of the zodiacal light——

Mr. KARTH. Would you say that again?

Dr. CLARK. The fluctuation of micrometeorites observed in the vicinity of the planet Venus, at those distances from the Sun, is down by a factor of 10,000 from the fluctuations observed in the vicinity of the Earth. This, again, is a measurement we need to go out and make.

Mr. KARTH. Its importance seems to be substantially diminished now over what it was, the importance of going out and making the measurement?

Dr. CLARK. You mean from the point of view of the hazard produced by the micrometeorites?

Mr. KARTH. Yes. It eliminates about all of them, doesn't it?

Dr. CLARK. So far as the size range which are reasonably frequent, this is certainly true, because this is a very low rate, indeed. The

problem is that one does not know, as yet, about the larger sizes. Remember, we are just talking about cosmic dust here. The grains that we were discussing in the last session of this committee, the distribution of these will not necessarily follow the same laws as will the distribution of the dust. And the grains are sufficiently infrequent to begin with, that we would not have expected to see any of these with the very small area plates that we could carry on the very lightweight Mariner II payload.

I would say it gives you an indication that you may be in better shape as you approach Venus, but assurance, no.

Mr. KARTH. It is still important that we conduct an experiment to make as sure as we possibly can?

Dr. CLARK. I would say so; yes. This is even more true when you go in the other direction toward Mars. Because in this direction, you are approaching the asteroid belt between Mars and Jupiter. At the present time we simply don't know what we may encounter at what distance, in terms of an increased density of matter that may be sufficiently massive to create a hazard to our spacecraft.

Mr. KARTH. Thank you, Doctor.

Mr. RANDALL. I have one more question, Mr. Chairman. I assume we will have to go through all of these items sometime before we reach our final conclusions, and go over them one by one, as we have these. You mentioned about the Mount Palomar doing some ground-based observations at the same time as the Venus flyby. Was it necessary that NASA finance that?

Wasn't there national scientific curiosity by someone along the line to check that out, or did we finance that?

Dr. CLARK. We did finance this, I think. The amount of money involved was very minimal. I strongly suspect that the amount of funds involved is probably in the order of a few hundred dollars.

Mr. RANDALL. Then if that is so, do you have any other instances—you mentioned that one only. What are some of your other ground-based activities? I just can't get my hands on this. I think you ought to spell two out in detail. I know this thing will be combed pretty finely before we are through.

If this is true of every item we have an awful lot of work to do.

Dr. CLARK. The only ground-based activities that we do are activities in which we can obtain data which we would otherwise have to obtain in a more expensive way through the use of space probes.

Mr. RANDALL. Are you using any new types of astronomy? Are you going back to the old? I though the whole trend was in the other direction.

Dr. CLARK. In this particular case, we were using infrared detectors of a new very sensitive type, to get measurements that were more sensitive——

Mr. RANDALL. Where is that being done?

Dr. CLARK. This is at California Institute of Technology.

Mr. RANDALL. That is in this $1,196,000 item? If not there it is somewhere along the line.

Dr. CLARK. I assume it is there. If not there, in a similar item.

Mr. RANDALL. Anything else besides infrared? Just this one project going on at Cal-Tech?

Dr. CLARK. For any ground-based measurements?

Mr. RANDALL. Yes.

Dr. CLARK. There are other items. For example, we have a number of ground-based observers who will be working in conjunction with the satellite ionosphere beacon which will be launched this year, about which Dr. Newell has told you. This is a beacon which puts out a number of harmonically related radio frequencies and these frequencies are received on the ground, and the difference in behavior between the various frequencies gives us a means of determining the variation of the Earth's ionosphere.

Mr. RANDALL. Ionosphere beacon?

Dr. CLARK. Yes. Another is the geodetic satellite in which observations are made of the flashing light——

Mr. RANDALL. That is funded here and not attached to the funds of the geodetic satellite?

Dr. CLARK. It depends on how we make the break. It is all part of the same project. I do not, offhand——

Mr. RANDALL. You can understand, Doctor, there is no effort to be tedious here, but we have to find where that break is, I assume many, many times along the line before this thing is wrapped up. That is all, Mr. Chairman.

Mr. STAEBLER. May I pursue a line of questions? In talking with people and trying to justify the expenditure of the overall amount of money about which we are talking, people poke at it in many ways, and one of the questions I have difficulty answering in my own mind is the need for doing, at the same time, the work in connection with the Moon probe and the more general, more basis research work in connection with planetary flight.

What would happen if, while we are passing through the period of maximum expenditure in connection with the Moon landing, we deferred some, let's just say some of the basic research on the planets? What would be the consequences?

Dr. CLARK. I think the primary consequence, Mr. Staebler, would derive from the fact that planetary exploration is considerably more difficult than lunar exploration from a scientific as well as a technological point of view. For example, we can launch probes to the Moon essentially once a month when its position is favorable. In the case of the nearby planets, we are only able to fly such a mission once every 2 years on a reasonably sized rocket.

So, from that point of view, to give you some feel for it, we are only able to get planetary data ¼ as rapidly (1 month as compared to 24 months, or 4 percent) as lunar data. Every time you miss an opportunity for a planet, you set yourself back by another 2 years, roughly, as compared with 1 month by missing an opportunity for the Moon.

We have transit times to the planets of the order of a half a year, during which our experiments must operate, instead of several days, which is the time through which your experiments must operate when going to the Moon. So the net result of this is to stretch out the amount of time required to get a comparable amount of information from the planets, as compared to the Moon, by a factor of perhaps 100 or so. This means to me that since it has taken, and is taking, at least a few years to get the necessary information about the Moon required to permit a commitment of man to go there and attempt to land and return, that we are going to have to expend a very much larger effort to get a similar amount of data from the planets.

It will be a great deal more economical to spread this out over a long period of time and do it in a rather deliberate manner, as opposed to waiting until the requirement is upon us to provide such information in support of a potential national decision to give greater emphasis to the planets.

Mr. STAEBLER. Would you venture a guess as to how long that period might be, if we took every opportunity, every 2 years, to send out probes, how long that period might be to secure the information, to put us in a comparable position with that which we hope to be in when we initiate the Moon landing?

Dr. CLARK. This is a very difficult question, because it is dependent, first, on how many attempts we make each 2 years, and how large the vehicles we use are. I am afraid that the answer, if we would go into Saturn class vehicles, with high energy upper stages, as quickly as they were available, would differ by an order of magnitude from that if we used the Centaur vehicle at the outset.

However, I think it is fair to say that the very minimum time period in any case will be in the order of a decade or more. It could easily stretch out to twice or three times this length, particularly if we did not have a graduated program in which we attempt to take advantage of what we can do reasonably and relatively inexpensively, doing this at a moderate pace, relative to those objectives which have established dates already tied to them.

I don't know if this is definite enough for you.

Mr. STAEBLER. This is very helpful. If we give up an opportunity, we give up 2 years each time we do that?

Dr. CLARK. Yes, sir.

Mr. STAEBLER. We have a course ahead of us that is at least 10 years' duration?

Dr. CLARK. Yes, and I am afraid this may be a rather serious underestimate. This is based on a sort of crash program that I don't think we could conscientiously recommend at this time, in view of the competition with other requirements for funds.

Mr. STAEBLER. That gives me just the kind of perspective I wanted. Thank you, Mr. Chairman.

Mr. KARTH. Dr. Bisplinghoff, I wonder if you could just give us kind of a summary of our human behavior itemization here of various budget requests, and at the conclusion, I wonder if you could tell us whether or not NASA has seriously investigated what the Air Force, or the other services, might be doing in the area of human behavior? It would appear to me that the behavioral sciences, the effects of space environment, neurological bases, and other things that I find listed under the request for NASA, such as crew performance, flight crew requirements, would certainly have been studied in some regard, at least, and in some degree by the Air Force and other military services.

If you could tell us what the difference is, in as few words as possible, between these eight or nine different items, and then what serious efforts NASA made to find out whether or not there was any possibility of duplicating things that have already been done by the Armed Forces or are being done by the Armed Forces, I am sure that this information in the record will be helpful to the committee.

Dr. BISPLINGHOFF. Yes, sir. I will start first with the item under my office, OART, SRT, and human factor systems. The Office of

Advanced Research and Technology has the part of the life science program, which is concerned with the ability of the human to live and perform meaningful tasks in space, and also the part which is concerned with the creation of the technology that might be required to support life in a spacecraft or in space, as you will recall, from our testimony where we talked about the life support part of our effort.

The first three items on page 54 are concerned mostly with the studies of the ability of humans to live and perform meaningful tasks in space. The very first one, entitled, "Psycho-Physiology and Behavioral Sciences" is concerned with studies of man's capabilities and capacities under combined stress factors associated with extended flight missions.

You may recall Dr. Konecci's testimony a week or so ago, in which he showed the results of a study at the University of Maryland to study the psychological effects of an extended period of isolation. We have also, at the Ames Laboratory, and other universities, other confinement studies with both animals and human beings, with sensory deprivation, and also studies of man's ability to acquire and process information and make decisions under stress conditions.

The second of these items, environmental physiology, again is concerned with man's ability to perform meaningful tasks. Here, we are studying primarily the physiological or biological effects of various physical conditions, such as altered atmospheres, acceleration, radiation exposure, magnetic field, electrostatic field, and even the toxicology of chemical environments.

The third of these items entitled "Biomedicine and Personnel Selection" is concerned with several things. One is the determination of the various types of medicine and laboratory procedures which would be required in an examination to qualify personnel for extended space flight, and also ground support roles.

Here we look at such things as pharmaceutics, or the science of using the various kinds of medicines that are available, or the prevention of disease, and their treatment. I would like to skip——

Mr. KARTH. This environmental physiology, and the behavioral sciences, how does this fit in with OART? Why isn't it in manned space flight, because, after all, manned space flight is concerned with all of these things, as a necessary part of their program. Manned space flight programs have an interest in whether or not they can keep the astronaut alive.

Why doesn't it more properly fit there? We have these budget requests spread over three different sections of NASA, Office of Manned Space Flight, they have some of it, the Office of Space Sciences, they have some of it, and the Office of Advanced Research and Technology, your division, you have some of it. How can we correlate the activities, investigation and research of these three agencies, all attempting, I suppose, to find out answers to the same questions?

Dr. BISPLINGHOFF. I think we have a very logical division here. As I mentioned previously, our job is to evaluate the ability of the human to live and perform tasks and to create the technology required to support life. The Office of Manned Space Flight, on the other hand, has only those responsibilities associated with the missions that they are performing, as I can describe to you if you wish me to go down through their items.

All of these items are concerned——

Mr. KARTH. Those are the only missions where man's life is involved?

Dr. BISPLINGHOFF. The items that are in this area are concerned with the Gemini and Apollo missions, per se. We are trying to understand man's ability and life support systems that go beyond those which would be supported with the approved manned space flight missions.

This is the distinction between my office and the Office of Manned Space Flight. The Office of Space Sciences, as Dr. Clark has pointed out, is oriented toward the biosciences, biology, and extraterrestrial life.

Mr. KARTH. Doctor, do the three offices have frequent get-togethers and discussions about what they are doing and how they are doing it?

Dr. BISPLINGHOFF. Yes.

Mr. KARTH. What advancements they are making, if any, and how one advancement may apply to the needs of the other office, and so on?

Dr. BISPLINGHOFF. Yes, I think we have a good coordination here. For one thing, the directors of the three offices, Dr. Konecci of my office, General Roadman of the Office of Manned Space Flight, and Dr. Reynolds of the Office of Space Sciences, have monthly committee meetings with a rotating chairman, in which they discuss their programs in detail. There are obviously interfaces which have to be continually monitored here.

We rely on this committee of the three directors to continually see we have a properly coordinated program.

Mr. KARTH. Doctor, has it been your experience that there is any division among the troops, so to speak, disagreements between the three offices, as to what should be under their jurisdiction, or what they should investigate, or what they should research?

Dr. BISPLINGHOFF. Yes, sir. We have disagreements. Dr. Newell and I occasionally are called on to settle disagreements that arise in these very meetings that I mentioned. I don't think you could——

Mr. KARTH. We have interservice rivalry in human behaviorial sciences, don't we, among other things? Is this going to worsen, would you say? Would you think this would become more of a problem as time goes on?

Dr. BISPLINGHOFF. I think it will improve as time goes on. I think this concept of having our life sciences in three offices is a workable concept.

Mr. KARTH. What if we put it all under one office, even though a certain portion of it would be to investigate the possibility of keeping man alive on interplanetary travel 10 years, 20 years, whatever it is, from now, as opposed to the manned programs that we presently have under consideration? Doesn't this really make more sense to you, Doctor? Let's say we put all of them under OART, wouldn't this make more sense?

Dr. BISPLINGHOFF. No, I think this is a good arrangement we have now. It is a workable arrangement. I think it is a better arrangement than a single office would be.

Mr. KARTH. It seems to me you are going to get more funds this way. I don't think there is any question about that. I am not so

sure that I can draw the same conclusion that on an overall basis, it is better for the program.

Dr. BISPLINGHOFF. If we do our proper job of avoiding duplication among the offices, I think the funds would be the same.

Mr. KARTH. You see, with this work being done in three different offices, I am quite confident that you don't have the same close liaison that you would as if it were being done all under the same office, under the same roof by the same people under one supervisor? I just can't understand how we could have this same interchange, having it done in three offices as having it done in one.

Mr. DOWNING. I would agree with you, Mr. Chairman. I was wondering why the bioscience program in all aspects couldn't be assigned to one office. Things could be assigned to one office and that office given that mission.

Would that be feasible?

Dr. BISPLINGHOFF. I think you will find if there are bioscience experiments conducted in any of the Gemini flights these experiments would be designed and proposed by Dr. Clark's office, and the Gemini would be just a truck to carry them out, and provide a service. I would think there may be some experiments that my office would wish to run as a part of the Gemini program, and it would provide the transportation for those experiments, but they would be designed and proposed by my office.

Mr. DOWNING. You have three different agencies here, all getting some funds for what looks like the same general purpose?

Dr. BISPLINGHOFF. No, sir. I think there are three well-defined areas here that we each do.

Mr. DOWNING. Thank you.

Dr. CLARK. Mr. Karth, I wonder if I could make a comment here?

Mr. KARTH. I was just waiting for you to suggest it, Doctor. Go ahead.

Dr. CLARK. I think one has to be very careful about taking any scientific discipline and pulling all of the work under that discipline together in an agency. The area of physics is another scientific discipline. The area of electronic engineering is another discipline. One could make the very same case of why not put all physics work together in one place. Don't have the Office of Manned Space Flight doing some of it, don't have the Office of Space Sciences doing some of it, but bring it together in one place.

I think that one has to determine what is the critical parameter about which each office must be organized, and what its focus must be. and these focuses are well defined in OART, OSS, and OMSF. The staffs that we have built up and the projects that we have undertaken are designed to make it possible for us to achieve each of our objectives.

The Office of Manned Space Flight has a tremendous challenge in its almost single focus of getting man on the Moon and back to Earth safely. It would be rather difficult, perhaps unfair, to charge that Office with tasks that are not directly related to accomplishment of that objective.

OART has very well defined objectives, indeed, in terms of looking ahead so that the necessary technology will be available when it is required by some of these offices with more concentrated focuses.

The Office of Space Sciences has a very specific objective in the scientific exploration of space. And in the case of this particular item

on human behavior, the Office of Space Sciences is not engaged in anything under human behavior. These items which have been picked up here are biological behavior, yes; but the behavior of lower life forms.

Our thrust here is the understanding of other life forms on Earth and how their behavior changes in space, and what light this sort of study might shed on how other life forms that we may encounter in space may be expected to behave. Questions like the nature of circadian rhythms, where biological forms seem to have intrinsic clock mechanisms which are not understood, and which make them go along in something close to a 24-hour day. What happens to the biological clock when it gets out in a satellite with a different "daily" period? Fundamental questions of this sort are what we are talking about when we in OSS talk about biological behavior.

Mr. KARTH. I think your analogy is probably one of the best I have heard. I expected that you would come up with a good one. You were sitting back there and thinking about this while Dr. Bisplinghoff was "on the pan." I doubt if I would agree in substance with the analogy that you drew, and that is that the physics of Apollo, for example, are certainly different from the physics of a Mariner spacecraft.

I don't think there is any question about it. I can see the reason why the Office of Space Sciences may be concerned with the physics of a Mariner, Ranger, or Surveyor, while the Office of Manned Space Flight may be concerned and should be concerned about the physics of Apollo.

I can very clearly see the difference between those. I am not so sure I can see quite as vividly the difference between the needs of the three Offices insofar as it applies to human behavior. I think you have made a very extraordinary effort, however, to justify this budget request.

Mr. DOWNING. May I ask one question?

Mr. KARTH. Yes.

Mr. DOWNING. Did the same agency handle the underground isolation tests of these men and the high-pressure tests which are now going on with the three men?

Dr. BISPLINGHOFF. I am going to ask Dr. Konecci if we can identify these high-pressure tests.

Mr. DOWNING. Some time ago, there were a number of men placed in isolation underground, I believe, for a long period of time, to study their human behavior. It was a Navy study.

There is going on a high-pressure test which involves three men under——

Dr. KONECCI. That is a Navy matter. I might add that of our presently committed $1.4 million the majority is in this area to DOD. We are using the Air Force to do physiological and biological research on radiation. As an example, the work being done by Dr. Graybiel on motion sickness at Pensacola comes under this area.

Vibration, by both Navy and Air Force, are being done under this area and funding and 1964 dollars will actually continue this work with an increase.

Mr. DOWNING. Is that funded in the space program or the Navy program?

Dr. KONECCI. The studies that you refer to are under the Navy. They are interested in high-pressure, principally for submarine work.

Dr. BISPLINGHOFF. Mr. Karth, with your permission, I might ask Dr. Konecci how we coordinate with DOD in this area.

Mr. KARTH. Yes, sir.

Dr. BISPLINGHOFF. That was the last part of the question.

Mr. KARTH. Dr. Konecci.

Dr. KONECCI. We have a liaison directly with the DOD in which Colonel Freiz and his staff meet with the various life sciences directors in NASA periodically to be sure that we are coordinating our efforts. The staff in the DOD is actually composed of Army, Navy, and Air Force. Colonel Freiz, himself, is an Air Force officer. Colonel Freiz has assigned the responsibility directly for Air Force coordination on an immediate basis to Colonel Talbott, who is stationed under General Rittland, in NASA.

We communicate with Colonel Talbott at least twice a week on our mutual programs to be sure that we are coordinating and there is no duplication of effort.

Mr. KARTH. Motion sickness, for example; the Navy has been doing research on this for about as long as the Navy has been the Navy, I suppose.

Dr. KONECCI. Yes, sir.

Mr. KARTH. We are doing some, too?

Dr. KONECCI. Yes.

Mr. KARTH. Do we need this?

Dr. KONECCI. This motion sickness involves the spinning of a person in a room; this was in the testimony a few days ago. We talked about the facility that NASA actually funded for the Navy, at the School of Aviation Medicine, to do some work that would be pertinent to the spinning of, for instance, space stations. We do not have a good handle on the physiology and the behavior or psychology of individuals under these Coriolis effects. They are trying to determine what additional effects there are, for design purposes.

Might I add now that the differences between the three offices are the basic fundamental nature of life: OSS is to study biology, for instance, OART is interested in research on man to come up with the design requirements for future vehicles long before these things become a reality, and the Office of Manned Space Flight confines the research to only answers that are not immediately available.

Much of the work in the Office of Manned Space Flight is being done because there was no human research being done previously.

Mr. KARTH. I am aware, Dr. Konecci, of what each one of the three offices are doing in the way of research. The only point I made was, wouldn't it make more sense, even though each of the three offices have a separate, distinctly different research effort, to have it all under one office and let one office be responsible for the three separate, distinctly different research efforts that are going on in three different offices?

This was my question, and I think Mr. Downing's question.

Dr. KONECCI. The agency felt that way when it was originated in 1958 and formed the Office of Life Sciences to, in fact, have all these functions performed by one office. With the reorganization of a little over a year and a half ago, I believe it was decided that in order to put the life sciences and human factors efforts into the program where

they belong it would be necessary to abolish that Office. Then these three areas were divided up and put into the existing offices.

Mr. KARTH. That decision had nothing to do with the fact that the Congress at that time wasn't looking very favorably upon the establishment of an Office of Life Sciences, was it, Doctor?

Dr. KONECCI. The Office was already established.

Mr. KARTH. The Congress was not looking too favorably upon the enlargement of a program if I recall correctly, because we had quite a debate within the framework of the committee on whether or not we should provide laboratory facilities.

The thought always occurs or maybe I should say in this instance, reoccurs to us, that maybe the reason we have diffusion is to get around this very thing that we can more intelligently look at when all the budget requests are in one place.

This is something that just happens to be in our minds at the moment, and I guess the only reason we prepared these four sheets and are today likewise going over them——

Dr. KONECCI. I can assure you, sir, at least on my behalf, that this area of life sciences has received a lot of public attention. The work must get done, because it is pertinent to all of the program areas I mentioned.

Mr. KARTH. Doctor, I think you just said it, that is right, and you see, by putting a little bit of it in many different offices, I think it gets less public attention, less congressional attention, too, if I may say so, than it would get if it was all in one big ball, under one office, under one supervision.

Dr. KONECCI. I must disagree; we believe the placing each life science group with the appropriate program is the best way to get the job done.

Mr. KARTH. You and I could argue this for a long time, I assure you. From where I sit, I don't think there is any question but what it would get more attention if it was all under one office, under one head, concentrated, so we could take a better look at it, rather than scattered helter-skelter in comparison, that is in three different offices.

I don't think there is any question about it. This took the staff a lot of time. There was a great deal of effort involved in just digging these things out, that appeared in various places throughout the budget, all seemingly at least having something to do with the same subject.

I think I could agree these things would get closer scrutiny if they were all together.

Dr. BISPLINGHOFF. Mr. Karth, could I add a comment on that subject?

Mr. KARTH. Dr. Bisplinghoff.

Dr. BISPLINGHOFF. As you have certainly observed, we do have this supporting research and technology in all of the offices. In planning this system originally, there was selected 57 categories of supporting research and technology, which are used as a means of codifying the whole system. This selection was made, I believe, a year or so ago. As we have pointed out, my office, the Office of Advanced Research and Technology, does the supporting research which is general in nature and which looks beyond the current approved missions, and the others do supporting research and technology closely related to their flight projects or missions.

However, all of this supporting research and technology is codified in terms of these 57 categories that were selected.

I would also like to add one other thing. My office has an additional responsibility beyond the one that has been apparent here, and that is of the responsibility of reviewing all supporting research and technology in all of the offices. This review is made as early as possible in the budget process to insure, first, that there is a balanced program, that there aren't any big holes in the program, and also, to provide a codified source of information on all of this work so that there could be a ready answer to any questions that might be asked and also to advise Dr. Seamans on duplication.

In this review, I can't give orders to the other heads of the offices, but I can advise Dr. Seamans if there is duplication. So my office does have a responsibility of looking over this whole mass of supporting research and technology and performing a service in this respect.

Mr. KARTH. I am aware that you do have this responsibility, Doctor. I want to congratulate you. I think, under the circumstances, you do an extremely good job. I might say, however, that I certainly can appreciate the problems you have, because last year this program changed so rapidly that NASA had to reprogram $200 million worth of funds; about $200 million, I think.

So I can see where when you make this evaluation, you may have everything well in hand and again, I say I congratulate you, because I think you do. But then 5, 6, 7, 8, 9 months later, I am not sure you could possibly have it in hand. Conditions might have changed. Then what kind of duplication have we gotten into as a result of reprograming or emphasizing the importance of certain programs, reorientation, I don't know, call it what you want to. I wonder how you can keep track of it, Doctor. You people never cease to amaze me.

I think you do an outstanding job under the circumstances. I don't know how you can do it.

Mr. MOSHER. Particularly, after they have to spend so much time up here on the Hill.

Mr. KARTH. Yes. And if all of these things were in the budget in one spot, let me tell you something, Doctor, we could save you a lot of time, just days and days, probably weeks and weeks. The more fuzzy these things become, I suppose the more time you will have to spend up here, because really all we want is to become informed. I hope you appreciate that.

Dr. BISPLINGHOFF. Yes.

Mr. KARTH. We are after information. It is not just a matter of asking for these funds, asking the Congress for them, it is a matter of us going back home and telling the people that we spent so much money, their money, you know. It is a little bit different in the legislative branch than in the administrative.

I appreciate your problems. I just hope that you appreciate our problems, too, because we do have some. The reason we take up so much of your valuable time is that we can hopefully, at least, be as well prepared as possible.

Dr. BISPLINGHOFF. We appreciate this fully.

Mr. KARTH. Taxpayers dollars are spent—I am not happy about this. If I did not have to do this, I could be doing something else.

Mr. STAEBLER. One piece of this discussion is missing in my mind. You have described the manner in which you carry on liaison between

the several research projects, groups of people who are conducting them in the biosciences in connection with the several programs.

You have indicated how you coordinate to make sure duplication is avoided. In the alternative type of organization which we are here talking about, what form would the liaison take? You would have the one office carrying on, having the responsibility for all projects.

What, then, would happen in carrying on liaison with the project for which a specific research inquiry was being conducted?

Dr. BISPLINGHOFF. I would visualize a liaison very similar to the liaison we have now. There are really three different groupings of people required in this program. There are, on the one hand, the biologists and the biophysicists that are found in Dr. Clark's office, who are interested in the biosciences and extraterrestrial life. On the other hand, we have in the Office of Manned Space Flight a large number of M.D.'s that are directly concerned with the individuals, the astronauts who will be doing the flights and a certain number of engineers, who are concerned with the actual creation of devices and the development of devices which will be used in the flight.

In my office we have M.D.'s who are, of course, acquainted with physiology and the requirements of the human being. We have engineers who are concerned with the advanced development of life-support systems. And we have biophysicists who have some knowledge of the more fundamental life processes. So we do have these three groups of people.

I think that the coordination that would be required would be quite similar to what we have now. Perhaps if they were in one office, they would be physically closer together, which would certainly be an advantage.

Mr. STAEBLER. I am pursuing the other end of it. If they are together, they, then, are separated from the people on whose projects they are working. What do you do to sew together their work with the larger concrete work into which they fit? What would be entailed under those circumstances?

Dr. BISPLINGHOFF. I am not sure I understand.

Mr. STAEBLER. Every organization always has the problem: Should you gather similar people together and coordinate at the edges, or should you divide them up and coordinate at the top, policywise.

You have described the second situation, how you coordinate policywise when you have people divided.

I am trying to find out what would happen in your case if you pull everybody together and have them coordinate with the specific work they are doing, what form would that coordination take? That is where you couldn't do it.

Now, you and the other policy people, by budgetary and other controls, know what is going on and you can apparently eliminate duplication. What happens when your people are working out on these separate projects, or even if working together, working for separate clients, as it were, in the organization on these special projects, how do you know?

How would they keep in touch with the other people working on that project? In the Moon landing, for instance, how would your biopeople keep in touch?

Mr. MOSHER. Would the gentleman yield?

Mr. STAEBLER. Surely.

Mr. MOSHER. Specifically, I assume you are interested in knowing whether any money would be saved by the change of organization and whether it would be any easier for Congress, say, to have oversight?

Really, that is what we are interested in here.

Mr. STAEBLER. Would it save money or cost more money when the liaison took place, from a centralized office with dispersed activities?

Dr. BISPLINGHOFF. I don't think the only liaison that takes place is at the top. I have consistently done everything possible to get technical liaison done at the working level.

That is the only thing I believe in, as a matter of fact. I don't think it makes sense in technical matters, to take them up to the top of the pyramid and then disperse them again. I think this is a senseless—is not a good process. I have done everything possible to avoid such a process. I have asked Dr. Konecci to do everything possible to get the working people together. I believe this works. I think they are getting together, and that the actual transfer of technical information does take place at the working level, rather than at the top.

Mr. STAEBLER. Now, if you pulled all the people into one office, how would this transference take place?

Dr. BISPLINGHOFF. You mean physically together?

Mr. STAEBLER. Budgetarily together, anyway.

Dr. BISPLINGHOFF. Again, I would only be happy if it took place at the technical working level. I think this is the only effective way for it to take place.

Mr. STAEBLER. You were saying one way or another, you have to get the plan from the central office together with the people who are working on the larger problem of which bioscience is a portion?

Dr. BISPLINGHOFF. Yes, sir. I believe this.

Mr. STAEBLER. This has to go on anyway?

Dr. BISPLINGHOFF. Yes, sir.

Mr. STAEBLER. Whether you have collected them all together or not?

Dr. BISPLINGHOFF. Yes, sir. I don't think you can ever do an effective technical coordination by just doing it at the top.

Mr. STAEBLER. There used to be those very unwieldy relations between governmental agencies where things traveled up through hierarchies and then down through layers, to get to people who were in parts of the same problem discussing the matter.

I take it your method avoids this and makes the problem of communication as easy as possible?

Dr. BISPLINGHOFF. As Director of this Office, I would be very unhappy if my people were not making every attempt possible to coordinate at the working level.

Dr. CLARK. Could I add a word in answer to this from the point of view of the space flight projects and saving of funds? In the Office of Space Sciences we have had the old problem of discipline versus project lines. We have found it more advantageous to organize along project lines, through which the bulk of the funds are expended and coordinated, crosscut by the discipline specialists who serve all the various projects, through the steering committee and subcommittee structure. The advantage here is that most of the vehicles

on which we have space flight experiments, are controlled by our office, funded by our office, managed by our office.

The Director of the Office can determine with full advice from all his discipline specialists, what would be the best balance of experiments and disciplines to carry aboard a spacecraft.

If we have an independent life sciences office, these people in the area of biosciences will need the same kind of payload space that they now need as part of OSS. They have but two choices. They can initiate their own space flight programs which could be exceedingly wasteful because you can now in some cases have the possibility of two spacecraft where one might have done the job. Or, they can attempt to get aboard other spacecraft, on many of which they will be minority passengers, on an equal basis with the physical scientists.

I feel that having the control of entire space flight projects in one office results in a more ceonomical expenditure of funds. Here we have a discipline-type coordination, which can be accomplished on a scientific level as Dr. Bisplinghoff said. It can be carried out on a lower pressure, more objective basis, because the decisions are technical.

Mr. STAEBLER. That is very helpful, Doctor.

Mr. KARTH. Dr. Bisplinghoff, as I look through this list of what the staff and the committee felt might be duplication, it is true that the OART, for example, is in almost every instance, if not every instance, working on advancing the state of the art?

Dr. BISPLINGHOFF. Yes, sir, this is true.

Mr. KARTH. While the Office of Manned Space Flight, or the Office of Space Sciences, are working on the problem of a more immediate nature?

Dr. BISPLINGHOFF. The support of their approved projects.

Mr. KARTH. This would be true in bioinstrumentation; for example, radiation effects, and shielding?

Dr. BISPLINGHOFF. Yes, sir.

Mr. KARTH. For example, we see substantial sums being requested for high energy radiation effects of shielding, et cetera; these are for Apollo and Gemini—at least, Apollo, I suppose?

Dr. BISPLINGHOFF. Yes.

Mr. KARTH. The OART request would be for something that is coming along in the future for which we don't have a sharply defined program established?

Dr. BISPLINGHOFF. Yes, sir.

Mr. KARTH. But for which we feel research work must be done so that if and when a national program is established, some of the groundwork will have been done that will no longer necessitate a crash program of sorts, to do the kind of work that is required, is this a fairly accurate statement on my part?

Dr. BISPLINGHOFF. This is a very accurate statement. In bioinstrumentation, for example, a good comparison would be that for the Apollo flights in which the Office of Manned Space Flight is adapting the standard method of blood pressure measurements, of wrapping the rubber tube around the arm, to their use.

On the other hand, in my office, we are working on very small devices which can be strapped onto an artery with a little transmitter in them, that can be used for this purpose. It is just a reflection of what you have said. They are adapting the present state of the art

to their needs and we are attempting to push the state of the art forward. In the cases of radiation, their concern is, again, the radiation problems which will be encountered in Apollo, the shielding problems, the development of a dosimeter using the present state of the art in measuring radiation.

Mr. KARTH. Would you repeat that, sir?

Dr. BISPLINGHOFF. Yes. The problems of shielding against particle radiation that will be encountered in Apollo are part of their supporting research——

Mr. KARTH. You said something about a dosimeter.

Dr. BISPLINGHOFF. The development of a dosimeter——

Mr. KARTH. The Navy has a beautiful one.

Dr. BISPLINGHOFF. Carried along by the astronaut.

Mr. KARTH. Can't we use the one that the Navy developed, Doctor? Yesterday I had the opportunity of visiting the Naval Research Laboratory just a few miles out of town here, and we saw one, we saw one of these small, I don't know what you call it, rods, I suppose. It is no larger than the lead in a lead pencil, if it is that large. It is extremely accurate.

Dr. BISPLINGHOFF. Is this a dosimeter that is used in the presence of the nuclear reactor——

Mr. KARTH. Yes, sir.

Dr. BISPLINGHOFF. Or atomic bomb situation?

Mr. KARTH. I guess so.

Dr. BISPLINGHOFF. Our dosimeter would also be exposed to the proton and electron type of radiation that we find in the Van Allen belt.

Mr. KARTH. I can't answer the question completely, but I think somebody from your office should answer the question so we don't have duplication.

Dr. BISPLINGHOFF. Yes, sir, I can put into the record a comparison of these two if you wish me to.

Mr. KARTH. If you are aware of this, I am not interested in your putting in a comparison——

Dr. BISPLINGHOFF. I am not personally aware of it.

Mr. KARTH. I stumbled on this thing yesterday. The Navy was quite elated about this dosimeter that they had perfected and I was impressed with it. When you mentioned the name, I thought, my gosh, maybe we don't need the research on that as long as the Navy has done considerable on it.

Dr. BISPLINGHOFF. The Office of Manned Space Flight's job is one of adapting the state of the art as it exists now to their problem. It involves, I understand, a 2-pound device with a battery and alarm system, which is worn on the astronaut, himself. I am not acquainted with its details or how it would compare with this Navy device.

Mr. KARTH. Let me suggest that you have one of your people check it out?

Dr. BISPLINGHOFF. Yes, sir.

Mr. MOSHER. Do you assume that someone in the organization is acquainted with what the Navy is doing?

Dr. BISPLINGHOFF. Yes.

Mr. KARTH. This was a relatively recent breakthrough apparently. I am not sure I recall exactly when they developed this dosimeter, but they are very enthusiastic about it.

Dr. BISPLINGHOFF. I was going to add that our work in bioinstrumentation is a combined effort between Dr. Konecci and Dr. Kelley, and I would expect that probably Dr. Kelley would have knowledge of this. He is here if you would like to ask him about it.

Dr. KELLEY. In all of these things, we have a problem of semantics. There are different types of dosimeters, just as there are different types of radios, FM and AM.

Mr. KARTH. This was a radiation dosimeter.

Dr. KELLEY. I mean there are different types of dosimeters. Because there are different types of radiation. I think the FM to AM radio analogy is a good example. The dosimeters that have been designed by the Navy are primarily for use on nuclear submarines to detect doses that might arise from a nuclear reactor.

As Dr. Bisplinghoff said, this is quite a different kind of radiation than the radiation you would expect in space, which is composed of different particles at different energy levels. So we both would be working on dosimeters, but in a completely different range. We have the same problem with other instruments, such as magnetometers. We both use the same name, but it may be a completely different instrument. It might use the same techniques, but to measure a completely different range of magnetic fields.

Mr. KARTH. Thank you, Doctor. Dr. Bisplinghoff. just winding up our hearings today, I wonder if you could then just briefly tell me whether or not the statement I made some moments ago about what your specific objection is, that is, the Office of Advanced Research and Technology, as opposed to the Office of Manned Space Flight, and OSS, would also be true so far as the general overlapping areas that we designate on page 4?

For example, your Office, I know, is asking for considerable funds, over $20 million, for guidance systems, communication systems data, acquisition. The Office of Manned Space Flight also has a request in for some $6 million for guidance control, communications, data, acquisition. And I see a little bit there for the Office of Space Sciences.

Would the suggestion I made as to what your individual efforts were relative to radiation effects and shielding and bioinstrumentation, also hold true in this general overlapping area that we designate on page 4?

Dr. BISPLINGHOFF. Yes, sir. I have gone over all of these items myself and I am sure that your previous statement also holds in this list called general overlapping areas.

Dr. CLARK. I would concur in this, from the OSS point of view.

Dr. BISPLINGHOFF. The first part of that under OART is really the heart of Dr. Kelley's program.

Mr. KARTH. We wouldn't want to do anything to Dr Kelley's program. Dr. Kelley, I wonder if you would, for the record, give the committee some idea of what way-out problems you are working on insofar as guidance and control systems, and communications systems, are concerned? Could you do this in 2 or 3 minutes?

Dr. KELLEY. Yes.

Mr. KARTH. I think it would be helpful to us.

Dr. KELLEY. I can run down briefly on each one of these line items if you want me to.

Mr. KARTH. I think just general summary.

Dr. KELLEY. As explained by Dr. Bisplinghoff and very succinctly defined by yourself, the difference between what we are doing in OART and what Manned Space Flight and Space Sciences are doing, would be characterized as "further out." The closer in, or more direct application, would be the project offices. In some of these areas, for example, in guidance systems, we are looking at some of the so-called exotic techniques, the cryogenic gyro, the electrostatic gyro, for use where we need very high accuracy for long flights or very high sensitivity, particularly for electric propulsion, where we have a very low push. It has been called a gnat's push, by some people.

Our present guidance instruments can't measure that level of thrust right now. In our control systems area, we are off into some of the more advanced techniques, such as the so-called inertia wheels, where we wind up a wheel or a sphere and orient the satellite that way, the fact that when we run or operate an electric motor, part of it will turn, and the base will push back, one doesn't always recognize this on the ground. This is action and reaction, as Newton defined it. By winding up an electric motor, in the form of a so-called momentum sphere, we can turn the satellite and get accuracy in pointing through precise control.

"Communications" I can talk about and "tracking," in a combined way, since they are quite related to each other. We will put a lot of emphasis on lasers, particularly, as communications devices.

As I mentioned in my earlier testimony, we see this as probably the greatest area of potential for advanced space communications, as well as advanced antennas, and antenna techniques. And we also have the problem of getting the most information back per unit of time, equipment, dollar, or resources in general, whatever way you want to call it.

In the area of instrumentation, we work on advancing the techniques, that is, what new physical ways can you develop to measure a phenomenon and translate it into something we can manage and handle and understand. This is usually an electric signal, or in some cases, the motion of a device.

In this area, we have put a lot of emphasis toward, and will continue to put more emphasis on, digital instrumentation. Right now, we process information largely through digital computers, that is, it is a pulse or no pulse, a one or a zero, and then there are various coded messages you use to translate the information.

Our instruments, up to date, have generally been so-called analog devices, that is, they measure, in terms of a motion, a voltage or current which is proportional to the level of the phenomenon that you are measuring.

In launch vehicle or satellite investigations, we have the problem of translating these into a digital message, which is sent back on telemetry, and telemetry coding is going digital; thus, handling the initial measurement in digital fashion expedites its translation and facilitates its use on Earth in terms we can understand as humans. There will be a lot of emphasis here on direct digital read-out instruments. We see this as a logical step to measuring phenomena in digital terms, to get it on the communications line in the form in which it is handled.

Mr. KARTH. Doctor, all of this you seek to do is different from what the Office of Manned Space Flight seeks to do in the same nomencla-

ture items, such as communications, tracking and data acquisition, and so on; as I understood you to say, their concern is to perfect the present state of the art, and apply this to the present pieces of machinery that they expect to fly.

Dr. KELLEY. That is correct, Mr. Karth. Theirs is largely technique application, or product improvement, trying to squeeze a little more out of the equipment they have, or applying a known technique which we would, perhaps, no longer be interested in, because we would be working farther out, and building an inventory, to be applied to one of their specific problems in the future.

For example, gyroscopes or guidance devices are a good example. Our interest is primarily in some of the more exotic devices. The Manned Space Flight people are still working and will continue to work on improving ball bearings for existing gyroscopes, which are largely ball-bearing devices.

We usually don't work in a separate vacuum or separate spheres of interest. We do coordinate these programs so we each know what the other one is doing.

Mr. KARTH. Thank you very much, Doctor. Are there any further questions? The next meeting of the subcommittee will be on Monday, in room 304 at 10 o'clock.

I think, Mr. Bisplinghoff, you and Mr. Ulmer will be asked to review the OART construction facilities program.

Dr. BISPLINGHOFF. Yes, sir.

Mr. KARTH. I would like, on behalf of the committee, to thank both you and Dr. Clark very much for appearing before us today. I might just say, insofar as I am personally concerned, I am very much enlightened about why so many of these items that appear to be duplicative, are found in different spots throughout the budget request. It certainly clears up any doubts I had in my mind. I want to thank you very much for appearing. The meeting is adjourned.

(Whereupon, at 12:10 p.m., the subcommittee adjourned to reconvene at 10 a.m., Monday, April 29, 1963.)

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1964 NASA AUTHORIZATION

MONDAY, APRIL 29, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SPACE SCIENCES
AND ADVANCED RESEARCH AND TECHNOLOGY,
Washington, D.C.

The subcommittee met at 10 a.m., Hon. Joseph E. Karth (chairman of the subcommittee) presiding, in room 304, Cannon Building.

Mr. KARTH. The meeting will be in order. Dr. Bisplinghoff, I understand you have a prepared statement, and you may wish to call on several members of your staff to cover various portions of the statement; you may proceed as you wish.

STATEMENT OF DR. RAYMOND L. BISPLINGHOFF, DIRECTOR, OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Dr. BISPLINGHOFF. Thank you, Mr. Chairman.

The United States has, through the years, established an unprecedented leadership in aeronautical progress. The former NACA was the basic national establishment for conducting research and its charter charged it with the responsibility of "scientific study of the problems of flight with a view to their practical solution."

Starting with the establishment of Langley in 1917, Ames in 1939, Lewis in 1940, and the Flight Research Center in 1946, the NACA became world famous for its research leadership in aeronautics and led the way to many new concepts that contributed to U.S. preeminence in aeronautics. To do this, NACA worked closely with the military and civil organizations that established the various operational requirements for U.S. aircraft and missile vehicles. Gradually, through the years, research competence was established by a professional staff of scientists and engineers that conducted theoretical studies and experimental investigations in ground facilities and in flight, to provide new scientific concepts, and follow-on design information for future use by manufacturers in an orderly development program.

The kind of research conducted by NACA, and now under the NASA OART program was not the comfortable product improvement type, but the radical improvement type. Frequently individual findings could not be immediately applied, but had to wait until other complementary research findings were made, and manufacturing methods developed by industry in order to realize the full advantages of a new research finding. This, prior to World War II, sometimes took 4 to 5 years. The laboratory scientists identified the problems,

conceived the research facilities that would be required to obtain answers to the problems and courageous Directors, Dr. George W. Lewis and subsequently Dr. Hugh L. Dryden, managed to sell them to the Bureau of the Budget and the Congress. It was the kind of research that made people uncomfortable, as it accelerated the rate of technical obsolescence of aircraft, both nationally and internationally. In fact, the Germans, in the early 1930's got the message so clearly, that after a delegation of their scientists visited Langley Field, they went home and quadrupled the scale of what they had seen as a basis for their future plans. The present configuration of the low-wing transport in wide commercial use was the outcome of this NACA research process just as the discussions that you have heard of a supersonic transport are the current result of this kind of research.

Prior to World War II, NACA had amassed a reservoir of fundamental research information. During the war, the reservoir was depleted, due to the fact that 90 percent of the NACA effort was shifted to solving urgent problems of military aircraft and missiles in the design, development, and operational stages. Since that time, the aggressive U.S. aircraft and missiles industry has absorbed the NASA output of fundamental research information as fast as it could be obtained. The demands on NASA for additional research requires that greater selectivity be used in the programs that are undertaken.

The facilities of NASA are unique national resources. Those under OART are intended primarily for research. Due to their unique nature, they could be used in World War II to solve specific problems of military vehicles. In addition to their continued use, for this purpose, they are similarly used to solve specific problems of NASA vehicles such as Apollo and Gemini. Their principal use, however, remains as research tools. Practically all of the former NACA research wind tunnels are being used to solve specific problems of Apollo and Gemini, in addition to their principal use for research. This usage ranges from the low-speed vertical-spin tunnel and the full-scale tunnel at Langley to the latest hypersonic wind tunnels and space vehicle environment research facilities.

As discussed in the hearings on the NASA Act of 1958, the orientation of NACA toward space started in 1952. Many of the facilities that NACA had could be applied to space problems such as rocket research and wind tunnel facilities. The history of NASA (NACA) facilities has been one of constant pioneering, improvement, and modification to meet new research needs. A study several years ago showed that on the average NASA (NACA) research facilities had a useful life in the original configuration, with only minor alterations and improvements, of some 10 to 15 years. At the end of this period, they were either modified to meet new research requirements, converted to other research uses, retired to strictly utilitarian uses, such as high-pressure air, or vacuum storage vessels, or dismantled. For example, a 6-foot stability tunnel at Langley was dismantled and shipped to the Virginia Polytechnic Institute for use in their educational program.

A prime example of maximum utilization of an old NACA facility as cited by Dr. Seamans in his statement before this subcommittee on April 1, 1963, is the former Lewis altitude wind tunnel, now called space power chambers. This wind tunnel, as Dr. Seamans pointed

out, was originally built for research on reciprocating aircraft engines under the reduced pressures and temperatures of altitudes up to 50,000 feet. Almost as soon as it was completed, it was switched to research on the effects of altitude on the then fledgling turbojet engines of 1944 vintage. Some of the first basic research data on the effects of altitude on turbojet engines were obtained in this facility, as well as the remedies required to maintain combustion to high altitudes. This former wind tunnel has been modified to provide one vacuum environmental chamber in which tests of the Centaur engine will be conducted this fall, and another proposed modification is in the OART research facilities budget for 1964 fiscal year now before the subcommittee.

The wind tunnel technique for studying the aerodynamic shapes and heating of bodies that move through the atmosphere at very high speeds is being stretched to its limits through the use of very high temperature airstreams heated by electric arcs and through the use of helium and other gases. New techniques and concepts are constantly being studied and applied by NASA research scientists to facilities that can provide improved simulation of space vehicle environments. It is a valuable national asset to have an organized group of research scientists who can conceive and develop these new concepts into improved research facilities. Light gas guns, particle accelerators, shock tubes, and ballistic ranges are being used singly and in combinations to simulate as closely as possible the high temperatures and flow fields that occur on reentry into the Earth's atmosphere from lunar and planetary orbits. In addition, entry into atmospheres of other planets is being simulated in these facilities.

As wind tunnels continue to be research and testing tools for the problems encountered by space vehicles during the launch, boost, and atmospheric entry phases of space flight, a relatively new research tool, the vacuum environmental chamber—in all sizes and shapes—has become a necessity for research on the problems of vehicles in space. Materials, structures, control, guidance, propulsion, life support systems, all require the availability of vacuum environmental chambers. Numerous small bell jar-size chambers are required for long-term tests of a year or more on structures and materials, while larger chambers are required for both long- and short-term tests of complete systems.

In materials and structures research it is necessary to extend the range of environmental conditions to the high temperatures of reentry conditions, and to simulate space accurately in terms of hard vacuums and solar radiation, both of the particle type and with spectral accuracy. There is a great need to accumulate a mass of scientific and technical information on the effects of the space environment on the strength and endurance of structural materials. It is also necessary to obtain much information on the effects of space on surface conditions which must retain specific optical and electronic radiation transmitting properties. Facilities for research to permit an understanding of all these effects are essential in order that both manned and unmanned spacecraft may be designed with such confidence that the materials and structures will not jeopardize a mission costing millions of dollars.

Control and guidance research also depends on the availability of vacuum environmental chambers. Research on the components

such as control jets, horizon seekers, star trackers, and stabilization devices is conducted in a space environment chamber using a simulated or actual spacecraft. By mounting the simulated spacecraft on a special air bearing, it is free to move without external air friction and respond very closely to the manner in which it would behave in space. The response of the individual components as well as of complete systems can thus be studied in a ground-based facility without the hazard of an expensive flight failure.

In the propulsion field, it is necessary to have facilities which will simulate the effects of space to investigate in detail the problems of operation and restarting of space propulsion systems, the operation of electrical propulsion systems and the efficiency of all components. This includes research on fluid physics under zero gravity conditions, pumping of cryogenic liquids, heat transfer from space radiators, characteristics of electric power conversion devices in a space environment, and neutralization of ion jet beams, as examples. This research is fundamental scientific and applied research, not product improvement research. Many of these things have never been done before, and the scientific problem is how to provide a satisfactory solution with the least weight. After some scientifically possible solutions have been obtained, it then become a problem for others to manufacture a practical article for use on actual space missions.

Facilities for the investigation of the problems of life support systems require vacuum environmental facilities which will permit as accurate simulation of significant space parameters affecting man's living and working in space. Not only must an environment be created in which man can survive in space, but in which he can move about in conditions of space vacuum and radiation to perform useful operations and to take scientific observations, all without unnecessarily impairing his life expectancy.

Continued preeminence of the United States in space requires that there be a continuous upgrading of the facilities for research leading to improved, more reliable space vehicles. It is a national goal to move ahead in space. Our scientists have been busy in determining the facilities that will be needed. The immediate needs for the 1964 fiscal year are in the budget before the subcommittee. In 1958, when the NASA first came into being, it had a research plant value of approximately $350 million. This includes all NACA facilities since NACA's mission was solely that of research. In the following discussion, I will discuss research facilities which have been added since the formation of NASA, which support the OART program. In order to put the discussion in context from the viewpoint of time, I will start with the 1960 fiscal year. This was the first full fiscal year of operation of NASA since its organization on October 1, 1958. The research facilities approved were based largely on pre-NASA planning. It will be seen that as the planning for research advanced under NASA, that new needs became apparent. This thesis will be developed under eight categories of facilities, showing that there is a well-conceived overall expansion to meet urgent research needs in each category of facilities.

The research facility programs for fiscal year 1960 through that proposed for fiscal year 1964 are shown in the accompanying tables in my testimony, of the following eight facility categories:

Materials and structures facilities;
Space environmental chambers and apparatus;
Guidance and control simulators and equipment;
Fluid flow and plasmadynamics facilities;
Space power and energy conversion facilities;
Life sciences facilities;
Nuclear rocket facilities; and
Electronics and telemetry facilities.

Research facilities are difficult to categorize by discreet technical discipline because of their versatility; for example, aeronautics facilities and chemical propulsion facilities are not categorized as such, but instead each is listed under the functionally descriptive category to which it belongs.

Many of these facilities provide simulation of environmental factors for advanced research and testing new technology concepts. With progress in aeronautics and space concepts, it becomes increasingly necessary to investigate the effects of subtle variations and combinations of environmental factors. In this respect, advances in facility design and fabrication techniques often pace our progress in research.

In the discussions of the facilities under each category, it will become apparent that each program area is being provided with new and modernized facilities.

(The tables referred to are as follows:)

Advanced research and technology facilities program

MATERIALS AND STRUCTURES FACILITIES

Name	Location	Cost by fiscal year (millions)					Operational date
		1960	1961	1962	1963	1964	
Gust tunnel conversion to noise research facility.	Langley	$0.3					February 1962.
Test cell conversion to high intensity noise facility.	do	.3					April 1963.
Zero power reactor	Lewis	.8					July 1963.
Basic Materials Laboratory	do		$4.0				May 1963.
Low frequency environmental noise facility.	Langley			$0.6			July 1963.
High vacuum space structures facility.	do			1.5			March 1964.
Environmental research facilities for spacecraft components and materials.	do				$1.0		June 1964.
Particle accelerator for micrometeoroid impact.	do				.9		August 1964.
Space Radiation Effects Laboratory	Langley (vicinity)				12.3		August 1965.
High temperature loads calibration facility.	Flight					$1.2	
Structural Dynamics Laboratory	Ames					1.6	
Fatigue Research Laboratory	Langley					1.3	
Space environment research facility	Ames					3.6	
Total		1.4	4.0	2.1	14.2	7.7	
Grand total		29.4					

Advanced research and technology facilities program—Continued

SPACE ENVIRONMENTAL CHAMBERS AND APPARATUS

Name	Location	Cost by fiscal year (millions)					Operational date
		1960	1961	1962	1963	1964	
Dynamics Research Laboratory	Langley		$4.0				October 1963.
Modification of space environment tank.	Lewis			$1.0			July 1963.
Space propulsion facility	do				$25.4		November 1965.
Spacecraft propulsion research facility and addition.	do				6.3	$3.5	January 1965 plus.
Alteration of space power chambers	do					5.7	
Zero gravity facility	do					2.7	
Satellite attitude control test facility	Ames					1.2	
Total			4.0	1.0	31.7	13.1	
Grand total		49.8					

GUIDANCE AND CONTROL SIMULATORS AND EQUIPMENT

Data Reduction Center	Ames	$2.3					July 1961.
Analog computer system	Flight	.4					February 1961.
Terminal guidance program facility	do	1.4					May 1962.
Centrifuge equipment	Ames		$0.5				December 1961.
All-axes motion generator	do			$0.6			September 1963.
Lunar landing facility	Langley			3.5			November 1963.
Space flight guidance research facility	Ames				$9.6		December 1964.
Visual flight simulator	Flight				.4		February 1964.
Stabilization and Control Equipment Laboratory.	Langley				1.4		August 1964.
Total		4.1	.5	4.1	11.4		
Grand total		20.1					

FLUID FLOW AND PLASMADYNAMICS FACILITIES

Mass transfer and aerodynamics facility.	Ames	$4.0					August 1962.
8-foot high-temperature structures dynamic tunnel equipment.	Langley	.5					August 1960.
Alteration to 9-by-8-foot thermal structures tunnel.	do	.4					December 1960.
Analytical computing equipment	do	2.6					January 1962.
Heater for hypersonic jet facility	do	.4					October 1962.
Hypersonic aerothermal dynamics facility.	do		$8.0				January 1964.
Hypervelocity free flight facility	Ames			$4.9			October 1964.
Equipment for magnetoplasmadynamics research.	Langley			1.0	$1.4		January 1963 and August 1964.
Radiative heat system for mass transfer facility.	Ames				2.2		January 1965.
Mach 50 helium tunnel	do				1.5		May 1964.
Additional power supply and improved arc chamber for 10-megawatt arc tunnel.	Langley				.8		October 1964.
Hot gas radiation research facility	do					$2.6	
Total		7.9	8.0	5.9	5.9	2.6	
Grand total		30.3					

Advanced research and technology facilities program—Continued

SPACE POWER AND ENERGY CONVERSION FACILITIES

Name	Location	Cost by fiscal year (millions)					Operational date
		1960	1961	1962	1963	1964	
Ion and plasma jet facility	Lewis	$5.4					August 1963.
In-pile loop	do	.5					January 1964.
Energy Conversion Laboratory	do		$4.5				December 1963.
Space power research facilities	do		1.1				November 1963.
Propellant flow facility	do					$1.3	
Electric power equipment test facility.	do					2.1	
Propulsion component evaluation facility.	do					1.0	
SNAP-8 assembly and spacecraft checkout building.	do					5.0	
Total		5.9	5.6			9.4	
Grand total		$20.9					

LIFE SCIENCES FACILITIES

Modifications to Flight Operations Laboratory.	Ames			$0.8			October 1963.
Life sciences research facility	do					$4.9	
Total				.8		4.9	
Grand total		5.7					

NUCLEAR ROCKET FACILITIES

Nuclear rocket development facility	Lewis-SNPO	$0.3					July 1960.
Engine test stand No. 2	NRDS			$14.6			June 1965.
Engine maintenance, assembly, and disassembly buildings, and additions.	do			7.9	$4.8	$4.5	October 1964 plus.
Nuclear rocket dynamics and control facility.	Lewis				3.4		February 1965.
Modification of nuclear aerospace research facility.	Fort Worth				3.1		September 1964.
NERVA facilities	NRDS				5.0		December 1964.
Hydrogen heat transfer facility	Lewis				2.4		Do.
Additions to engine test stands 1 and 2.	NRDS					6.7	
Radioactive materials handling, decontamination, and storage complex.	do					4.3	
Total		.3		22.5	18.7	15.5	
Grand total		57.0					

ELECTRONICS AND TELEMETRY FACILITIES

Vehicle antenna test facility and addition.	Langley				$1.7	$1.8	February 1965 plus.
Electronics instrumentation laboratory.	do					2.8	
Electronics Research Center						5.0	
Total					1.7	9.6	
Grand total		$11.3					

Dr. BISPLINGHOFF. Under the category "Materials and structures facilities" are the environmental simulators that shake, vibrate, stress, impact, heat, irradiate, and subject to vacuum and pressures, the materials and structural concepts under study in the advanced research and technology program. As more is learned of the environment to which spacecraft materials will be subjected, the requirements for these simulators become more complex. The vacuum chambers in this category are of small size (about 8 cubic feet maximum) and are required in number because of the long duration of tests characteristic of materials testing.

In fiscal year 1960 there were two facility conversions at Langley to provide facilities to investigate problems of high intensity noise expected from high thrust rocket motors. Also in the fiscal year 1960 program, was a zero power reactor at Lewis for simulating the radioactive field of a nuclear reactor. The fiscal year 1961 program included a Basic Materials Laboratory at Lewis for investigations of metals and ceramics related to propulsion research. The fiscal year 1962 and 1963 programs for materials and structures research comprised five facilities at Langley to provide advanced environmental simulation, including low frequency noise, vacuum, vibration, stress, micrometeoroid impact, and space radiation. For fiscal year 1964 our program proposes four projects in this category; a high temperature loads facility at Flight, a fatigue research facility at Langley, and a structural dynamics and a space environmental research facility at Ames. These Ames facilities will provide that center with the tools to continue important advanced research on materials and structures.

The category "Space environmental chambers and apparatus," comprises the large vacuum chambers necessary to research studies and to full-scale testing of complete spacecraft systems. The Dynamics Research Laboratory at Langley in the fiscal year 1961 program will provide that center with two large chambers for structures testing, one equipped with a centrifuge to obtain combined acceleration and vacuum. In the fiscal year 1962 program, the modification of the space environment tank at Lewis provided increased cryogenic pumping facilities for materials research under combined solar radiation, vacuum and temperature simulation. Two large propulsion research facilities at Lewis made up the fiscal year 1963 program in this category. For fiscal year 1964, it is proposed to add hard vacuum, liquid nitrogen cryo-cooling, and solar simulation to the spacecraft propulsion research facility, and to provide, also at Lewis, a facility like an evacuated mine shaft to obtain 10-second tests at zero gravity for important advanced research in liquid-propellent physics. Also in the fiscal year 1964 program is a satellite attitude control test facility at Ames which will be necessary to research in advanced systems, under vacuum and near frictionless conditions.

Under the category "Guidance and control simulators and equipment for fiscal year 1960" were data reduction, computer, and display facilities at Ames and Flight. The fiscal year 1961 program included centrifuge equipment at Ames for control simulation. Fiscal year 1962 and 1963 programs comprised five facilities; an all-axes motion generator, and a space flight guidance research facility at Ames, a lunar landing facility and a stabilization and control equipment laboratory at Langley, and a visual flight simulator at the Flight

Research Center. These facilities appear to satisfy, temporarily, the research requirements for facilities of this type and none are proposed for fiscal year 1964.

The facility programs under the category "Fluid flow and plasma-dynamics facilities" show the evolution of wind tunnel design from subsonic flow to the hypersonic phenomena of atmospheric reentry and entry into planetary atmospheres. The fiscal year 1961 program comprised a high temperature aerodynamics facility at Ames and a high temperature structures tunnel, computing equipment, and improvements to both the high temperature structures tunnel and the hypersonic jet facility at Langley. For the fiscal year 1961 program, Langley got the hypersonic aerothermal dynamics facility, and for fiscal year 1962 and 1963 equipment for magnetoplasmadynamics research and improvements to the 10 megawatt arc tunnel. Ames, in the fiscal year 1962 and 1963 programs, received approval for a hypervelocity free flight facility, a radiative heat system for the mass transfer facility and a mach 50 helium tunnel. The fiscal year 1964 program proposes a hot gas radiation research facility at Langley for simulation of rentry from planetary missions and entry into planetary atmospheres.

The space power and energy conversion facilities category shows the foreseen increases in facility requirements of the advanced space power and propulsion research at Lewis. The ion and plasma jet facility and the in-pile loop for fiscal year 1960 provide research tools and the energy conversion and the space power research facilities in fiscal year 1961 will provide the basic experimental and laboratory facilities for the programs. For fiscal year 1964, there are four proposed projects: a propellant flow facility for advanced systems research at Plum Brook; an electric power equipment test facility; a propulsion component evaluation facility; and a SNAP–8 assembly and spacecraft checkout building at Lewis.

Life sciences facilities are hospital-type wet laboratories for biotechnology and biomedical research at Ames. The fiscal year 1962 program included modifications to the Fight Operations Laboratory to provide housing for this work, and for fiscal year 1964 a modern life sciences research facility is proposed.

Nuclear rocket facilities include all of the NASA projects necessary to provide test stands, assembly areas, handling equipment, and special environmental simulation facilities for the nuclear rocket program. These facilities started with a design contract for development facilities in fiscal year 1960. Engine test stand No. 2 at NRDS in the fiscal year 1962 program was the first facility funded by NASA rather than AEC. Also in fiscal year 1962 program was the engine maintenance, assembly, and disassembly building (E–MAD) with additions in the fiscal year 1963 and the proposed fiscal year 1964 programs. The fiscal year 1963 approved program was modified because of the decision to slip the reactor-in-flight test (RIFT) program schedule. A reprograming action funded modification of an Air Force reactor facility to satisfy the requirements for the fiscal year 1963 radiation effects facility at a saving of about $4 million. The construction program for fiscal year 1963 included at Lewis a nuclear rocket dynamics and control facility, and a hydrogen heat transfer facility, and at NRDS, a NERVA test stand, components test and support facilities.

The fiscal year 1964 program proposes additions to engine test stands 1 and 2, and a radioactive materials handling, decontamination, and storage complex.

Finally, the electronics and telemetry facilities category reflects the increased NASA interest in these fields. At Langley, addition to the fiscal year 1963 vehicle antenna test facility to increase its size and capabilities, and a modernized Electronics Instrumentation Laboratory are proposed for fiscal year 1964. The fiscal year 1964 proposal also includes land acquisition and design and engineering services for the new Electronics Research Center.

In summary, the Office of Advanced Research and Technology of NASA is responsible for producing research data and advanced technology needed to support the NASA mission of manned and unmanned scientific exploration of space for peaceful purposes. Continued national preeminence in this field requires that the latest techniques to obtain the required data, be incorporated in economical ground-based facilities and in relatively simple flight experiments. This discussion has been limited to ground facilities covered by the "Construction of facilities" appropriation title.

Starting with the first full fiscal year of NASA operation through 1964 fiscal year, the average facilities budget for research facilities has been $33.5 million, or approximately 10 percent per year of the NACA plant value when it was absorbed by NASA. This increase is modest since increases up to 15 percent per year appeared desirable in the light of NACA experience. Nuclear rocket development facilities started in fiscal year 1960, and have averaged $11.4 million per year through fiscal year 1964. Other facilities include administrative support, shops and utilities, and have averaged about $7 million per year, 1960 through 1964 fiscal years. The individual year's figures are given in the following table.

NASA budget for facilities supporting OART programs, 1960–64 fiscal years

[Millions of dollars]

Fiscal year	Research	Nuclear rocket	Other	Total
1960	19.6	0.3	----------	19.9
1961	22.1	----------	----------	22.1
1962	13.9	22.5	1.5	37.9
1963	64.9	18.7	18.5	102.1
1964	47.3	15.5	15.4	78.2
Total	167.8	57.0	35.4	260.2

In view of the foregoing, we feel that our request for 1964 fiscal year construction of facilities funds is a reasonable request. NASA scientists have been faced with the challenge of reproducing the hostile space environment in new facilities and in providing facilities for adequate and safe tests for the nuclear rocket development program.

U.S. preeminence in the peaceful uses of space is going to be dependent on the university, industrial, Government complex working together as a team with NASA as the team leader. Progress will be strongly dependent on the advanced facilities and the high caliber professional talent available to exploit the facilities and to identify and pursue the problems that will advance the U.S. aeronautics and space program.

Mr. Chairman, that completes my background statement. With your permission, I would like to suggest that you might take up first the Life Science Research Laboratory, which is under the direction of Dr. Konecci of my office. I would like to call him up here with me, if I may, to discuss that.

Mr. KARTH. All right, sir.

Before Dr. Konecci begins, I wonder if I could just hold in abeyance his testimony for a few brief questions by counsel.

Dr. BISPLINGHOFF. Certainly.

Colonel GOULD. On page 4 you indicate facilities constructed in the past had a useful life in their original configuration of some 10 to 15 years. Are we now finding that our research facilities are approaching a stage of obsolescence long before the life expectancy of the buildings?

Dr. BISPLINGHOFF. Before the life expectancy of the buildings?

Colonel GOULD. Yes, sir.

Dr. BISPLINGHOFF. I would believe the life expectancy of the newer buildings would probably be less than in the NACA days. We had a period of relative stability during that time in the field of aerodynamics. I would say perhaps our newer facilities would have a lesser useful lifetime than they had in those days, and may very well be obsolescent before the buildings wear out. In that case, I think we would need to adapt these buildings to newer uses.

Colonel GOULD. Most of the construction being done at the newer centers are permanent buildings, with a life expectancy of probably 40 to 50 years; is this correct?

Dr. BISPLINGHOFF. Yes.

Colonel GOULD. Would it be possible to get by with buildings of a more temporary nature, rather than building long-life structures?

Dr. BISPLINGHOFF. I think that would have to be addressed to individual cases. I am sure there are cases where relatively temporary buildings could be employed.

Colonel GOULD. Also on page 4 you indicate that within 10 to 15 years after the construction of a building, modifications were then in order during the days of NACA.

Dr. BISPLINGHOFF. Yes.

Colonel GOULD. Under present-day conditions you say this will be less. What is your estimate of how long a building could remain in use before it would have to be modified under present-day conditions?

Dr. BISPLINGHOFF. It is very difficult for me to make such an estimate. I can only offer the indication in my mind that alterations will perhaps have to be in lesser time than 10 or 15 years.

Colonel GOULD. There has been a total of $140 million authorized in fiscal years 1962 and 1963 for construction of new facilities, according to your chart.

Dr. BISPLINGHOFF. Yes.

Colonel GOULD. How much of this amount has been committed?

Dr. BISPLINGHOFF. Let me ask Mr. Ulmer if he can answer that.

Mr. ULMER. I would have to give an average that might cover the agency as a whole, but I would estimate perhaps 70 percent of the 1962 program is under obligation and perhaps 25 to 30 percent of the 1963 program is under obligation.

Your question, I believe, was specifically related to the amounts committed. All the amounts are committed in that the projects have been approved by the Associate Administrator and funding released to the program offices except for approximately $20 million of the 1963 appropriation. Except for that $20 million, all the remaining funds have been released and sent to the program offices for obligation.

We can supply the exact obligation figures for the record, Colonel Gould.

Colonel GOULD. Would you please supply for the record the total amount of funds out of this $140 million previously authorized that has been committed, the total amount that has been obligated, and when the balance of these funds will be obligated?

Mr. ULMER. We will be very glad to, Colonel.

Mr. KARTH. I wonder if I may ask that this be done at a relatively early date.

Mr. ULMER. There will be no problem, Mr. Chairman. The figures are available.

(The information requested is as follows:)

The status of the $140 million listed in Dr. Bisplinghoff's opening statement as the Office of Advanced Research and Technology total construction of facilities program for the 1962 and 1963 fiscal years is given in the table. The table lists by centers, in the first column, the amounts tentatively programed as of November 30, 1962. The data for this point in time were used as a basis for the totals given on page SUM 4 in part I of the construction of facilities budget book for the space research and technology and aircraft technology programs. The second column shows the committed amounts. The third column shows the amounts obligated to date, and the fourth column shows the estimated dates for obligation of the balance of the programed funds.

It should be emphasized that from the start of design, it takes about 3 years on the average to complete a complex NASA research facility. Advance design funds are of great importance in achieving early completion of the facilities. By having design already underway on important facilities, earlier obligation of appropriated funds for actual construction is possible.

Office of Advanced Research and Technology, construction-of-facilities program for fiscal years 1962 aud 1963

[Millions of dollars]

Location	Tentative program, Nov. 30, 1962	Commitments	Obligations	Date balance obligated
Fiscal year 1962:				
Ames Research Center	6.3	5.1	4.8	September 1964.
Langley Research Center	6.6	6.2	6.1	November 1964.
Lewis Research Center	1.0	.9	.9	August 1963.
Nuclear rocket development station	22.5	6.1	6.1	February 1964.
Advanced design funds	1.5	1.5	1.5	
Total, fiscal year 1962	37.9	19.8	19.4	
Fiscal year 1963:				
Ames Research Center	13.3	.8	.4	February 1965.
Flight research center	1.7	1.7	1.2	June 1963.
Langley Research Center	8.9	3.1	2.0	June 1964.
Lewis Research Center	43.5	8.6	7.2	September 1964.
Nuclear rocket development station	17.4	5.4	5.4	February 1964.
Atlantic Missile Range	[1] 5.0	0	0	
Various locations	12.3	6.9	6.9	December 1964.
Total, fiscal year 1963	[1] 102.1	26.5	23.1	
Total, OART fiscal year 1962 and 1963	[1] 140.0	46.3	42.5	

[1] The AMR project Apollo Static Test Facility at 5,000,000 was inadvertently classified as an OART facility instead of manned space flight. It is included here for completeness. The totals should be reduced by 5,000,000 to give the corrected total construction-of-facilities program for 1963 charged to OART.

Colonel GOULD. In the 1963 program a lunar landing facility was authorized at Langley.

Dr. BISPLINGHOFF. Yes, sir.

Colonel GOULD. What relationship has this facility to the proposed construction at White Sands Proving Grounds in the amount of $15 million?

Mr. MYERS. $15 million——

Colonel GOULD. Included in the manned space flight program.

Mr. AMES. May I speak first as to the Langley facility? The intention in going ahead rapidly with that facility was to provide us at the earliest date possible with experience on the overall problems of landing a space vehicle structure controlled by a man in a simulated lunar environment, where we have, say, one-sixth gravity, and no atmospheric braking such as we have in the atmosphere here. It has an overhead track with a crane, and as the vehicle moves down the track it descends as though making a tangential lunar landing. In such a program we can test the reaction of the pilot to an abort maneuver, if, say, he has to recover or decides "I can't make a landing in this spot." If the vehicle makes this landing we can study the structural dynamics of the vehicle, or the response of the structure as it drops to the lunar surface.

Construction is now underway at Langley, and it was approved primarily as a research facility. I was trying to look up the manned space flight facility when you asked your question. I don't believe I can put a direct answer in the record at this time.

Colonel GOULD. Is this project at Langley now under construction?

Mr. AMES. Yes, it is.

Colonel GOULD. The actual construction been started?

Mr. AMES. Yes, I believe it has.

Mr. MYERS. Yes, at Langley.

Colonel GOULD. Are there additional items planned for Langley in the lunar landing program?

Mr. AMES. No, we have a fatigue facility, on cyclic loading—of materials and structure.

Mr. KARTH. When was the appropriation made for this lunar landing facility at Langley? When was that appropriation last made?

Colonel GOULD. When was it authorized?

Mr. ULMER. The Langley facility was authorized under the congressional reprograming procedures in the fiscal year 1962. I believe the amount was $3.5 million, which was funded by reprograming within the construction appropriation; $3.5 million worth of other facilities were deleted to fund this facility.

Colonel GOULD. Would you please provide for the record a specific statement as to the status of that project at Langley, when it was started, and when construction will be completed?

Mr. MYERS. Yes. It is well along.

(The information requested is as follows:)

Langley Research Center project lunar landing facility construction was approved October 25, 1961, and the contract is now 60 percent through the scheduled time allowed for its completion and is essentially on schedule. Approximately 95 percent of the authorized $3,500,000 is obligated. The first major contract, that for the gantry structure, was awarded in June 1962. The estimated project acceptance date is January 1964.

A 2-month period is scheduled to allow for system checkouts, facility operational training, and final servo tuneups. This brings the date of first research operation to March 1964.

Colonel GOULD. In answer to a previous question, I should say there has been consideration of extending the length of that facility, but as yet there has been no technical decision made in our office to do this. We have run into some problems, and some of the lunar landing problems that have come up with respect to landing on the surface may make it wise to lengthen this somewhat.

We are planning to build a $25 million facility at White Sands, which appears to be justified, on the same basis as what you are doing at Langley. We were concerned as to whether there was any duplication in the two activities.

Mr. MYERS. I think you should speak to the manned space flight people about that. Their emphasis is primarily on the production systems, where ours is primarily on the guidance, control, and so forth.

Colonel GOULD. I would suggest, sir, that you speak to the people in the manned space flight program and make that determination.

(The material requested is as follows:)

DESCRIPTION OF THE LANGLEY LUNAR LANDING RESEARCH FACILITY AND THE LUNAR EXCURSION MODULE TEST FACILITY AT WHITE SANDS MISSILE RANGE

LUNAR LANDING RESEARCH FACILITY, LANGLEY RESEARCH CENTER

Construction of the lunar landing research facility was approved in late 1961 by emergency authorization with funds provided by the fiscal year 1962 construction of facilities budget. This facility was required as a means to quickly provide advanced research information on the problems of controlling a rocket-powered spacecraft near the lunar surface. This facility will consist initially of a 10,000-pound research vehicle tethered to a movable overhead suspension system supported by a gantry-type structure 200 feet high and 400 feet long. To simulate the reduced lunar gravity, the suspension system will support five-sixths of the weight of the test vehicle. This system will permit advanced research investigations of low-altitude approach landings, problems of controlling the vehicle, and possible solutions to various abort emergencies by the pilot. The main engines and altitude control motors for the vehicle will utilize hydrogen peroxide fuel for ease in handling and wide range of controllability.

At the present time, the support structure of the lunar landing research facility is 60 percent complete and is on schedule for the required completion date of January 1964. First research tests are scheduled to begin in March 1964. Initial research will be directed toward solution of potential problems of the manned lunar landing program utilizing a vehicle which closely simulates the flight characteristics of the lunar excursion module. The objective of the first phase of research will be to determine if the low-level flight, hovering, and landing characteristics of the lunar excursion module will be adequate, and, if not, what changes will be required for acceptable performance. The second phase of research will be concerned with investigation of various abort situations and determination of best techniques to handle these emergency situations.

The problems inherent in the design and operation of lunar landing and take-off vehicles have no precedent. Thus, a research facility of this type can provide required experimental verification of how much excess thrust should be provided, method of thrust control of the rocket, and methods of controlling the direction of thrust. All are vital to successful design and operation of LEM-type vehicles. Other problem areas are concerned with achieving the most efficient flight instrumentation and with the position of the pilot in the vehicle as it affects his ability to control and to see the landing area. In addition, problems exist which are peculiar to a rocket-propelled vehicle which must be used near the lunar surface. These problems include the question of using a vertical approach or an approach along a glide path, the effects of jet blast on the lunar surface, creating clouds of dust which may obscure visibility or possibly damaging the vehicle,

and the sloshing effect of large amounts of liquid propellant which may influence the control characteristics of the vehicle. By making minor modification to the facility, it is also possible to study the problems which will be encountered in designing manned planetary spacecraft such as would be used in flights to Mars and Venus. The lunar landing research facility will allow study of these problems with a high degree of realism. It is expected that investigation and solution of these problems will provide much of the necessary experimental research needed not only for design and operation of the lunar excursion module, but for use in future manned planetary landings as well. This facility at LRC obviated the need for a similar facility which had at one time been planned for construction at the Manned Spacecraft Center at a saving of $6.5 million.

LUNAR EXCURSION MODULE TEST FACILITY, WHITE SANDS MISSILE RANGE

The 1964 budget estimates for construction of facilities includes a proposed lunar excursion module test facility to be located at the White Sands Missile Range in New Mexico. This is a propulsion test facility required for development tests of the engines used in the lunar excursion module of the Apollo spacecraft. In order to meet the tight time schedule established for the manned lunar landing programs, this facility will be necessary so that earliest possible development and operational testing of the two-man lunar excursion module can be achieved. The module will have two engines. One will be used as a landing and touchdown engine and will be throttleable over a thrust range of 1,000 to 10,000 pounds. The other engine will be used for takeoff and return of the module to the orbiting Apollo command spacecraft and will have a thrust capability of 4,000 pounds. Both engines will utilize hypergolic propellants (i.e., propellants that spontaneously ignite upon contact with each other) which require extreme technical diligence in static and flight development testing techniques.

The two separate propulsion stages of the lunar excursion module will require the proposed test facility to have available four test stands with supporting buildings for simultaneous testing of two units of each stage. For propulsion-unit testing, two of the four test stands will be capable of taking both the lunar touchdown and lunar takeoff engine assemblies in mated positions during combined static firings. For operational testing of the engine controls by the astronauts, the other two stands will be provided with elevators and movable "clean rooms" for checkout and crew entry into the lunar excursion module. A hover flight-test pad approximately 200 feet in diameter will also be constructed for use with a test structure to support the lunar excursion module in a tethered flight condition. I ecause the engines are not designed to lift the module to a hovering condition on the Earth, partial support of the vehicle will be achieved by vertical cables linking the module to the test structure. By allowing the module to move in a vertical direction, the astronauts will be able to study in hovering flight such developmental problems as starting, thrust control, and management of the actual landing and takeoff engines of the complete lunar excursion module. It is expected that full operation of the lunar excursion module test facility will commence in about 18 to 24 months from the start of construction.

Colonel GOULD. You indicate that over the past 5 years in the OART programs, Dr. Bisplinghoff, you have secured authorizations and authorization of $260.2 million. In all the justification I read in the fiscal year 1964 program here, after review of your master plans at your various installations, I can find very little projections beyond fiscal year 1964 as to what it is going to cost to meet the known missions of the OART programs.

Do you have any estimate of the long-range requirements for facilities at your installations over the next 5 or 10 years?

Dr. BISPLINGHOFF. No, sir. I cannot give you any estimate here. We have various internal studies we have made of this. However, I would put in the report an indication of our thinking.

Colonel GOULD. You are relatively certain of your missions at the present time within NASA. I think it would be of interest to this

committee to know your thinking, based upon known requirements as to how much it is going to cost over the next 10 years, let us say, for new facilities. Would you provide that for the record, please?

Dr. BISPLINGHOFF. Yes, sir.

(The information requested is as follows:)

We agree with Colonel Gould that the OART research and technology mission is well known within NASA. Prediction of facilities needs over the next 10 years for the NASA advanced research and technology effort can only be given in general terms. The OART research program must be geared to identify problems 5 to 10 years ahead, provide adequate facilities to work on these problems, and provide the technical and scientific research information needed for their solution. Advanced planning on OART facilities requires flexibility. It is necessary to assimilate new research information on the space environment as it is acquired in order that the latest thinking may be incorporated into research facilities. It is also important that NASA research facilities be continuously updated, and improved as additional knowledge is obtained from research in space, on the conditions that must be simulated in ground-based facilities.

NASA has technically reviewed more than $450 million worth of research facilities since its inception in 1958. In this review process, many proposed facilities have been eliminated, some deferred because of monetary limitations, technical state of the art projections, and actual knowledge of the environment that must be simulated. This is a reiterative process which must be updated constantly as new research problems are identified, research techniques generated, and research data requirements are established. Often times, older facilities may be more readily modified to do the research that is required. The NASA requests for research facilities that are finally presented to the Congress usually represent the minimum needs to enhance the national research facility asset required to establish and maintain preeminence in space and aeronautics, respectively.

The goals for NASA are finally determined at the highest national levels; the White House, the Space Council, and in consultation with the Department of Defense and the Atomic Energy Commission. NASA is authorized to make research analyses of advanced missions. The information obtained from these analyses serves to identify problems and to guide research. The information also helps to establish national goals and to determine the facilities needed by the Office of Advanced Research and Technology. From these facilities, research data are obtained which are required to make sound technical decisions on the future goals of the U.S. space and aeronautics activities.

Since the Wright brothers' use of the simplest wind tunnel, it has been necessary to exploit the physical and engineering sciences to provide better research tools to move ahead. It has also become OART's responsibility to explore the life sciences in order to match the capability of man to his required duties in the operation of manned space exploration vehicles.

It is anticipated that over the next 10 years there will be a continuing need for new research facilities. Many proposed facilities are studied in preliminary design form and only those which fulfill a clearly established technical need are presented to the Congress. The facility presented to the Congress must not only be technically feasible, but, in many cases, the value has been clearly demonstrated in small-scale pilot models. There have been many new research facilities where a single series of tests early in the program has provided information of such value that it has paid for the entire cost of the facility. In the experience of NACA, the national aeronautical research agency, facilities averaged 30 percent of the total NACA budget over the fiscal years 1950 through 1959.

Under NASA, for research and development facilities supporting the OART program, the average for fiscal years 1960 through 1964 for proposed facilities is approximately 14 percent of the total OART budget. The request in the 1964 fiscal year for OART facilities is therefore considered quite modest. The table on which this comparison is based is given below.

Historical data on construction of research facilities relative to the total research program

[In millions of dollars]

Fiscal year	Total NACA research budget	NACA construction of research facilities
1950	128.0	35.0
1951	63.1	17.3
1952	69.0	18.3
1953	66.3	17.7
1954	62.4	11.4
1955	56.9	4.6
1956	72.7	12.6
1957	76.7	14.0
1958	117.3	41.2
1959	101.1	23.0
Total, 10 years of NACA [1]	813.5	245.1

Fiscal year	Total OART budget	OART construction of research facilities
1960	107.4	19.9
1961	216.8	22.1
1962	259.2	36.4
1963	470.1	83.6
1964	571.8	62.8
Total, 5 years of OART [2]	1,625.3	224.8

ANALYSIS

Organization	Fiscal year period	Construction of facilities program in terms of total research budget
NACA [1]	1950–59	$\frac{245.1}{813.5}$ = [3] 30.1
NASA–OART [2]	1960–64	$\frac{224.8}{1625.3}$ = [3] 13.8

[1] Only NACA appropriations for fiscal year 1959 were used for these data.
[2] The construction of facilities totals for each fiscal year include the research and nuclear rocket facilities as shown in the summary table of Dr. R. L. Bisplinghoff's statement on Apr. 29, 1963.
[3] Percent.

Mr. KARTH. Mr. Morris.

Mr. MORRIS. What is the NASA's test facility at Las Vegas?

Dr. BISPLINGHOFF. The NRDS facility?

Mr. MORRIS. Yes.

Dr. BISPLINGHOFF. This is $15.5 million, sir, in answer to your question.

Mr. MORRIS. Is that what you asked for, $15.5 million is what we are asking for in the 1964 budget for NRDS facility?

Mr. KLEIN. That does not include the support facilities.

Mr. MYERS. About $20 million total. But Dr. Bisplinghoff is speaking of the research facilities, in the $15 million. There are also support facilities in there for the NRDS operations.

Mr. MORRIS. This is not included under your office?

Mr. MYERS. Yes, it is.

Dr. BISPLINGHOFF. Yes, I inadvertently omitted that.

Mr. MORRIS. Where is that on page 24?

Dr. BISPLINGHOFF. These facilities that are listed as $15.5 million on page 24 are the research facilities. Those facilities which go directly toward research. The total facilities at NRDS can be found in our facilities budget request, $20.5 million—and where is that shown, what page?

Mr. MYERS. It is at the NRDS facilities, given on page CF 12 of the budget estimates.

Mr. MORRIS. Well, you have a total figure on page 24 of your testimony, Doctor. Does that include everything?

Dr. BISPLINGHOFF. No. What I have tried to lay out in this testimony I have here——

Mr. MORRIS. The reason I ask this: this is not the figure that was presented to the President, and to Dr. Weisner at Los Alamos and out at Nevada. What is the difference between the figure presented now and those given to the President?

Dr. BISPLINGHOFF. The figure presented to the committee is $20.5 million. In giving this testimony I attempted to summarize those facilities in our OART program that are used directly for research. This is what the page 24 sums represent. There is a supporting facility also at NRDS which must be added to the 15.5 number, to bring it up to 20.5.

Mr. MORRIS. What do you call your facility there now, NRDS?

Dr. BISPLINGHOFF. Yes. The Nuclear Rocket Development Station.

Mr. MORRIS. That is the official name?

Dr. BISPLINGHOFF. Yes, sir.

Mr. MORRIS. If you total all the money, the figure on page 24 should be about $20 million, or more?

Dr. BISPLINGHOFF. Yes, actually $20.5 million.

Mr. MORRIS. It says "NASA budget for facilities supporting OART programs."

Mr. KARTH. Doctor, you say on page 18:

> As more is learned of the environment to which spacecraft materials will be subjected, the requirements for these simulators become more complex.

My question would be, do we not run the risk of building too many of these specialized facilities at an early date, where later we will find they become obsolete as we learn more about the materials? Isn't this really a pretty risky proposition? We are risking only dollars, but that happens to be of considerable importance. Aren't we running the risk that many of these will become obsolete?

Dr. BISPLINGHOFF. I think we must design these facilities so they can be modified to incorporate the improvements in methods of simulation, or to update them as we learn more about the space environment. But I believe the basic facility, basic vacuum chamber and devices that go in it are things that can be easily modified without upsetting the facility as a whole.

Mr. KARTH. I have never seen an office under NASA come in and say, "Look, we would like to modify this simulator or this vacuum chamber. They come in and say, "We need a different one." They may have one 35 by 50. And they come in and say they must have one 37 by 48 feet, and give all kinds of reasons why they have to have a different chamber.

It seems to me when we discussed this during the regular hearing we did question the validity of the request as it related to new vacuum chambers of almost the same size as we have now in existence. And there wasn't any question then of updating or changing, if you will, the existing facility to meet the new requirement; rather, we had an additional requirement, we needed additional testing, we needed just a little bit different size vacuum chamber. We are not going to have so many vacuum chambers in this country within a relatively short period of time, as we have wind tunnels, so that we are vacuum chambered to death, are we. Is there any question that this might happen?

You know, everybody got into the wind tunnel testing business, Doctor, during World War II—or was it immediately thereafter? And I think we have probably more wind tunnels in this country than Carter has liver pills, if we made a careful check in private industry as well as Government in-house facilities. I wonder if there is a possibility that this might happen with vacuum chambers?

When are we going to update or change these? Where are the plans for updating or changing? What makes you so sure they lend themselves to change or updating? Is this built into the plan now? If so, where is the plan?

The answer to Colonel Gould's question, as I understood it, is that we don't really have any construction of facilities plans beyond 1964. I wonder how well we can plan. I wonder how we can be so sure that these things lend themselves to change or that we will update these facilities, when in fact we don't even have any plans beyond 1964.

I have asked a series of questions here.

Dr. BISPLINGHOFF. We have plans beyond 1964, Mr. Chairman, but I will have to go back to our internal planning documents and dig out information which I would supply for the record. I just cannot give you offhand what they are.

On the matter of alterations of existing facilities, I know of cases that have actually happened in the past where we have made changes in existing facilities, and I could also supply for the record details of those specific changes that have been made, and I would be very glad to do so.

Mr. KARTH. I have seen those deep vacuum chambers at Goddard. I am not expert in this new state of the art, to determine whether they lend themselves to updating later on, but I would say in most cases I don't think they do. This is a very carefully built piece of equipment, and has very thick walls, and so forth. I just don't see how it can be changed without costing more money than if you started from scratch and built a different one.

Dr. BISPLINGHOFF. It would be improvements in vacuum pumping techniques which could be applied to the pumps: it would be improvements to the devices by which we simulate radiation. This is something that could be done continuously by changing the devices in the chamber. It could be improvement in our ability to project small particles at high velocities. I think these things could all be built into these chambers. I believe that the basic chamber will in all cases have to be made rugged and of materials of sufficient wall thicknesses so that we can provide vacuums and provide the kind of environment we will want ultimately.

But I believe the improvements in the level of vacuum, in the type of radiation, and in the type of particle impact are things that can go on constantly as we improve our abilities to do these things.

Mr. KARTH. If these are the things that are required for updating and changing to meet our changing requirements, why, then, do we have to build so many of different sizes? This year there are several requests for slightly different sizes and some for sizes which already exist, but we just have to have these slightly different sizes. So if the guiding factor which requires change to update is the pump, or the this or the that, as you have alluded to them, why, then, do we need these various new chambers that are being requested?

Dr. BISPLINGHOFF. Well, one factor is the updating of the individual facility to provide better environmental conditions. But there is a second factor——

Mr. KARTH. So, there are really changing requirements or changing conditions, that cause us to change our overall configuration or overall tank, without necessarily just changing the pumps or whatever else you referred to; is that correct?

Dr. BISPLINGHOFF. The main changes in an existing facility would be such things as pumps, hypervelocity particle devices, and so forth.

Mr. KARTH. These would be made just to update the capability of the existing chamber?

Dr. BISPLINGHOFF. That is right. There is the second factor in the need for new chambers and that is the need to carry on research in new areas or to accommodate materials or vehicles that cannot be accommodated in existing chambers. This is just a matter of hours of the day, more than it is of producing a new environment. We find this kind of facility cuts across the board when we work on structures, on propulsions, on guidance systems, and on materials. We need these kinds of facilities for all these things. It is virtually impossible to use the same facility because of the time involved in testing.

Mr. KARTH. You don't think we are running a high risk of obsolescence at too early a date, by building as many of these as we need for the immediate future?

Dr. BISPLINGHOFF. I think if the program is well planned we are not running a risk of obsolescence. I am speaking of the planning of each individual basic facility. If it is planned so it can be improved as we learn more about our ability to simulate these environments, the facility will have a long and useful lifetime.

Mr. MORRIS. May I ask a question?

Mr. KARTH. Mr. Morris.

Mr. MORRIS. Doctor, let us put it another way. How many buildings have you built since NASA has been an official statutory agency? How many of them have been altered?

Dr. BISPLINGHOFF. I can supply that for the record, Mr. Morris. I cannot tell you offhand what that figure is.

Mr. MORRIS. Would you do that?

Dr. BISPLINGHOFF. Yes, sir.

(List of buildings and modifications on p. 2595.)

Mr. MORRIS. Perhaps one way to judge whether something is well planned is to see what has been done in the past, see how they have stood the test in the short time NASA has been an agency. Maybe that is not a fair way to judge it, I don't know. But it would be something you could look at and see.

Dr. BISPLINGHOFF. Would you want this information just for NASA or for the NACA period, as well?

Mr. MORRIS. I am not interested in NACA. I am just concerned with NASA now. NACA is out of existence, isn't it?

Mr. ULMER. The NACA ceased to exist when the Space Act was passed, Mr. Morris. Its functions, powers, duties, facilities, personnel, and funds were transferred to NASA.

Mr. MORRIS. I am sorry, Doctor, I just assumed "under your office." I said NASA in general. I beg your pardon. I only meant, of course, the ones you have responsibility for.

Dr. BISPLINGHOFF. Yes, I understood.

(The information requested is as follows:)

In the fiscal years 1960 through 1963 when NASA had full responsibility for defending and implementing its construction-of-facilities program, there have been 48 approved construction projects in the Office of Advanced Research and Technology program area. Of these 48 projects, 23 could be termed "new laboratories" or "new buildings." Of the remaining 25 projects, 1 was for design only, and the other 24 were additions or modifications to modernize existing facilities.

Mr. KARTH. Are there any further questions at this time?

Dr. Konecci, if you want to proceed.

Dr. KONECCI. Mr. Chairman, it is again a pleasure to appear before you.

This morning we will be discussing the Life Sciences Research Laboratory. In previous testimony we have attempted to give you some feeling for the biological and human research program under OART. We have tried to stress and emphasize the importance of getting this human research and biotechnology ahead. In the early 1950's this country was preeminent in this area, and since that time has now fallen behind the Soviets in the advanced research area.

Mr. KARTH. How do we know, Doctor, that we fell behind the Soviets?

Dr. KONECCI. Sir, the Soviets—many of us have been keeping track of the Soviets' research, actual basic research and technology in their literature for the last 10 or 15 years. There are printed documentations of this. We have, as presented to the committee in my last testimony, two books that were given to us and have been authenticated, since they are from the Academy of Sciences, with actual data in the research area, presented at the last meeting—at the meeting last year in Paris.

There is a third volume on space biology that is now being translated in this country.

Mr. KARTH. So that I better understand what you said, did you say we have fallen behind the Soviets in the last several years in research?

Dr. KONECCI. Yes, sir.

Mr. KARTH. Or that we have fallen behind them in life sciences work?

Dr. KONECCI. I am trying to refer only to the life sciences area, in the areas of life support, in the areas of human research.

Mr. KARTH. It may be that the Soviets had a lot of catching up to do. The question is: Are they just doing more research in the last several years than the United States is doing in the life sciences area, and are catching up, and is that what you predicate your assumption

on? Or is it that they are actually ahead of us in things they have done in the life sciences field?

Dr. KONECCI. It is in the latter category that they have data that is beyond anything we have in this country. On weightlessness they have not only specific data on the 7 days of the dog Laika, which was obtained in 1957—and this has actually helped them in planning their vehicles, with which we are concerned in OART—but in addition they have collected the kind of basic information required for planning biotechnology, instrumentation, and so on, over a period from 1950 to, say, 1958, 1959, having their athletes run around and getting biotelemetry data on conditions of man, so in the early 1950's they solved the problem of electrodes for EGK records, on how to paste them on and keep the electrodes from affecting the signal noise ratio.

Mr. KARTH. Have they built more laboratories, or is it a more practical research? You know, when the athlete runs 10 miles they measure his heart beat, respiration, and so forth.

Spend a few minutes telling this committee exactly where we are behind, and why we are, and where the Russians probably place their emphasis. Do they have, for example, more laboratories than we have in the life sciences field?

Dr. KONECCI. It is a difference of philosophy and approach. They have had from the early days one goal—manned space flight. All their physical and life sciences research has been coordinated toward one goal to achieve manned space flight. This is their stated objective in their literature.

We have established a much broader base of research in all areas, including life sciences. There are many areas. I don't mean to indicate we are behind in all areas. I specified in manned research advanced biotechnology; in other words, the area we in this Office are responsible for.

Mr. KARTH. Can we reasonably expect to be ahead in all these areas?

Dr. KONECCI. No, sir. But here is an area of prime importance to this country in obtaining the proper design requirements for future vehicles; and to establish this preeminence in space we need this kind of research to be conducted now, not only to catch up but to go ahead. In this last year with the funding made available to the Office of Biotechnology and Human Research we have gone, in fact, ahead in areas like life support, and tried to bridge the gap.

Mr. KARTH. What is this philosophical difference that you speak of?

Dr. KONECCI. They have complete control over their engineering and science to where they can essentially put people on a specific project and have them work only in an area of importance to that program. For example, many of the nuclear physicists that have been so-called surplus in the Soviet Union, after work on the atomic bomb, have now been reoriented to biophysics and are working specifically on those problems, and——

Mr. MORRIS. Doctor, how do you know this?

Dr. KONECCI. We have been in communication with several of the very prominent scientists in the Soviet Union. Dr. Parin, who just received the Lenin Medal, has been responsible for the medical aspects of the Soviet man in space program.

Mr. KARTH. I am not sure it will serve any valuable purpose, if this may tend to eliminate a source of information.

Dr. KONECCI. On the contrary, sir, I might indicate it has actually increased our flow of information, since the Soviet scientists are very open in terms of our criticism toward their program, and vice versa. It has been in this area we have had the greatest flow of information. And I believe one of the reasons is because it is open and——

Mr. KARTH. Completely unencumbered?

Dr. KONECCI. Oh, no; since they do not give us technical details on their equipment, which they consider classified. But as far as scientific principles are concerned, we have obtained quite a bit of information.

Mr. MORRIS. Do you notify the Central Intelligence Agency of this information?

Dr. KONECCI. I am not involved with the intelligence community. We have had international committees——

Mr. MORRIS. You seem to know more about their program than any other agency, and specifically I mean the Central Intelligence Agency.

Mr. KARTH. You ought to join up.

Well, proceed.

Dr. KONECCI. Thank you.

I wanted to point this out, because we have tried in the last year to solve our problem by utilizing the present NASA centers, DOD, industry, and universities to complete our program. However, the major competence within the NASA for research and development pertaining to life sciences is being systematically developed at the Ames Research Center. During the last 2 years scientific personnel of high international stature, like Professor Ogden, formerly the chief of physiology at Ohio State; Dr. Haymaker, formerly of the Armed Forces Institute, are members of this organization. They are carrying out research programs which were initiated some 2 years ago. This staff is now being housed in temporary laboratories located through the NASA Ames Research Complex in locations such as airplane hangars and shops, electrical service buildings, transsonic wind tunnel, supersonic wind tunnel, and space-flight simulations labs. This diffusion of personnel induces management problems and the use of laboratories restricts the type of research that can be accomplished.

The proposed Life Sciences Research Laboratory is required to house the onboard cadre of qualified scientists and to provide them with the laboratory facilities necessary for the time completion of tasks in support of the life sciences program.

Mr. KARTH. What are you going to do with the facilities they are presently working in if the Congress should authorize this?

Dr. KONECCI. These temporary facilities or spaces were taken away from other required activities at Ames, which will return to their former utilization. There was a priority here, and the life sciences actually commandeered space at Ames.

Mr. MORRIS. So, actually, if we built the life sciences facility somewhere else it wouldn't cause any problem at Ames, as far as economics are concerned? They would have programs to fit right into the buildings?

Dr. KONECCI. Two years ago I would have agreed. However, right now there are about 150 people that have been brought in, recruited. When the total facility is in the building we will have 300 people to house.

Mr. ULMER. Many of the people at Ames who are being housed in rental facilities as well, and we want to get them out of the rental facilities as quickly as possible.

Dr. KONECCI. For your information, I would like to describe the facility we are talking about. The building will be reinforced concrete structure, earthquake resistant, similar to other Ames buildings. Facility construction, however, includes special building equipment required to adapt the building for life sciences work, such as special ventilation systems, air, gas, vacuum, and oxygen distribution systems, lead-lined rooms for X-ray protection and static-free floors in surgical rooms and surgical waste crematorium.

Mr. KARTH. Why don't we build these somewhere where you don't have to worry about earthquakes, if that is important? How much less would it cost if we didn't have to prepare against earthquakes?

Dr. KONECCI. I cannot answer that question, sir.

Mr. KARTH. All right.

Dr. KONECCI. I mentioned the fact the Laboratory would house 300 people, of which we have now 141. Additional people will be distributed in the surrounding laboratories.

Now, the facility cost is $4.88 million, and the breakdown, for the record, is site development and utility installations, $300,000; facility construction, $2.940 million; equipment instrumentation and support systems, $1,400,000; and design and engineering service, $240,000.

Mr. KARTH. Are we doing any of this life sciences work in Ohio?

Dr. KONECCI. Yes, sir. We have research contracts with the Air Force, specifically, to do vibration studies at Wright Field.

Mr. KARTH. Where is Wright Field?

Dr. KONECCI. Dayton, Ohio.

Mr. KARTH. Why don't we build this research laboratory, at Wright Field? Geographic location doesn't mean much to me, except that I would like to have it make sense, from the program standpoint, where you can take advantage of existing facilities, for example, even though they may be within some other agencies of the Government.

You tell me why we decided to put this at Ames, instead of at Lewis? Why did we make this decision?

Dr. KONECCI. Sir, again the decision was made——

Mr. KARTH. You do this for me——

Dr. KONECCI. Yes, sir.

Mr. KARTH. First of all, prepare for the record at a very early date who made the decision, the names of the people on the committee, if there was a committee. Then, why the decision was made to put the facility at Ames instead of at Lewis, for example, or some other location.

Dr. KONECCI. Yes, sir.

(The information requested is as follows:)

The importance of the life sciences activities in the national aeronautics space programs and description of the extent of the national life sciences effort was documented in the report, "An Inventory of Related Programs Resources and Facilities," from the Committee on Aeronautical and Space Sciences of the U.S. Senate, dated July 15, 1960. Pages 38 and 39 of this report are reproduced below.

"The role of the life sciences in the National Aeronautics and Space Administration program was evaluated by the Bioscience Advisory Committee at the request of the Administrator.

"The objectives of space research in the life sciences are twofold: (1) Investigation of the effects of extraterrestrial environments on living organisms, including the search for extraterrestrial life; (2) scientific and technologic advances related to manned space flight and exploration.

"The same reasons which prompted the establishment of NASA and gave it responsibility for all space research and development devoted to peaceful purposes require that NASA assume responsibility for leadership, coordination, and operation of the biomedical aspects of the national space program.

"Present and future needs were considered in three broad categories:

"1. Basic biologic effects of extraterrestrial environments, with particular emphasis on those phenomena associated with weightlessness, ionizing radiation, and alterations in life rhythms or periodicity as well as the identification of complex organic or other molecules in planetary atmospheres and surfaces which might be precursors or evidence of extraterrestrial life.

"2. Applied or technologic aspects of medicine and biology as they relate to manned space flight, including the effects of weightlessness on human performance, radiation hazards, tolerance of force stresses, and maintenance of life-sustaining artificial environments.

"3. Medical and behavioral scientific problems concerned with more fundamental investigation of metabolism, nutrition, blood circulation, respiration, and the nervous system control of bodily functions and performance in space equivalent situations.

"The Bioscience Advisory Committee makes the following recommendations:

"1. That NASA establish an Office of Life Sciences having the responsibility and authority for planning, organizing, and operating a life sciences program including intramural and extramural research, development, and training.

"2. That a Director of Life Sciences be appointed who is directly responsible to the Administrator of NASA in the same manner and at the same directional level as the other program directors.

"3. That the internal organization of the Office of Life Sciences include Assistant Directors for Basic Biology, Applied Medicine and Biology, Medical and Behavioral Sciences, and the life sciences extramural program.

"4. That an intramural life sciences program and facility be established with three sections:

"(*a*) Basic biology.

"(*b*) Applied medicine and biology.

"(*c*) Medical and behavioral sciences.

"5. That the Director of Life Sciences recommend advisory committees made up of consultants outside of NASA to be appointed by the Administrator.

"6. That maximum integration of the personnel and facilities applicable to the space-oriented life sciences in the military services and other Government agencies be arranged in the most appropriate manner indicated by the nature and extent of the specific problem at hand.

"7. That the Office of Life Sciences assume proper responsibility for education and training in the space-oriented life sciences through postgraduate fellowships, training grants to institutions, and short-term visiting scientist appointments to be integrated with other NASA efforts in this area.

"8. That the NASA life sciences program place special emphasis on the free exchange of scientific findings, information, and criticism among all scientists.

"9. That security regulations be exercised with great caution and limited to matters in which national security is clearly involved.

"10. That the NASA life sciences facilities be considered a public trust in implementing national and international cooperative efforts."

Recommendations contained in report of NASA Bioscience Advisory Committee January 25, 1960, were implemented by the NASA and carried forth in principle with the reorganization of NASA life sciences activities in 1962. The members of the Committee were as follows: Seymour S. Kety, M.D., chairman; Wallace O. Fenn, Ph. D.; Donald G. Marquis, Ph. D.; Cornelius A. Tobias, Ph. D.; Clark T. Randt, M.D., executive secretary; David R. Goddard, Ph. D.; and Robert S. Morison, M.D.

Subsequent to the formation of the Office of Life Sciences, as recommended in the above-cited report, this Office reviewed various locations, including Lewis Research Center, Langley Research Center, Ames Research Center, Goddard Space Flight Center, and other non-NASA locations, to determine the best site for locating the in-house and day-to-day management capability of the NASA life sciences programs. In addition to reviewing such items as available and ade-

quate space for housing personnel and laboratories and expansion of same, proximity to engineering shops and engineering community to support these programs, the social, industrial, and university life scientists were queried relative to the importance and influence of the site location in determining whether they would accept positions with this organization.

A recommendation was made by this Office to the Administrator and his staff that Ames Research Center be designated as the site to systematically build up the NASA life sciences in-house and day-to-day management capability. The Administrator, Dr. Glennan, approved this recommendation. In consonance with this decision, the NASA has systematically been building up the life science in-house capability at the Ames Research Center and now requires the proposed Life Sciences Laboratory for the expressed purpose of housing required scientific and support personnel and providing these personnel with adequate laboratory facilities necessary to give some degree of assurance for timely completion of essential tasks in support of life sciences programs.

Summary and Recommendations

The role of the life sciences in the National Aeronautics and Space Administration program was evaluated by the Bioscience Advisory Committee at the request of the Administrator.

The objectives of space research in the life sciences are twofold: (1) Investigation of the effects of extraterrestrial environments on living organisms, including the search for extraterrestrial life; (2) scientific and technologic advances related to manned space flight and exploration.

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The Bioscience Advisory Committee makes the following recommendations:

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training grants to institutions, and short term visiting scientists appointments to be integrated with other NASA efforts in this area.

8. That the NASA life sciences program place special emphasis on the free exchange of scientific findings, information, and criticism among all scientists.

9. That security regulations be exercised with great caution and limited to matters in which national security is clearly involved.

10. That the NASA life sciences facilities be considered a public trust in implementing national and international cooperative efforts.

Mr. KARTH. Will you go ahead.

Dr. KONECCI. That completes my statement, sir.

Mr. KARTH. Colonel Gould?

Colonel GOULD. In addition to interplanetary manned space flight, the justification for this project indicates its application to the lunar flight. Assuming approval of this project, and probably 18 to 24 months leadtime in construction, it would appear this facility won't be available until late or mid-1965. Is it going to be in time to be of benefit to the manned space flight to the Moon?

Dr. KONECCI. The target date is actually 16 months from date of beginning to completion. The principal reason for the facility is advanced research and technology beyond the Lunar program, though there it will assist 16 months from now to back up the program.

Colonel GOULD. You indicate you are using rented space to a certain extent to meet this need at the present time. How much space are we leasing for the personnel who will occupy this building, and what is the annual cost?

Dr. KONECCI. Sir, I do not have in front of me the actual numbers. I will get them for you.

Colonel GOULD. Will you supply that for the record?

(The information requested is as follows:)

Ames is using 13,140 square feet of rental space for housing 25 life sciences personnel. The cost is $2.40 per square foot per year, not including utilities.

In 1963 $924,000 was authorized for a bioscience laboratory. Does that have any relationship to this project?

Dr. KONECCI. Principally the justification here is for our OART facility and building. The facility you just mentioned is part of the biosciences, though we will have the exobiology in one wing of the proposed facility; I believe, 27,000 square feet, will be used by exobiology. Some of the staff members can work on both OART and OSS programs.

Colonel GOULD. What criteria were used in establishing the size of this building, please? I am particularly concerned with the administrative space that is going to be provided. How many gross square feet per person are you allowing?

Dr. KONECCI. The total facility is 106,000 square feet. This is to staff 300 people. I am trying to look up these numbers for you, sir.

Colonel GOULD. Just give me a rough breakdown between laboratory space and administrative space.

Dr. KONECCI. Only 6,000 square feet of office space and other areas common to all divisions. The remaining part, 21,000 square feet laboratory space, for small laboratories, and then the large, 64,000—out of the 106,000 6,000 are office space and other common space, and 100,000 for laboratories.

Colonel GOULD. How many administrative personnel are you going to accommodate in this building?

Dr. KONECCI. Would you define for me, so I——

Colonel GOULD. People who are going to occupy the office space we just talked about.

Dr. KONECCI. The head of the laboratory, his division chiefs.

Colonel GOULD. How many of these?

Dr. KONECCI. All the professional people will have to have office space.

Colonel GOULD. How many are there?

Dr. KONECCI. You mean in the completed building? There are 150, sir. Actually, Ames has a ratio of one professional to one support, at this——

Colonel GOULD. 150 people will occupy this office space?

Dr. KONECCI. Plus wherever else they can find space.

Colonel GOULD. Would you supply for the record the criteria used in developing the needs for office space?

Dr. KONECCI. Yes.

(The information requested is as follows:)

Criteria used for developing the needs for office space are as follows:
The 6,000 gross square feet of office space would be utilized as follows:

	Net area, square feet
3 Division Chiefs	750
3 Assistant Division Chiefs	600
12 Branch Chiefs	1,320
1 conference room	750
1 secretarial bay and record room	780
Total (net)	4,200

Access ways, restrooms, and service rooms totaling 1,800 square feet are included in the 6,000 square feet of gross area. The remaining personnel who occupy this building will have combined work-office space in the 100,000 square feet of laboratory space.

Colonel GOULD. The building shell for housing this structure is estimated at $22.90 per square foot. An administrative building is also scheduled for Ames at a cost of $19.50 per square foot. What structural characteristics has this Laboratory that are different from the administrative building at Ames; one at $22.90, the other at $19.50? I don't see the reason for the variance.

Dr. KONECCI. The difference comes in the actual equipment. The ventilating system——

Colonel GOULD. But that is a separate cost element in your estimate; ventilation equipment, laboratory plumbing, air conditioning, and electrical systems are separate, over and above the cost of the building, which is $22.90 a square foot. Possibly Mr. Ulmer could shed a little light on that.

Mr. ULMER. I can't answer that specific question at this time, Colonel. But we do have an answer for it, and I would be glad to look it up.

Colonel GOULD. Would you provide that for the record?

Has the design been started on this building?

(The information requested is as follows:)

The following will illustrate the differences in structure characteristics between the administration building and the Life Sciences Research Laboratory building:

(*a*) Room heights in laboratories and lighting levels are different than the administration building.

(*b*) Floor loadings are considerably higher.
(*c*) There is a requirement for extra plumbing which would necessitate more holes in the walls and plumbing lines.
(*d*) The Life Sciences Laboratory is a hospital-type building with requirements for surgical suites and laboratory areas which require special tile flooring and tile walls for sanitation purposes.

Dr. KONECCI. No, sir. The $240,000 was made available by the Administrator to study this detail. This is just a preliminary plan.

Colonel GOULD. You say the money was made available for design already for this structure?

Dr. KONECCI. I believe the money was released in February, $240,000, from the Administrator's Office. This was made part of the record earlier, sir.

Colonel GOULD. Was this from fiscal year 1963 advance design funds?

Dr. KONECCI. I believe so.

Mr. KARTH. Was this in the $9 million allocated for this purpose?

Dr. BISPLINGHOFF. It came from the overall $9 million, yes.

Colonel GOULD. If advanced design funds from fiscal year 1963 have been provided why did you ask for another $240,000 in fiscal year 1964?

Dr. KONECCI. The money would be subtracted, sir, from that.

Colonel GOULD. Thank you, that is all.

Mr. KARTH. Any other questions?

Mr. MORRIS. Yes, sir.

Exactly what do you mean by life sciences, now?

Dr. KONECCI. I suppose we mean the same thing as the physical sciences.

Mr. MORRIS. But in connection with this facility, just what do you mean by life sciences?

Dr. KONECCI. We will utilize this Government facility to support life sciences activities related to space programs. We are doing human research, also the technology or biotechnology required to get life support systems to protect man in space.

Really, we are trying to study living systems, principally man, to come up with a design criterion for future vehicles. That is our objective.

Mr. MORRIS. Are you going to study animals?

Dr. KONECCI. Yes, sir; animals have always been studied. We cannot take a man to a terminal case.

Mr. MORRIS. What do you call the work NASA is doing at Holloman Missile Development Center in New Mexico in this field? Is this life sciences?

Dr. KONECCI. Yes, sir.

Mr. MORRIS. That is what you define as life sciences?

Dr. KONECCI. Yes, sir.

Mr. MORRIS. The reason I ask this is that many people use different definitions for different titles, and, frankly, I sometimes get rather confused when they start interchanging them and I find one has a different meaning to one office than it has to another.

But what you are doing at Holloman Missile Development Center is life sciences work?

Dr. KONECCI. Yes, sir.

Mr. MORRIS. Thank you. I think I have that straight, Mr. Chairman. I hope so, anyway.

Mr. KARTH. Are there any other questions?

Dr. Bisplinghoff, whom would you like to call upon next?

Dr. BISPLINGHOFF. I would like to ask Mr. Sloop to come forward and talk about our propulsion facilities.

Mr. KARTH. Mr. Sloop.

Mr. SLOOP. Thank you.

I want to describe briefly the facilities in propulsion requested for fiscal year 1964. They are all at the Lewis Research Center.

They are, first, the addition to a spacecraft propulsion research facility authorized in fiscal year 1963. What we are requesting in fiscal year 1964 is the addition of cryogenic panels and an increased vacuum facility, so that we can cool and soap the entire spacecraft propulsion system to simulate conditions in space for long periods of time.

Mr. MOSHER. Mr. Chairman, I would like to have Mr. Sloop distinguish between Plum Brook and Lewis.

Mr. SLOOP. When we say Lewis we mean facilities at Cleveland and Plum Brook, which is near Sandusky. This stand is at Plum Brook.

Mr. MOSHER. Yes. I wondered which would be at Plum Brook.

Mr. SLOOP. Fine. This stand is at the Plum Brook station.

Mr. MORRIS. What is the difference between Lewis and Plum Brook, now?

Mr. MOSHER. Lewis is located in Cleveland, right at the Cleveland Airport. It is an immense facility which has used up its available land, and they were able to get the additional land that they needed some 60 miles away, roughly, at an old Army installation. The Army had given up this installation of several thousand acres. It is called Plum Brook. So Plum Brook is really an annex to Lewis, operated out of Lewis, all part of Lewis; but out in our area we differentiate between Lewis and Plum Brook.

I think you are going out to see it, aren't you, this coming week?

Mr. KARTH. Yes; the committee has scheduled a trip out there.

Mr. SLOOP. This addition would be in the amount of $3½ million, and would be completed in approximately mid-1965.

The second——

Mr. KARTH. When was this spacecraft propulsion research facility completed, for which we are now requesting an addition?

Mr. SLOOP. It was authorized in fiscal year 1963, and it is underway now.

Mr. KARTH. Is it under construction?

Mr. SLOOP. No; not the construction.

Mr. KARTH. No construction has yet started?

Mr. SLOOP. That is right. It is in engineering design.

Mr. KARTH. All right, sir; proceed.

Mr. SLOOP. The second facility is in the amount of $5,655,000, and is an alteration to the space power chambers Dr. Bisplinghoff mentioned earlier. This is a modification of an existing facility which originally was built for altitude testing of piston-type engines. It will provide a vacuum chamber 40 feet in diameter, approximately 100 feet long, and will be complete with pumps and with cryo-panels and solar simulators to simulate the conditions in space.

Mr. KARTH. Is this downpayment, or the total cost of the project?

Mr. SLOOP. Total cost of this project. This is an alteration of an existing facility.

Mr. MORRIS. When was this facility first constructed?

Mr. SLOOP. I transferred to Lewis in 1942, and it was under construction then. So this is an old one. It has been 21 years. I believe they began to design this around 1940.

Mr. ULMER. That is right.

Mr. MORRIS. Approximately 20 years old.

Mr. KARTH. I didn't know we had been in business that long. I mean the space power chambers business.

Dr. BISPLINGHOFF. This was a high altitude wind tunnel, used for testing engines at high altitude.

Mr. SLOOP. I believe it was the first high altitude facility for propulsion built in this country.

Mr. KARTH. Thank you.

Mr. RANDALL. It might be well to clarify—we brought out that Lewis was close to the airport, and ran out of ground. What was there? What had been done at Lewis before we moved from Huntsville up there?

Mr. SLOOP. It was originally planned for and is still basically a propulsion facility.

Mr. RANDALL. Before NASA, but by whom?

Mr. SLOOP. It was planned by NACA, a number of years ago.

Mr. RANDALL. NACA is not too old.

Mr. SLOOP. Yes, sir; 1915.

Mr. RANDALL. Oh, NACA, yes. It has always been under NACA before it was under NASA?

Mr. SLOOP. Yes, sir. The space power chamber is at Cleveland, by the way.

Mr. MOSHER. That is right.

Mr. SLOOP. The third facility is a $2,100,000 alteration to an existing test facility in Cleveland, for electric power equipment. Here we are planning to make use of a building originally designed for testing piston engines. We are moving out some of the equipment in the basement and providing space for testing electrical equipment that can be used in space.

The reason for doing this——

Mr. KARTH. What kind of equipment?

Mr. SLOOP. Electric power equipment, used in nuclear power generation and solar and chemical power generation. The reason we want to use this space is that there is a lot of electrical power available that has been already brought into this area, and we will also use the existing structure.

The fourth facility is a $2,002,000 modernization of an instrument research laboratory at Cleveland. This is to add on to a structure built a number of years ago. It is primarily for instrumentation research and service for the type of research work done in Cleveland. It will involve equipment for the specialized needs of nuclear electric and solar and chemical power generation systems.

The fifth facility is a $1,316,000 addition to the Plum Brook station in the propellant flow systems facility. It consists essentially of two big tanks, one a supply tank of liquid hydrogen, which is a cry-

ogenic storage vessel, and a receiver tank. We can run liquid hydrogen from the supply to the receiver tank, passing through experimental equipment in between the tanks. The experimental equipment consists of such things as pumps, valves, and so forth.

The unique feature of this facility is the size of the flow system. It will have the ability to test components up to approximately 18 inches in diameter, so it is a very large flow system. To my knowledge, there is no existing facility like this in the country.

Mr. KARTH. Mr. Morris.

Mr. MORRIS. Won't you be testing fuels that will be somewhat hazardous? Liquid hydrogen; isn't that considered hazardous?

Mr. SLOOP. This will use liquid hydrogen; yes, sir.

Mr. MORRIS. What about the safety of the surrounding population?

Mr. MOSHER. This Plum Brook annex is away from the metropolitan area.

Mr. SLOOP. This has been spaced according to safety manuals and practices as agreed upon by the various Government agencies.

Mr. MORRIS. Doesn't temperature affect the safety of liquid hydrogen?

Mr. SLOOP. Well, it is about minus 420°, and if you spilled some it would immediately vaporize and, being lighter than air, it would immediately rise. It will not ignite spontaneously in air, but it ignites very easily. The ignition limits of hydrogen in air are very wide.

This will increase the existing facilities already at Plum Brook in fluid dynamics.

The sixth facility is a propulsion component evaluation facility which is at the Lewis Research Center, and, again, this is a modification of existing facilities to provide the kind of tools we need in this new space age, namely, vacuum chambers to simulate the hostile environment of space. In this particular alteration we intend to investigate components subject to vibration, low pressure and a temperature range.

This is just a quick description of these facilities, Mr. Chairman. I will go into more detail if you wish. But I am open to questions at this time.

Mr. RANDALL. One question, Mr. Chairman, please.

Mr. KARTH. Mr. Randall.

Mr. RANDALL. This last item here, one million four, back on the $1,316,000, you said there was no facility like this in the country. That is fine. On the last one, the component evaluation facility, that is the vibration, pressure, temperature points of view, isn't it true that some private industries are doing this same thing right now? And I will ask you directly, Isn't it true that Douglas at Tulsa is doing this very same thing right now?

Mr. SLOOP. I don't know of the particular facility, at Douglas. But I can answer, yes, that there are a lot of companies that shake, rattle, and roll their equipment to make sure it goes through the necessary environmental conditions. This we think is good.

One of the things that is absolutely essential, I believe, for reliable spacecraft is to subject all of its parts and its components to very vigorous environmental tests, and such tests are necessary at a number of different places. It is necessary at the developer or manufacturer's plant, it is necessary at research centers such as we are talking about here——

Mr. RANDALL. Couldn't there be findings and conclusions reached—assuming Douglas is just interested in quality control for their own product, I think you are saying, but hasn't the ground been plowed? What do you seek to find out here beyond what has been found out already?

Mr. SLOOP. We know very little about the conditions we will find in space. What we are trying to do in our space-simulation facilities is to get a better knowledge of what the equipment will do, how it will behave under space environmental conditions. This means we do need these kinds of facilities. It means we need research data versus ad hoc testings. What we are really after here is research data whereas the other test at a manufacturer's plant is more a proof test sort of thing.

We are trying to find out why things behave as they do, why they break down, what are the things we must design for. This is the type of thing we do in research. We are not seeking to proof test someone's product here at all, but trying to learn about the behavior of devices under the environmental conditions of space.

Mr. RANDALL. You have mesmerized me again.

Mr. SLOOP. I am sorry.

Mr. KARTH. Colonel Gould.

Colonel GOULD. In furtherance of the chairman's questions on the space chambers, I notice this new project has 11 new chambers in it. Would you explain specifically what these 11 new chambers are needed for?

Mr. SLOOP. There are six bell chambers, 3 cubic feet, at vacuums of 10^{-8} to 10^{-9}. I am reading a list that is in the budget request; two vacuum chambers 20 to 100 cubic feet——

Mr. KARTH. Stopping at the six bell chambers for a moment, why do we need six of them?

Mr. SLOOP. We have a number of different research projects that require a vacuum. This is the environment that our spacecraft equipment must work in. Therefore, it is necessary to investigate or to study the behavior of equipment or materials such as valves, mechanisms, devices, under the environment of space. It is a basic environmental condition that we work with. We must find out, for example, if elastomers flow or creep in a vacuum. We must find out about the cold welding of metals or lubrication problems in space.

So, Mr. Karth, a vacuum chamber is a basic tool.

Mr. KARTH. What problem areas do we have, which problem areas will be researched in these six bell chambers? You give me six problem areas, answers to which will be attempted to be found in these six.

Mr. SLOOP. All right. Take lubrication, friction, and wear.

Mr. KARTH. This is one of them?

Mr. SLOOP. Yes.

Mr. KARTH. What is a second?

Mr. SLOOP. Leakage, fittings, how do you keep fittings from leaking in the environment of space?

Bearings, which is a subpart of lubrication, friction, and wear.

Valves——

Mr. KARTH. We can't test those two things at the same time? It sounds pretty integral. Why do you need two different chambers?

Mr. SLOOP. We are talking about the tools needed for a professional staff of around 1,000 people. They need different types of equipment for many different studies. They need equipment to conduct their studies.

In answering your question I am trying to visualize some of the problems that will be investigated.

Mr. KARTH. Of this thousand, we won't have a dozen people over here who feel they need a valve chamber to make tests and another dozen over there who feel they need a chamber to make tests? I don't say it is necessarily duplicative. But is it in this instance?

Mr. SLOOP. We have a very well thought out and integrated research program. This is the responsibility of the research leaders, to see that there is no needless duplication.

Mr. KARTH. You are not aware of whether or not that would be the case in this instance, in the request for six bell chambers; is that correct?

Mr. SLOOP. I am certain the men working on projects using these six bell chambers will not be doing things of the same type. This is the duty of their supervisor, of course, to be sure they are working on pertinent problems which are necessary in the space effort.

I might add at this point that nothing is more distasteful to a research worker than to duplicate someone else's work.

Mr. KARTH. Well, I might add, too, there is nothing more distasteful to a researcher, I think even more distasteful than the illustration you gave, than not to have every single facility he wants to have to do his research in. That is the most distasteful thing to a research man, as I recall it from when I went to school. Isn't that true?

Mr. SLOOP. A research man likes to use his ingenuity and imagination, and simulate——

Mr. KARTH. That is true, but those of us who are not researchers must on occasion evaluate those things from a little more practical standpoint, and use judgment that the researcher probably finds he cannot exercise.

Mr. SLOOP. That is correct. That is why in our budget reviews we have gone into these things very carefully.

Mr. KARTH. Yes.

Colonel Gould.

Colonel GOULD. Do you have anything more to say about these vacuum chambers?

Mr. SLOOP. Did I answer your question?

Mr. KARTH. He answered one, and I think I stopped.

Mr. SLOOP. Would it help if I tried to explain why we need different sizes?

Colonel GOULD. Yes, sir.

Mr. SLOOP. The kinds of projects we are visualizing require different sizes. For example in systems we must put together a number of components to make them work as a system, and this requires larger volume than a smaller experiment, such as a basic materials study. The latter might be a study of cold welding of two materials, which requires only a small vacuum chamber. If you were studying leakage problems of a large turbopump you might want to put the pump in the chamber along with auxiliary equipment and this takes space.

By having a variety of sizes we are able to select a chamber which best fits the experiment. This will save power and pumping equipment. As you know, it takes time to evacuate to a high vacuum.

Mr. KARTH. But it won't save cost in building vacuum chambers, will it?

Mr. SLOOP. It does. If we tried to build them all to handle the largest size it wouldn't save money; don't you agree?

Mr. KARTH. It might if we built 5 big ones instead of 11 small ones. It probably wouldn't if you built five big ones instead of five small ones.

Mr. SLOOP. Time is a big factor here.

Going back a moment to another kind of facility, say a wind tunnel, we used to make as many as 10,000 measurements in 1 evening in some of our supersonic wind tunnels and investigate a large variety of variables in a relatively short time. In space, time and what happens over a period of time is important. For example, consider the behavior of materials in a vacuum over a long period of time: You may have one experiment that will tie up one vacuum chamber for 6 months, and if you had only one or two vacuum chambers you would very drastically restrict the progress we could make. We need to forge ahead simultaneously on some of these problems, and that is why it requires a number of vacuum chambers.

Colonel GOULD. Mr. Sloop, how many vacuum chambers exist at the present time at Lewis?

Mr. SLOOP. I believe we have a list of that, sir.

Mr. KARTH. Then, could you supply for the record the number and size of vacuum chambers that exist within NASA at their various research centers?

Mr. SLOOP. Yes. I believe such a list has been already made and is available for the record.

Mr. KARTH. Could you supply that for the record at this point?

Mr. SLOOP. Yes. Would you like to see it?

Mr. KARTH. Yes. I assume it answers the colonel's question, as well, as to how many vacuum chambers we have at Lewis.

Colonel GOULD. Are they all listed here?

Mr. SLOOP. They are as far as I know.

Mr. ULMER. In making a compilation of this kind, you have to have a cutoff point. I believe we have only those environmental chambers with an interior dimension of 6 feet or over. We have not listed the small bell jar-type of laboratory facilities which are essentially laboratory tools.

Mr. KARTH. Those are what you would, without embarrassment, call vacuum chambers; is that right?

Mr. ULMER. Yes, sir, Mr. Chairman. It is like a machine shop; you need a lot of small tools, and then you also need more substantial facilities such as planers, lathes, and shapers.

Mr. RANDALL. With the contractors with which NASA is now contracting, can you tell us how many vacuum chambers there are scattered around over the country, great big ones, wide ones? I would like to know that. I think maybe they might be used by someone other than the contractor. Maybe contract for the use of them. I don't think you can do it now.

Mr. SLOOP. I don't have a list of those.

Mr. KARTH. Dr. Bisplinghoff, before you make a request such as you have made this year for 11 new facilities, do you survey the industry at all to find out whether or not the capability to do this job that needs to be done actually exists someplace in the country? I know this is difficult, but these are difficult days. Do we do this?

Dr. BISPLINGHOFF. We do not make a specific survey of industry. However, a large part of our R. & D. budget goes into industry for research and advanced technology, in the OART case—some 70 percent of our R. & D. funds go into industry, and we assume industry will tool up its research laboratories, and will purchase environmental equipment sufficient to carry out this research.

Mr. KARTH. They are probably tooled up so well today that we wouldn't have to do some of these things.

Dr. BISPLINGHOFF. We make a very careful survey of our in-house capabilities in this area, however.

Mr. KARTH. It might well be that our in-house capabilities are very much duplicative of our private industry facilities; isn't that right, sir?

Dr. BISPLINGHOFF. I think you would find duplicative facilities in-house and in industry, but I believe it is necessary because as Mr. Sloop pointed out, some duplication is necessary.

Mr. KARTH. I would agree a certain amount of simultaneous testing is necessary. But if you made a blanket statement that all the duplication that exists is necessary I wouldn't agree. I doubt if you could say that all of it that exists is necessary, welcome, or needed.

Dr. BISPLINGHOFF. I agree there is a certain amount of duplication which has occurred, that we cannot avoid. However, we are doing everything we can to avoid as much of it as possible.

Mr. RANDALL. This is not a question, but I notice, observing the full committee, we sometimes have a member who wants something to be in the record, and I would like this to be in the record: That I have observed chambers, devices to test, much as we are talking about here, that I am firmly convinced are not in use at all times. Whether the ad hoc distinctions or the pure research applies or not—it may have an ad hoc purpose. But I am convinced there is a great deal of the time of a year or month that that is not in use and might be contracted to be used by NASA to avoid duplication of some of these facilities.

That is a statement, not a question, Mr. Chairman.

Mr. KARTH. Colonel Gould.

Colonel GOULD. Turning now to the spacecraft propulsion research facility, to get that in the proper perspective, a space propulsion facility was authorized in fiscal 1963 in the amount of $6,275,000.

Mr. SLOOP. That is correct.

Colonel GOULD. Is this project in addition to the 1963 item?

Mr. SLOOP. Yes.

Colonel GOULD. What is the status of the fiscal year 1963 item?

Mr. SLOOP. It is in design.

Colonel GOULD. Construction has not been started?

Mr. SLOOP. That is right.

Colonel GOULD. When is it anticipated that construction will get underway?

Mr. SLOOP. I have a schedule. I believe actual construction will start this year. It will start—I have one item that says November.

I am not sure it is the first item of breaking ground, or not. It will be November or sooner.

Colonel GOULD. How long is it going to take to complete the fiscal year 1963 item?

Mr. SLOOP. Scheduled for completion January 2, 1965.

Colonel GOULD. This addition, would you proceed to modify the construction contract to include this addition and make it one package, or will this be a separate contract? I am speaking of the fiscal year 1964 item now.

Mr. SLOOP. I am not sure of that. I believe there is a separate design for the addition which would not interfere with the fiscal 1963 plan. However, I believe that they will be made compatible, so that there is no rework or modification to the fiscal year 1963 plan to do what we ask for in fiscal year 1964.

Mr. KARTH. May I interrupt at this point? If these two things were tied in with each other at this date it seems to me that we wouldn't necessarily have to spend the $6¼ million that was authorized earlier, and the $3½ million that you are asking to be authorized now. If both projects were authorized it seems to me these figures could be adjusted so as to represent a combined effort, an integrated effort. The architecture and engineering work could be less. It wouldn't be two separate projects, is my point.

It seems to me the total, which is now $9¾ million, the same work could probably be done for $6¾ million.

How much consideration has been given to that proposition?

Mr. SLOOP. I believe that the addition—that the fiscal 1963 authorization and design is such that the fiscal 1964 request can be added without any additional change or modification. In other words, it is planned that the fiscal 1964 addition will fit in. It may take a moment of explanation here. The fiscal 1963 facility provided the basic facility and the capability of operating a propulsion system at approximately 100,000-foot altitude. In fiscal 1964 we wish to add cryopanels and solar simulation and additional vacuum pumping equipment so that the spacecraft will be subjected to all environmental conditions.

Mr. KARTH. Is this all for Centaur?

Mr. SLOOP. No, sir; this is not Centaur. This is for research.

Mr. KARTH. I thought we had to do a little on Centaur yet.

Mr. SLOOP. There are other facilities for Centaur, sir. The fiscal year 1964 additions will allow us to simulate a space propulsion system as it coasts through space for a long period of time, alternately heated and cooled depending on its orientation to the sun and also in vacuum. There is one vacuum system that takes care of the rocket exhaust gases, an ejector system, corresponding to that of about 100,000-foot altitude; and a second vacuum system to simulate the vacuum that surrounds the spacecraft. The second is a greater vacuum, 10^{-8} millimeters.

The fiscal year 1963 and 1964 would then make a complete facility for space simulation of nontoxic propellants.

Mr. RANDALL. I thought I heard you say—what type of panel?

Mr. SLOOP. I called it a cryopanel. That is a name for a panel that is cooled by liquid nitrogen so that it is a heat sink. It simulates the coldness of outer space, so that a warmer section of the spacecraft can lose heat to it by radiation.

Colonel GOULD. Has the design on this been initiated yet?
Mr. SLOOP. Yes.
Colonel GOULD. What funds were used to initiate this design?
Mr. SLOOP. $335,000.
Colonel GOULD. Is this from fiscal year 1963 advanced funds?
Mr. SLOOP. Yes.
Mr. KARTH. Excuse me, who did the design work? Who did you use to do the A. & E. work?
Mr. ULMER. Individual architect-engineers are selected for each project. We negotiate for these services by examining the competence of several architect-engineers and selecting one who might do the best job.
Mr. KARTH. Negotiated by whom; NASA?
Mr. ULMER. By NASA for those projects for which it carries the construction management responsibility. The Corps of Engineers does it in the cases where we have assigned the responsibility to them. On the job Mr. Sloop is talking about, a group of experts is convened at the Lewis Center and they constitute a source selection board to review the qualifications of potential architect-engineers. This is done individually project by project.
Mr. KARTH. Thank you.
Colonel GOULD. There is $335,000 included for design in the 1964 project; is that the same amount?
Dr. BISPLINGHOFF. Yes.
Colonel GOULD. So this project could be reduced by $335,000; is that correct?
Mr. SLOOP. Yes.
Mr. MYERS. That is right.
Mr. KARTH. Why is that in there?
Mr. ULMER. Mr. Chairman, it is essentially a matter of time. At the time we put together the budget you see before you, we were just in the process of learning what our current year's budget would be. We did not at that time have the appropriation from which to allocate the advanced design money for the facilities we would be requesting in the budget that is currently under review by Congress. After the 1963 appropriation was provided, we identified the highest priority projects that had to be placed under design to keep the program moving and allocated advanced design money for those projects.
Colonel GOULD. I think used the word "duplicates." I think that is correct in the sense that we use some design money to start work on certain facilities for which we are requesting design money in the coming budget. In those cases we identify these funds as the first place to take any appropriation cut. If the Appropriations Committee cuts our budget below the authorization, these funds immediately drop out. If we have a situation where the appropriation is identical to the request—we have not yet experienced such a situation—this money would be available for other uses. So this is the first place we would take any cut.
You understand that the advanced design account is used both for getting an advance start on the next year's facilities, as well as to start the design of facilities that might be requested in subsequent budgets.
Mr. KARTH. I think I understand it, including the reasons you do it. Thank you.

Colonel GOULD. On the second project, the alteration to the space power chambers; last year, out of fiscal year 1963 money, I think I am correct, you reprogramed $316,500 for modification of the space power chamber, also. Then in the 1962 program you had a modification to the space environmental tank amounting to $1,142,000. What did these two prior actions involve?

Mr. SLOOP. The altitude facility is essentially a large tank, making a complete circle, that has been subdivided to make several individual environmental chambers. I believe the $1 million item you mentioned was for a Centaur vehicle test chamber in the same big facility. We are talking about taking another part of the same facility and making another space chamber. This will be, I believe, the second space power chamber, made out of this former altitude wind tunnel facility.

Colonel GOULD. Over a period of 3 years, including this project, we are spending quite a lot of money for modifying this chamber. Are there any more modifications beyond fiscal year 1964?

Mr. SLOOP. I don't know of any. But I would like to point out, here is a case of using existing equipment to make an installation at less cost then if we did it from the ground up. For example, we are using the existing vacuum pumps and the walls of the tunnel. We are putting a smaller inner chamber inside the tunnel and maintaining a pressure between the two walls of the order of 10^{-2} millimeters of mercury. This reduces the cost of the inner chamber. We are taking advantage of existing equipment.

Mr. KARTH. All of the costs total up to exceed the cost of the new facility if you started over; isn't that so, Mr. Sloop?

Mr. SLOOP. I don't think so. I am sure if you built these facilities from the ground up it would cost more than the alterations.

Mr. KARTH. I mean the alterations plus the sum of the original facility. I am talking about total cost versus total cost.

Mr. SLOOP. The facility exists. This was a case of modifying an obsolete facility for a new use.

Construction of this facility was underway in 1942, so this is a very old facility.

Mr. KARTH. I see; I understand.

Mr. SLOOP. If in future years they find another way to modify this facility to adapt it to the new requirements, I am sure we would come back to ask for more money for modification.

Mr. KARTH. If it was originally constructed in 1942 I understand the need for modification.

Colonel GOULD. For the record, I will point out that this project includes another vacuum chamber.

Mr. SLOOP. Yes, sir; 40 by 100 feet.

Mr. KARTH. We don't have any more 40- by 100-foot vacuum chambers, do we?

Mr. SLOOP. I am not sure of the size of the chamber for Centaur, in the other end of the same building. I think it is smaller.

Mr. RANDALL. For the purpose of the record, would Colonel Gould cite where he is getting this figure for this last vacuum chamber?

Colonel GOULD. It is located on page CF7-7, sir.

Mr. RANDALL. Thank you.

Colonel GOULD. I notice the cost per square foot of the access building is $46. Would you explain the reason for that apparent high cost?

Mr. SLOOP. It is 65 feet high, and this may be the reason.

Colonel GOULD. Has the design been started on this facility?

Mr. SLOOP. I do not believe it has.

Can you answer that, Mr. Myers?

Mr. MYERS. The money was provided for design and I am not sure whether the design is actually started. I could check and get it for you.

Mr. KARTH. Is there anyone in the audience who might be able to answer?

Mr. ULMER. It has not been started. The money was just released in the last week, I believe.

Colonel GOULD. That is from fiscal year 1963, in the amount of $550,000 shown here?

Mr. ULMER. I beg your pardon. The $550,000 was released in January, so it is likely the design is underway. It was the $335,000 which was released a few weeks ago.

Colonel GOULD. On the electric power equipment test facility, shown on page CF7–8, you show that no facilities for the testing of electric power equipment exists at Lewis. Do they exist anyplace else?

Mr. SLOOP. To my knowledge, the facilities we are asking for, testing power generation equipment in a vacuum, will be unique. I have not studied all the possible facilities in the country. This facility will require specialized equipment such as variable frequency equipment, and speed drives up to 15,000 horsepower. The types of equipment and tests that we envision in space exploration are quite new. It is my opinion that this particular facility will be unique. It uses a large amount of electric power, it uses vacuum chambers, and it uses motor drives, and, of course, these are not unique. It is the bringing together of these components for this purpose, and using them for research in power-generation equipment, which I think will give us a head-start in this area, and this is why we have requested it.

Colonel GOULD. This project, I notice, includes a solar simulator. What type will that be?

Mr. SLOOP. I am not certain of the exact type. We recently had a conference within NASA on solar simulation equipment. Mr. Ames sponsored this conference. At that time they reviewed the various types of lamps and other electrical methods of simulating the Sun's radiation. I might say that none of them are exactly duplicative of the spectrum we would like to have. This is an area Dr. Bisplinghoff mentioned earlier, where, as we became more proficient in simulating the Sun's radition, we will undoubtedly revise our equipment. This is a continuing problem at this time.

I think they use xenon and carbon arc lamps. The carbon arc lamps are packed with some rare earth metals so that the radiation from these rare earth materials will more exactly duplicate the Sun's spectrum.

Do you wish to add to that, Mr. Ames?

Mr. AMES. I think you covered it very well.

Colonel GOULD. The modernization of the Instrument Research Laboratory—this is on page CF7–18—involves a new wing which will contain offices, laboratories, and specialized equipment, as I understand it.

Mr. SLOOP. That is correct.

Colonel GOULD. How much of the space that is going to be added will be devoted to administrative space?

Mr. SLOOP. It depends on your definition of "administrative." I would say that the 10,000 square feet of office space requested will be for research people and their supervisors, and these we do not classify as "administrative." By "administrative," if you mean clerks, procurement people, general administrative, they will not be there.

Colonel GOULD. How many people will be accommodated in the 10,000 square feet you have requested here?

Mr. SLOOP. One hundred.

Colonel GOULD. Since this is an addition to an existing building, the cost of the utility installations and connections appear to be rather high. Is there any special reason for this?

Mr. SLOOP. It will require a very large amount of electrical power for the types of equipment to be used. The work includes liquid metal instrumentation, a low-temperature measurements, mechanical equipment, electronic equipment, things of this sort. I don't have an exact answer to your question. I could investigate it further, if you would like.

Colonel GOULD. Has this facility been designed yet?

Mr. SLOOP. It has not.

Mr. LITTELL. There is a reason for the higher utility costs, Colonel. Rerouting of gas and sewer lines, because of the geography of that particular location.

Colonel GOULD. The gas and the sewer lines only account for about $26,000 of this total.

Mr. SLOOP. Twenty-eight. The largest item I notice is in electric power and communications.

(The information requested is as follows:)

MODERNIZATION OF THE INSTRUMENT RESEARCH LABORATORY, LEWIS RESEARCH CENTER

Electric power and communications, $40,000.—The electric power and communications item includes extension of 2,400-volt feeders, revision of the associated distribution system, installation of new telephone cable to the private automatic exchange (PAX), installation of additional telephone equipment in the PAX, and installation of the necessary dust banks. The detailed estimate of the equipment and installation costs is as follows:

Transformer, 2,400 to 208 volts, 225 kilovolt-amperes	$6,150
Transformer, 2,400 to 480 volts, 100 kilovolt-amperes	3,800
Circuit breaker, 2,400-volt	4,500
Powerline extension	1,450
Telephone line extension, 100 pairs, lead covered, 1,200 feet	4,550
Switching equipment for 100 telephones	12,900
Telephones (100)	650
Relocation of existing powerloads	800
Potheads and terminations	650
Extension of 2,400-volt power from engine research building	4,550
Total	40,000

Colonel GOULD. What is the item of "Special research and evaluation equipment"?

Mr. SLOOP. A helium cryostat, transducers for temperature, high frequency voltage; laboratory standards, things like that.

Mr. KARTH. It seems like you should be able to buy that stuff a little cheaper.

Mr. SLOOP. A helium cryostat is a device for liquefying helium, which is around 4° Kelvin or near absolute zero. It takes special refrigeration equipment to do this.

The laboratory standards, are quite expensive.

Mr. KARTH. Laboratory standards?

Mr. SLOOP. Yes, standards for example, of pressure gages, temperature standards, things of that sort.

Mr. KARTH. Maybe we have some in surplus with the Army or somewhere.

Mr. SLOOP. We will certainly make every effort to use existing equipment.

Transducers for temperature, and pressure, are often very special, and here we do have a problem of finding what we want commercially. I can cite an example of pressure transducers for measuring pressure oscillations in rocket engines. We have been working on this problem for many years. It is a very difficult problem. It is difficult to get instrument people to work on specialized equipment where the end use is only a few devices. A great deal of work has to be done to make new or adapt existing equipment to the special needs of the experiment. There needs to be a very close liaison between the research man and the instrument man who is helping him measure his unknowns. It takes a knowledge of the particular situation. I feel that there must be a give and take between a research man and an instrument man to obtain the best measurements. Research work is only as good as the things measured, I feel this is an area we cannot emphasize too highly in research.

Mr. KARTH. Isn't there a lot of research going on in the transducers field right now?

Mr. SLOOP. We have a contract with Princeton University for $75,000, to investigate pressure transducers for combustion oscillations, in fiscal 1963. I believe there is additional work to be completed in the coming year. This is a very difficult problem. The reason it is difficult is that our requirements keep rising sharply. For example, we ask a pressure transducer to follow oscillations of several thousand cycles per second in an environment where the heat transfer may be as high as 20 B.t.u.'s per square inch per second, which means we have to have a very excellent cooling method. We must both cool this pressure transducer and ask it to be very sensitive to small pressure variations at the same time so one requirement makes problems for the other. As we get more sophisticated we ask for transducers that can respond to higher frequencies than before, and to work in a hotter environment.

We constantly push forward the frontiers of what we can measure, as we get more curious or measure new things. This means laboratory measurements and instrumentation are in a constantly changing state as we seek to improve and measure things better.

Colonel GOULD. That is all I have, Mr. Chairman.

Mr. KARTH. Are there any further questions?

I thought we could possibly take one more. The reason I suggest that, Doctor, is because I would like to finish tomorrow.

Dr. BISPLINGHOFF. We would be happy to go on. Mr. Ames is ready to go right now.

Mr. KARTH. Mr. Ames.

Mr. AMES. Thank you, Mr. Chairman.

First, I would like to discuss with you our request for authorization for a structural dynamics laboratory at the Ames Research Center. This laboratory will cost us $1,644,000. It will be completed in 14 months. This is a unique building in that it has a 100-foot-high section with 2,500 square feet of floor area, with a special foundation. Another section is 30 feet high. The floor area would be 10,500 square feet. Then we have a third area for equipment and offices, which is 6,000 square feet.

The construction cost of this special building will be $814,000, and the equipment to go in it, which would include shakers, heat sources, and so forth, will cost $830,000.

Now, the proposed structural dynamics laboratory would provide us with means for extending some very important research work which we are doing on buffeting of launch vehicles to studies of complex factors such as acoustic loads in a high temperature environment on not only launch vehicles, but also on future reentry vehicles.

In the past the work on launch vehicles has been conducted in subsonic and lower supersonic speed wind tunnels where temperature effects have been unimportant and where we have not considered the effects of noise. We propose to extend this work, because of the extreme competence of the group at Ames, to reentry vehicles where higher velocities, high temperature, and acoustical effects are important.

Essentially this facility would be used to provide us with a realistic environment to check out the dynamic models which we would be testing in other facilities.

I could go on, sir, but I would like to stop at this point to ask if you have any particular questions on this facility. Our objective here is to pull together work which has been spread all around the center wherever space might be available, where calibrations of dynamic models were often delayed because of other tests going on in this area. We feel it is necessary now to expand this work because of new environmental factors that are becoming important, and to centralize this activity and equipment. This is our primary objective in asking for this facility.

Mr. KARTH. How many such laboratories exist in-house in Government today, do you know?

Mr. AMES. For this particular type of work I know of no other laboratory which could be used to calibrate models of this nature.

To give you one example of work that this facility did, I mean this group of people——

Mr. KARTH. We must certainly have laboratories that calibrate a good many things in structures that might be a little different.

Mr. AMES. Our purpose here is to test these models in wind tunnel environments.

Let me give you one example of a problem we anticipate. Take a hypothetical case, perhaps in Dr. Newell's program, where he wants a spacecraft to go into the Mars environment; in other words, it must enter a planetary atmosphere. The gravitational field there is one-

third that of the Earth, and the atmosphere close to the surface is about one-tenth. We could try to land a spacecraft which may, for example, erect an antenna, or may carry with it a fuel tank and rocket engine so it could leave that environment and return to the Earth.

I agree this is a long-range research problem. But there are many difficult structural problems involved in this mission.

Mr. KARTH. No question about it. But the key to this whole structural testing we are talking about is the wind tunnel, isn't it?

Mr. AMES. Yes sir, here the purpose is to provide a research facility at Ames Research Center where these delicately constructed models could be calibrated in the heat environment, noise fields, and vibration environments before putting them in the wind tunnel. There is no request for a wind tunnel here, simply an extension of the use of a competence at Ames where we have done an outstanding job.

Because of the outstanding competence of this group, Dr. von Braun was anxious to have them conduct the dynamic wind tunnel testing on the Apollo-Saturn combination, using a flexible model in the wind tunnel.

Mr. KARTH. You would make a request for the Houston Space Flight Center for such a structural dynamics facility, would you?

Mr. AMES. I would anticipate we might well make one, one of these days, if we have a need for such a facility. We don't have at the moment.

Mr. KARTH. You have heard of the Houston Space Flight Center?

Mr. AMES. I certainly have, sir.

Mr. KARTH. And there is no structural dynamics facility request in the budget for the Houston Space Flight Center this year, is there?

Mr. AMES. Not to my knowledge, to do this type of work, where we calibrate those models for wind tunnel tests.

Mr. KARTH. Colonel Gould.

Colonel GOULD. Following up the chairman's question, there is included in the 1964 program a Hot Structures Test Facility at Langley and an Atmospheric Reentry Materials and Structure Evaluation Facility at the Manned Spacecraft Center. Both of those projects appear to be required for studies in the areas of vibration and heating problems. Would you please explain the relationship between those two other facilities and this one?

Mr. AMES. Facilities requested at Manned Spacecraft Center, as is the case for the facilities at Marshall, are in direct support of approved flight programs where ad hoc proof-testing is required of materials which have been selected for use in specific des[illegible], such as fastening a heat shield to the Apollo capsule, which is a major problem in technology. That would be my understanding of the facility requested for the Manned Spacecraft Center. But that is not a facility for the calibration of models for sophisticated research testing in hot wind tunnels.

Now, the Langley facility——

Colonel GOULD. The Hot Structures Test Facility: It is included in one of the projects as a subitem, I believe.

Mr. AMES. I think I know the one you refer to.

Dr. BISPLINGHOFF. Hot gas radiation research facility?

Colonel GOULD. The one I had reference to is included in a project as a subitem.

Just a moment, please. It is in the Fatigue Research Laboratory.

Mr. AMES. I am going to address myself to that in just a minute.

Colonel GOULD. Tell us right now what the relationship is between those two, would you please, in general terms?

Mr. AMES. Yes. Well, this work at Ames is devoted specifically to the vibrational characteristics of a vehicle system where the local structural stresses are important. For example, you are familiar with the fact that as the launch vehicle takes off, a high noise field reflects back from the Earth and acts on the vehicle and as we accelerate through the atmosphere we have buffeting on the vehicle, and some heating effects also. As the vehicle reenters or enters, a planetary environment it might carry along with the spacecraft the means for returning from that planetary environment, and we would have aerodynamic problems that cause local buffeting and structural excitation. These are short duration dynamic loads. The facility referred to at Langley is a fatigue facility where many cycles of loading and unloading in very complex combinations are involved. The fatigue facility at Langley is an extension of our Langley structures activity, and is related to both aeronautics and to space flight.

One of the major objectives of this fatigue research center at Langley would be to test hot wing structures, loaded and unloaded many, many times, such as you would have during the operation of a supersonic transport, or perhaps even the TFX. Conditions covered at the Langley facility, I believe, do not exceed 4,000°.

Mr. KARTH. I am not sure why we are doing all this advanced way-out research. I am not aware, you see, of any specific goal. I am aware of one goal, the manned lunar landing and return program. I am not aware of any other national goals where this advanced technology or advanced research may be applicable. So before I forget it, I would request of NASA that they provide me with a new 10-year plan. I assume we have updated the 10-year plan. I would ask NASA to provide me with a new updated version of the 10-year plan I saw last year.

Mr. AMES. May I try to give you a quick reply?

Mr. KARTH. I am not sure I need a quick reply. I think all I need is an updated 10-year plan, so the subcommittee can better evaluate whether or not we really need all of these advanced research projects.

Mr. AMES. That is why I wanted to try to give you a quick reply—do I have your permission?

Mr. KARTH. Yes, sir; you go ahead. The only reason I am a little hesitant is because we have a quorum call on right now, and this committee is going to have to adjourn.

Dr. BISPLINGHOFF. We will supply an updated 10-year plan.

(The information requested is as follows:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION,
OFFICE OF THE ADMINISTRATOR,
Washington, D.C., May 15, 1963.

Hon. JOSEPH E. KARTH,
Chairman, Subcommittee on Space Science and Advanced Research and Technology, Committee on Science and Astronautics, House of Representatives, Washington, D.C.

DEAR MR. CHAIRMAN: This is in response to your letter to me and subsequent request to Dr. Raymond L. Bisplinghoff, Director, Office of Advanced Research

and Technology, during hearings before your Subcommittee on Space Sciences and Advanced Research and Technology on April 29, 1963, for an updated version of the 10-year plan that you received last year. Upon review of this matter with the Office of Plans and Program Evaluation, it has been found that the plan that you previously received is the latest NASA plan.

In context with your line of questioning, however, it is proposed that the attached statement be inserted in the record (p. 1923 of transcript) as the official mission of the NASA Office of Advanced Research and Technology.

Sincerely yours,

PAUL G. DEMBLING,
Director, Office of Legislative Affairs.

MISSION OF THE OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY

GENERAL RESPONSIBILITY

The Office of Advanced Research and Technology is responsible for the planning, direction, execution, and evaluation of all NASA research and technological programs conducted primarily to demonstrate the feasibility of a concept, structure, component, or system that may have general application to this Nation's aeronautical or space objectives. Mission-oriented research and technology programs are the responsibility of the cognizant headquarters program offices; however, the Office of Advanced Research and Technology is responsible for the overall review of the complete NASA advanced research and technological programs.

TECHNICAL AREAS OF RESPONSIBILITY

The technical areas of responsibility of the Office of Advanced Research and Technology include—

(a) Spacecraft technology.
(b) Launch vehicle technology.
(c) Space power generation.
(d) Nuclear systems technology.
(e) Electric propulsion technology.
(f) Liquid and solid rocket propulsion technology.
(g) Life sciences technology.
(h) Aeronautics.
(i) Electronics and control.

These program areas in turn are supported by research on materials, loads, structures, fluid mechanics and aerodynamics, liquid and solid propellant rockets, air breathing propulsion, electronics communications, and control, space vehicles, electric power generating systems for space vehicles using solar, chemical, and nuclear energy sources, electric rockets, nuclear rockets, rocket propellants, biotechnology and human research, V/STOL aircraft, aircraft operating problems, X-15 research aircraft, supersonic transport.

These more specific categories of research in many cases relate to both space and aeronautical activities as there are numerous mutual contributions. These were discussed in more detail in Dr. Bisplinghoff's opening statement before your committee on March 27, 1963.

In carrying out its mission in the areas listed above, the Office of Advanced Research and Technology has the responsibility of working 5 to 10 years ahead of any project requirements in order to obtain research data that are needed to make sound technical decisions and to assist in the guidance of NASA top management and in the establishment of national goals for space and aeronautics activities to maintain U.S. preeminence as charged by the NASA Act of 1958.

Mr. AMES. We started advanced research work, in 1952, on space flight over many objections and it took us many years to solve the basic problems of, for example, reentry with a man. We achieved the first ballistic missile reentry 5 years after the blunt-nosed vehicle concept was conceived, but it took a great deal more development and testing work to do this with a man in 1962.

In 1959, in the Office of Advanced Research Programs, the predecessor to OART, we immediately began to look at manned lunar missions, and we were told just what you tell us now, sir, but, because of our

past experiences we didn't stop, we worked very hard on looking ahead, anticipating that the lunar program would probably begin about 1965. But the Apollo decision was made in 1961 instead of 1965, and since then we have been rushing just to keep our space technology up to date.

Mr. KARTH. That is why I think we should decide more in advance what your future programs are going to be. I am on your side. All I say is: God help us if we don't do a better job than we have in determining where we are going, that is all I am saying.

Has a determination been made as to where we are going? What direction are we following?

Mr. AMES. Dr. Newell mentioned Venus and Mars explorations beginning in 1965 and 1966. I do not believe we can do the job we should do if we base our spacecraft designs for those years on today's technology.

Mr. KARTH. But if they are not going to be manned I am sure we could do away with a lot of the research we are involved in.

Mr. AMES. Those unmanned flights cost about $20 million a shot and we may go through three, or four, or five unsuccessful experiments. I know that once the die is cast on a vehicle program, it is awfully hard to change the vehicle. People say, we are stuck; we have to make it work, no matter what failures we have, and I don't think that is the way we should run the program.

Mr. KARTH. Nor do I. But I think a great deal of the research we are now becoming involved in is, in effect, taking into consideration or assuming you will have manned flight to the planets in the future, as opposed to instrumented flights. I just say if we have none of these manned flights planned at this point in time it seems to me maybe we had either better plan them so we know what our objectives or goals are going to be, or we shouldn't be doing research that will be applicable to a manned interplanetary flight that is not forthcoming.

Mr. AMES. We may have a mission for an unmanned experiment, to land a capsule on Mars, set up an antenna, and send data back to the Earth.

Mr. KARTH. That is true; but we are doing a lot of research. If you could say to me: None of the advanced research you are doing today is being done for the purpose of being applied to manned interplanetary flight later on, I could say to you: Fine, we are going on the right course, because we have no program. But as soon as we have a program I think we ought to do different research.

Mr. AMES. Saturn will give us a tremendous capability to put 5- to 10,000-pound payloads out toward the planets. They don't have to be manned. They could take the course this subcommittee discussed earlier, where we would have heavier, but very reliable subsystems and guidance systems. But if we don't have a configuration that can successfully enter the planetary atmospheres; endure the heating; set up the antennas, and do it remotely, and send back the data we want, the whole experiment would be a failure.

Mr. KARTH. You don't have a program planned for that, though?

Mr. AMES. In research we do.

Mr. KARTH. But in NASA's program, we don't have a program planned on this, even in the package field.

Mr. AMES. I had a discussion with Mr. Cortright, and Dr. Newell, about a year and a half ago, about how to erect an antenna on the surface of Mars, and I showed you some of my work which would lead to such capability.

Mr. KARTH. They are in trouble with Ranger and Surveyor at this point in the road, and Centaur, I will tell you. I am for research. The only point I make is that with limited resources—it is too bad we don't have unlimited, but we don't—but with limited resources we have to take care of the programs that are already initiated, and do all we can to make them successful, including the research you people are doing, which is fine, and you are doing a tremendous job. But maybe we should not be going on into the future, where we really have no definitive programs yet, as much as we might like to. That is the reason for my questioning.

How far out are we going where we don't even have plans to utilize the knowledge, the procedure, or what we are establishing, in the field of advanced research and technology?

I think the committee is going to have to recess now. Dr. Bisplinghoff, if you feel Mr. Ames has anything to add you could bring him back tomorrow.

Dr. BISPLINGHOFF. He has to be at the Pentagon in the morning. I would prefer to let him go there if it is all right with you.

Mr. KARTH. Perfectly all right.

Thank you very much.

(Whereupon, at 12:45 p.m., the subcommittee adjourned.)

1964 NASA AUTHORIZATION

TUESDAY, APRIL 30, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SPACE SCIENCES
AND ADVANCED RESEARCH AND TECHNOLOGY,
Washington, D.C.

The subcommittee met at 10 a.m., the Hon. Joseph E. Karth (chairman of the subcommittee) presiding, in room 304, Cannon Building.

Mr. KARTH. The meeting will be in order.

Dr. Bisplinghoff, it seems to me that yesterday, in addition to your general statement, we heard from Mr. Sloop and Mr. Ames and Dr. Konecci. You can begin with whomever you wish this morning, hopefully so that we can finish the hearing with the five remaining gentlemen.

Dr. BISPLINGHOFF. Thank you, Mr. Chairman.

I have with me this morning Mr. Charles H. Zimmerman, the Director of our aeronautics program, and he will discuss with you the two facilities which we propose at the Flight Research Center. This is Mr. Zimmerman.

Mr. KARTH. Will you proceed please.

Mr. ZIMMERMAN. Mr. Chairman and members of the subcommittee, I would like to speak very briefly in support of the NASA request for the construction of two additional facilities at the NASA Flight Research Center at Edwards Air Force Base.

The first facility I will discuss is a Flight Research Support Laboratory to be constructed in 14 months at a cost of $2,924,000. This proposed laboratory will provide housing and supporting equipment for the flight simulators used in conjunction with and as support for the research flight testing conducted by NASA at the Center.

The principal item of $1,392,000 is for the construction of a concrete building, 165 feet by 335 feet to house the simulators and associated equipment and provide necessary office and working space.

An additional $1,080,000 is requested for equipment, $257,000 for site development, and $195,000 for design and engineering services.

Experience with the X–15 has indicated the need for and value of such equipment, and we expect to make greater use of it in the future flight programs.

The present equipment used in conjunction with the X–15 program is inadequately and inefficiently housed.

This new facility will remedy the existing deficiencies and make reasonable provision for anticipated future needs.

This is the first of the two items.

Mr. KARTH. Does this Flight Research Support Laboratory, Mr. Zimmerman, include research on any of today's programs or is this a research center for future programs that have not yet been defined?

Mr. ZIMMERMAN. It will be used in what is remaining of the X–15 program. It will be very useful in that program and we anticipate it will be used in work that we think we will be doing with the B–70, the TFX, the F–111, and hopefully on a new hypersonic research vehicle that we anticipate in the future.

Mr. KARTH. Where is this to be built?

Mr. ZIMMERMAN. At Edwards Air Force Base, along side of the existing facilities there.

Mr. KARTH. Doesn't the Air Force have facilities of this kind for flight simulators?

Mr. ZIMMERMAN. Not of this type; no. They have some analogue equipment, but they do not have this type.

Mr. KARTH. What is this laboratory equipment primarily? Could we briefly go over that?

Mr. ZIMMERMAN. In a general sort of way, when we purchased or when the Air Force purchased the X–15, they purchased along with it a cockpit setup——

Mr. KARTH. The Air Force purchased it?

Mr. ZIMMERMAN. The simulator itself for the X–15. The Air Force purchased it.

With this simulator we have computing equipment so arranged that the pilot can operate the controls and the computing equipment will put in the necessary inputs which can be fed actually into the cockpit instruments that we have in the airplane simulator sitting nearby.

It can be fed into the airplane controls and we can check out the whole system to simulate an actual flight and what would happen under the actual flight conditions. This is basically what we are trying to do.

Now we are getting a simulator setup with the Jetstar that we are purchasing.

Now, we do this because in research flight testing we are in many cases, you might say, working along the side of a cliff in the dark and——

Mr. KARTH. You are not doing any research on the Jetstar any more, are you?

Mr. ZIMMERMAN. Oh, no; but we have mentioned that we are purchasing or have purchased a Jetstar to be used as a flight simulator in conjunction with the supersonic transport program.

Now, along with this will be ground simulation equipment to be used in conjunction with the flight simulation. This is one additional facility.

Now, this building will also house the space——

Mr. KARTH. You don't have to buy the simulator. We get that from the Air Force. Is that what you are saying?

Mr. ZIMMERMAN. It is included with the purchase of the Jetstar.

This is quite a small, relatively simple item, actually, this particular thing.

Mr. KARTH. What are we buying for this $3 million?

I guess that is my question.

In the way of support equipment? We are building a building, too, are we?

Mr. ZIMMERMAN. We would be building a building.

Mr. KARTH. What are we going to put in it?

Mr. ZIMMERMAN. The items or major items are $200,000 for modernizing the existing computing equipment which is now in existence and will be moved into this building from the present location, plus $220,000 for additional computing equipment.

Mr. KARTH. Who did we buy all of the computing equipment from?

Mr. ZIMMERMAN. I am not aware of who, but I can find that out if you like. I don't know the contractors who would supply this.

Mr. MOSHER. Mr. Chairman, it is purchased, it isn't leased, is that right?

Mr. ZIMMERMAN. This will be purchased. To my knowledge it will be purchased.

Mr. KARTH. Proceed. What other items will go into this building?

Mr. ZIMMERMAN. There is $170,000 for biotechnology laboratory equipment and $275,000 for air-conditioning equipment for the electronic equipment. Those are the major items, on page CF 2–4 in the book.

Mr. KARTH. Is there a request to budget for biotechnology laboratory equipment? Didn't we just discuss this the other day, Dr. Bisplinghoff?

Dr. BISPLINGHOFF. The equipment we discussed yesterday was at the Ames Research Center.

Mr. KARTH. Why do we need biotechnology laboratory equipment, Mr. Zimmerman?

Mr. ZIMMERMAN. If I may answer, the purpose is for actual work with the pilots who are going to fly the aircraft in the conditions of high temperature, high vacuum, and high stress associated with research test flights at extremely high speeds and altitudes.

In fact, what we hope to do in the future is to be able to put the actual cockpit in under these circumstances.

Mr. KARTH. Colonel Gould.

Colonel GOULD. Mr. Zimmerman, on a recent visit to Edwards it was learned that 90 percent of the technology that can be gleaned from the X–15 that has already been, and you spoke briefly of hopefully having future flight projects. Specifically what are these projects beyond the X–15, and when might you expect to be involved in them?

Mr. ZIMMERMAN. The statement that 90 percent of what we get for the X–15 has been gleaned, I think is a mistaken statement.

What we have done is learn 90 percent of what is needed in order to fly the flight profile that the X–15 was designed for.

Now, this building, hopefully, will be available, these facilities, in time to complete it—we have 15 projects lined up.

I don't have the list with me, but I could supply it for you, of those that are now in progress, and in addition, we are making a combined study with the Air Force of the needs in hypersonic research for the future, and we anticipate that we will be using the X–15 to carry out additional research in this hypersonic area.

Now the specific projects we do not as yet have laid out. There is still a lot of discussion of what should and shouldn't be done but we do anticipate that we will be doing this sort of thing.

Now, as you know, the X–15 No. 2 was damaged recently, and the Air Force is proposing that it be rebuilt to go Mach 8 instead of 6, and this will give us additional work in that area that will be important.

Colonel GOULD. Doesn't this type of research, Mr. Zimmerman, lend itself more readily to the Air Force mission and the capability inherent in that agency than it does to the NASA mission?

Mr. ZIMMERMAN. No, sir, definitely not.

Colonel GOULD. Would you comment further on that?

Mr. ZIMMERMAN. The Air Force is set up to check and see if an airplane fulfills the missions set out for it. Our function is to explore what can be done with the airplane to measure things like heating, the effect on structures, the effect on the boundary layer, in these new flight regimes that we haven't entered before, and to see what can be done in the future, so we have an entirely different approach and a different capability.

Colonel GOULD. As a followup question to one asked by Mr. Mosher, why don't you lease your computing equipment rather than buying it outright? In this way you would take advantage of new equipment as it was developed by the manufacturers and it would save modernization costs.

Mr. ZIMMERMAN. I am not prepared to answer that.

Possibly Mr. Ulmer or someone else could.

Mr. ULMER. Colonel Gould, the great majority of this type of equipment is rental equipment. There is some of it that is procured. It depends on the use, the function, the type of equipment, and how long we propose to keep it. There is a decision made in each case as to whether it would be more economical for the Government to rent or to buy.

Now in the R.D. & O. budget I think you will find a complete listing of all of the rental equipment at each center. I believe you will find that the great majority of this equipment is rented.

Colonel GOULD. That is the source from which my question was generated.

Apparently in some instances you decide to buy and in other instances you decide to lease, but it appears as though with the rapid advancement that is being made in the computer field that our computing equipment reaches a stage of obsolescence in 2 or 3 years, at which time we spend great sums of money in modernizing equipment such as we are doing at this particular center.

For $200,000 you are modernizing equipment, existing computing equipment that I think is only 3 or 4 years old; is that correct?

Mr. ZIMMERMAN. Of this order. I don't know precisely.

Colonel GOULD. Here we have made an investment of some $400,000 or $500,000 3 or 4 years ago, and now in a very short while we are spending another $200,000 to modernize it. It would appear to me, at least on the surface, that it is much more economical to lease because you take advantage of new equipment as it comes into being and is provided by the contractor.

Mr. ULMER. I think generally your statement is sound. There was a reason for procuring this equipment. As I say, each case is looked

at individually and we would be glad to supply the reason why this particular one was procured rather than rented.

You will also recognize, I am sure, that some of the equipment cannot be rented. There are some companies that make equipment available only for purchase. Each case is specifically documented and the reasons for it are set out, and I would be happy to see that the explanation is put in the record.

Colonel GOULD. Would you supply that for the record?

Mr. ULMER. Yes, sir.

(NOTE.—This information is contained in testimony given by Mr. Littell on p. 2628.)

Mr. KARTH. While you are at it, you may explain why it cost $275,000 to air-condition the equipment.

Mr. ULMER. I don't have that specific answer with me, Mr. Chairman. I would have to check that.

Mr. KARTH. I see the request is for $275,000 to air-condition the electronic equipment which is costing $200,000.

This is a rather disproportionate amount.

I was wondering if there was any justification for this.

Mr. ZIMMERMAN. If I might comment. This is really for equipment that originally cost $400,000, that is being remodeled at the cost of $200,000, plus another $220,000, so it isn't quite as disproportionate.

Mr. KARTH. You mean it was never air-conditioned?

Mr. ZIMMERMAN. It was not air-conditioned before except the building was air-conditioned, and this has not been entirely satisfactory.

Mr. KARTH. Can you explain why?

Mr. ZIMMERMAN. I could not myself explain why. I understand it has not been air-conditioned.

Mr. KARTH. It may not have been entirely satisfactory.

I wonder if we can justify the $275,000, however, to make a situation entirely satisfactory which previously was not quite entirely satisfactory.

I am wondering why or what were the problems that caused us to request $275,000 to air-condition equipment which previously had not been air-conditioned?

Mr. ZIMMERMAN. I will try to find that answer. Possibly Mr. Ulmer could find the answer to why it cost $275,000.

Mr. ULMER. It is available.

Colonel GOULD. Possibly I can supply the answer as to why the existing equipment is not air-conditioned.

Actually it is. It is located in existing office space that is in a building that is already air-conditioned and they have a group of small air conditioners in that office space so that when the new building is constructed this equipment will be moved to the new building, and it must be air-conditioned, but I certainly agree with the chairman. that is rather excessive cost for air-conditioning a small part of this new building.

Mr. ZIMMERMAN. Possibly Mr. Ulmer can get that.

(The information requested is as follows:)

FLIGHT RESEARCH SUPPORT LABORATORY

Air-conditioning equipment for electric equipment, $275,000.—The $275,000 item includes all of the air conditioning for the facility. Requirements for air conditioning for the parts of the facility are as follows:

Air conditioning load item:	*Load in tons*
IMB 704 and GE 225 computers	50
Monitoring control center	50
Present analog computers and new computer equipment	50
Normal building needs	200
Total air-conditioning load	350

Total installed cost of 350 tons of air conditioning, at approximately $800 per ton, is estimated at $275,000.

Colonel GOULD. Would you define for us the extent of $116,000 required for the electrical extension? This building is right adjacent to the existing engineering building, and it would appear that $116,000 for extension of existing electrical lines is rather excessive.

Mr. ZIMMERMAN. My understanding of this situation is that this $116,000 is included in this other facility because there is $190,000 included in the high-temperature load-calibration facility.

Colonel GOULD. You have split the electrical project, is that correct?

Mr. ZIMMERMAN. It is necessary—there are two things involved here.

Let me see if I can figure it out.

We have to get power for the new high-temperature load-calibration facility as well as this facility.

Now, that total amount of power is not available from the Air Force and we have to get it from the Boron-California Power Co. line.

Mr. KARTH. This is at Edwards Air Force Base.

Mr. ZIMMERMAN. This is near Edwards Air Force Base.

Mr. KARTH. They don't have this kind of power at Edwards? That is a fantastic installation.

Mr. ZIMMERMAN. This is the information here. Now, possibly, and this I would have to check, because I don't know personally, possibly it is cheaper to get this from this California Power Co. line than it is from wherever the Air Force facility is located at Edwards.

Mr. KARTH. Mr. Zimmerman, somebody must have the answer.

Mr. LITTELL. I believe I can answer that.

The Air Force does not have available at the base the amount of regulated power required by the proposed facilities, and it is necessary for NASA to run a new line to the substation where the Air Force takes off its power.

I believe I could also supply answers on the previous question on the computer equipment, if you so desire at this time.

Mr. KARTH. I would like to have the record complete as soon as possible.

Mr. LITTELL. On the flight research support laboratory, the item of modernization of existing computing equipment is primarily the addition of a read-out system for the analog computers. The read-out system is essentially a method of presenting graphically on a real time basis an integrated picture of the flight test data—the flight

conditions—and this is special equipment designed for the monitoring of flight operations.

That tends to be more one of a kind rather than the type you would rent.

The new computing equipment represents an item of approximately $130,000 for a digital computer, an analog digital converter for $90,000, making up the $220,000.

Colonel GOULD. The answer on the leasing problem then is that this is special equipment and cannot be leased.

Mr. ZIMMERMAN. That is right.

Colonel GOULD. Do you know whether we tried to lease equipment of this nature or not?

Mr. LITTELL. No, I do not.

Mr. KARTH. Doesn't the Air Force have equipment such as this?

They have been in this business for quite some time, I understand. The air wing in the Navy—don't they have equipment such as this?

Mr. LITTELL. This is the control center for the X–15 operations.

Mr. KARTH. Who has been taking care of the X–15 for the several years it has been taken care of? Has it also been under NASA?

Mr. LITTELL. Yes, sir.

Mr. KARTH. How have we been taking care of it up to this point?

What is so magic about this new formula we are going to apply here as opposed to the checkout and read-out and everything else we have been doing up to this point?

What is so different about it? Why is it necessary? What are we going to learn with this approach we didn't learn with the approach that we have used for years, or ever since the X–15 has been going?

Mr. ZIMMERMAN. The equipment that is now being used, the computer equipment which is now being used, is housed in the hangar facility.

The airplane cockpit part of the simulation equipment is housed in the loads calibration hangar, which is not a satisfactory arrangement, although they have been able to get by with it. They have worked with it.

In addition to that they have 16 mobile-home-type trailers around the laboratory that have housed auxiliary equipment to this and the purpose of this new building is to bring all of this equipment together into an efficient operation, and also to make some provision for what we anticipate in the future. This is——

Mr. KARTH. Who owns the trailers?

Mr. ZIMMERMAN. I do not know whether we rent them or whether we own them. I do not know.

Mr. KARTH. Does anybody know?

Mr. ULMER. I believe we rent them, Mr. Chairman.

Colonel GOULD. What impact would the deferral of this project for 1 year have on your programs? Could you continue the use of existing facilities for 1 year?

Mr. ZIMMERMAN. I am sure the program could continue, and would not continue as satisfactorily, and we would be in the same situation. We would not have this facility for the—we have a Jetstar coming along and we have the $400,000 visual flight simulator which is more of a space project which is intended to be housed in this building. We

would be faced with a continuation and expansion of this inefficient operation.

Mr. KARTH. What are we going to do with the Jetstar we are purchasing?

Mr. ZIMMERMAN. The Jetstar is itself a variable-stability airplane.

Mr. KARTH. I have flown in it several times. If I knew it was that experimental, I wouldn't have done it.

Mr. ZIMMERMAN. You misunderstand me. The Jetstar itself is a proven airplane, but what we are doing is putting equipment in the airplane—black-box equipment, such that when the pilot controls the airplane it behaves like some other plane and we can adjust its characteristics—we can give it in effect, say, more dihedral than it normally has through the black-box equipment, so that we can simulate the behavior of a 707 or a supersonic transport or other aircraft, and in this way we can find out what characteristics are really desirable for these machines or what are the worst things we can live with and what will happen in certain emergency situations with these other aircraft.

That is what we will do using the Jetstar as a simulator itself.

Mr. KARTH. Has that had all of the test and experimentation that the 707 has been put through that would be sufficient to take care of the 707?

Do we have to simulate with a Jetstar all of the 707 conditions?

Mr. ZIMMERMAN. I can assure you the 707 has by no means perfect characteristics, and the airlines would be much happier if its characteristics had been more thoroughly proved before it was put into service.

We are trying to avoid that.

The airlines are asking that the supersonic transport be better than the 707, and it is this kind of study that we are trying to do to make them better.

Now the purpose for simulating the 707, for example—I just cited that as an example—with simulation equipment you try to simulate as part of your program something whose charactertistics you already know to give you a base point from which to investigate into the situation that you have.

Mr. KARTH. This is extraneous, I admit, but what are the weak points in the 707? What characteristics don't meet specifications or desires?

Mr. ZIMMERMAN. The aircraft or the characteristics, the behavior at slow speeds is less stable—it is hard to describe it in other terms—than we would like it to be.

It has a tendency to perform the Dutch roll that has to be fought against.

Mr. KARTH. Has any of them ever gone into this Dutch roll you talk about and ended up in a crash?

Mr. ZIMMERMAN. Only in experimental flight—it has happened.

Mr. KARTH. Isn't it true that all high-speed aircraft have a tendency to operate less favorably at slow speeds than at high speeds?

Mr. ZIMMERMAN. That is absolutely right.

Mr. KARTH. You are never going to eliminate that; are you?

Mr. ZIMMERMAN. We do have to work very hard to get them good enough so we can live with them.

Mr. KARTH. Who has been doing the work before, the FAA?

It isn't a matter of elimination, it is getting them so we can be with them.

Mr. ZIMMERMAN. NASA has done a great deal of research on that.

Mr. KARTH. NASA has been around for 4 years. Who did it before that?

Mr. ZIMMERMAN. The NACA.

Mr. KARTH. And FAA? Did FAA have a lot of experimental money in their budget previously?

Mr. ZIMMERMAN. Not to my knowledge. It has been NACA's job to try to provide the information that the manufacturer can use to make high-performance aircraft so one can live with them, and it is not easy.

Mr. KARTH. So this responsibility has been transferred to NASA from NACA, who, prior to NASA, was responsible for it?

Mr. ZIMMERMAN. That is correct. Yes, sir.

Mr. MORRIS. Have you settled this supersonic transport problem? Has it been settled now definitely that we are going to build a supersonic transport?

I can't seem to get it clear. One day one agency says yes, and the next day, that they are not sure, and then they come up with all of the plans ready to go, and another committee, that I am on, they come in and say, "No, we are not—we haven't made any decision yet."

Mr. ZIMMERMAN. This is in the process, sir, of being discussed within the executive department.

The Vice President is heading up this thing.

The decision certainly has not been made, and I certainly couldn't tell you what the decision will be. It is just as confusing to some of us as to you.

Mr. MORRIS. Is it just as confusing to you people sometimes as it is to some of the rest of us?

Mr. ZIMMERMAN. Yes, sir; absolutely.

Dr. BISPLINGHOFF. Mr. Morris, I think the point, as far as we are concerned, is that we all feel there will be a supersonic transport some day, and we must continue on a modest level research in this area. NASA has done this for the past few years, and we hope to do it in the future.

Mr. MORRIS. I think that is good. I don't object to that at all. The only thing is, I feel like sometimes we are wasting a lot of time trying to make a decision one way or the other.

I just read this morning—I understand the French are already working on a supersonic transport.

Mr. ZIMMERMAN. The British and French are building one cooperatively.

Mr. KARTH. They are already building one.

Mr. ZIMMERMAN. Yes.

Mr. KARTH. How far in advance of us does that put them?

Mr. ZIMMERMAN. At least a year, and possibly 2 years.

Mr. KARTH. I thought we had a leadtime from the drawing board to actual assembly or production of about 3 years?

Mr. ZIMMERMAN. They are just beginning to cut metal at this time.

Mr. KARTH. They are more than a year ahead of us?

Mr. ZIMMERMAN. Well, a year is a minimum. My guess would be more like 2 years, actually, but certainly a year is a minimum amount.

You realize that our manufacturers have been making preliminary designs over a period of years so that they might be able to get in a position to cut metal fairly rapidly if they got a go-ahead.

Mr. STEEBLER. May I inquire whether the American plans and the joint British-French plans envisaged the same speed plane?

Is it not true the British plane is something like 2,000 miles per hour?

Mr. ZIMMERMAN. The British plane is designed as we understand it for Mach 2.2, which is the maximum that aluminum airplanes will permit because of the heating problem.

In this country the decision has not been made as to whether we will stay with an aluminum airplane that would be limited to 2.2 or whether we should go to a steel or titanium airplane that could go as high as Mach 3.5. The decision has not been made.

Mr. KARTH. What are the French doing?

What is their plan?

Mr. ZIMMERMAN. They are working with the British. This is a cooperative effort.

Mr. KARTH. They are with aluminum too.

Mr. ZIMMERMAN. They are with aluminum, yes, sir.

Mr. MOSHER. I was wondering, do we have access to their research?

Is this a competitive thing basically or could we be in on the cooperation if we want to?

Mr. ZIMMERMAN. The way it seems to be developing is a competitive situation which in some respects is less than desirable.

Mr. MOSHER. You mean less competitive than desirable?

Mr. ZIMMERMAN. I am sorry, I gave the wrong impression.

We in the past have had fairly free interchange of research information with our British and French friends.

Now, as a result of this move toward a competitive situation, this interchange is not as free as it once was.

Mr. MOSHER. The exchange is less?

Mr. ZIMMERMAN. Right.

Mr. MOSHER. The ultimate goal or decision would be a decision made by Congress in terms of appropriations, is that right?

Mr. ZIMMERMAN. Right.

Mr. MOSHER. And Congress is not at this point considering any appropriations recommendation?

Mr. ZIMMERMAN. Not to my knowledge.

Mr. MOSHER. Other than this relatively minor appropriation?

Mr. ZIMMERMAN. That is right. We have made only a relatively minor request to carry the research forward at a reasonable level until such time as the decision is made one way or another.

Mr. MOSHER. You say some group headed by the Vice President is considering the possibility of a recommendation to the Congress?

Mr. ZIMMERMAN. Right.

Mr. MOSHER. This year—I mean this session?

Mr. ZIMMERMAN. I just can't answer. It could be sir, but I certainly couldn't vouch for it.

Mr. MOSHER. But you feel it is your obligation to be as ready as possible in terms of facilities?

Mr. ZIMMERMAN. Right. Very definitely.

Mr. KARTH. Mr. Zimmerman, haven't we spent as much money in research in this country on this type of thing as all other countries combined—certainly more than any other individual country.

We have spent in this country in the last several years, more money on basic and applied research than all other nations in the world combined. Where are we?

Why does something like this happen to us?

This is a rather important area.

Mr. ZIMMERMAN. I can't answer with certainty that we have spent more than all of the world, including the Communist bloc, because we don't know what they have spent but we have certainly spent more than the rest of the world that we know about.

Mr. KARTH. Other than the Soviets, yes. I don't know what is there either. We don't seem to know too much about what is going on there.

Mr. ZIMMERMAN. There is no question that we could proceed to build a supersonic airplane. There is no question in my mind, personally, that we can build a better airplane than the one that the British and French are building.

I am sure in my own mind that we can, on the basis of what we know.

There are large questions of economics and desirable speed ranges and effect of things like the sonic boom, and also political questions that have to be answered, aside from the technical questions.

Mr. KARTH. They apparently aren't going to worry about the little ones, are they?

Mr. ZIMMERMAN. They have worried very much about the sonic boom.

Mr. KARTH. They worry about it but they are building an airplane.

Mr. ZIMMERMAN. They are going ahead and building an airplane.

Mr. KARTH. The worry about these problems is not preventing them from building an airplane, is that correct?

Mr. ZIMMERMAN. That is right.

Mr. KARTH. And it is preventing us from building an airplane?

Mr. ZIMMERMAN. Up to this point.

Mr. KARTH. Well, I think we have gotten off the track here, but this has been very interesting. I never cease to be amazed.

Mr. MORRIS. Mr. Chairman, getting back to this flight research supporting laboratory and this high temperature load and calibration facilities, why does it have to be at Edwards Air Force Base?

Mr. ZIMMERMAN. This is where we do our high-performance flight testing.

These facilities are to support that work. They would not be suitable anywhere else for this work.

Mr. MORRIS. How do you know it wouldn't be suitable anywhere else?

Mr. ZIMMERMAN. Well, I mean these facilities we are asking for are to support high-speed flight research. Now, obviously——

Mr. KARTH. It is in addition to existing facilities you have there?

Mr. ZIMMERMAN. Yes. Now we could certainly—there are other

places where we could do this, but that would be very inefficient to move to some other place to do it.

Mr. MORRIS. What are you going to do when Los Angeles County takes over Edwards Base for a county airport, which they propose to do?

Mr. ZIMMERMAN. Sir, I don't know the answer to that. I don't know what is involved there. I haven't heard of that before.

Mr. MORRIS. When you start putting all of this money into facilities which are going to be extremely costly, and also permanent, what about the density of air traffic there?

Mr. ZIMMERMAN. As you realize, sir, this is well out in the desert.

Mr. MORRIS. I know where it is. I have been there a dozen times.

Mr. ZIMMERMAN. Frankly, I just can't conceive any reason why the county would want to take it over. I don't know the circumstances. I haven't heard of this.

Mr. MORRIS. Have you asked or have you made any studies of the density of the air traffic in the area?

I am not talking about now, for next fiscal year or the next 5 years—I am speaking now of your building these facilities you say that will last from 5 to 10 years.

Mr. ZIMMERMAN. Right.

Mr. MORRIS. So what you are doing is you are thinking about putting money into a facility that you are going to consider is going to be a good one 5 or 10 years from now, and this is what the point is——

Mr. KARTH. Fifty years.

Mr. MORRIS. I am sorry; I was under the impression it was 10 years. All right that even makes it more ridiculous in my opinion, if it is 50 years.

What about the density of air traffic in that area?

Mr. ZIMMERMAN. Sir, I would think it would be relatively low in that area, although I haven't made a study of it, but the main traffic density will be along the coast, and of course there is the transcontinental traffic, but no matter where you were in a country you would have that problem.

I would think this would be about as good a place as we could possibly find, if not the best.

Now, if it were so that it was interrupting the traffic along the west coast, certainly it would be a serious problem, but there isn't, or doesn't need to be, such a situation in that area.

Mr. MORRIS. How long? You can't just take off and test the X–15 in a matter of a hundred miles, can you?

Mr. ZIMMERMAN. That is true. We use that whole desert area out there, but unless we lease the Sahara Desert, for example, I just can't imagine that there is a better place for it. I don't see how there could be.

Mr. MORRIS. Have you ever made a study of what the air traffic density is?

Mr. ZIMMERMAN. In that area?

Mr. MORRIS. Yes.

Mr. ZIMMERMAN. Not to my knowledge.

Now, it is possible it has been done, but I am not aware of what has been done. In fact, I hadn't thought of it as being a problem.

Mr. MORRIS. What about this instrumentation that you mentioned—visual optical instrument?

Mr. ZIMMERMAN. The visual flight simulator?

Mr. MORRIS. Yes.

Mr. ZIMMERMAN. I am not very familiar personally with that because it is being used as I understand for space rendezvous, experimental things of this sort, and I would have to ask someone else.

Mr. MORRIS. Is that in your department?

Mr. ZIMMERMAN. That is not, but the equipment will be located in this building.

Mr. MORRIS. If you get the building?

Mr. ZIMMERMAN. If we get the building.

Mr. MORRIS. And if you get the equipment to go into it?

Mr. ZIMMERMAN. Well, the equipment was in last year's budget, I believe.

Mr. MORRIS. Have you spent all of the money for the equipment?

Mr. ZIMMERMAN. Sir, I could not answer that.

Mr. MORRIS. How much have you spent of this money for this equipment? Does anybody know?

Mr. MYERS. We can furnish that for the record. We have records of what has been spent.

Mr. MORRIS. I would like to know the technical designation of every instrument that is involved under that authorization.

Mr. MYERS. Every instrument in these particular facilities at the Flight Research Center?

Mr. MORRIS. All of NASA's equipment at Edwards Air Force Base. Do you understand what I mean now?

Dr. BISPLINGHOFF. Are you referring to everything that would be housed in the Flight Research Supporting Laboratory that we are proposing?

Mr. MORRIS. That NASA pays for.

Dr. BISPLINGHOFF. All right, sir, we will supply that.

Mr. MORRIS. Thank you. Will you send that to me in a letter also, when you supply it for the record.

Dr. BISPLINGHOFF. All right, sir, we will do that.

(The information requested is as follows:)

Detailed information on equipment, instrumentation, and support systems for the Flight Research Support Laboratory and the High Temperature Loads Calibration Facility proposed for Flight Research Center is given in the following table:

Flight Research Support Laboratory:	
Equipment, instrumentation, and support systems	$1,080,000
Air-conditioning equipment	275,000
To handle heat from electronic computers as well as normal building needs—350 tons capacity	
CO_2 fire control equipment	30,000
Office and shop equipment for 35 persons	25,000
Modernization of existing computing equipment	200,000
Improved readout system	25,000
Modification for digitally set potentiometers and generators	125,000
Modification to include high-speed multipliers	50,000

Flight Research Support Laboratory—Continued	
Equipment, instrumentation, and support systems—Continued	
New computing equipment	$220,000
Digital computer (1 unit)	130,000
Interface equipment (analog)	90,000
Biotechnology laboratory equipment	170,000
Chamber provisions	100,000
Servicing patchboard	30,000
Chamber installations and modifications	70,000
Laboratory servicing equipment	30,000
Biotechnical, biophysical, physiological test equipment	40,000
Display and guidance laboratory equipment	20,000
Random wave-shape generator	5,000
Dual-beam oscilloscope	3,500
Closed-circuit TV system	3,000
TV monitors	3,000
Oscilloscope	2,000
Frequency generators	1,000
Miscellaneous	2,500
Control system laboratory equipment	65,000
Sinusoidal roll table	50,000
Oscillograph	4,000
Alternating current and direct current 400-cycle power	2,300
Servo breadboard	1,500
Oscilloscope	1,500
X–Y plotter	1,500
Miscellaneous equipment	4,200
Control center and data acquisition equipment	75,000
Strip chart recorders (3)	25,000
Interface equipment for real time PCM displays	15,000
Construction of specialized monitor room consoles	10,000
Communications provisions (intercom and RF tiein)	10,000
Display equipment	15,000
High-temperature loads calibration facility:	
Equipment, instrumentation, and support systems	655,000
Power controllers and programing computers	125,000
Heat lamps and connections	115,000
Cables and connections	25,000
Heat lamps and reflectors	90,000
Hydraulic power and loading equipment	115,000
Hydraulic power unit	30,000
Rams and load programers	70,000
Miscellaneous hydraulic equipment	15,000
Loading jigs and lamp supports	50,000
Personnel protection screens	10,000
Transducers	20,000
High-temperature wiring	40,000
Specialized data-recording system	150,000
Data tape transport	30,000

Mr. KARTH. Colonel Gould.

Colonel GOULD. You have been accomplishing your construction at this Center with an in-house capability, is that correct?

Mr. ZIMMERMAN. I believe that is correct.

Colonel GOULD. I was told while I was out there recently that you were having a few problems in trying to accomplish this by in-house. Are these proposed fiscal year 1964 items going to be accomplished with in-house forces or are you turning to the Corps of Engineers for these projects?

Mr. ZIMMERMAN. I cannot personally answer that.

Mr. ULMER. We have that matter under discussion at the present time, Colonel. I believe it would be fair to say that we probably will ask for the Corps help on these facilities.

Colonel GOULD. Would you tell me the basis of the item "E" on page CF 2–4 for design and engineer services? It works but to 14 percent of facility construction and site development, and a much lesser cost if you take into account the equipment involved.

Do you know what the basis for that estimate is?

Mr. ULMER. I don't have the details with me, but normally if you find the design and engineering costs exceed what you expect on the building proper there is a substantial amount involved in the utilities and equipment design. We do have the breakdown on that, and will be happy to supply it, sir.

Colonel GOULD. I don't see any items of equipment here that are going to require much design. Most of these items are probably of the off-the-shelf variety, so I assume the $195,000 requested was strictly for construction.

Mr. ULMER. I would not assume that.

Colonel GOULD. Would you supply that for the record?

Mr. ULMER. Right.

The information requested is as follows:

(The information requested is as follows:)

DESIGN AND ENGINEERING SERVICES, $195,000

The design and engineering costs for this facility are higher than the average, because of the following special requirements:

- False floors for computer rooms.
- Special ducting for computer cabling.
- Unusual features to house the visual-flight simulator.
- Special air-conditioning requirements.
- Special support-system installation.
- Special ducting for computer air conditioning.

Mr. KARTH. Mr. Ulmer, how long do we debate this question as to whether or not we should use the existing Corps facilities or use some other A. & E. contacts? How long has that been going on?

Mr. ULMER. I don't think it is a matter of a continuing debate, Mr. Chairman.

Our situation today is as follows: At the older NASA centers where NASA had a construction competence in existence, we continue to do our own construction management.

As the new centers were added, and as you know they were added rapidly and the staffing expanded rapidly, we were in a period where we required a very heavy construction program.

It was physically impossible for us at that time to build up our own in-house competence at these newer centers. We were very fortunate in being able to acquire during this period the services of the Army Corps of Engineers. Our requirements coincided with a period in their program where their level of effort was dropping because the missile base construction program was leveling off or decreasing. We were in a very fortunate position in being able to get them to act as our construction managers at these newer centers.

We have followed this practice at the Manned Spacecraft Center at Houston, at the Mississippi Test Facility, at Cape Canaveral and at the Marshall Center.

Now, the flight station is a borderline case in that they have seldom, over the years, had substantial construction programs.

They, at the most, have had one or two projects a year.

I think perhaps this is the largest construction program proposed by the Flight Center since it has been in existence, and they are seriously questioning their ability with their limited staff to handle the construction management of a program of this size.

Mr. KARTH. How long do they seriously question this before they make a determination that they are not capable of doing the work?

Mr. ULMER. It will be decided very quickly. As I mentioned, I believe the decision is going to be that if these facilities are authorized, we will probably ask the corps to help us in this area.

Mr. KARTH. How do we arrive at the $175,000 figure? This is of some concern to me.

Mr. ULMER. The amounts for architect-engineer services are required whether we do our own construction management or whether the corps handles it for us.

Mr. KARTH. If you ask the corps about this thing it will probably give you an estimate of $75,000 instead of $175,000. I don't know. I say, how do you arrive at the $175,000 if you don't know who is going to do the work?

Mr. ULMER. The estimate in here is the amount of architect-engineer services that will be required regardless of whether we select the architect-engineer or whether the corps does it for us.

On top of that, if we do it, we have our own in-house costs involved, and if the corps does it, we have an additional fee that must be paid to the corps.

In response to some written questions from your full committee, we have supplied the relative comparison of costs between the corps managed projects and those under our own management. I believe, also, in response to a question from you several days ago, Mr. Morris, I indicated that the total costs are somewhat comparable.

Mr. KARTH. Have you supplied those?

Mr. ULMER. Yes, the figures have been supplied to Mr. Miller. The statement consists of a detailed analysis of several projects under corps management, and under our own management.

Mr. KARTH. Fine. Thank you very much.

How about the high temperature loads calibration facilities? We would like your briefing as to that.

Mr. ZIMMERMAN. The high temperature loads calibration laboratory will permit us to calibrate the instrumentations that are used to measure stresses, deformations, and temperatures of structural com-

ponents such as tail services and control services of the aircraft to be flight tested while the components are being subjected to the heating and loading approximating those expected in flight.

So far we have only been able to calibrate the instrumentation while being loaded in the cold condition.

Although we have gotten by with it, it hasn't been a desirable situation.

Our experience with the X–15 has shown the need for this equipment. We expect it will increase both the safety and research value of the flight tests of future aircraft and space vehicles which will be going into increasingly severe heating situations.

Now, this facility will cost $1,157,000. The major expenditure will be $655,000 for equipment, instrumentation, and support systems. This equipment will be housed in a building of simple construction, 60 by 100 feet, and costing $165,000.

The site development and utility installation will cost $270,000, and $67,000 is required for design and engineering.

Now this facility will give us an added capability we haven't had before, and which we have come to realize is highly desirable from the standpoint of safety and better understanding also of what goes on in the aircraft structure.

Mr. KARTH. I see we use a great many computers in almost anything we do today.

If we have a test facility we have to have an electronic device to calibrate it or test it, or measure it or something.

We buy all of our computers on competive bid?

Mr. ZIMMERMAN. Sir, I would presume so, but here again, I would like to ask Mr. Ulmer.

Mr. KARTH. It seems that NASA has only heard of IBM. I understand they do not let these things to bid and I understand there are very good manufacturers other than IBM.

I am not saying IBM is not good; I know they are very good, but I know there are others that might want to get in on this gravy.

Mr. ULMER. I think the great bulk of our equipment is rented.

Mr. KARTH. I assume they all rent them.

Mr. ULMER. No; some manufacturers do not. Some manufacturers only manufacture for procurement.

Mr. KARTH. How about the big three or four. Do they all rent their equipment?

Really I speak from ignorance—I don't know. I am asking; do they or don't they?

Mr. ULMER. I don't know all the details. Most companies do produce equipment for rental. There are some companies that make equipment that cannot be acquired under rental. We have acquired both types of equipment. Some equipment is just better for one type of application, and in another application you have to go to a different type of equipment.

Where we can, we fill our needs on a competitive basis, but this is not always feasible.

Mr. KARTH. I don't want to get into an argument with you about that because this could be a very lengthy argument, I am sure. How do you develop competency?

You know this is a real good question.

Mr. ULMER. Yes, sir.

Mr. KARTH. Do you develop it within one company at the taxpayers' expense, and after you develop it say no one else is competent any longer?

Mr. ULMER. No, sir.

Mr. KARTH. Really what you do with Government dollars is prevent competition. I am not so sure that there is any validity to this kind of an operation at all, but I am sure this occurs, this does happen.

Whether or not it is true in this case, I don't know, but I think maybe we should take a look at that.

Mr. ULMER. This may be the result in certain cases, but it is certainly not the motive.

Mr. KARTH. I am sure it is not the motive, but I think it is the result we have to be worried about.

I know you all want to do the best job possible.

Whether or not the result is right, I am not sure.

Dr. BISPLINGHOFF. In looking at the computer thing I think you will find most of the manufacturers of digital computer devices will rent them. We have all through these facilities a good many analog computers and generally those are bought as special purpose devices.

Most of our simulators involve analog computers to a great extent.

Mr. KARTH. Let me ask this question which might be completely irrelevant at this point.

Is there any feeling whatsoever that the purchasing agent, if I may call him that, feels compelled, let's say, to select IBM over everything else because if the equipment really doesn't work or if it doesn't work as well as it should work, or if it doesn't work as it was intended to work, he is less apt to be criticized because after all IBM is IBM. But if he selects XYZ, which is not really as well known and the reputation hasn't been established over a long period of time, and XYZ doesn't work as well as expected, then, of course, he would be subject to disciplinary action, or at least ridiculed or whatever action might be taken, appropriate or otherwise.

Is there any feeling like this at all among those who have the responsibility of choosing or selecting those items that are not on a competitive bid?

Dr. BISPLINGHOFF. This may very possibly be in the back of the minds of the people who do the actual selection, but I would hope they would do it on the basis of technical excellence of the devices themselves, and the costs also—those two factors.

I hope they would be the major factors in the selection.

Mr. MYERS. I think I can answer your question from personal experience at both Lewis and Langley, where I conducted research at one time.

With some particular computing devices which were specially designed for a special purpose, research purpose, there are some I am very familiar with and we have, whether we rent or buy, we have conditions in here that equipment must operate satisfactorily or they do not get paid.

In the case of rental equipment, the particular company, and we deal with all of the companies in my experience, the particular company has a representative who is there constantly until the equipment

does perform as written in the specifications so that they get paid, so I don't think, and of course, I can't tell what is in the minds of the people that make the selection, but from our experience the companies either perform or take the equipment back.

Mr. KARTH. Once you get an installation loaded with a certain type of equipment, I think it is almost like Friday following Thursday, that you continue with that type of equipment because someone else's equipment doesn't fit into the complex. So once you get started with XYZ's equipment and I think, in most cases we have started with one manufacturer's equipment—I say in most cases—it seems to me any additions that we make to that equipment has got to come from that same manufacturer for any number of reasons.

I know that we each go through the exercise of letting this on bid, letting it out to bid on occasion, but for some reason it generally goes to the same person time after time, and I am really serious, if there is anything this subcommittee looks into, I think very seriously I am going to recommend to the committee that we take a good close look at this.

I understand that it may even be done at the request of those people in the particular location that is affected, where the equipment is going to be installed.

They just don't want to go through the exercise of explaining to other manufacturers, I guess, of how they would have to tie into this XYZ's equipment or whatever the technical problems are, and I assume that there are.

I don't hesitate to admit there might be substantial technical difficulty if you went from one manufacturer to another when you are adding to the complex.

But that doesn't necessarily make it the best choice just because it is the easiest.

If we do things the easy way, I can make a lot of suggestions as to what we should do, in and out of NASA, and I am sure you can, too. It isn't always that the easiest selection or the easiest choice is the best.

It is the most convenient at the moment, I am sure.

This may indeed be the long way from being the best.

I really think the subcommittee or one of the subcommittees or a special subcommittee should take a look at this, because I have heard it time and time again, and quite frankly, I am sick of hearing it.

I don't know why these people beat on my head, and I know they beat on the heads of other committee members.

They think it is atrocious, they really think something is wrong, and this, I think, is only normal, too.

If you are not the fatted calf you think you are suffering from malnutrition, see, and you think it is on purpose, but there might be a little fire where there is a lot of smoke, and I say maybe we ought to take a look at it.

Mr. MYERS. I would like to comment very briefly, and that is there are times in computing equipment for some of the special needs which the old NACA and NASA has that there is no equipment available that would make the measurements we want, and in those cases some of our in-house people and computing people work out the techniques

and requirements and in those cases this information goes to all companies.

Mr. KARTH. Yes, sir, and I know you can write requirements and specifications so that 90 percent of the companies can't even compete, they can't even bid. They are not in the ball park.

I know that, and you know it, so let's not argue about that.

Mr. MORRIS. Also, whenever you enter into a contract with that corporation for that special equipment, what you are doing is you are using taxpayers' dollars to build up a technical competence in that company.

Mr. MYERS. I say we go out to all companies with that particular specification.

Mr. MORRIS. Yes, I know you go out to all companies.

There is only one or two companies that can possibly come under the specifications that your in-house people write.

Now, you know that and we know it. Everybody else knows it, too.

Mr. KARTH. In many cases this is true.

Mr. MORRIS. It may not be true 100 percent of the time.

Mr. KARTH. I think we should make every effort to see it doesn't happen.

Again, we have kind of gotten off the beaten path here, but maybe it is good on occasion that we change the subject.

Colonel Gould, I think you had some questions on this last one.

Colonel GOULD. Yes, sir. What is the latest date this facility must be provided in order to preclude delays in any programs you now have?

Mr. ZIMMERMAN. There are things we would like to do with the X–15 that we haven't done because we haven't had the capability of determining the details of structural behavior under combined heating and loading conditions.

We estimate that this building will be completed within 9 months from the time it is started, and then we can work this into the continuing X–15 program.

It will be quite valuable to us to do that.

Colonel GOULD. Why can't you continue existing facilities in use to meet these requirements?

Mr. ZIMMERMAN. The existing facility will be continued in use but the existing facility can only measure or make the calibrations under cold conditions, and we are concerned about the hot conditions which this facility will take care of.

Colonel GOULD. Has design been initiated on this project?

Mr. ZIMMERMAN. So far as I know, only preliminary design, but here again I might ask Mr. Ulmer what he might know about that.

Mr. MYERS. Yes, $60,000 is provided for design.

Colonel GOULD. Out of fiscal year 1963 advance design funds?

Mr. MYERS. Yes.

Colonel GOULD. Then the amount you are asking for in this project would not be necessary at this time; is that correct?

Mr. MYERS. It would be subtracted; yes.

Mr. KARTH. Is there anything else you would like to add, Mr. Zimmerman?

Mr. ZIMMERMAN. I have nothing further to add.

Mr. KARTH. I want to thank you very much. I enjoyed your presentation.

Dr. Bisplinghoff, whom would you like to call now?

Dr. BISPLINGHOFF. Our next expert will be Dr. Kurzweg, our Director of Research, and he will discuss the space environment research facility at Ames, and the hot gas radiation research facility at Langley.

Mr. KARTH. Dr. Kurzweg, would you proceed?

Dr. KURZWEG. Thank you very much.

This year I have two facilities which, when built, will give many answers on questions which are especially of interest in my particular area. As I pointed out in my testimony before, there are several areas where we simply don't know the answers today. One problem occurs when we go to very high reentry speeds, beyond that of Apollo. This area is concerned with the heat production and the radiation of the heat into the body, and another area of ours is how materials behave under space and environmental conditions.

Now, these two areas will be covered by these two facilities. One facility at Langley will take care of the radiation business. We know that the thermal radiation will be predominant if you travel at speeds of 40,000 to 50,000 feet per second. The electromagnetically produced heat which goes into the body exceeds the heat which is produced by friction and direct contact of the air.

Mr. MORRIS. When you speak of "the body" you are speaking of the space vehicle?

Dr. KURZWEG. Of the space vehicle when it reenters the atmosphere or any atmosphere of the planets. Now, we came up with a theoretical deduction and extrapolated experimental values which we have from existing facilities, and we have come to the conclusion that the blunt-nose bodies are not the right shapes anymore. We have to go to more slender shapes again. This has not been experimentally checked or proved. It is deducted from what we know, theoretically and experimentally, from facilities at the lower speed range.

Now, this new facility will enable us, for the first time, really, to get experimental data on a body and on the behavior of the air at these very high speeds. We do not have such a facility. Well, I should correct this. We have built a very small pilot facility which shows that the principle is sound.

We will get these high speeds and we will get the right radiation. This is sort of a shock tube, but it is not a shock tube in the normal sense as they already exist.

Dr. BISPLINGHOFF. He is addressing himself to the Langley first, Mr. Chairman.

Mr. KARTH. Yes, I see.

Dr. KURZWEG. The energy which we have to release in this particular shock tube is pretty high—it is 10 million joules, which is 10 times more than we have used in existing shock tubes so far. The joule is, of course, the unit of energy the physicists use and we normally talk in kilowatt-hours. Ten million joules is approximately 3 kilowatt-hours. That sounds small but if you release 3 kilowatt-hours in a few tenths of a second you have a tremendous power and we will operate this particular shock tube in a very, very short time, of the order of a few tenths of a second.

Mr. KARTH. Colonel Gould.

Colonel GOULD. I just have a couple of questions on this one, Mr. Chairman. You speak of the existence of a ballistic shock tunnel. Where is this facility located?

Dr. KURZWEG. The ballistic shock tunnel is at Ames. It is a combination of a gun and a shock tunnel.

Colonel GOULD. Why can't this be used to meet the need in lieu of building a new facility?

Dr. KURZWEG. The ballistic gun tunnel, which we have at Ames, shoots small particles and with this facility we get very high speeds. We come within the vicinity of 40, or even more, thousand feet per second but these are relatively small particles which we can fire and if we want to make detail studies, we need larger models and there is no possibility of firing the bigger bodies in the gun facilities. We can learn overall radiation effects but we cannot learn, from existing facilities, the distribution of the radiation rate and so forth.

Colonel GOULD. Is this ballistic shock tunnel out at Ames the one that was improvised out of a 16-inch naval gun?

Dr. KURZWEG. Yes.

Mr. KARTH. The justification also speaks of much experimental research having been carried out in the field of radiative proper and the bulk of this research was conducted by shock tube processing. Where are these existing shock tubes that you refer to in your statement and are referred to in the justification?

Dr. KURZWEG. These shock tubes are distributed over the country quite a bit and all of these people work in the field to determine the properties of gases at these high temperatures. We know quite a bit how air behaves at high temperature conditions but we still do not know how it behaves at high temperatures associated with speeds of 50,000 fet a second or so.

Colonel GOULD. To the best of your knowledge, is there an existing shock tube facility anyplace in industry or in the educational field that could be used for this?

Dr. KURZWEG. There is not a shock tube of this type. This is an entirely new idea which goes in this particular one and there is no other facility of this type.

Colonel GOULD. You consider this very essential to your ongoing program?

Dr. KURZWEG. I think it is one of the most essential things, that we learn if our theoretical predictions which we make are correct and this is so much cheaper than if we have to fire big rockets for flight tests to confirm our predictions.

Colonel GOULD. What are the design and construction leadtimes for this project?

Dr. KURZWEG. We think that in 18 months we can get this facility ready for shakedown.

Colonel GOULD. That is for design and construction?

Dr. KURZWEG. Design and construction, yes.

Colonel GOULD. Would you tell us what the procurement leadtime is for the tubes in the test sections and drives that are included in your testimony?

Dr. KURZWEG. I couldn't give you the answer at the moment.

Colonel GOULD. Could you supply that for the record?

Dr. KURZWEG. Yes.

(The information requested is as follows:)

The leadtimes for the tubes and capacitors for the hot gas radiation research facility, Langley Research Center, are given in the following table:

Procurement leadtime including installation

Item	*Months*
Capacitor bank	16
Expansion tube	18
Shock tube	18

Colonel GOULD. What is meant by an energy storage sunshade?

Dr. KURZWEG. I think this is simply the shell—the energy storage is a set of capacitors which are stored outside and they have to be sheltered.

Colonel GOULD. It is not a very scintilating item.

Dr. BISPLINGHOFF. Mr. Chairman, I think this comes as near to a breakthrough as we have seen in this kind of facility recently. As Dr. Kurzweg pointed out we are going to be able to get to higher velocities and more nearly approximate this radiation condition than we have ever been able to before with this idea. It is really quite a unique idea and it is sort of a chop-through operation. I have a very strong feeling about this because of the tremendous expense that we would have to go to if we do this sort of thing by flight testing. I feel that we in the NASA must work very hard in this area to try to do these things in the ground. If we would get out of this facility one flight test to give us the kind of information that I hope we will get out of this facility, it would cost us perhaps 5 or 10 times as much as this facility will cost us and I think this is an area that we in NASA have got to address ourselves with great vigor in the future. This I think is a good example of the means by which we can save money in the future to avoid flight testing.

Mr. KARTH. Dr. Kurz eg, is there anything else you would like to add?

Dr. KURZWEG. Not for this particular facility. I would like to say something on the——

Mr. MORRIS. Mr. Chairman, I would like to ask the Doctor a couple of questions. What made you determine that Langley was the place for this particular installation? Can you do it with less expense at Langley than you can at some other place?

Dr. KURZWEG. I don't think that you could do it less expensively at Langley but we have the talent at Langley who developed this particular idea. These things are so much dependent on the people you have and they are located at some particular place and they developed at Langley this principle of the acceleration of air. They have worked in this area for quite a while and they built this little pilot tunnel so I think I would trust them more with that thing than anybody else at the present time.

Mr. MORRIS. You say this is going to be used for research on vehicles that have a speed of 15,000—what is the requirement for such a vehicle? Does NASA have a requirement for such a vehicle at the present time? What is the mission that it is to be used for?

Dr. KURZWEG. Well, we talked, of course, after the Apollo mission about exploring deeper space. We want to go a little deeper than to the Moon and if you go farther out, the return speeds are higher. You

come up with speeds in the return flight which are about 40,000 feet a second or more.

Mr. MORRIS. We talked about a lot of things. We have been talking about the supersonic transport off and on ever since I can remember. But is it the policy of your division to build a facility of this nature when you don't have a requirement for it?

Dr. KURZWEG. I think so, because——

Mr. MORRIS. Because you are involved in basic research? Is that the justification?

Dr. KURZWEG. That is correct. I have to see what we can expect in 5 or 10 years from now. Even if we have no project going or even if it is not in the mission, we have to think about what we will run into because it takes about 10 years to develop these new ideas. A few years ago everybody thought the blunt nose was the ultimate thing for reentry into the atmosphere. Now, we know this is not right. If we ever go out of this region of speed to higher speeds, we have to go away from the blunt concept.

Mr. MORRIS. You are satisfied that Langley is the place to build this?

Dr. KURZWEG. I think Langley is the place to build it, and I am almost sure that, at a later date, it might be not sufficient to have just this one. I have a feeling that in a few years that we may need more than just one such facility.

Mr. MORRIS. We are getting into this 50 years planning thing so if we plan these things we have to have them for 50 years and this is why I am concerned about where these things are located. Once you get your foot in the door and the foundation laid and the thing started you in effect do just like you do to the computer companies; you slam the door in everybody's face.

Mr. KARTH. Would you like to go to the space environment research facility now?

Dr. KURZWEG. Yes.

As you know, we are, of course, very much concerned how materials will behave under space environmental conditions. Many people, of course, in this country have the various experimental tanks and so forth but in my opinion there is no place where these investigations are really made under consideration of all possible things which will happen in space. From the purely basic standpoint, I do not know if I understand crack propagation under high vacuum, or if it is the same if I bombarded the material with electrons, or if I have impacts of micrometeoroids. I don't know. That doesn't mean that these single investigations are of no value. Of course, we have to investigate individual effects but materials is one field where we have to make investigations, even if on small samples only, where we combine all of these effects, and we think that the Ames people, who have done quite a bit in acceleration of particles, are quite competent in the investigation of environmental effects and they have a good group of people which understand the polymer materials. This is a good place to put such a laboratory. We do not have any facilities of this kind in this particular area, the San Francisco Bay area. There are quite a few industries there. We thought this would be a very good place to have such a facility. We have a good staff of people, good competent people.

Mr. KARTH. How many laboratories is NASA requesting Congress authorize this year? Do you have any offhand opinion?

Dr. KURZWEG. You mean materials laboratories?

Mr. KARTH. Call them whatever you want, laboratories of various kinds. How many are we asking for this year?

Dr. KURZWEG. I couldn't answer that. In our area, perhaps four or five entities that we call laboratories. In the other areas——

Mr. KARTH. A research facility is really a laboratory?

Dr. BISPLINGHOFF. Yes, it is really a question of semantics here.

Mr. KARTH. About 21.

Mr. MYERS. About 29 projects in the Office of Research.

Mr. KARTH. There must be a few in the other offices. How many total?

Mr. ULMER. A rough guess is 30, Mr. Chairman.

Mr. KARTH. Is it the feeling that this work just can't be done anywhere else by anyone else and therefore we have to build another in-house laboratory? Is this really the end conclusion that has been drawn in every single one of these 30 requests for laboratories or research facilities? Is this true, Doctor?

Dr. KURZWEG. I think it sounds more than it really is. I mean, we talk about a new space environmental laboratory, but actually there is a group of people, a competent group of people who work in this area quite a bit already but they need tools and they need a room where they can put a few things which they need for the experimental investigation.

Mr. KARTH. Don't tell me we have been paying them for years without giving them any tools. What have the people been doing?

Mr. KARTH. The only thing that worries me, and you're probably the wrong man to say this to, but it seems to me that for some reason or other all of a sudden we need nice new shiny research facilities, that is structures, buildings, to do our research and experimenting in.

I have done a good deal of traveling around this country and I find a lot of enterprising people, instead of building a new building to house a facility, they might even go and polish an old one up, just give it a fresh coat of paint, do a little polishing on the floors and thereby beat the leadtime construction item of 16 or 18 months because we are in a hurry anyway. We are supposed to be doing these things at a very rapid pace and they are in business but we have to build new buildings.

I am exploring. It does appear to be strange to me we have to have new buildings and new facilities for every single one of the problem areas.

Why can't we rent some facility or polish up an old one, or why can't we repaint a warehouse or something, and save zillions of dollars and, even more important, probably get in operation sooner.

Don't worry so much about or don't spend so much time on throwing together bricks and mortar.

Could you give me an idea?

Mr. ULMER. This is about the same speech we give our people.

Mr. KARTH. They were not listening, I can tell you that.

Mr. MORRIS. They won't listen to you either.

Mr. KARTH. Maybe if you had not made the speech you would have had 60 requests, who knows.

They may have listened very well.

Dr. KURZWEG. We looked very carefully into the possibility of using buildings we have at Ames and remodeling a few things.

Mr. KARTH. How about some place else. Let us say we have to rent a warehouse some place else or even purchase one for peanuts. Is it the theory we have to keep all of these scientific minds together even though their disciplines are so widely varied?

Dr. KURZWEG. It would be a little difficult.

Mr. KARTH. It would be difficult, Doctor, I agree.

Dr. KURZWEG. How would you take this ballistic gun tunnel, for instance, and move it to that other place when we need the combination of these two things?

Mr. KARTH. I say I am probably talking to the wrong fellow now because you may not be able to take this ballistic gun and move it some place else but in general I guess my question is, is this trip necessary—do we have to do this in every single instance?

Mr. ULMER. Mr. Karth, I would like to say that that question is asked on every facility that you see in this budget and it is not only asked all of the way up and down the line, it is asked by Dr. Seamans, Dr. Dryden, or Mr. Webb before they approve the inclusion of a new facility in the budget.

To speak to your question on the use of existing facilities, I think the NASA record is rather outstanding in this area. We continually modify and improve our facilities wherever we can. A large percentage of the budget before you consists of modifications, extensions, additions, or alterations.

We are continually altering and modifying to avoid building new facilities.

You mentioned the question of going out and renting facilities. We do that where it is absolutely essential and normally we do it only to house people. If you put a facility out in a rented building you have the problem of the logistics of the shop and administrative support for the facility. Frequently the logistic costs required would exceed the cost of a new building on site. Everybody in NASA is thoroughly indoctrinated with trying to make with what we have before we ask for new facilities. I think all of these gentlemen you see here today have been asked this question not only by Dr. Bisplinghoff but by me and Dr. Seamans and Mr. Webb before a new facility is included in the budget.

Mr. KARTH. But their answer is always the same.

Mr. MORRIS. I might say I asked that question many times. There are a lot of us getting asked this question several hundred times—every time we get close to anybody who is paying the bill, and I am not making any remark that everything that is presented here is not justified, but you fellows are not the only ones that have to answer for this construction program.

Mr. ULMER. Yes, sir.

Mr. KARTH. I feel very reassured, Mr. Ulmer, with this kind of an effort going into determining is this facility absolutely necessary. Can't we make something else do or can't we polish up some existing building, and I am primarily concerned with buildings.

Mr. ULMER. I understand.

Mr. KARTH. I do agree insofar as the equipment is concerned in most cases I think your whole program is unique and you have to design and redesign things almost on a continuing basis.

I was just wondering about buildings, you know good old concrete and stone—why we involve ourselves in so much of this when time is of the essence.

Now maybe somebody is pulling somebody's leg—I don't know, but I have just accepted this as being the fact—time is very critical, and how can we get on with the show much more rapidly, and I just thought that maybe we did not need 5, 10, or 18 months to put up a structure to house a piece of equipment, we would just save 15 or 18 months.

It is rather simple arithmetic I use and it is probably too simple, that is why you cannot answer the question.

Mr. ULMER. Your point is well taken.

We do have many facilities we are now renting to house people simply because we have been unable to provide facilities on site.

That is an expensive way for the Government to house people in the long run.

Mr. KARTH. In the long run I think these things are true but with these things becoming obsolescent over a short period of time I am not sure it is more expensive there.

Mr. ULMER. Some of the technical facilities become obsolescent and are altered and changed but we feel this is a continuing program and will go on in the future.

If it were a temporary program we certainly agree we should only build temporary facilities.

Mr. KARTH. I know this: That once you built an in-house capability, even though the problems presented are no longer critical, it is like the hungry animal you raised, you fed him until he grew up and now you don't know what to do with him—you just keep feeding him; you know—so I am concerned about the long run where we built up an in-house capability that we are more or less stuck with, and it becomes an item in the budget over which Congress no longer has any decision-making power.

I mean it is very simple arithmetic after that—there are so many people involved, the building is there, the maintenance is so much, the heat, light and electricity so much and that is it, so there is $3 million in the budget.

This is not even questioned—I mean it is not supposed to be and usually it is not—it is just a check list item.

You just accept it. I am not sure this is good, you see. This is why I ask the question how many laboratories and research facilities are we requesting this year in NASA alone and somebody said 30.

That means, Dr. Bisplinghoff, that the taxpayers of this country are going to have to support a growing number. Well, I don't know when anyone has ever shut one down—I am sure it has happened but it has happened very, very infrequently.

It means the taxpayers are going to have to keep feeding this thing forever or almost that long, and they are beginning to ask these questions, you see.

You say, "Gee, when you build up these tremendous in-house capabilities, it makes a good argument to say we can save so much money,

you know, because rent and this and that and the other thing over a long period of time would be more."

Well, this might be true if the proposition lent itself to this long period of time, without bureaucracy growing up and making it necessary when really it is not necessary. This is the problem that concerns me. It is indeed a tough one to answer and that is why I ask your assistance on it because I know you are interested in doing the right thing and not necessarily building up a big in-house capability that is not required.

Colonel Gould, did you have some specific questions?

Colonel GOULD. One general question about Ames. And possibly Mr. Ulmer could answer this: The facilities at this Center are becoming very congested. Is there any thought being given at this Center for the acquisition of additional real estate to provide more space for all of these new facilities at the Center?

Mr. ULMER. I believe on three occasions we have proposed additional land acquisition at Ames and it has been denied either at the Bureau of the Budget level or at the congressional level, with the suggestion that we see if we can't make arrangements with the Navy to acquire some of their land.

I am very happy to report that within the last 2 weeks we have a policy agreement with the Department of Defense and the Department of Navy that approximately 110 acres of Navy land at Ames will be transferred to NASA.

This is land contiguous to our site. It has one Navy installation on it, a warehouse, which will continue to be operated by the Navy; this will not interfere with our operations. The Navy Department has been very cooperative and helpful in making this additional land available to us.

This action will eliminate the necessity for any new land acquisition at Ames for several years.

Colonel GOULD. The Navy has a considerable amount of real estate there that I am sure could be made available to you.

Mr. ULMER. Yes; the 110 acres is part of that real estate.

Colonel GOULD. What are the design and construction lead times for this project?

Dr. KURZWEG. Twelve months.

Colonel GOULD. Has the design already been started?

Dr. KURZWEG. No.

Colonel GOULD. Are funds being made available from fiscal year 1963 for design?

Dr. KURZWEG. Yes.

Colonel GOULD. How much?

Mr. ULMER. $70,000.

Colonel GOULD. That is the item shown in item D here?

Mr. ULMER. Yes, sir.

Colonel GOULD. Could somebody tell us what scope of the work is involved in the $300,000 for electrical distribution is in this project, please?

Mr. LITTELL. I have some information on that.

Electrical distribution system for $300,000 is to be distributed to power for the items of equipment to be used in this building, which requires sizable amounts of electric power. It is internal distribution.

Colonel GOULD. What size line are you to install for that amount of money and what distance?

Mr. LITTELL. This is—I don't know the external utility but it is internal.

Colonel GOULD. I assume the internal distribution system is included in the cost of the structure, is it not, Mr. Ulmer?

Mr. ULMER. Normally that is the case; yes, sir.

Colonel GOULD. I assume this $300,000 is for external distribution.

Mr. LITTELL. The information I have is that it is for the internal. I will check that for the record.

Colonel GOULD. The reason I ask is that I looked at the proposed site for this facility about 3 or 4 weeks ago and there appears to be a substation within a hundred yards of where the facility is going to be built and it appears that $300,000 is excessive for such a short distance.

Would you check on that please?

Mr. ULMER. Normally the internal electrical system is included in the cost of the building to give a fair square-foot cost for comparative purposes. If they have special internal electrical requirements, we sometimes set that out as a separate item so it does not distort the square-foot-cost picture.

(The information requested is as follows:)

SPACE ENVIRONMENT RESEARCH FACILITY

Electrical distribution $300,000.—The existing adjacent substation is already loaded to capacity by the unitary wind tunnel. The power requirements of the facility must be supplied by a new substation and transmission cable as described in the following list of required equipment:

Description of item	*Estimated cost*
Disconnect switch, 110,000 volt	$3,000
Circuit breaker, 110,000 volt	30,000
Transformer, 110,000 volt to 6,900 volt, 5,000 kw	40,000
Step voltage regulator, 750 kv.-a	45,000
Substation feeder switchgear	18,000
High voltage transmission cable, 1,500 feet	9,000
Manholes and hardware	18,000
Duct banks, 1,500 feet	30,000
Switchgear, 6,900 volt	20,000
Three transformers, totaling 4,500 kv.-a	22,500
Distribution switchgear, 480 volt	32,000
Installation (10 percent of equipment)	27,500
Total cost, approximately	300,000

Colonel GOULD. Is the laboratory bay included here an industrial type of structure?

Dr. BISPLINGHOFF. Yes, that is correct.

Mr. LITTELL. Yes, sir.

Colonel GOULD. $450,000 for micrometeoroid bombardment apparatus.

Would you define what that is?

Dr. KURZWEG. There are several types of these, of course.

One possibility is to charge these particles electrostatically and then accelerate them in the electric field—this is the most promising method.

The other method is, of course, to fire them from a gun but these are usually much larger particles.

We talk about micrometeoroids less than a micron in size and then for that purpose——

Colonel GOULD. Have you determined which method you are going to use?

Dr. KURZWEG. We will use the electrostatic method.

Mr. KARTH. Dr. Bisplinghoff, if I may, this seems to be quite an apparatus, this micrometeor bombardment apparatus.

Can't we use this instead of doing some of the other meteorite or micrometeoroid experimentation we have been talking about for days?

There are several requests before this subcommittee for micrometeorite or micrometeoroid experimentation.

Can't we just put it inside this building whatever it is?

Dr. BISPLINGHOFF. This as I understand it, will be a Vandergraft accelerator which will have to be a device which is contiguous with the rest of the environmental examiner.

Mr. KARTH. And the information we get from other micrometeoroid experiments is insufficient to provide for this?

Dr. BISPLINGHOFF. There will be a close relationship between the two. However, here as Dr. Kurzweg pointed out, the material will be subjected to all of the environmental conditions.

One of the things I might point out here is that if the material is unvacuumed, if the material is heated and if it is bombarded simultaneously, these combined influences are quite different than if one looks at these properties individually.

The point of this whole facility is to bring all of these environmental conditions together at one time. There will be, however, as you have observed a close interrelation between what happens here and what we will do when we study the meteroid penetration problem by itself on the outside.

Mr. MORRIS. May I ask one question?

Mr. KARTH. Mr. Morris.

Mr. MORRIS. This high energy linear accelerator the AEC is building in connection with Stanford University for $125 million I believe it is, could you have any connection with this?

Dr. KURZWEG. No, this is a molecular size accelerator and these micrometeoroids are many thousands times as big as a molecule so this is entirely different.

Mr. KARTH. Doctor, are these downpayments or are these the total costs of the facilities?

Dr. KURZWEG. This is the total cost.

Mr. KARTH. These are total costs?

Dr. KURZWEG. Yes.

Colonel GOULD. What type of a cryogenic system are you going to install for $500,000?

Dr. KURZWEG. Well, there are again two different types. For the 5-foot sphere we will use liquid nitrogen and for the very low pressures we would have to go to liquid helium.

Colonel GOULD. How does the cost of this equipment compare with the one put in or being put in at Lewis, do you know?

Dr. KURZWEG. I really could not say that.

Mr. MYERS. It is very similar. I don't remember exactly but it is very similar.

Colonel GOULD. Would you make a cost comparison and put it in the record?

(The information requested is as follows:)

A comparison of the cost estimate item "Cryogenic system, $500,000," reference fiscal year 1964 budget estimates, page CF 1–24, and the cost of the cryogenic system for the Lewis Research Center addition to spacecraft propulsion research facility, reference CF 7–4:

The cryogenic systems differ in purpose. The Ames facility requires that the material under test be held at near absolute zero, whereas the Lewis facility is required only to hold the test chamber to about —300° F. The Ames facility is small in size, but includes a liquid helium generator for recovery and reliquification, whereas the Lewis facility is very large, uses a liquid nitrogen tank farm for a supply, and requires 2,000 feet of supply pipe to permit servicing the tank farm at a safe distance from the tests in the chamber. The differences between the installations will be evident from the following table. Panels for the Ames facility cost more because of special design requirements.

Comparison of cryogenic systems of the Ames space environment research facility and the Lewis addition to spacecraft propulsion research facility

Feature	Ames	Lewis
Refrigerant liquid	Nitrogen and helium	Nitrogen.
Chamber temperature	−452° F	−320° F.
Chamber pressure	10^{-10}	10^{-8}
Cryogenic panel area—square feet	100	14,000.
Supply of refrigerant	Reliquification system	Tank farm.
Panel cost installed per square foot	$400	$100.
Costs of major parts:		
Recovery and reliquification system	$340,000	
Piping and control	$120,000	
Liquid nitrogen supply and piping		$100,000.
Nitrogen pumps and storage		$50,000.
Installation and checkout		$136,000.
Cryogenic panels	$40,000	$1,400,000.
Total cryogenic system	$500,000	$1,686,000.

Colonel GOULD. How many space chambers are you providing?

Dr. KURZWEG. Two.

Colonel GOULD. How many do we have proposed at Ames in the fiscal year 1964 program?

Dr. KURZWEG. Just these two, in my jurisdiction.

Colonel GOULD. I believe there is one in the services Research Laboratory and one or two in satellite control and one in the structural dynamics?

Mr. MYERS. I could give you that list.

Colonel GOULD. What is meant by "auxiliary test equipment" for $400,000?

Dr. KURZWEG. Well, this test equipment is of course this very high vacuum chamber. There is also the source of the ultraviolet radiation and the power supplies for the mechanical and physical properties testing equipment for materials, metallurgical equipment, chemical laboratory equipment—all kinds of instrumentation and test equipment you need for materials investigation.

Colonel GOULD. When you say instrumentation, you also have an item of $461,000 in addition to the $400,000 for auxiliary test equipment.

Dr. KURZWEG. That is instrumentation which you would use for instance the electron pulse to measure the ultraviolet radiation, instrumentation for that, not the production of the ultraviolet radiation but the measuring of it.

Then we have photocounters and electron multipliers, signal generators, and so forth.

Colonel GOULD. What type of solar radiation are you going to use in this facility?

Dr. KURZWEG. We want to come as close as possible to simulating the rays of the Sun.

Colonel GOULD. How would it compare for example to the one at JPL?

Dr. KURZWEG. It is about the same.

Colonel GOULD. What did the one at JPL cost?

Dr. KURZWEG. I don't know.

Mr. RANDALL. Mr. Chairman, I was trying to follow this. You were measuring ultraviolet radiation and then I heard the words "metallurgical test."

What are you testing? Be specific.

Dr. KURZWEG. If you have a piece of metal and the metal has certain strength——

Mr. RANDALL. Metal from what? A spacecraft?

Dr. KURZWEG. A spacecraft.

Mr. RANDALL. It has already been up and come back?

Dr. KURZWEG. No, it is a design so that you know what you can expect from a piece of metal when you use it for the skin on the spacecraft.

We can go of course in our laboratory under atmospheric conditions and measure this but this is not the same as if the metal is subjected to radiation, this ultraviolet light that comes from the sun, to meteoric impact, and which is subjected to wind influence and so forth and we want to simulate these things, on a piece of metal in this particular facility.

Mr. RANDALL. You are telling the committee there is no way in any of—or at least the portion of the budget we have jurisdiction over—that this can be tested, except right here?

Dr. KURZWEG. As I pointed out, it is a beginning. There are, of course, facilities where samples of this kind are tested, but there are no facilities where it is simultaneously tested with all environmental factors, so we have to have some facility to do this.

Mr. RANDALL. Don't you put in your contracts with the producers of these that they are to be tested this way? Doesn't the maker of these also test them for these same things?

Dr. KURZWEG. Unfortunately, there is no possibility to test them under all of these things simultaneously. They test them under a high vacuum and the solar test and the special heat stresses, and so forth, but not a combined investigation where we have ultraviolet, where we have different gases, and where we have bombardment of the same type of micrometeoroid. This doesn't exist.

Mr. RANDALL. One more question. Talking about the downpayment here, after we get this; is this going to do the job, or are we going to have to come back and do it all over again?

Dr. KURZWEG. We hope, of course, it will do the job, and especially we are interested in the basic understanding of what is going on. It is not so much a component testing. We do not want to put a whole satellite in this chamber.

We cannot do this. This is small equipment. But we want to get research data, a basic understanding, and from the basic understanding we can extrapolate the basic thinking, but this is what we don't know today. We cannot extrapolate because we don't know even in the small unit what happens if you have the simultaneous influence of all of these things.

Mr. KARTH. Anything else you would like to add?

Dr. KURZWEG. No, sir. Thank you.

Mr. KARTH. If not, I believe that is all for the moment.

Dr. Bisplinghoff, can you be with us tomorrow?

Dr. BISPLINGHOFF. Yes, sir. My trip to Minneapolis is Thursday. I leave Wednesday afternoon.

Mr. KARTH. Don't cancel that.

Dr. BISPLINGHOFF. No, sir.

Mr. KARTH. If you find you would like to be doing something else tomorrow, and Mr. Finger and Dr. Kelley and Mr. Myers wish to proceed solo, it is not necessary from our standpoint you be here.

We would like to have you here, but we don't want to keep you here every day, and you have the Senate to take care of, and we know your time is very valuable and you are spending a great deal of it up here.

Dr. BISPLINGHOFF. I will be here.

Mr. KARTH. I am sorry, but we can't avoid all of them. I don't think we would get through the other three today.

Dr. BISPLINGHOFF. Our next speaker would be Mr. Myers, who does the administrative management at Ames, and model and construction of the building at Ames, and the utility of the building at Ames.

Mr. KARTH. Why don't we see if we can get through with that today, and tomorrow we have Dr. Kelley and Mr. Finger. Mr. Finger has a list of eight items, I think, and it might take some time to get through that.

Why don't you proceed, Mr. Myers.

STATEMENT OF BOYD MYERS, DIRECTOR OF PROGRAM REVIEW AND RESOURCES MANAGEMENT, NASA

Mr. MYERS. The first facility I would like to discuss is the administrative management building at Ames, at a cost of $1,375,000. This facility has a one two-story center section of approximately 170 by 100 feet, and two single-story wing sections approximately 100 by 40 feet. This will give us 65,000 square feet of space.

The purpose of this building is to house our administrative people which are now spread around in various places at Ames. During the years we have been forced, as we have added administrative staff and as the staff has grown through the years, we have been forced to put these people in various places, such as the 6 by 6 tunnel room, an old building that we used to use for storage, and now it is called an administrative annex in various facilities around there, which I can discuss later. And in the program since NASA's program, since 1962, we have added a 17-percent increase in complement there and approximately 23-percent increase in fiscal 1963. As you know, Ames has taken on some of the space science's responsibility and also some project responsibilities, and there has been a growth at Ames. The overall

situation is that we are getting into a rather untenable position in trying to house these people, and we are proposing this year to house our administrative services, our personnel, legal and patent, and our procurement contract negotiators, price analysis people, and procurement and review, and legal counsel in this new building.

Mr. KARTH. This is all administrative management?

Mr. MYERS. Yes, sir.

Mr. RANDALL. You say they are in a 6 by 6 wind tunnel. They are housed in there at the present time; did I understand you right?

Mr. KARTH. The question is, how are they getting along.

Mr. MYERS. The 6- by 6-foot supersonic tunnel—we refer to it as 6 by 6—this is an older facility that we have been forced to crowd the engineers there and make some space available for some of our procurement people.

They also have some procurement people in the so-called administrative annex building which I mentioned. We have fiscal people in the 12-foot wind tunnel and also some in the administrative annex. We have some of our administrative services people, about 20 of them, in the present administration building, which was built in 1942, and 16 over in the data reduction building, which is primarily their—they are way out of place, but that is where we had to put them. That is a relatively new facility, and while they are getting the equipment into that facility and getting into operation, they commandeered some of the space there, and also we have some of our personnel people in the data reduction building, so that is the approximate distribution of the way it is now.

We would like to bring these administrative services groups together because we think the problem is going to get worse before it gets better, and we have been considering such a move for more than 3 years, and Ames management has been proposing this.

This was the first year we could see our way clear. It has gotten to the point where we feel we must go ahead and look to the future as to what our problems are going to be.

Mr. KARTH. This must be quite a wind tunnel. How big is it?

Mr. MYERS. Which one, the 6 by 6?

Mr. KARTH. The one housing all of the people. That is just 6 feet wide and 6 feet high?

Mr. MYERS. That is the size of the test section, and that is the way they are named, by the size of the test section.

Mr. KARTH. How long is it?

Mr. MYERS. I don't recall exactly, but the 6- by 6-foot tunnel is something like 200 feet long and 80 feet wide. I haven't been in the 6 by 6 for a few years.

Mr. KARTH. Someone said we built too many of those. I don't suppose you care to comment on that. Apparently they are serving quite a number of uses.

Mr. MYERS. No, I don't think we have built too many. We have used all of the wind tunnels which have been provided since 1917 to good use. And as has been pointed out, we converted these facilities wherever the technology moved ahead. I know at Langley when I was doing research there in the 7 by 10 foot, this was originally 7 by 10 foot low speed, and then we had the high-speed tunnel and transonic tunnel, and now we are back to the low-speed tunnel, which is

becoming quite useful in some of our space work in landing vehicles and such things on the surface, so as the technology changes we are taking advantage of this and we are real proud of our record in this area of decommissioning facilities and using them for something else, or the few that have been actually dismantled and shipped to educational institutions.

Colonel GOULD. Mr. Myers, you say this building will provide 65,000 square feet of space to accommodate, I believe, 325 people?

Mr. MYERS. Yes, sir.

Colonel GOULD. This works out to roughly 200 square feet per person, gross?

Mr. MYERS. Yes, sir.

Colonel GOULD. Is this the criteria used in designing the structure?

Mr. MYERS. That was the overall criteria. If I may address myself to the individual criteria, I mentioned the types of people here, the legal officers, administrative services, public information, reproduction, management analysis, procurement, and personnel, as the types of people that would be in this building. Some of the types of people do have certain types of functions which require a little larger space because the personnel people, for example, where they are interviewing people, where they have personnel interviews; procurement, where you are dealing with contractors or going over cost estimates and this type of thing where you may have large groups, we have analyzed this on the basis of two criteria, really—100 square feet for the normal working person, shall we say, and 250 square feet for those who require extra room. And this has been broken down into—I have the breakdown here and I can give it to you roughly or individually. But about a third of the people are of the 250-square-foot criteria, and the other two-thirds are 100-square-foot criteria.

Colonel GOULD. Overall it does work out to about 200 square feet, gross, is that correct?

Mr. MYERS. Yes, sir.

Colonel GOULD. The reason I am asking the question—and possibly Mr. Ulmer might be able to shed some light on it—last year's law instructed NASA to proceed with the development of standards, and it is my understanding that you have recently entered into a contract with an A. & E. firm to develop these preliminary criteria for further review.

Mr. ULMER. Yes, sir.

Colonel GOULD. We learned in recent hearings before the Manned Space Flight Subcommittee that the Office of Manned Space Flight uses a factor or a criteria of 150 square feet gross per person in laying out administrative-type facilities. Furthermore, they indicate that they use 110 square foot net in computing administrative-type facilities.

Now, here in Ames, which is, I believe, quite similar to the structure that is being proposed at Houston, we have a different set of criteria, and I wonder what degree of coordination within NASA has taken place to try to bring these like types of facilities into the proper perspective.

Was this done?

Mr. ULMER. This was done in a gross way, Colonel, but this is precisely the effort that we are attempting to get into in setting up our

program on design criteria and construction standards. I am not familiar with the recent testimony on the square footage and the criteria used on the Houston facilities. We would have to see what they were talking about on the conversion factor from net to gross.

Colonel GOULD. They gave us an overall criteria of 150 gross square feet per person, 110 square feet net per person. Here we are talking of 200 square feet gross, and I suppose it works out to about 150 square feet average net, is that correct?

Mr. MEYERS. That 200 includes the hallways.

Colonel GOULD. I know, any gross figure includes all of the area within the walls. We do have a variance in like type facilities.

Mr. ULMER. We do, but we also have a variance in the function, in the people, and in the equipment for which the building is required. We don't yet have standard tables that we can use to pick out the size of a building depending on the number of people or types of people to be housed. This is the criteria and standards program that we hope to be developing in the coming months. We agree it is essential and we must do more work in this area.

Colonel GOULD. The justification mentions leased space now being used at Ames. How much space do you now have under lease?

Mr. MYERS. I think I am correct in saying that we have leased space for 25 people, that I know of. There may be additional, but it is not in the OART program. I am not aware of it.

Do you know?

Mr. ULMER. I don't have an exact figure with me but we will supply it for the record.

Colonel GOULD. If this project is approved, you will only take 25 people out of leased space, is that right?

Mr. MYERS. Yes, sir; that is what I understand.

Colonel GOULD. The rest of the people are now housed in existing facilities at the Center?

Mr. MYERS. Yes.

Colonel GOULD. Will the design of this building be identical to that of the data reduction building?

Mr. MYERS. The design of the building is a—I think you have looked at the picture—it is a mirror image, actually of the data reduction building, sort of flopped over onto a circle. The internal design, however, will be somewhat different. The data reduction building required heavier floors because of the heavier equipment that is in there, where this more normal office space, and that is primarily the difference in cost as quoted here in the estimates of $19.50 per square foot for the office area and $15 for the basement area, as opposed to, I think, $21.80 a square foot on the data reduction.

Colonel GOULD. What will the basement area in this building be used for?

Mr. MYERS. Office space.

Colonel GOULD. Has the design been started on this facility?

Mr. MYERS. $70,000 has been provided for the design and information and the information I attained yesterday is that they are in contact with the A. & E. firm and discussing the internal arrangements right now, so I assume that they have let a contract with A. & E.

Colonel GOULD. Are you using fiscal 1963 design money to get this underway?

Mr. MYERS. Yes, sir.

Colonel GOULD. Aside from inconvenience and somewhat reduced efficiency, you could continue to operate at Ames without this facility in 1964; is that correct?

Mr. MYERS. I think as a general answer to that the answer is "Yes."

I think that the conditions now are getting to the point where I don't know how much longer we can hold out, so to speak. We can always operate longer. We have a mission to perform and we will perform it one way or another.

I think in discussing this with Dr. DeFrance, the same day I think you were out there, the only alternative here as he sees it is to rent a provisional space and procure some trailers and I think this is the problem now.

Colonel GOULD. I don't know where you would put the trailers.

Mr. ULMER. I would like to say that we are not going to put trailers on that land if I have anything to do with it. I would like to make a plea, Mr. Chairman: Please don't turn the Ames Center into another Jet Propulsion Laboratory. JPL is a prime example of what happens by not paying enough attention to housing the people as the workload increases. We are paying for it and paying for it dearly.

The chairman asked why we need a large number of new buildings. The program is expanding and we are adding staff. The wrong way to do it is the way it was done by JPL by building temporary buildings and by renting trailers. You wind up paying far more in the long run.

Colonel GOULD. What is the end fiscal 1964 planned strength?

Mr. MYERS. Fiscal 1964 is 2,309.

Colonel GOULD. 1965?

Mr. MYERS. 1965 has not been determined yet but there will be an additional increment but I have not gotten it.

Colonel GOULD. All told how many people at Ames do you now have in leased space other than the 25?

Mr. MYERS. The 25 is the only one that I know of. There may be additional that I am not aware of. I am only aware of those people that are working in the OAR program and we support 90 percent of the Ames program at the moment and the space sciences reporting primarily to me.

Colonel GOULD. Would you provide for the record the total amount of leased space now, the annual cost and number of people being accommodated?

Mr. MYERS. Yes, sir.

(The information requested is as follows:)

Ames Research Center is leasing space for a total of 25 persons, all engaged in the life sciences program. The total leased space is 13,140 square feet, and the cost is $31,536 per year plus utilities.

Colonel GOULD. That is all of the questions I have, Mr. Chairman.

Mr. KARTH. Can you come back tomorrow, Mr. Myers?

Mr. MYERS. Yes, sir.

Mr. KARTH. I think we will have to adjourn until tomorrow morning at 10 o'clock.

Thank you very much.

(Whereupon, at 12:15 p.m., the committee was adjourned, to reconvene at 10 a.m., Wednesday, May 1, 1963.)

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1964 NASA AUTHORIZATION

WEDNESDAY, MAY 1, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SPACE SCIENCES
AND ADVANCED RESEARCH AND TECHNOLOGY,
Washington, D.C.

The subcommittee met at 10 a.m., Hon. Joseph E. Karth (chairman of the subcommittee) presiding.

Mr. KARTH. The meeting will be in order.

Dr. Bisplinghoff, yesterday when we adjourned I believe Mr. Myers was testifying on the administrative management building, or had concluded his testimony on that item and was about to testify on model construction buildings and the utility installations; is that correct?

Dr. BISPLINGHOFF. Yes, sir.

Mr. KARTH. Would you like to proceed, then?

FURTHER STATEMENT OF DR. RAYMOND L. BISPLINGHOFF; ACCOMPANIED BY BOYD C. MYERS, MILTON KLEIN, WILLIAM WOODWARD, DR. ALBERT J. KELLEY, RALPH ULMER, AND ROBERT LITTELL

Mr. MYERS. Yes, sir. The model construction building on page CF 1–12, at the Ames Research Center is a $347,000 item proposed for fiscal year 1964. This is a single story building which is made of reinforced concrete, 102 by 154 and will contain a large main shop and a plastic fabrication room, boiler room, office, tool crib and locker room and laboratory and will also have a mezzanine floor over the boiler room and this will give us some additional working space.

The main justification for this facility is that our present model construction building at Ames was built in 1941 and in the growth of the Ames Laboratory through the years we have gradually overcrowded this model shop with activity that has been put in various and sundry places around the laboratory but even that has become inadequate with the new requirements that we have and the various techniques which we need in making models for the various tunnels and tests which we conduct.

This is the major reason. We just need more room and better facilities than we have available. I would be glad to answer any questions.

Mr. KARTH. What do you need a plastics fabrication room for?

Mr. MYERS. The type of research that we do, particularly in the reentry work at very high temperatures, requires some unique techniques in getting models that are less expensive so that we don't have to

go to the very expensive machine models and one of our people at Ames has worked out a technique using plastics, making plastic models themselves and also using plastics for the molds so that you can get these very thin shields, very high temperature models which we put into the various tunnels.

To give you an example, we have the kinds of thing we are working with, as you know the temperatures required in this kind of work run up to three and——

Mr. KARTH. I know they are very excessive.

Mr. MYERS. 3,000° and 4,000°.

Mr. KARTH. What do you mean by fabrication?

Do you mean manufacture?

Mr. MYERS. These are special models. I have some pictures here if you would like to see them, Mr. Karth, of some of the special types of models.

Mr. KARTH. You are talking about having the raw material made by some industrial manufacturer and then making your model from the raw material that you purchase?

Is this it?

Mr. MYERS. Yes, sir; the raw materials are furnished to us from the manufacturer.

It is this kind of model which if you want to get temperature stability in a short room on some of these very high speed tunnels they have to make to get temperature stability in a short period of time; for some of these short runs you have to have very thin wall models.

Here are some of the lifting body models we have discussed in the previous testimony.

It is this kind of thing we must put into our facilities. These are very unique things that are done on more or less a day-to-day basis from requirements as you run one set of tests you find you have to change the configuration to get the data and it is very necessary in the research work to have this capability right at hand.

Mr. KARTH. Is this a ceramic or plastic?

Mr. MYERS. I think this one is a ceramic, yes.

I can leave this with you if you like. Some of those models you see there are molybdenum and beryllium and these are kinds of metals that we are using in some of these models.

Mr. KARTH. Colonel Gould?

Colonel GOULD. What is the size of the existing model shop, Mr. Myers?

And the other three buildings that are being used for these purposes? How much space is involved?

Mr. MYERS. I don't recall the exact size but it is in the notes I have there. I made the tactical error of giving you my notes.

Colonel GOULD. Why don't you read from this until we get through the testimony?

The total square footage in the existing model shop and the other three faciilties that are being used for this purpose, please?

Mr. MYERS. The other facilities we are using right now, the ceramics shop, is located at the moment in building 215, which is the 7-by-14-foot wind tunnel building.

The precision metal casting shop is located over here in the full scale wind tunnel in the back side. There is a room there that we are using.

The glass laminate shop is over in building 227, which is the unitary plan wind tunnel building.

Mr. KARTH. What will you do in the glass laminate shop?

Do you mean you are going to laminate glass?

Mr. MYERS. Some of the requirement we have on certain models you use glass laminates to build up the model surface so you can get the smooth surface to study such things as boundary layer and you must have a very smooth surface to do this so you build this up with glass laminate so you can machine it and you can also get the kind of contour you would like to have.

Mr. KARTH. This again is a matter of you purchasing the raw material?

Mr. MYERS. Yes.

Mr. KARTH. And applying it for testing and doing your research and experimental work?

Mr. MYERS. Yes, sir; we buy all of the raw materials.

Mr. KARTH. And to get the proper configuration?

Mr. MYERS. Yes, sir. I can't seem to find right offhand, Colonel Gould, the area of the present shop. I don't recall it.

However, we can furnish that for the record.

(The information requested is as follows:)

The amount of space now being used for model construction at the Ames Research Center and the use to which it will be put when the proposed model construction building is put in operation are as follows:

1. Model shop in building No. N-220; 10,000 square feet. This space will become a precision machining clean room for hypervelocity research model construction.

2. Ceramic shop in building No. N-215; 900 square feet. This space will be occupied by materials acceptance test equipment now inoperative because it was displaced from the sheet metal shop by the biosatellite project requirements.

3. Precision metal casting shop; 768 square feet. Under the 40-by-80-foot wind tunnel. This space will be used for preparation of panel flutter models for use in the 2-by-2-foot transonic tunnel.

4. Glass laminate shop; 1,800 square feet. Temporarly located in the unitary wind tunnel shop. This space will be used as contractor shop area for the unitary tunnel.

5. Large-scale model fabrication will continue to be performed in the 40-by-80-foot wind tunnel and in the large hangar, building No. N-211 on an as-required basis.

Colonel GOULD. What will be done with the existing space when the new facility is completed?

Mr. MYERS. All of the other facilities such as a unitary wind tunnel and what have you, these are just places we have been forced to go.

I don't know whether you have visited the full-scale tunnel at Ames. I think if you did you saw all of the large models which we need to fabricate and change. We are just using space that is needed by the engineers in working with models, and we have been forced to fabricate these things in available areas that will keep them under cover.

Colonel GOULD. What about the existing model shop?

What will be done with that space after you complete this new facility?

Mr. MYERS. They are planning to continue the use of that, although only partially for models. There is also a requirement to move some of the electrical people out of their building to make room for the life sciences people that are now crowding and there is some talk or dis-

cussion that maybe some of the electrical services group might go in there.

Colonel GOULD. Isn't the existing building about 10,000 square feet?

Mr. MYERS. It is of that order. I don't remember exactly.

Colonel GOULD. That would give you a total of 25,000 square feet for model construction?

Mr. MYERS. Yes, sir; if we used all of the space for that purpose.

Colonel GOULD. In model fabrication, what types of model construction require "clean room" facilities under controlled atmospheric conditions?

Mr. MYERS. Well, we have need for a clean room for fabricating, for example, of some of the life sciences work.

We get some of these restraint harnesses for some of the animals that are used and in some of the tests where you are actually operating on the brains and hearts of these animals and so forth, these things must be put together in a very antiseptic manner and fabricated that way.

Colonel GOULD. You speak of new and improved model-making techniques employed in plastics, et cetera. Do you now have the capability for plastic fabrication?

Mr. MYERS. Yes, sir; we have some capability.

Colonel GOULD. How about ceramics?

Mr. MYERS. Yes.

Colonel GOULD. And precision metal casings?

Mr. MYERS. Yes.

Colonel GOULD. Are you going to build an additional capability into your proposed facility?

Mr. MYERS. By additional capability, we have the capability—in fact, the Ames people pioneered this kind of work.

Mr. Clark out at Ames was given an award for pioneering some of this work and is expanding this and what they are planning to do is add a few additional fabrication pieces of equipment to take on the new area of providing models in this manner.

Colonel GOULD. The reason I ask this, Mr. Myers, is I don't see anywhere in the estimate any new equipment to be purchased so I assume that you already have this equipment and are merely going to set it up in a new facility?

Mr. MYERS. That is correct.

These will be small, as some of these pictures indicate, relatively small models and this would be purchased out of R.D. & O. money.

Colonel GOULD. I thought that in the construction program we were using the so-called "turnkey concept" within NASA that would provide a complete facility in all respects?

Mr. MYERS. This is correct on all of our research facilities.

However, we don't look at the model construction shop as a research facility. And also as Mr. Clark has pointed out and his division chief, they are not quite sure because this is some new pioneering work, they are not quite sure exactly how they are going to design this and this will be designed and proposed to be purchased out of R.D. & O. money when they get to know exactly how they are going to build it.

Now you realize that some of the equipment, of course, is now crowded in other places and will be brought into this model construction building.

Colonel GOULD. I assume all of it will, since you are asking for no new equipment. Actually could you continue to operate in the present facilities and still meet your on-going program objectives?

Mr. MYERS. In answering this question yesterday on the other facility, we can always say we can continue but we think in this particular area that we have held off long enough—in fact, maybe too long, and we really feel that this is a very necessary vital part of our research program and we would like to have this to go ahead.

Colonel GOULD. No further questions, Mr. Chairman.

Mr. KARTH. Where else within NASA do you do work on plastics and ceramics?

What other installations do this kind of work?

Mr. MYERS. I can speak for the research centers. We do similar work at Langley and at Lewis.

We do very little at the Flight Research Center.

Mr. KARTH. What about their facilities?

Is the effort here to build up a capability in all of these areas in all of your centers or a major portion of your centers?

At one point the testimony of Dr. Bisplinghoff or someone from NASA was that these centers more or less but primarily more, have built up a unique capability within their own framework and I am not so sure that this is true, as I go through these budget requests, when I find that you are pretty much asking that we duplicate this expertise at various NASA centers around the country.

I wonder if you would tell us why you need this same capability at Ames that you now have at Lewis and at Langley?

Mr. MYERS. Yes. I may make just a slight comment here about going back to the NACA days. When NASA was formed, the NACA was the nucleus of the new agency and in effect there were 9,000 people conducting strictly research in the four research centers, Langley, Lewis, Ames and Flight.

Then of course we were charged with space exploration and space research which went over and above the area of aeronautical research which we had in NACA, and the centers adapted themselves to these new areas, new environments, new facilities required to study the problems and produced data that would form the basis for design of these new vehicles and at the same time carry on a healthy aeronautical effort.

Now in all of these centers we had wind tunnels, we had other types of heating tunnels, we had equipment for structures research and these have been expanded now for the new problems but within each center and within each program at each center which we control in OART as to what the balance of the program is between centers, there are requirements for models in all of these facilities. As the technology increases and as the problems are broadened with respect to temperature and atmosphere and vacuum and what-not, you have new techniques required for models in order to just test and understand what is going on, so that each center has to have some capability to produce these models that the research engineers from day to day in carrying out the technical part of the program have to have in order to get the data required.

So that when you say we are expanding at all centers, I think what we are really talking about is we are updating our techniques in order

to study the new problems and the expansion as such is in keeping with the expansion of the general program rather than expansion of any given thing like model techniques. We are just updating our technical knowledge.

Mr. KARTH. Shouldn't they be thinking about putting all of these under one roof someplace, rather than quadruple our activities?

Mr. MYERS. We have about a $500 million plant which is in the four research centers. I think it would be rather——

Mr. KARTH. In the long run this might save some money.

Mr. MYERS. Are you talking about putting all centers under one roof or the model construction?

Mr. KARTH. No, putting all centers under one roof.

Let's take the big jump instead of nibbling away at this thing like mice at the cheese.

Mr. MYERS. I think if you did that you would destroy probably one of the assets this country has because I think it would be unmanageable if you put the 10,000 to 11,000 people we have in our research centers under one roof, plus of course the added cost of tearing down all of these very expensive and permanent facilties.

Mr. KARTH. You don't tear them down.

Mr. MYERS. I mean take them down.

They are, in effect, under one roof under OART management, under Dr. Bisplinghoff, and each center has certain missions and each program carries out certain objectives.

Mr. KARTH. Except each center seems to be getting involved in the same thing that other centers are becoming involved in and I am not so sure that we are not going down the same road, but in four different directions. This is the only thing that disturbs me.

Mr. MYERS. I would like to reassure you on that point. As part of my responsibilities in the Office of Advanced Research and Technology, I am Director of Programs Review and Resources Management and one of my responsibilities is to see, under Dr. Bisplinghoff's approval, that our whole program is documented very carefully and each research task that is done, whether it is done at Marshall or Lewis or what have you, is documented and these are approved in advance before funds are ever appropriated and allocated to the centers to conduct these and this is why I speak of a balanced program, that these 4,000 tasks we are working on this fiscal year, each one of them has been carefully examined by technical people and I do not think they are going down the same road.

Mr. KARTH. Do we have a model construction building at Lewis?

Mr. MYERS. Yes, sir. We don't call it a model construction building as such. It is shops at Lewis.

Mr. KARTH. Do we have one at Langley?

Mr. MYERS. Yes, sir.

Mr. KARTH. In those model construction buildings or in those shops, do we do model work on plastics and ceramics and laminates?

Mr. MYERS. Yes, sir. We exchange information between centers on any new technique as they come up so that each center—at Lewis if they have a high temperature model they must test with respect to popuIsion they would try to take advantage of the same technique to get improved models and this constantly goes on.

Mr. KARTH. Can't we build up a capability—let's take Lewis—geography does not mean much but let's take Lewis or Langley and my question is can't we build up this capability at Langley or Lewis or Goddard or someplace else, or at Ames and forget about it at the other research centers.

Can't we do this and have all of the plastic research that is done or the fabrication of these models and the laminates and the other work that you speak of to be done under the roof of the model construction buildings, can't we do it all at one center?

Mr. MYERS. The answer to your questions is "Yes," it could be done in one center but I think it would be very inefficient and very ineffective because every time an engineer needs a model and he is working on a very detailed technical investigation and he finds from his data he must go to a certain shape and so he gets a drawing made and he has to go over to the shopman and explain to him why this is the way it is and why the specifications are what they are and what he needs and the time he needs it in. If he had to do this at a central place—say if we put it in the middle of the country since our centers are fairly well spread around——

Mr. KARTH. Let's say we do it at one of the existing centers. I am not worried about the geography of the thing. The reason for my question is to decide whether or not we need this capability in every center or whether or not we could build up a good capability at one center and do all of the research work, if we can call it that, or all of the fabrication work if you would rather call it that, at just one of the centers and build up a real good capability there.

Mr. MYERS. My answer is twofold: You could do it in one place but I think it would be very ineffective if you did. And the second answer is "Yes, we need this capability at each center."

I hope you will have an opportunity on Friday, when you are at Lewis, to see some of the model work they do there to get a feel for the kinds of models that are required.

Mr. KARTH. Sure, we will take a look. Any further questions?

Colonel GOULD. No, sir.

Dr. WEAVER. I am not quite sure I understand your testimony. You really feel you need it at each of the different installations because of the particular problems of that installation demanding research in the field?

Mr. MYERS. Yes, sir; because of the technical work that each installation is charged with, they must have models in order to test them in these facilities and each investigation practically requires a model unless it is a theoretical investigation, but each experimental investigation in a facility requires a model of some sort, whether it is a high temperature model or what have you.

Dr. WEAVER. Do you feel the distances between the centers would make it difficult in transporting models back and forth or readjusting them if you did get one?

Mr. MYERS. I think it would be a real detriment to the program; yes, sir.

Dr. WEAVER. You have talked about possible duplication within the NASA.

Of course you cannot speak for the Air Force or for the Army or Navy, but in looking at their installations you have seen duplicates

of that effort in this field of research in special materials and special plastics and special metals for high-altitude space?

Do you feel there is any duplication in your effort or their efforts of yours—let me put it that way.

Mr. MYERS. We think our effort of research—are you speaking of models now?

Dr. WEAVER. I am talking about research itself.

Mr. MYERS. I think that witnesses have indicated over the past few weeks and we think we have a well-coordinated program with the military services and the AEC and FAA and other agencies, the Bureau of Standards, because we sponsor a lot of work in all of these agencies and we have constant exchange so I do not think there is any unnecessary duplication.

However, each service and each organization has its own peculiar requirements.

I think if you went to Wright Field or down to Tullahoma or other military installations you will see model shops and where they require models for their facilities and they are larger models usually because they do development work and not the same type of research that we do, but I think you will see the same sort of thing but I would not call this duplication—I call this a means of carrying out their mission for military purposes.

Dr. WEAVER. You are satisfied with the relationship as far as NASA is concerned?

Mr. MYERS. Yes, sir.

Dr. WEAVER. Is there going to be an effort, Mr. Chairman, to talk with the other services involved, or the witnesses, to see how they feel about this relationship or would it be possible for us to do it from the other services?

Mr. KARTH. You mean the military?

Dr. WEAVER. Yes.

Mr. KARTH. I had not planned on it but this is open to discussion within the committee.

Dr. WEAVER. I would think if it were done it would be done with these gentlemen present.

Mr. KARTH. We would do it in open hearing. I think what we will do is just talk about this in executive session.

If the committee members feel they would like to call additional witnesses, certainly I would not object.

Dr. WEAVER. Thank you.

Dr. BISPLINGHOFF. I would expect, Mr. Karth, that you would find in any reasonable-size laboratory, either in the military services or in the NASA that there are support and services that are common to most of these laboratories.

One of these would be a machine shop and a woodworking shop. I think there would be an instrumentation shop that would be common to most of these in which the standard state-of-the-art electronic measurements techniques could be brought to bear and also I think something like a model shop would be fairly common to most of these laboratories since the heart of this laboratory work is doing experiments which involves models or small product to types of some kind of a larger system.

Mr. KARTH. I think it is good to get in the record because the question is being asked more and more as time goes on. We are going to

have to justify this if we accept these recommendations and proposals.

I want the record to show that the justification is made.

Dr. BISPLINGHOFF. Yes.

I think it is an important question because you can have these kind of service groups duplicated over and over to an extent which is too great.

There is some optimum arrangement for this.

Mr. KARTH. I think this was probably our concern more than questioning the idea whether or not we should have duplicate machine shops, because although we say duplicate machine shops, I think every member of the committee recognizes each one of the centers needs some kind of a machine shop to do the work pecular to that center.

How far you go down that road is another question.

It always seems to be a knotty problem where the break is concerned.

Utility installations—would you care to address yourself to that?

Mr. MYERS. This is at Langley and this project is $1,249,000 and it is essentially in two parts: One part is road construction and this is the extension of the Ames Road at Langley for approximately 3,500 feet of a 30-foot-wide paved road and it includes the clearing, drainage, excavation, grading, and whatnot.

The second part is a utilities tunnel extension which is a construction of 3,800 linear feet of tunnel extending the existing walkthrough tunnel from the west area heating plant to the area where new facilities are being located or proposed to be located.

This tunnel is a 7-foot-wide by 7-foot-high utilities tunnel, as I mentioned.

I would be glad to answer any questions on that if you like.

Mr. KARTH. This is at Langley?

Mr. MYERS. Yes, sir.

Mr. KARTH. It seems to me we should have vacated some buildings or some of the facilities there as we moved the Manned Spacecraft Center from Langley to Houston.

What has happened to these buildings and these facilities as we moved?

Mr. MYERS. The Space Task Group, as it was known when Project Mercury first came into being, was located in the east area at Langley which, colloquially speaking, is the Air Force side of the field and this used to be the original part of NACA.

When NACA expanded through the years it moved over to the other side of the field, the so-called west area, and this is where practically all of our facilities are now.

When the Space Task Group moved to Houston, they had two buildings if I remember correctly that they were occupying. The Space Task Group was a project office and as such did not have facilities like a research center has.

They had engineers that wrote specifications and got things out on contract. We did do a considerable amount of work at the Langley Research Center in support of Project Mercury—don't misunderstand me—but their main responsibility was project work so primarily they were occupying office space over there.

When they vacated there was some discussion that the Air Force would like to take the space over. They were running out of space

and needed more, but we are now occupying the space with some of our project people, such as Project Fire, in the old building which used to be the old administration building, the original NACA. Everything now in the way of research facilities is in the west area, except the full-scale tunnel, which is a very large tunnel in the east area.

Mr. KARTH. What are we using now for the utilities at Langley? This is apparently an expansion program?

Mr. MYERS. This is an extension, Mr. Karth.

The chart, if you turn to page CF 5–21, perhaps it may clarify it.

The heavy black lines are the extensions of the utilities tunnel and road. The narrow line, the black line, is the tunnel and the wide line is the road.

If you see the building numbers there—they are kind of small but you see the building 1251, that is the unitary plan wind tunnel.

At the present time we have no road, nothing but a dirt road, and there is no way to get out, for example, to the landing loads track except this old existing dirt road which for years, since the landing loads track was in existence, has been very difficult to navigate with heavy models and landing gear which we use on the landing loads track. Sometimes this road is impassible.

This whole area just to the left and up—say to the northeast of building 1251——

Mr. KARTH. Are you talking about the hypersonic physic test area now?

Mr. MYERS. Yes, the hypersonic test area, which is in existence, and the hot gas radiation research facility Dr. Kurzweg spoke to you about yesterday, and the test facility, a part of which was authorized in 1963 and for which we are asking an addition in 1964, for the stabilization of control laboratory and electronics instrumentation laboratory, and over on the left the lunar landing research facility, which is rushing to completion at the moment.

Mr. KARTH. What are we going to put in there?

Mr. MYERS. In where?

Mr. KARTH. The lunar landing research facility?

Mr. MYERS. That was a facility constructed and is under construction from the 1962 program.

Mr. KARTH. We got that started before we moved to Houston but now we have moved to Houston, what are we going to do with this?

Mr. MYERS. We are conducting research in this facility or intend to conduct research in this facility where we have a large crane or I should say an overhead steelwork—it is all open steelwork which just supports a track on which the model moves along the track and at the same time through control mechanisms can descend as if you are making a transition landing on the Moon or some other planet and what we are doing here is, as Dr. Kelley mentioned in his program, we are studying stability and control techniques and systems that will have possible implications in vehicles that will be required to land on other planets different from the Earth's atmosphere and gravity.

Mr. KARTH. Are you going to conduct lunar landing tests there?

Mr. MYERS. Yes. What do you mean—for Apollo?

Mr. KARTH. Yes.

Mr. MYERS. This was called the Lunar Landing Facility back in 1960.

Mr. KARTH. That was the basis upon which it was justified, isn't it?

Mr. MYERS. No, sir; it was justified on the basis of research. The earliest missions of this type that were visualized would have been a lunar landing and therefore it was named a Lunar Landing Facility but it can be used for studying landings in other environments.

Mr. KARTH. It can be, I know that.

Mr. MYERS. Well, it is being designed for that.

Mr. KARTH. This thing was orginally justified on the basis you needed this facility to test craft for the lunar landing, isn't that correct?

Mr. MYERS. Not to test craft for the lunar landing but to test this type of vehicle. It was not for——

Mr. KARTH. We are not going to be engaged in semantics here but let me ask you this: Are we building one of these things at Houston?

Mr. MYERS. No, sir. I understand that has been deleted now.

Mr. KARTH. Of course, if your theory of what we should do at these various centers stood the test of this one, why then I would say we should build this thing at Houston. We should have the facility at Houston, shouldn't we, in support of a lunar landing program?

Mr. MYERS. Sir, this is a research facility in which we study many kinds of control systems that will apply to many types of vehicles. It was just that it was visualized——

Mr. KARTH. You don't even have any plans for any other type of vehicle yet?

Mr. MYERS. When this facility was visualized in the space exploration program we knew we were going to have to land on various planets in space exploration and how to do this and which technique to use, whether you use visual control, automatic control, on-off systems, these have to be studied because your gravity field is different and this simulator in effect will simulate the various gravities that are required and put you in the right environment to try out the various control techniques, so that we are producing data from this facility or will produce data which will be applicable to many types of vehicles whether they land on the lunar surface or others.

Mr. KARTH. Now, the two big administrative buildings that were being used by the manned space flight group are not being used by those people since they are now at Houston.

What did you say we are doing at these buildings or what are these buildings for?

Mr. MYERS. These are office buildings and primarily we are using them as office buildings at Langley to house some of our people and I said or I used the example of Project Fire, which Mr. Ames described to you, as being a project office located there. There are other projects Langley is handling and they are using other parts of that building for those people.

Mr. KARTH. We could not convert either one of those two structures or a portion of them to some of these other needs, is that right?

Mr. MYERS. Sir, this is a brick office building which was constructed I think in 1921 that is strictly an office building. It does have a cafeteria in it that was used as a shop at one time.

Mr. KARTH. Why do you have to construct this utility installation so far away from everything?

I notice that 3,500 feet of pavement are involved here at a cost of $325,000.

Is this something the engineers decided is absolutely necessary?

Mr. MYERS. The area here—yes, sir.

If you look at the Langley layout I think you can see that the existing and older part is getting to be fairly crowded and complex.

It is on page CF 5–1 right about the middle. You see the area we are talking about is part of the long-range plan of where to expand the facility area.

The area there as you can see on the left is very marshy and the water tables are such that we have to go to certain locations if we place a new facility. This is an area that is an extension of the very crowded area which you see on the right hand side. This is merely an extension from our heating plant of heat that is required, electrical utilities, high pressure steam for ejectors that is required for these facilities I spoke of out here in this area. It is merely an extension of what we need, plus the road which we feel is very important in trucking things out to these facilities.

Mr. KARTH. Mr. Morris?

Mr. MORRIS. Is this a test facility or is this just going to be a research facility?

Mr. MYERS. Well, the utility installations, the item I am speaking of, is primarily to add water, electricity, steam to the facilities that are proposed and are existing; or under construction in this particular area.

You ask if all of the facilities which are here are research facilities. These are not ad hoc testing facilities, these are research facilities.

Mr. KARTH. You have outgrown your present utility capability, is this right?

Mr. MYERS. We have to provide utilities for these facilities and we have to provide a means for getting them there and that is what this is.

Mr. KARTH. You are talking about the facilities that are proposed?

Mr. MYERS. Proposed and under construction, yes, sir.

Mr. KARTH. Haven't we budgeted for this utility installation before for those that are under construction, for those projects already authorized?

Mr. MYERS. We had some funds in the Lunar Landing Research Facility for electrical but we had not funded for the other utilities because we have visualized this area was being built up and we would like to put in a tunnel which can take all of the utilities out in that area and then we can tap off from that tunnel as expansion requires it.

Mr. KARTH. I am not attempting to be critical but it seems to me it is rather poor engineering to build buildings or ask authorization of funds and appropriation of funds to build buildings in an area where you don't have utility services and then ask for authorization or appropriation of funds to construct those utilities at a later date.

What if we turn this utilities installation request down?

You mean that building is a great cost out there?

Mr. MYERS. No; if you turned it down we would have to come back in for additional funds or try to make some other arrangements out of other funds in order to do it.

Mr. KARTH. Don't you think these utilities installations funds should have been requested at the time the buildings were proposed and requested?

Mr. MYERS. I think it may have been difficult and it was part of our plan here to do it this way because we are only putting in one facility, the vehicle antenna test facility which is going to take a little over 2 years to construct in fiscal 1963, which is now just getting into the design stage.

Mr. KARTH. Except you see the position you put Congress in.

I don't recall what the proposal was last year or 2 years ago, whenever it was when the request was made for facilities in this area that we now have to supply utilities to and I recognize the need for the supplying of utilities, but I think it is kind of misleading to the Congress to say now this is what we need for this project and then later on come in and say well this is what we needed for the project except we also need utilities now so you have to provide another $2 or $4 or $6 million, whatever it is.

I am really somewhat disturbed about the procedure.

Mr. MYERS. The vehicle and antenna test facility authorized in fiscal 1963 which is the one under construction here—these others are 1964—we did provide some utility extension in these particular projects but at that point in time we in our advance facility planning knew we were going to propose additional facilities for this area.

Our engineers at Langley felt that it would be much cheaper in the long run, rather than putting above-surface facilities, that is exposed pipe and exposed power lines and so forth, to individual facilities and then as each one is built to add another separate line and so forth, to put in a facilities tunnel and this was in their planning and once we decided that we were going ahead with these facilities, then the facilities tunnel was proposed and that is why it is proposed in 1964 and we will have it in operation, if it is authorized, by the time these other facilities need the utilities.

So it was part of the plan.

Mr. KARTH. What if we don't authorize this utility installation and you finish the construction of those buildings that are now under construction? You can't operate them, can you?

Mr. MYERS. We would have to provide individual lines to each of the facilities.

Mr. KARTH. Colonel Gould?

Colonel GOULD. You are requesting $325,000 for about two-thirds of a mile of 30-foot roadway which works out if my arithmetic is correct to $487,000 a mile. This is a pretty expensive road.

Would you define specifically what you intend to do for this $325,000?

Mr. MYERS. Yes, I mentioned the water table there as rather high and so this is not an usual type of road.

This road item is an 8-inch reinforced concrete road with a rolled curb on it, 16,800 square yards of road at $7.60 per square yard, including the cost of curbing and there is some minor amount of sidewalk involved—$4.20 per square yard, and included in the road construction are storm drains for area drainage which account for approximately half of the cost of the item and I have some additional breakdowns here on the storm drainage if you would like those.

Mr. KARTH. The colonel advises me that modern highway construction, you know where you are running these huge transcontinental trucks over repeatedly, costs about $300,000 per lane.

Do you plan greater things for this road than our modern highways?

It is just a matter of curiosity.

Mr. MYERS. I think I mentioned that half of the cost is in the drainage because of the high water table there.

Now Langley has built other roads in this similar area and these estimates are based on our previous experiences in building these roads.

Colonel GOULD. Why are we building concrete roads at this station rather than blacktop?

Mr. MYERS. Well, we have found through the years—I think if you have been at Langley you see that all of our roads are concrete there except some that run around the airfield there which are temporary roads—and we found through the years this is much cheaper for us to build and they stand up better and there is less maintenance involved and they have been very satisfactory.

Colonel GOULD. At the Mississippi Test Site we are building a four-lane highway as part of the Mississippi Test Facility at $300,000 a mile, blacktop, with much the same conditions you have at Langley.

This cost appears to me to be excessive.

As a matter of fact the two-lane highways in Mississippi are only running $150,000 a mile.

Mr. Ulmer, could you correlate the variance of costs between road construction at Langley and that in Mississippi for example within the NASA program?

Mr. Ulmer, could you give us some explanation for this?

Mr. ULMER. We will do our very best to, Colonel Gould, but I would like to point out there are these drainage conditions involved.

There are clearing costs involved and the figure you see here lumps all of these together in this estimate.

We would have to break out the individual items and compare them for you.

Colonel GOULD. I think in view of the high cost of this item, Mr. Myers, that we should have a detailed breakdown placed in the record as to what comprises this $325,000 and some additional justification as to why the cost is so high.

Mr. MYERS. I would be glad to give you that.

(The information requested is as follows:)

Breakdown of item "Road Construction" (approximately 3,500 feet of pavement, 30-feet wide), $325,000, and justification of these costs under project "Utility Installations," Langley Research Center, reference fiscal year 1964 budget estimates, page CF 5-22.

Cost breakdown

Storm drain pipe and installation	$142,150
Manholes, storm inlets, outlets, and laterals	8,820
Site preparation, excavation, and backfill	44,360
Road paving 16,800 square yards at $7.60	127,680
Walk paving 500 square yards at $4.20	2,100
Total road construction	325,110

JUSTIFICATION

A comparison of the above cost estimates for the road construction with costs of recent highway construction in the Langley area shows equivalent costs except for the drainage system. For example: Magruder Boulevard, near Langley, was completed this year. It is an 8-inch concrete dual highway with 48 feet total width, 4.135 miles long. Including deep ditch drainage, the average cost was $308,000 per mile, roughly equivalent to $192,000 per mile for a 30-foot-wide road. To compare costs, the Langley road, when estimated with this type of ditch drainage, comes to $197,000 per mile.

The drainage system planned for the Langley project brings the cost of the road to $340,000 per mile. The total area to be paved is equivalent to 5,040 feet of 30-foot-wide road. The drainage system is required for storm water drainage of a large area of low flatland through which the road passes. The ditch type drainage would not be suitable for this type of installation.

Colonel GOULD. Now the cost of the utility tunnel works out as I calculate it, to about $148 a linear foot.

How does this compare with the cost of utilities tunnels at Houston, for example?

Mr. Ulmer, possibly you can answer that.

Mr. MYERS. I cannot speak to Houston.

I can speak to one of our other facilities which I am familiar with.

Mr. ULMER. I don't know how the Langley figure compares to the Houston figure. The Langley figure is comparable to similar tunnels at the Lewis center on a unit cost basis.

Colonel GOULD. What were the comparative costs at Lewis?

Mr. MYERS. This was higher than the cost of a similar sized utility tunnel at Lewis and it is primarily due again to the high water table which requires, I think—what was the thickness of that wall, Mr. Littell? I have forgotten it.

Mr. KARTH. I am beginning to think we ought to put it above ground.

Mr. MYERS. It requires 8-inch-thick wall because of the height of the water table and also requires some sheet steel piling support so this is a little more expensive for its size than the one at Lewis. The conditions at Lewis are different than they are here but they are comparable.

Colonel GOULD. Following up on Mr. Karth's question, if you do have a drainage problem at Langley why did you decide to go to underground utility ducts rather than overhead lines?

Mr. MYERS. We have found through the years also that the underground utilities are much cheaper in the long run. Also, you can add other utilities by just putting a line through these.

They are easier to maintain. When you need a new computing service, for example, in a facility it is very easy to put a line right through these tunnels to the data reduction center rather than construct above ground and our experience has been for many years that this is a much cheaper way for us to do it.

Also, they are easier to maintain.

Mr. KARTH. Why would it be cheaper to lay a utility pipe in a tunnel than to lay it above ground?

I don't understand why it would be cheaper.

Mr. MYERS. Because you have maintenance, you have breakdowns and you have leaks in your system and so forth and it is much easier to protect this in a tunnel than it is to expose it above ground.

This has just been our historical experience.

Colonel GOULD. What are the design and construction leadtimes for these utility installations?

Mr. MYERS. Fourteen months was the design construction leadtime.

Colonel GOULD. Have you started design already?

Mr. MYERS. Yes, sir; we have provided $70,000 in fiscal year 1963 funds out of the advance design funds.

Colonel GOULD. That is from fiscal year 1963 funds?

Mr. MYERS. Yes, sir.

Colonel GOULD. That is the $71,000 that shows up on page CF 5–22?

Mr. MYERS. It is my understanding we were only able to provide 70 instead of the 71 that shows here.

Colonel GOULD. Mr. Ulmer is keeping pretty close control of the purse strings?

Mr. MYERS. Yes, sir.

Colonel GOULD. Would you define for us, please, the scope and extent of the high pressure steam and water piping that you have included here for $241,000?

Mr. MYERS. Yes, sir.

The tunnel carries steam 350 p.s.i., hot and cold waterlines and compressed air.

In the high-pressure steam line it is expected that 20 percent of the 274,000 pounds of steam per hour of the boiler will flow through this tunnel, which is going to be an 8-inch distribution line, and can handle a peak load of 35,000 pounds per minute.

There will also be a 4-inch condensate return line. The steam usage is estimated at 60 percent for building heating and 40 percent for process purposes.

The hot water system will have continuously circulating water of 140° F. and a 4-inch line, the compressed air line, will handle 110 p.s.i. and 1,800 p.s.i.

Colonel GOULD. How many linear feet of high-pressure steam line?

Mr. MYERS. Well, it is the length of the tunnel.

I don't happen to have that.

Colonel GOULD. 3,800 feet?

Mr. MYERS. It may not go all of the way.

I would have to check that.

Colonel GOULD. Will you provide it for the record, please?

Also the length of the condensate return line and the length of the water pipe?

Mr. MYERS. Yes, sir.

(The information requested is as follows:)

For the Langley Research Center utilities installations, the length of the high-pressure steam line, condensate return line, and the waterlines is the full 3,800-foot length of the tunnel.

Colonel GOULD. What is included in the item "Electrical Installations" for $24,000?

Mr. MYERS. Electrical installations, $24,000.

This is for lighting and ventilation fan power and sump pump for the tunnel.

Colonel GOULD. Is this going to be an overhead line?

Mr. MYERS. No, sir; not to my knowledge.

Colonel GOULD. These lines run through the utility tunnel also?

Mr. MYERS. Yes.

Colonel GOULD. I notice no provision being made for sewage disposal here. Would you comment, please?

Mr. MYERS. No; not that I know of in this tunnel.

Colonel GOULD. Where are the sewer lines and system included for the projects now under construction and those planned for 1964?

Mr. MYERS. I am not familiar with that detail. I will have to find it and furnish it for the record. Do you know, Mr. Littell?

Mr. LITTELL. No, I don't know.

Colonel GOULD. The reason I ask this is because in fiscal 1962 and 1963 there were no utility projects as such, and as I understand it NASA's policy in programing facilities is that a project for a facility takes the utilities out to about the 5-foot line or just outside the building and from that point on you pick it up with projects for utility mains.

I can find no provision having been made for a sewer system to support the buildings now under construction and proposed for 1964.

Mr. MYERS. I will have to get that information for you. I really don't know.

Colonel GOULD. Do you happen to know, Mr. Ulmer?

Mr. ULMER. I do not.

Colonel GOULD. Would you provide that for the record?

It may be one of these items buried in some other project, and following up on Mr. Karth's questioning with reference to these utilities projections, I think it should be defined as to where it is included.

Mr. MYERS. Yes, sir.

(The information requested is as follows:)

INFORMATION ON SANITARY SEWERS FOR RECENT AND PROPOSED FACILITIES IN THE AREA OF THE UTILITIES INSTALLATIONS PROPOSED FOR LANGLEY RESEARCH CENTER

A sewer line exists which connects to the west area sewage disposal system and extends to the intersection of Ames Road and Warner Road. Extension of this line along Ames Road and Freeman Road to the vehicle antenna test facility is a part of the utility installations cost of the vehicle antenna test facility construction in 1963 fiscal year. This will permit short sewer connections for all facilities in the area except the lunar landing facility, which has its own septic system and drain field. All sewer connections and the above septic system are a part of the utilities installations item for the individual facility.

Mr. KARTH. Mr. Myers, have you determined what the aboveground costs of these utility installations would be as opposed to the in-tunnel costs?

Mr. MYERS. I personally have not but our people at Langley look at these at any time they put in something like this to see the length, the capacity and so forth, and which is the cheaper way to do it.

Mr. KARTH. Would you provide in the very near future the cost estimate for aboveground utility construction as opposed to tunnel construction?

Mr. MYERS. Yes, sir.

(The information requested is as follows:)

COST ESTIMATE OF ABOVEGROUND UTILITY CONSTRUCTION AS OPPOSED TO TUNNEL CONSTRUCTION FOR THE LANGLEY UTILITIES INSTALLATIONS PROJECT

EXPLANATION

The higher cost of the utilities tunnel is considered to be offset by the following distinct advantages provided:

(*a*) The tunnel provides an ideal means of running data cables between buildings and to the data reduction center.

(*b*) The tunnel is available for economical tie-in of all facilities along its length.

(*c*) The tunnel presents no problem to the utilization of land crossed as aboveground utility lines would.

(*d*) The tunnel is a proven system for the area, as much of the existing electrical and mechanical utilities at Langley are underground. This is based on Langley's experience with approximately 8,000 feet of existing utility tunnels.

(*e*) The tunnel provides for future piping and will allow later installation of a chilled water distribution system.

Comparison of estimated cost

A. Below ground walk-through steam tunnel	
1. Concrete tunnel	$563,900
(*a*) Excavation, fill, grading	60,000
(*b*) Waterproofing, expansion joints	130,000
(*c*) Concrete	303,900
(*d*) Reinforcing steel	70,000
2. Mechanical piping	241,600
(*a*) Valves and fittings	24,000
(*b*) Pipe covering	38,000
(*c*) Piping	179,600
3. Electrical installations	24,200
Total	829,700
4. Design and engineering services	49,800
Total estimated cost	879,500
B. Above ground except at street crossings	
1. Aboveground requirements	236,500
(*a*) Concrete supports and anchors	53,000
(*b*) Concrete underground street crossings	76,300
(*c*) Expansion joint shelter	40,600
(*d*) Additional fittings at street crossings	6,700
(*e*) Weather-proofing pipe insulation	20,100
(*f*) Duct bank for data and telephone cables	66,800
2. Mechanical piping	241,600
(*a*) Valves and fittings	24,000
(*b*) Pipe covering	38,000
(*c*) Pipe	179,600
3. Electrical installations	24,200
Total	529,300
4. Design and Engineering services	31,700
Total estimated cost	561,000
Difference	318,500

Mr. KARTH. And also would you provide the cost estimate of blacktop road for the 3,500 feet you request as opposed to the 8-inch concrete that you propose in this budget?

Mr. MEYERS. Yes, sir.

(The information requested is as follows:)

COST ESTIMATE OF BLACKTOP ROAD AS OPPOSED TO THE PROPOSED 8-INCH CONCRETE ROAD FOR THE LANGLEY UTILITIES INSTALLATIONS PROJECT

EXPLANATION

The lower initial cost obtained by use of blacktop paving instead of 8-inch concrete would be approximately $69,000.

Concrete 16,800 square feet at $7.60	$127,680
Asphalt 16,800 square feet at $3.50	58,800
Difference	$68,880

Experience at Langley Research Center has shown that the concrete is more feasible because of its lower maintenance cost and longer life. This is a local condition resulting from the poor load-bearing characteristics of the soil. The distribution of load afforded by concrete is needed to compensate for the soil condition. So-called flexible paving such as blacktop has proved unacceptable for area roads subject to heavy trucks (20 tons) used to service the facilities at Langley.

Colonel GOULD. Would you send me a copy of that directly please?

Mr. MYERS. Surely.

Mr. KARTH. Mr. Morris?

Mr. MORRIS. As I understand it, you have not started the construction of this vehicle antenna test facility?

Mr. MYERS. I did not hear the question.

Mr. MORRIS. You have not started the construction; is that correct?

Mr. MYERS. That is correct.

Mr. MORRIS. And this was authorized in 1963 and now you are asking for about $1.7 million in addition to it now?

Mr. MYERS. Yes, sir.

Mr. MORRIS. Well, this is a test facility and not a research facility?

Mr. MYERS. No; this is a research facility.

It will also be capable and I think Dr. Kelley will speak to this this morning. It will also be capable of taking certain antenna systems and running certain types of tests but it is a research facility.

Mr. MORRIS. Is Langley going to do any of the testing?

Is this going to be a testing center also?

Mr. MYERS. I think to answer that question there are always tests which can be run in any development project that are required and which our research facilities often have unique capabilities in the United States and where a test can be run in an existing facility, arrangements are made to do so and the research projects wait until those tests are done, if it is of high enough priority in the development program, so in general the answer to your question is many of our research facilities do conduct some specific tests for specific development projects where they have unique capability.

Mr. MORRIS. You know we are building a test facility at White Sands out in New Mexico and that is a test facility. Now are you still trying to build up Langley as a test center too?

Mr. MYERS. No, sir.

Langley is primarily a research center even though it does——

Mr. MORRIS. Are you going to do any testing of lunar exercusion module at Langley?

Have you planned on any?

Mr. MYERS. We have none in our present test program but if it is required and if it looks like it is appropriate, I am sure we would make arrangements to do so.

But our work is of a general research nature and it would be interrupted for some specific work like that if it were requested.

Mr. KARTH. You will be doing some testing at the lunar landing research facility, won't you?

Mr. MYERS. Yes, sir.

Mr. KARTH. Then the answer is yes you will be doing some testing?

Mr. MYERS. I think it depends on what you mean by testing. All our research work as I say——

Mr. KARTH. You will be doing some Apollo testing there, won't you?

Mr. MYERS. It is my understanding at the moment that the Apollo people would like us to because this facility will have unique capability and they would like us to take on some tests there, yes, sir.

But this will be part of a general program.

This will be a specific part of a general research program.

Mr. MORRIS. Such as?

Mr. MYERS. I understand taking the module and actually flying it down to the ground and testing the specific systems that have been designed for that module.

Mr. MORRIS. We are going to have some real differences of opinion when you start out on that.

Mr. KARTH. Any other questions?

Mr. MORRIS. I just want to make sure there is no misunderstanding?

Mr. MYERS. Yes, sir.

Mr. KARTH. Thank you very much, Mr. Myers.

Dr. Bisplinghoff, whom would you like to call now?

Dr. BISPLINGHOFF. Mr. Karth. Mr. Finger was called out of town today and we have with us this morning his two deputies and I would first like to call on Mr. Milton Klein, who is Deputy Manager of the Space Nuclear Propulsion Office.

This as you know, is the office which is a combined operation between the AEC and NASA and Mr. Klein will describe for you the facilities which we propose at the Nuclear Rocket Development Station.

In your list you can see there are five facilities which are indicated by NRDS location.

Mr. KARTH. Where is that?

Dr. BISPLINGHOFF. That is in Nevada, north of Las Vegas.

Mr. KARTH. Yes, sir.

Mr. Klein?

Mr. KLEIN. As Dr. Bisplinghoff said, I will describe briefly the projects before you which are part of our program of developing the facilities capability at the Nuclear Rocket Development Station in Nevada for the nuclear rocket program.

Our facilities effort there, as you know, is aimed at providing for the ground development testing of nuclear reactors, nuclear engines, and ultimately nuclear stages.

The facilities requested here are all required for the NERVA program. NERVA, as you know, is the first generation nuclear rocket engine now under development. The first project in your list is the additions to Engine Test Stand No. 1.

Engine Test Stand No. 1 is the first stand designed for testing a complete nuclear rocket engine and is also the first stand at which we will be able to test in a downfiring position.

All of the reactor tests that have been conducted and will be conducted prior to this facility are upfiring.

The purpose of these additions is to——

Mr. MORRIS. Mr. Klein, you will explain what you mean by upfiring and downfiring to be sure there won't be any misunderstanding.

Mr. KLEIN. Yes, sir; I will be happy to.

What we mean is the way in which, for these ground tests, the hydrogen is expelled.

In the reactor test for testing simplicity, we fire the reactors so that the expelled gas fires upward.

It is just simpler to handle that way.

In actual use obviously the rocket engine will fire downward and this first engine test stand, the Engine Test Stand No. 1, will enable us to test it in that configuration.

Mr. MORRIS. So far the reactors you have tested, where have you tested them?

Mr. KLEIN. These have all been tested thus far in what we call Test Cell A—at the Nuclear Rocket Development Station.

We also have essentially completed now a second reactor test cell, Test Cell C.

Mr. MORRIS. This is all funded in this year's budget, the completion or the construction on Test Cell C vehicle?

Mr. KLEIN. Test Cell C was funded in a prior year's budget and is about finished.

Actually the construction is completed. We are in the checkout phase for the facility.

Mr. MORRIS. Mr. Klein, when do you expect to make your first test of the first, the first static test of the NERVA engine?

Mr. KLEIN. This is scheduled now in the latter part of 1965.

Of course the testing of that depends upon the progress we make in the reactor program.

Mr. MORRIS. I was coming to that.

When do you expect to make the next test of the reactor?

Mr. KLEIN. This will be either late this year or early next calendar year for the hot test which I think you are referring to.

Mr. MORRIS. Yes.

Mr. KLEIN. We will have several cold flow tests in the intervening period as well as a rather extensive program of vibration testing, component testing, in various locations.

Mr. MORRIS. Have you decided actually on the reactor yet that you are going to go with?

Mr. KLEIN. Yes, sir; we have. The basic reactor has been decided upon.

What we are involved with is the details, some of the crucial details of design, particularly in the support area but the basic reactor design we have decided upon and are moving with.

Mr. MORRIS. And what do you call that? How do you designate this reactor?

Mr. KLEIN. We call this, the basic design that we have used is the Kiwi-B4 design, and the NRXA. They are essentially equivalent designs.

Mr. MORRIS. So you actually don't feel that you will need test stand No. 1 until 1965?

Mr. KLEIN. That is correct, sir.

These additions to test stand No. 1 are needed in order to enable us to enhance the data collecting aspects of the stand and to enable us to test with greater frequency, to minimize the time between tests.

The additions provide for instrumentation and control, equipment to facilitate this acquisition of data and to enable us to minimize the crosspatching that is needed from one test to the next.

It provides for certain piping and valving additions so that we can handle these remotely and again minimize time between tests. Another significant item in this addition is decontamination equipment for the exhaust duct so that the radiation that collects, plates out on this duct from test to test, can be cleaned to minimize the radiation levels at the test stand for people to work around.

Colonel GOULD. Before asking questions, on a recent visit out there I had a very fine briefing by your construction man at Jackass Flats and he provided me with four charts I thought were very helpful in explaining the relationship between AEC and NASA and SNPO and if the chairman has no objection I would like to introduce these into the record.

The first chart shows the relationship between these organizations (fig. 311); the second chart shows the mission of the support center (fig. 312); the third chart indicates the categorical breakdown of construction which I thought was very, very helpful (fig. 313); and the fourth chart defines the construction management functions of the Catalytic Construction Co. who manage your construction at this site (fig. 314).

If you have no objection, Mr. Chairman, I would like to introduce these into the record at this time.

Mr. KARTH. There are no objections.

Colonel GOULD. Construction of test stand No. 1 was financed by AEC?

Mr. KLEIN. That is right.

Colonel GOULD. How much was involved in their part of it?

Mr. KLEIN. About $20 to $21 million.

Colonel GOULD. What is the status of this stand at the present time?

Mr. KLEIN. Much of the actual building construction is and much of the piping is completed or is certainly nearing completion.

There are several major items that have yet to be completed. Probably the longest item is the exhaust duct for handling the hot hydrogen during a firing. That duct design has been a development problem in itself and it is the longest and most critical item remaining to be done from a timing point of view.

We expect it to be done on the schedule I have indicated.

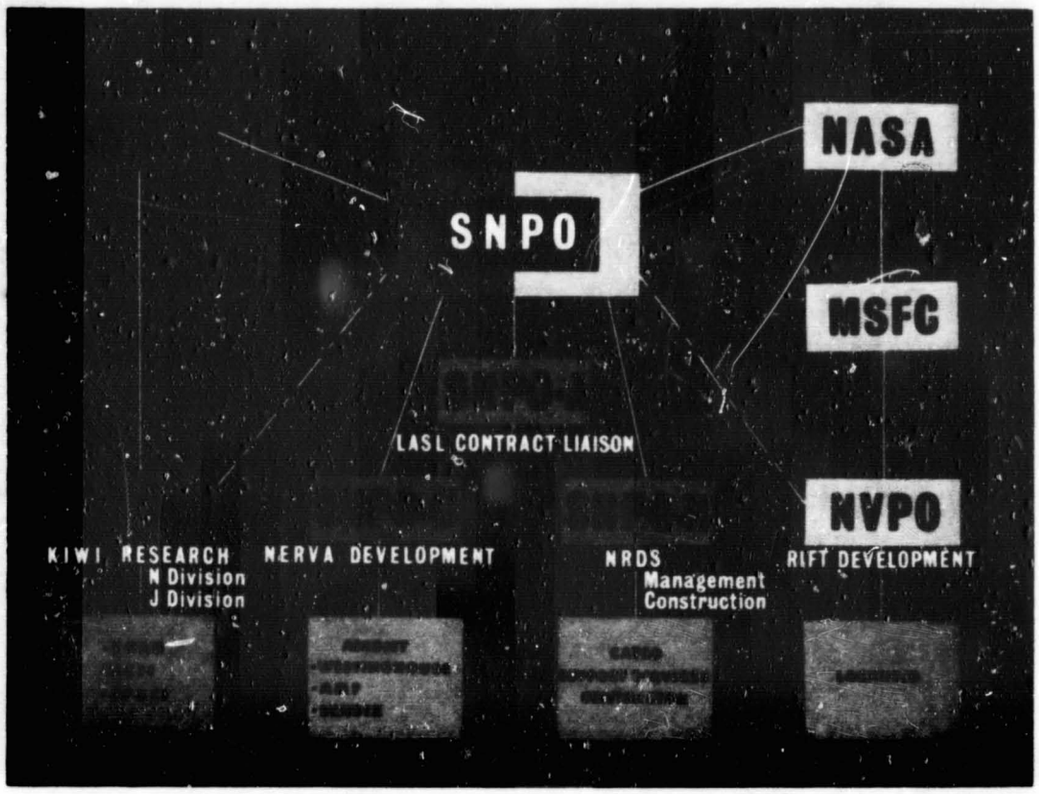

FIGURE 311

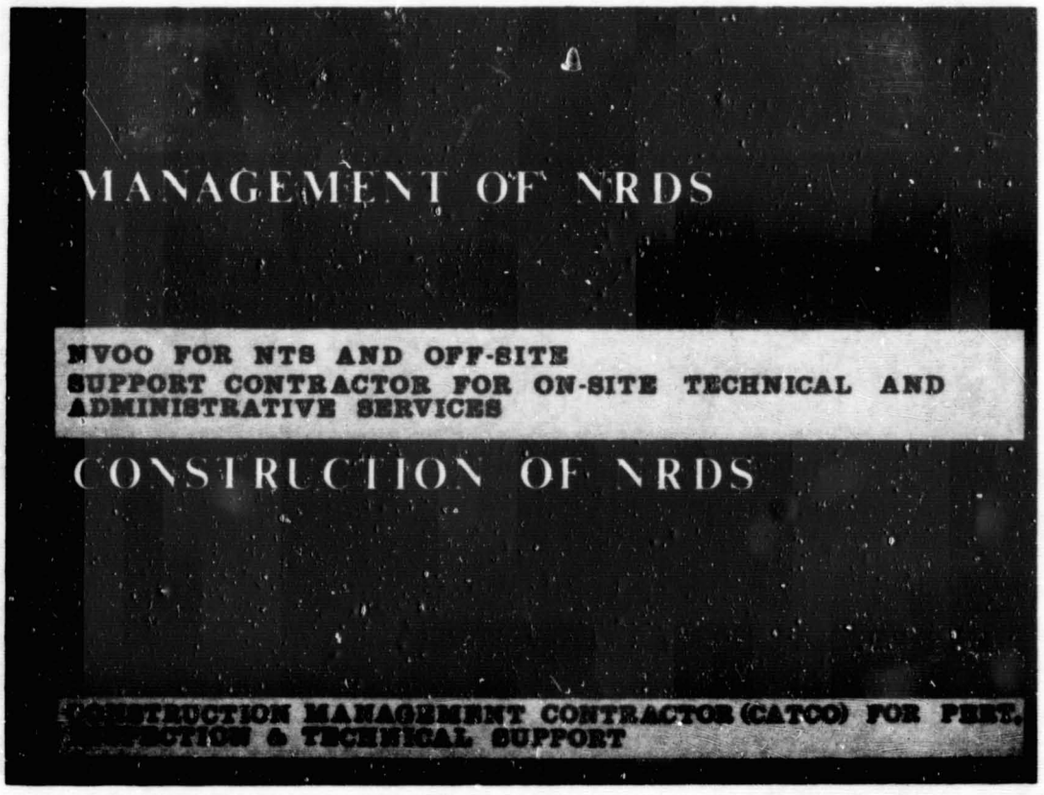

FIGURE 312

96-504 O—63—pt. 3b——40

FIGURE 313

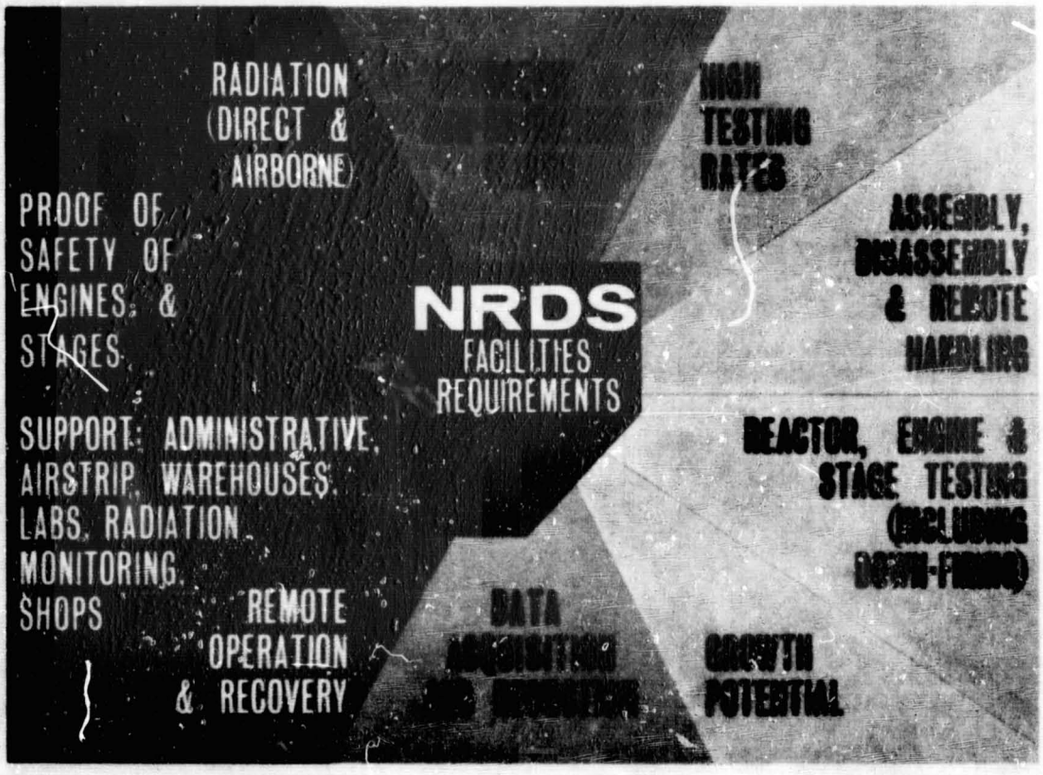

FIGURE 314

Colonel GOULD. Have all of the problems in the duct design been solved or are we still faced with some delay?

Mr. KLEIN. I think I would be too "Pollyannish" to say they have all been solved.

I think that we see the way clear to an adequate solution at least for these early tests. There are compromises involved and we are still pursuing the development program associated with the duct for use in ETS–2 and for possible future modifications as necessary at ETS–1.

Colonel GOULD. We recently had a release from NASA indicating an 18-month slip in the Kiwi program and since the NERVA program is dependent on the Kiwi development, what impact has that had on the requirement for the test stands?

Mr. KLEIN. I don't know the release you are referring to in the Kiwi program.

Colonel GOULD. I think it was put out by NASA.

Mr. KARTH. It was probably put out by AEC.

Mr. KLEIN. I would probably know that, too, and I am not aware of the release.

Colonel GOULD. It was during February.

Mr. KLEIN. Without referring to that specifically, we have delayed the timing of our next hot tests while we are doing some of this components examination work, cold flow work, vibration testing work, that I referred to a few moments ago. That means that the next hot test will be, as I said late this year or early next, rather than about now or a month or so ago as it was originally thought—I mean as it was thought before the last test.

Mr. MORRIS. Mr. Klein, a year ago about this time it was planned to make a hot test which you are going to make next January, probably. It may be late November or January then; is that correct?

Mr. KLEIN. My recollection, Mr. Morris, is not really clear on that but I know as of last fall this next test we are planning was to be in about February of this year.

Mr. KARTH. How about last spring? When did you contemplate it then?

Mr. KLEIN. My guess is it was probably several months before then but I don't remember for sure.

Mr. MORRIS. Actually this hot test we are speaking of coming up next is actually a year behind, isn't it?

Mr. KLEIN. That is right.

It is at least a year behind, that is right.

Mr. MORRIS. And possibly 18 months would be closer?

Mr. KLEIN. It could be.

Mr. MORRIS. Just one question, Colonel Gould, and then you may proceed.

Have any of these requests previously been funded for?

Mr. KLEIN. These requests before you here, sir?

Mr. KARTH. Yes.

Mr. KLEIN. No; these are additions to facilities that have previously been funded.

Mr. KARTH. It seems to me my recollection calls my attention to the fact last year we did authorize funds and funds were appropriated for some of this nuclear test work which later was not spent for that purpose and was transferred or reprogramed into some other area.

Mr. KLEIN. There were several facilities you authorized last year.

One related to this engine maintenance, assembly, and disassembly building for which we are asking additions here. Some other facilities were involved in the stage program, the so-called Rift program. It is those later facilities which have been reprogramed to other uses outside of our program.

Mr. KARTH. So this year we are asking for funds——

Mr. KLEIN. We are still not asking for funds for the stage program in the budget.

Mr. KARTH. Not the stage but for the addition for engine maintenance, assembly, and disassembly building, is that correct?

Mr. KLEIN. Yes, sir.

Mr. KARTH. What portion of those funds or what portion of the $4.5 million had previously been funded and then reprogramed into some other area?

Mr. KLEIN. None of that. We have all of the funds that you have authorized last year for the engine maintenance, assembly, and disassembly building.

Mr. KARTH. They have not been spent?

Mr. KLEIN. They have not been spent but the design is underway. The construction has not started but it is expected to be started in the next several months.

Colonel GOULD. The justification indicates that NASA has conducted a safety review of the design and apparently certain safety features were left out of the original design, is this correct?

Mr. KLEIN. This refers to some of the aspects of the tunnel, as I recall; yes.

This I should emphasize is not a nuclear safety question but normal industrial-type safety considerations and in going through the design it appears that some additional things ought to be done to the tunnel area.

Colonel GOULD. This was a design deficiency; is that correct?

Mr. KLEIN. I think that is probably as good a term as any.

Colonel GOULD. The reason I raise this question is, AEC is usually pretty careful about the safety features of their projects and I am surprised you were able to find a deficiency in their design.

Mr. KLEIN. I hope there aren't too many.

Mr. MORRIS. Is this the tunnel that connects to where you have the tank?

Mr. KLEIN. With the control room; yes, sir.

Colonel GOULD. Of the $1.7 million requested here, how much is for the correction of these design deficiencies?

Mr. KLEIN. Let's see if I can pinpoint that.

Colonel GOULD. For safety matters.

Mr. KLEIN. I believe it is about $9,000, if I am reading this right.

Colonel GOULD. $9,000?

Mr. KLEIN. I see a couple of items and I can't identify specifically how much of it you would associate with that point, but these two items in total add up to about $40,000 and I would think some part of that at least is associated with this question.

Colonel GOULD. What additions to the remote engine control systems for $204,000 are involved?

Mr. KLEIN. These are to facilitate the operation of this ETS–1, engine test stand No. 1, and engine test stand No. 2.

In the projects, as they have now been authorized, a good part of the control equipment as well as a good part of the gas tank farm and hydrogen system were common-use items.

As we go into more frequent testing, it is important that these facilities be capable of operating essentially independently. These additions to the remote engine control system are the things needed in the ETS–1 complex to accomplish that.

You will see companion items, actually more expensive items in the addition to ETS–2.

Colonel GOULD. What additional power system requirements are necessary?

Mr. KLEIN. These are largely to take care of the power required for the additional instrumentation and control systems in this project.

Coloned GOULD. What does it consist of, a half million dollars?

Mr. KLEIN. Well, it provides changes to—I can give only a general answer to that—it provides changes to the power circuits to accommodate the load demands of this instrumentation and control system change.

It provides changes to the substation to provide for additional power and additional diesel generator sets.

Colonel GOULD. Do you now what the additional power requirements are?

Mr. KLEIN. In kilowatts, no, sir; I do not have that information.

Colonel GOULD. Mr. Chairman, I believe that should be supplied for the record because if I recall correctly out of the $21.6 million financed by AEC, I believe there were almost $1 million, included for power and electrical distribution system and it does not appear from reading the justification and talking to the people on the site that we have actually added that much to the power requirements.

Mr. KLEIN. We will supply this for the record.

Colonel GOULD. I think we should have some additional justification on it.

Mr. KLEIN. All right.

(The information requested is as follows:)

The power system additions are estimated to be:

1. Modification to emergency diesel generator system to separate instrumentation and control emergency power from critical loads	$204,000
(a) 300 k.w. diesel generator package added	110,000
(b) Modify ETS–1 substation wiring to accomplish separation	76,000
(c) Relocation of present and new additions to diesel fuel storage and pumping system	18,000
2. Modify electrical distribution system to provide power for 600 h.p. motor for NES gas generator system	155,000
(a) Additional transformer and switchgear at substation	75,000
(b) Housing 1000 kv-a. switchgear and control	54,000
(c) Modify overload protection and control compatible with increased requirements	26,000

3. Provisions for tiein of utility power systems with emergency power systems [1]	$120,000
(a) Switchover equipment, including synchronization and voltage control equipment	120,000
4. Zero-potential ground to water table to provide low background noise lead for instrumentation and control system. (Present system is satisfactory for personnel and equipment protection only.)	82,000
Total	561,000

[1] Above change will provide utility power with suitable control for checkout and calibration of all systems between runs without undue wear on emergency systems.

Colonel GOULD. Would you explain for me the basis for the $150,000 in design and engineering services?

Mr. KLEIN. These are the services involved, the design and engineering services involved, in these modifications both to the facility and to the instrumentation and controls that I described to you and that are described in the project data sheet.

Colonel GOULD. Who is managing the design of this facility?

Mr. KLEIN. The design of this facility is managed by our Cleveland extension office which is our program office on the NERVA program. The design work is being done by Aetron and some of the design on the instrumentation and controls is being done by the firm of Edgerton, Germeshausen & Greer, Inc.

Colonel GOULD. Do you happen to know what the percent of the total construction involved is for A and E services?

Mr. KLEIN. For this particular addition?

Colonel GOULD. Yes.

Mr. KLEIN. Well, it looks—to do some of the arithmetic here—it looks about 10 percent.

Colonel GOULD. That would include not only the design cost but supervision and inspection costs?

Mr. KLEIN. Yes. I meant all engineering services.

Colonel GOULD. What percent is for design?

Mr. KLEIN. The design accounts for about I think 7 percent of this 10, because the title III work—title III as we use it is the inspection services and shop drawing approvals and so on—is about 2 or 3 percent.

Now there are, in addition to that, the costs of construction management functions which I believe are included in the construction costs.

Colonel GOULD. You say 10 percent.

Do you base your engineering and design cost shown here on item C or item C plus D?

Mr. KLEIN. I think this is C plus D to a large degree. You get into a problem with instrumentation because there is some vendor engineering that is involved in the instrumentation and control systems as well but I think a fair basis is C and D.

Colonel GOULD. The Catalytic Construction contract, is that a CPFF contract?

Mr. KLEIN. It is a CPFF contract only to the extent of Catalytic's own forces, which are essentially a general contractor, general construction contractor forces.

All of the construction work which is done under the Catalytic contract—almost all and to date all—is done under fixed price competitive bid work so that although the way the money gets to the constructor is through the prime contract, it is not CPFF construction.

Colonel GOULD. In other words, the construction contracts are let on competitive bid basis but the management or the supervision of the construction is under a CPFF contract?

Mr. KLEIN. That is correct, sir.

Colonel GOULD. Do you happen to have with you a fee schedule for the Catalytic contract?

Mr. KLEIN. Yes, sir, I do.

Colonel GOULD. I wish you would provide it for the record.

Mr. KLEIN. Yes, sir.

Colonel GOULD. That is all of the questions I have, Mr. Chairman.

Mr. KLEIN. The copy I have here today is an office copy.

I will supply another one to you.

Colonel GOULD. I think all we are concerned with is the fee schedule.

(This information will be contained in the committee files.)

Mr. KARTH. Mr. Morris?

Mr. MORRIS. Mr. Klein, have you selected the service contractor yet?

Mr. KLEIN. No, sir; we have not. We are in the final stages of selection. We have screened down from the 28 proposals that we received to 4 and those are now being examined in detail.

Mr. MORRIS. You have screened them down to four as I recall?

Mr. KLEIN. That is correct, sir.

Mr. KARTH. Would you care to proceed to the next item?

Mr. KLEIN. The next is the addition to engine test stand No. 2. This, as the name indicates, is a second engine test stand.

These facility modifications or additions are required for the point I made a few minutes ago, to achieve an independence of operation between engine test stand No. 1 and engine test stand No. 2.

This is very important to us because it will insulate us from delays in one stand carrying over to delays in the other stand.

It will minimize the down time, the cross connecting that needs to be done between use of the two stands and it also provides us a backup capability in case we have some serious accident on one stand that might incapacitate some of these common-use facilities.

Now included in this primarily are separate gas storage facilities, about 4 million cubic feet, and liquid hydrogen storage facilities and piping.

In addition there is the control complex we are setting up independently of ETS–1.

Mr. MORRIS. Mr. Klein, after you test the NERVA engine on test stand No. 1, undoubtedly there will be some changes made in the engine?

Mr. KLEIN. That is right.

Mr. MORRIS. Now will you be able to test at what you think might be full power now?

Mr. KLEIN. Yes, sir, we can do that in engine test stand No. 1 and engine test stand No. 2.

These two stands essentially will both be used for testing the same kinds of things.

Mr. MORRIS. They are actually the same thing, aren't they?

Mr. KLEIN. That is right.

Mr. MORRIS. What you really want them for or think you need them for is you may have a much heavier test schedule in the future; is that correct?

Mr. KLEIN. That is exactly right.

Mr. MORRIS. Of course if things don't go as well as we all hope in this program, it might be that it won't be necessary to have this test stand No. 2 as quick as you have it scheduled now.

In fact, I notice on the schedule you have it 1965 and 1966 and actually you are not going to need it in either 1965 or 1966.

Mr. KLEIN. Yes, sir; I think we will.

Actually these stands, they are phased about 6 months apart, recognizing at least in part that during the first few months it will take a longer time between tests than beyond that, but we certainly intend very early in our engine testing program to utilize both stands and that we will have to utilize both stands if we are to make anywhere near the kind of progress we are talking about.

We have a difficult problem in our testing program that reflects directly into the facilities.

We can't turn around with a particular test on the facility as quickly as you can with a normal rocket test stand.

As a result the tendency is to need more facilities. We know they are expensive so as a result we are actually trying to get by with less engine test facilities than is true of the conventional rocket program and the way we are trying to do this is to emphasize component testing, subassembly testing without the reactor on other facilities back at the home plants, and, then, just doing the integral testing on these facilities. The way our schedule shapes up we certainly expect to need these about as we are planning.

Mr. MORRIS. You may have to make more modifications to this as you go along.

I mean here is the point I am getting at.

When you finally get the reactor developed and tested then you start out with the NERVA engine.

Now the first test that you make using test stand No. 1 as I understand the schedule——

Mr. KLEIN. That is the first one.

Mr. MORRIS. After these series of tests it may be that what you will find during those tests will make necessary very substantial changes in the other test stand.

Mr. KLEIN. I would think not, sir, from the standpoint that the test stands themselves are largely independent of the exact designs of the reactor and the engine. The engine actually gets plugged into the stand so that the mating of the two is not very sensitive to the design of the engine itself.

Colonel GOULD. The configuration of the engine?

Mr. KLEIN. That is right. It would take a very major change, one that I can't really envision, to cause that kind of a problem.

Colonel GOULD. I have some questions.

Mr. KLEIN. Oh, excuse me.

Colonel GOULD. In your justification you indicate that program plans currently call for approximately 90 static tests to be performed on 30 different engines.

Over what period of time?

Mr. KLEIN. This is about a 3-year period, sir, and every time we look at it the number goes up.

It is a little higher than that right now.

Colonel GOULD. Are there any plans underway to provide for a third test stand?

Mr. KLEIN. Yes, sir; there are in our thinking and in our planning additional stands, some of which are for the stage, the RIFT stage, and in addition we presently envision at least one additional stand, what we call a close coupling stand, is needed that could be used for either the RIFT stage testing or engine testing.

Colonel GOULD. What is the total testimated cost of all known construction requirements for this site?

Mr. KLEIN. It is somewhere between $100 and $150 million.

Colonel GOULD. How much do we have in the ground now?

Mr. KLEIN. About $50 million.

Colonel GOULD. How much authorization do you have that is not yet under construction at this time?

Mr. KLEIN. Let's see. I would guess about $25 million.

Colonel GOULD. For engine test stand No. 2 I notice that in the 1962 program Congress authorized about $9 million, $8,965,000 for the stand.

In addition to that, $7.5 million was reprogramed from R. & D. to construction facilities, bringing your total to somewhere around $16.5 million for test stand No. 2.

Mr. KLEIN. That is right.

Colonel GOULD. How much of that has been obligated?

Mr. KLEIN. Essentially none of the construction has been obligated. We are in an early stage of design on that.

Colonel GOULD. When will the design be completed?

Mr. KLEIN. The construction will begin on this stand, we expect, early next calendar year.

Colonel GOULD. Next calendar year?

Mr. KLEIN. Early 1964.

Colonel GOULD. What is the estimated construction completion date?

Mr. KLEIN. We expect it to be operational in early 1966.

Colonel GOULD. The Facility Operation and Control System in the amount of $899,000; what does that consist of?

Mr. KLEIN. As I mentioned, our facility, our basic ETS–2 complex, as originally authorized, essentially used the same facility control, the same engine control, and the same data acquisition system as is being built for ETS–1 or for engine test stand No. 1.

This item is to provide the same kind of equipment, essentially coming close to duplicating what we have in ETS–1, but obviously for the second stand.

Colonel GOULD. ETS–1 and 2 will be basically the same when you get through?

Mr. KLEIN. They will be basically the same.

We are actually building into ETS–2, in the substructure, a capability for testing higher power engines.

Colonel GOULD. In view of the long leadtime that you have for the basic construction on stand No. 2, the fact that the construction has not yet been initiated, why could not the additional requirement await the 1965 program?

Mr. KLEIN. Well, I think the reason for this is simply that it is dangerous to the program to have the interrelationships between ETS–1 and ETS–2 that would exist without these changes.

Anything that delays a test, just a given test on engine test stand 1, would automatically delay the use of engine test stand 2.

It will delay the use because some of the same equipment is directly involved, secondly, it would delay the ability to change over, to make the cross patching in the instrumentation and control area as well as some of the piping from one stand to the next. Beyond that we have no backup capability in case something happened to these common use items.

Colonel GOULD. I understand the necessity for having both test stands about the same time.

I am looking at it however, primarily from the standpoint of the construction leadtime.

If this project were slipped, for example, until the 1965 program, you would probably have your funds in the summer or fall of 1964.

The leadtime on this $5 million would probably be about 12 or 13 months.

Mr. KLEIN. I don't think so, sir. I think there is a good deal of leadtime in the purchase of some of the equipment. As a matter of fact, this early next year date for the beginning of the construction is actually the letting of the contract for the hydrogen facilities and tank farm equipment—the dewars and tankage do have long leadtime associated with them before they are even delivered to the site. Then there is the problem of installing them at the site and piping them in and checking them out.

Colonel GOULD. Specifically in the list of equipment under item D on page CF 12–13, which of these items have leadtimes in excess of 12 months?

Mr. KLEIN. Well, I can mention some of them. I may miss some in the process.

Colonel GOULD. I am talking purely equipment now, not installation.

Mr. KLEIN. Yes. The hydrogen run tank, the liquid hydrogen storage and piping, those are the two that I know of.

As I say there may be others that I am just not familiar with but I could supply this for the record.

Colonel GOULD. Would you analyze the equipment list and provide for the record those items for which the procurement leadtime is in excess of 12 months?

Mr. KLEIN. Twelve months in advance of the time you need it installed and ready to go?

Colonel GOULD. Yes.

That is all I have, Mr. Chairman.

(The information requested is as follows:)

Due to the specialized nature of the equipment required, the majority of the equipment listed has a leadtime in excess of 12 months. Examples are as follows:

1. Five high-pressure gas storage vessels having an estimated capacity of 1,770 cubic feet each at 3,600 pounds per square inch or 882,000 storage cubic feet each (cylinder 5 feet I.D. by 65 feet long).

2. One 250,000-gallon liquid hydrogen dewar.

3. Approximately 1,000 feet of cryogenic piping, largest single line estimated to be 8 inches 1.

4. One 70,000-gallon liquid hydrogen run tank.

5. Instruments for liquid hydrogen and high-pressure gas storage such as rakes, temperature sensors, pressure transducers, flow meters, hydrogen sniffers, vent valve and flow controls, etc.

6. Remote engine control equipment (consoles, instruments, and controls) which is designed and fabricated specifically in accordance with the operational requirements of the engines to be tested.

7. Approximately 50 percent of the facility operation and control equipment such as motor control valves for transfer of propellants and pressurants, hazards warning system, etc.

8. Equipment for data acquisition system such as sensors, line amplifiers, signal conditioning equipment, recorders, which are not standard equipment but must be designed and fabricated especially for this type of operation.

Mr. KARTH. Could you explain for my benefit the difference between NERVA and RIFT? What you mean by each one of these designations and are they the same program with different nomenclature or what?

Mr. KLEIN. They are parts of the same program but they are distinctly different parts of it. The NERVA program is the work aimed at developing the first generation in nuclear rocket engine. The letters NERVA stand for nuclear engine for rocket vehicle application.

It is the engine, the propulsion device itself. It incorporates a reactor and all of the other equipment, instrumentation and so on that goes with an engine.

The RIFT program is the work aimed at flight testing that engine. It therefore involves the design and development of the stage, the nuclear stage, the propellant tankage, the integration of the engine with the tankage, the guidance and control that goes along with it. So again, in simple terms NERVA is the engine, RIFT is the whole stage.

Mr. KARTH. What does RIFT stand for?

Mr. KLEIN. Reactor in flight test.

Mr. KARTH. Thank you.

Would you like ot proceed to the next item?

Mr. KLEIN. Yes.

The next is the "Addition to the Engine Maintenance Assembly and Disassembly Building."

You have already authorized the basic facility which includes a hot bay, a large hot shielded area for disassembly of the hot engine, a cold bay for assembly of the engine before it goes out into test, and then smaller shielded cells, for further disassembly of the engine into small parts and the post mortem examination of these smaller parts for analytical purposes.

What we have in this addition are several items needed to essentially make maximum use of these facilities from the standpoint of being able to accommodate to an increased testing schedule.

This includes additional shielding windows. There are windows in the base facility but the use of these facilities is very, very, clearly tied to the number of windows you have around because you are restricted to working near these windows. The more windows you have the more use you can make of the space you have. The facility was designed having in mind that these additional windows would be added as needed.

In addition there are several shielding doors to isolate some of the major areas so you can work in one area and still be able to maintain in another area.

There is an item for a small sheet metal building that will be an adjunct to the basic facility and that will be used for storage of parts before they go into the assembly area, the idea being to avoid using this expensive space in the main building for things that are basically storage.

Mr. KARTH. All of these things sound like afterthoughts of your original request of last year?

Mr. KLEIN. No, sir.

Mr. KARTH. Why were they not included—for example, the doors?

Mr. KLEIN. Some of this was purposely phased.

Another item I did not mention was manipulators. Items like windows and manipulators were purposely phased with the progress of the program or with the testing frequency of the program. We have in this particular facility some items that were deferred because other things came up in the design and construction of the base facility that were required and were higher priority. We felt these items could be deferred without interfering with the program to this time.

The other major item in the equipment list is manipulators, both the master slave type manipulators and some rectilinear manipulators which are the ones you push buttons to operate rather than having the direct coupling between the hands of the operator and hands inside the cell.

Mr. KARTH. Colonel Gould?

Colonel GOULD. What is the history of the authorizing legislation for this facility?

I found it confusing trying to reconstruct it.

I know that in fiscal year 1962 you were authorized $6,034,730. In the fiscal year 1963 program was there another increment?

Mr. KLEIN. Yes, sir.

Colonel GOULD. Was this under the title, Stage Demating Maintenance and Dissambly?

Mr. KLEIN. A piece of it. As I recall the history of that particular nomenclature, that included some facility that was a piece of this as well as some facilities aimed at the stage, the RIFT program.

This latter part was reprogramed.

Colonel GOULD. $8,660,000 was authorized in fiscal year 1963 for this stage facility.

How much of that was intended to finance phase 2 of this particular facility?

Mr. KLEIN. I believe it was about $4.5 million. Is that correct?

Mr. ULMER. It was $4.8 million; yes.

Colonel GOULD. This results in a total of $10.8 million authorized for this project?

Mr. ULMER. That sounds about right. I believe the 1962 funding was subsequently increased to $7.8 million for a total for the 2 years of $12.6 million.

Colonel GOULD. Do you intend to build it in three phases?

Mr. ULMER. Correct.

Colonel GOULD. Phase 1 being financed from fiscal year 1962 and phase 2 being financed in fiscal year 1963 and phase 3 in 1964?

Mr. ULMER. That is right.

Colonel GOULD. What are the requirements for additional facilities beyond 1964?

Mr. KLEIN. I hope very little.

I can only say that there has been some question as to whether we will need some additional small cells.

We specifically have not gone along with a second large hot bay and we do not intend to unless we can see that we really are short on space for a second large hot bay. Let me say we don't have any

specific needs that we know of coming up but there is conversation on some of these things.

Colonel GOULD. I think it would have been helpful had you broken down the cost estimate between 1962, 1963, and 1964, by these various elements in the estimate. Since we don't have it in the justification books would you provide that for the record, please?

Mr. KLEIN. Certainly, sir.

(The information requested is as follows:)

The requested information showing present estimates on the funding breakdown for the E-MAD facility for fiscal years 1962, 1963, and 1964, is tabulated on the following chart:

Item	Fiscal year 1962	Fiscal year 1963	Fiscal year 1964
A. Land acquisition			
B. Site development and utility installation:			
Roads and site preparation	$48,669		$8,000
Electrical distribution	49,717	$20,000	
Substation and switchgear	40,460		10,000
Railroad trackage and switches	226,900		80,000
Water tank	54,675		
Radioactive waste tile field		25,000	
Roads, walks, and paving		23,000	86,000
Total	420,421	68,000	184,000
C. Facility construction and modification:			
Reactor assembly area	238,420		
Reactor disassembly bay	4,428,973		
Aggregate	22,000		
Shielding check	50,000		
Manipulator sleeves	5,494		
Shield doors	41,497	314,000	375,000
Viewing windows	147,941	618,000	400,000
Hot cell addition		2,139,000	
Office addition		120,000	
Critical parts storage building			75,000
South gallery structure		86,000	
Exhaust stack plenum		75,000	
Protective coatings		136,000	
H and V system (K-7)		30,000	
Miscellaneous building systems		72,000	
Total	4,934,325	3,590,000	850,000
D. Equipment, instrumentation, and support systems:			
Crane and hoist	258,863	38,000	15,000
Remote control manipulators		350,000	130,000
Turntables		154,000	
Wall-mounted handling system	1,100,000		1,200,000
Master-slave manipulators			230,000
Emergency air compressor			16,000
Air conditioning	(1)		84,000
Emergency diesel generator			110,000
Lighting fixtures with conduit and wire	(1)		156,000
Health and safety equipment			100,000
Fire protection equipment	(1)		15,000
Fork lifts			20,000
Machine shop equipment			320,000
Vault storage equipment			10,000
Physical counting room equipment			12,000
Industrial cleaning equipment			16,000
Personnel counting room equipment			100,000
Miscellaneous shop tools and equipment			12,000
Assay laboratory equipment			10,000
Main bay radiation monitoring equipment			140,000
Office equipment	(2)		15,000
Total	1,358,863	542,000	2,711,000
Contingency and construction management	[3] 856,400		
E. Design and engineering services	280,000	[4] 600,000	755,000
Total estimated costs	7,850,000	4,800,000	4,500,000
Advanced-design funds for next fiscal year's addition	[5] 350,000	[6] 250,000	
Total fiscal year funds programed to project	8,200,000	5,050,000	4,500,000

[1] Included above.
[2] On hand.
[3] This item is shown for fiscal year 1962 only, since the figures shown for other items are the lump sum bid numbers. The contingency and construction management costs for fiscal year 1963 and fiscal year 1964 are included as a part of the estimated costs for each item.
[4] Includes $400,000 for design of RIFT stage demate facility, and $200,000 for design of fiscal year 1963 E-MAD addition.
[5] Funded from fiscal year 1962 advanced facility planning and design.
[6] Funded from fiscal year 1963 advanced facility planning and design.

Colonel GOULD. Since this is in addition to a facility which eventually will exist, I fail to understand why we need an additional $40,000 for switches and an additional trackage when we already have $80,000 for this type of gear now under contract.

Mr. KLEIN. This is to provide in essence a turnaround location for the engine installation vehicle and the test car. It will be designed so that it also provides a basis for the trackage, the takeoff for the trackage going to the RIFT facilities when they come in in subsequent years.

Colonel GOULD. The same applies to rc[illegible], walks, and paving—was financed $20,000, I believe, in 1963 and now you are asking for $86,000 addition?

Mr. KLEIN. On these, I have only very general information to the effect that this does provide some additional walkways and paving for use in the area.

I don't have anything more specific than that.

Colonel GOULD. What is the size of the emergency diesel generator included for $110,000?

Mr. KLEIN. I do not have the exact size but I can certainly get it for you.

I will get that for you.

(The information requested is as follows:)

The emergency diesel generator listed as a part of the E-MAD equipment is estimated to be a 300-kilowatt, 480-volt, 3-phase, 4-wire, 60-cycle generator set, with a 0.8 power factor. The estimated cost includes building modifications, modifications to the distribution system, switchgear and controls, and installation.

Colonel GOULD. Machine shop equipment in the amount of $320,000 is included in this facility, and I notice also included in the support facilities is additional machine shop equipment.

Why do we need two separate machine shops?

Mr. KLEIN. Our planning for the whole nuclear rocket development station calls for the development of a central shop area to support all of the areas.

We will permit in individual areas or individual facilities only those minimum shops needed to have right at hand for quick work.

Now in this particular facility, in addition to a minimum type shop like that, we do have problems of having shop equipment for cells, for use in contaminated areas.

Colonel GOULD. Is this estimate of $320,000 for machine shop equipment based upon a detailed breakdown of what you are going to buy or did somebody pick the figure out of the air?

Mr. KLEIN. I saw a detailed breakdown on this—I think it came to about this amount—I saw a detailed breakdown several weeks ago.

Colonel GOULD. You could certainly equip a very elaborate shop for a third of a million dollars.

Mr. KLEIN. That is a lot of equipment.

I can assure you that we will not permit in this facility any more equipment than is needed for the purpose of this facility.

Mr. KARTH. Don't you have a shop there now?

Mr. KLEIN. We have a small shop that was developed in connection with the Kiwi program of Los Alamos which we will continue to use. What we are talking about here are the necessary expansions of those facilities as the program expands out there.

Colonel GOULD. What are we buying in the way of general health and safety equipment for $100,000?

Mr. KLEIN. Well, this involves to a degree, I believe, personal-type safety equipment for decontamination purposes, the monitoring equipment, although monitoring may be covered separately here. I don't recall whether portable monitoring equipment is in here or not. It is items of that sort at any rate.

Colonel GOULD. How many more manipulators are we going to have to buy?

Mr. KLEIN. We have in this 10 of the master slave manipulators and 3 of these rectilinear-type manipulators.

Colonel GOULD. These are very expensive items?

Mr. KLEIN. Yes, they are.

Colonel GOULD. I notice in the 1963 program there was $680,000 set aside for this type of equipment and you have $1,200,000 for wall mounted handling system; $230,000 for a master slave manipulator and $130,000 for the rectilinear manipulators.

Mr. KLEIN. Right.

Colonel GOULD. This totals to somewhere around $2.5 million.

Mr. KLEIN. That is right, and it is expensive. You are absolutely correct. They are the tools of the trade in this business. You were out there. I don't know whether you observed any operations there, but you can see it is a slow process and the only way you can take care of the necessary operations in a reasonable time scale is to have several going.

Colonel GOULD. Do these manipulators you are purchasing represent any improvement over the ones that AEC have in their facility?

Mr. KLEIN. Largely these are outgrowths of those manipulators. Some I am sure are identical. We do not have in our program development of improved manipulators, although in some of these systems we are kind of pushing the state of the art. But we are not developing additional ones.

Colonel GOULD. With reference to design and engineering services, in fiscal year 1962, $350,000 in advance design was set aside for this facility, $250,000 in fiscal year 1963; $660,000 was included in the 1963 program for design and engineering services and now you are asking for another $755,000. This is getting to be pretty expensive from the engineering and design standpoint. Do you have any comment on that?

Mr. KLEIN. I am not sure I have any very helpful comment on it. This is a tricky facility to design because it is an expensive one—the walls are expensive, they are not very readily changeable. A good deal of analysis has to go into the work flows in these facilities. In addition to that, the way in which the equipment is spotted, the way in which windows are spotted, for example, is quite critical to the utility of the facility, so I would expect the design cost on this to be fairly high.

Colonel GOULD. Are you telling us that we didn't learn anything from the one that was built for AEC?

Mr. KLEIN. No, sir; I wouldn't say that. We learned a good deal and, of course, have worked very closely with the people who had designed the facilities that now exist in the reactor MAD building there. We work very closely with them. We have also called on the

help of other AEC organizations. The one that comes to mind is Argonne Laboratory which has a very fine remote handling group. We have called them in to consult with us. We are trying to make maximum use of experience.

Colonel GOULD. Just one final question. Could phase I and phase II be operated as an entity or are these phases that you have planned dependent upon some of these fiscal year 1964 items?

Mr. KLEIN. They are operational as an entity. They wouldn't be operated necessarily at their maximum efficiency, but they are operable and useful as entities.

Colonel GOULD. That is all I have for now, Mr. Chairman.

Mr. ULMER. That was one of the conditions under which the budgeting was permitted to be done on this basis, Colonel.

Mr. KARTH. Proceed to the next item.

Mr. KLEIN. The next item is the "Radioactive Materials, Handling, Decontamination, and Storage Complex." That title encompasses several different facilities. Their purpose, or common purpose, is to take care of the radioactive materials, equipment, components, that arise out of the testing program at NRDS. They specifically include a spent-fuel storage area. In this area we will store primarily spent reactor cores; that is, cores that have been used in a test and are no longer needed, or useful for a test. They will be stored in vaults for two purposes: One, they are held up here pending the recovery of the valuable uranium that remains in them; and, secondly, they are held up there for a time to see whether we would want to analyze any parts of them beyond the analysis that is done shortly after the test.

The second area is the hot-engine hold area. It is a relatively simple facility to which the engine is removed right after test and held up there in case there is something going on in the MAD building that prevents it from going into MAD for immediate disassembly.

There is an additional facility which is called a warm-engine-parts storage building—again a relatively simple facility which, as the name implies, is an area for storage of hot parts pending decontamination or pending later use. Many of the engine components we hope ultimately to reuse after some decontamination. We can't do that with the reactor.

Mr. KARTH. You don't have such storage facilities now?

Mr. KLEIN. We have out there now, associated with the reactor program, some above ground, some open areas where things are stored around. I don't recall whether there is any real covered area at all.

An additional part of this project is the decontamination building which does involve shielding. It is a building in which hot parts are brought and are decontaminated for either further analysis or for reuse on subsequent engine tests.

Then we have the temporary burial site for taking care of miscellaneous waste before it is carted completely off the site.

Mr. KARTH. Colonel Gould.

Colonel GOULD. What is AEC using to meet this need at present?

Mr. KLEIN. Well, there is very little out there now to meet this need. Some cores have been stored, but they are trying to figure out what to do with them right now. Actually what is probably going to happen is that they will be put in this facility, the spent-fuel storage part of this facility. There is an area in which components are put out or

away as I recall without any shelter, but there is essentially nothing out there now.

Now, of course, the frequency of testing that we have had up to now has been very low and there hasn't been much of a buildup of these parts. We certainly expect this is going to be changing very shortly.

Colonel GOULD. Will AEC use this facility, also?

Mr. KLEIN. Yes; that is right.

Colonel GOULD. How much are they going to contribute toward the cost of it?

Mr. KLEIN. We have tried to use a rule of reason in splitting between the agencies. We have set up guidelines that AEC would fund certain facilities, certain kinds of work; the NASA would fund other kinds of facilities and other kinds of work. In some of the support areas, however, we have not seen any particular advantage to the Government in a split down the middle and we have tossed it one way or the other depending on where we think the burden really ought to lie.

Colonel GOULD. Is there a published agreement with reference to this site between NASA and AEC?

Mr. KLEIN. There is an agreement and I believe it is available and published.

Colonel GOULD. Would you submit one to the committee, please, not necessarily for the record? We will determine whether it will go in the record.

Mr. KLEIN. Right.

(The material was submitted in a letter to Col. Gould and is in committee files.)

Colonel GOULD. On the decontamination building, a cost of $70 per square foot is indicated. I imagine that the high cost is basically attributable to lead shielding. Are there any other structural characteristics that make the cost so high?

Mr. KLEIN. You are right. This does include the thick walls and shielding. The only other item is the cost of windows. Shielding windows are included in this item.

Colonel GOULD. What type of construction do you propose for the warm storage building and the classification "hold area"?

Mr. KLEIN. I believe that those are sheet metal facilities. I can check. I am pretty sure that is the case. Yes, sir; they are sheet metal.

Colonel GOULD. Structural steel and sheet metal?

Mr. KLEIN. Yes.

Colonel GOULD. What is the ceiling height?

Mr. KLEIN. I have a sketch. I don't know whether that is obvious from the sketch or not. I am afraid it is not. I can perhaps judge. To the peak it is perhaps 35 feet—something of that sort.

Colonel GOULD. Just provide for the record, if you would, a narrative description of the structural characteristics of both of those buildings, please.

Mr. KLEIN. Yes.

(The information requested is as follows:)

The warm-engine-parts storage building will be a standard steel building with a 25-feet eave height. The siding and roof will be of corrugated steel, and the doors will be standard roll-type doors. The building will be equipped with standard lighting and other utilities.

The hot-engine hold building will be a standard steel building with a 25-foot eave height. The siding and roof will be corrugated steel and the doors will be standard roll-type doors. In addition to standard lighting and utilities, a special power supply and special ventilating system will be provided in order that radioactively hot engines will be protected from afterglow heating while being held in the building.

Colonel GOULD. What is a glove and dry box?

Mr. KLEIN. These are equipment items or facility items in which contaminated material is placed for individuals to work on them. The way they work on them is through ports in the front of the facility in which, literally, gloves are installed. The man places his hands in the gloves and he operates with them. It is a sealed box in which he can view directly and work directly through these gloves.

Colonel GOULD. What type of radiation monitors are you buying?

Mr. KLEIN. I can't—I am not sure I understand.

Colonel GOULD. $185,000 for radiation monitors. What will they be?

Mr. KLEIN. There are several kinds of monitoring equipment involved. One is essential built right into the facility so you can pick up radiation as soon as it gets beyond tolerances, so you can detect problems hopefully as early as possible.

In addition, there is monitoring equipment involved in monitoring the personnel, routinely checking them for contamination as they move out of the hot areas, and then there are portable types of monitoring equipment as well.

Colonel GOULD. Specificially what are you buying for $185,000?

Mr. KLEIN. I do not have a list but I can supply that.

Colonel GOULD. Would you supply that for the record?

Mr. KLEIN. Yes.

Mr. KARTH. May I interrupt? How many glove or dry boxes are you requesting for the $30,000? I have seen these things and they didn't look that expensive to me.

Mr. KLEIN. Let's see if I have that, sir. I do not have it, but I will get it for you, sir.

(The information requested is as follows:)

The radiation monitoring equipment estimated for the complex is listed in the following table:

Decontamination building	**$44,000**
Conduit and wiring	**18,000**
Conduit to E-MAD	**1,000**
Gas sampling	**10,000**
Gamma and neutron detectors	**10,000**
Distribution	**5,000**
Warm storage	**20,000**
Conduit and wiring	**10,000**
Conduit to E-MAD	**2,000**
Distribution at site	**6,000**
Gamma detectors	**2,000**

Fuel storage	47,000
Conduit and wiring	15,000
Conduit to E-MAD	1,000
Gas sampling	20,000
Distribution at site	6,000
Gamma detectors	5,000
Storage tanks	16,000
Conduit and wiring	9,000
Conduit to E-MAD	1,000
Detectors	5,000
Distribution	1,000
Hot engine hold	26,000
Conduit	20,000
Distribution	1,000
Detectors	5,000
Alarms	32,000
Conduit and wiring	20,000
Distribution	6,000
Conduit to E-MAD	1,000
Instruments	6,000
Total for radiation monitoring system	185,000

The estimate of $30,000 provides for six 72 by 42 inch stainless steel boxes with shatterproof glass view windows, including double fold service inlet, two glove panels per side, forced air inlet. The following services will be included in the box; water, gas, air, vacuum, and transfer locks.

Colonel GOULD. What is the tile farm for?

Mr. KLEIN. This is to take care of low-level liquid waste by dispersion.

Colonel GOULD. Dead Storage Crushing and Burning Equipment for $200,000. What does this consist of?

Mr. KLEIN. This takes care of miscellaneous contaminated items and essentially crushes them just to save volume for temporary and permanent storage, if permanent storage is involved, and for transportation. You save money on the volume of storage and transportation facilities that are involved.

Colonel GOULD. What is the basis of $500,000 for design and engineering services?

Mr. KLEIN. Here again this is the estimate for these facilities. It includes not only design, but it does include inspection and supervision services. Some of these facilities are simple and others are far from simple. I would expect that that is an average figure and certainly doesn't apply to each of the four facilities involved.

Colonel GOULD. Based on the total cost of the project?

Mr. KLEIN. The total cost. It pays for the design-engineering services for the whole project.

Colonel GOULD. When you say it was based on the total cost, I was wondering what kind of design you would have to have for materials handling equipment, for example?

Mr. KLEIN. This does not include design of specific items of equipment. It involves the design—when it is off-the-shelf equipment—of the installation requirements.

Colonel GOULD. That is all I have, Mr. Chairman.

Mr. KARTH. Support Facilities.

Mr. KLEIN. Yes, sir. The Support Facilities are, as the name implies, facilities that are going into our support area for the Nuclear Rocket Development Station. You authorized last year the first part of this facility. These are additional facilities now involved and they include additional administration and engineering space, technical shops and storage and maintenance shops and storage and utilities to go with them.

The area involved in the administration and engineering building is about 60,000 square feet, which is about equal to the amount proposed to be built from fiscal year 1963 funds. The technical shops building is 11,000 square feet roughly. The technical storage building, 7,100 square feet, the maintenance shop and warehouse in total amounts to about 7,000 square feet.

These facilities are all tied into the additional work that is planned to be out there with the NERVA program.

Mr. KARTH. Are these support facilities to support some of those items already authorized?

Mr. KLEIN. They are to support the activity on some of those items, yes. That is correct, yes.

Mr. KARTH. How much, do you know?

Mr. KLEIN. I would say the facilities that will be supported largely from this project are the engine test stand No. 1, engine test stand No. 2, and the MAD building, the engine MAD building.

Those three facilities are the ones that these will support basically.

Colonel GOULD. In the 1963 program I believe that you had a central service building of 10,800 square feet. Is the administrative and engineering building addition, requested as part of this project going to be attached to the central service building?

I am not clear on the square footage involved.

Mr. KLEIN. There is an administration and engineering area in the 1963 project, about 50,000 square feet, and this will be another wing on that, a second wing on that same basic facility.

Colonel GOULD. That is not what you told us you were going to build last year. I am reading from the 1963 justification book which says you are going to build a central services building of 10,800 square feet. Did you change your mind after that?

Mr. KLEIN. What may have happened is in that justification there may have been several items that got lumped into one building, into one larger building. I would have to look at that to be able to identify it.

Colonel GOULD. Be my guest.

Mr. KLEIN. Now, let's hope I can answer it.

Colonel GOULD. The point I am making is that you indicated last year you were going to build a 10,800-square-foot facility and now you tell us it is 50,000 square feet.

Mr. KLEIN. This includes some of the items talked about here, but this description is not clear as to the way we are proceeding now.

There clearly has been contemplated reprograming based upon this description.

Colonel GOULD. Your construction status reports do not indicate any reprograming.

Mr. KLEIN. I can't answer that.

Mr. ULMER. Colonel Gould, we will have to check into that. Generally, when we change the design of a facility from the manner in which it was described to the Congress and still carry out the intent of the Congress and stay within the approved scope, we do not go through a reprograming procedure. For example, if we obtain authorization for two or three or four small buildings and it looks better from an engineering standpoint to construct one building of approximately the same square footage we consider that merely a change in the technical approach to providing what Congress authorized. However, if we do change the scope or if we propose to add substantially more capability than the Congress authorized, we then come in with a reprograming action.

I will have to check the details on this.

Colonel GOULD. Do you know how much the 50,000-square-foot administrative building cost? Do you have that figure?

Mr. KLEIN. We don't have a bid figure on it.

Colonel GOULD. What is your estimate?

Mr. KLEIN. The preliminary engineering estimate is about $1.3 million for that building. This does not include the engineering costs, but is pure facility costs.

Colonel GOULD. That $1.3 million was included in the $2,125,000 authorized for support facilities so you must have deleted something from the 1963 program.

Mr. KLEIN. It looks like the largest thing we deleted is some of the items on the latter category in the sheet you have there.

Colonel GOULD. Equipment Instrumentation and Support?

Mr. KLEIN. Yes. I don't think the emphasis is as we are now viewing it.

Colonel GOULD. I recommend, Mr. Chairman, that we ask the witness to provide for the record a detailed breakdown as to what the fiscal year 1963 funds were used for so that we might compare these.

Mr. KLEIN. I can give some of this now if you like.

Mr. KARTH. Why don't you provide it in one package for the record? Make sure Colonel Gould gets a copy.

Mr. KLEIN. Yes, sir.

Colonel GOULD. I have no further questions on that project.

(The information requested is as follows:)

Following is the current estimated cost of the support facilities which is under study at the present time compared to fiscal year 1963 submission.

Description	Fiscal year 1963 submission	Current
A. Land acquisition		
B. Site development and utility installation	$320,000	$150,000
Roads and parking area	40,000	30,000
Waterline extensions and distribution	120,000	20,000
Electric power line extensions and substation	160,000	35,000
Communications		25,000
Sanitary sewer		40,000
C. Facility construction and modification	674,000	1,760,000
Central services building	324,000	1,450,000
General shops	250,000	220,000
Shipping, receiving, and general stockroom	100,000	90,000
D. Equipment, instrumentation, and support systems	1,006,000	90,000
Tools and equipment for shops	221,000	30,000
Calibration and test equipment	515,000	60,000
Decontamination system	50,000	
Communications and safety system	220,000	
E. Design and engineering services [1]	125,000	125,000
Total	2,125,000	2,125,000

[1] Presently under contract.

The description, justification, and cost estimates for the support facilities requested in the fiscal year 1963 budget estimate were based on the development and testing program as envisioned at the time of preparation in October 1961. The original estimate stated that a minimum of 10,800 square feet of office space would be required in the early phases of the program. This building would be constructed of concrete block on a concrete slab floor. It would be a single-story structure designed for expansion to accommodate all office personnel who would be associated with the NERVA and RIFT programs when they reach peak strength.

At the time of the budget submission it was anticipated that addtional office space would economically be provided, for an interim period, by the use of trailers.

Subsequent to the budget submission and prior to the initiation of the design of the support facilities for the NRDS included in the fiscal year 1963 NASA budget, a thorough restudy of the support requirements was made. This study indicated that it would be advisable to construct a larger administration and engineering building (approximately 52,000 square feet) than originally anticipated. Several factors which influenced this decision are discussed in the following paragraphs..

An analysis of the projected personnel requirements at the Nuclear Rocket Development Station (furnished by the various users) indicated that by early 1964, about 390 people will be in temporary facilities unless permanent office spaces are provided.

This conclusion was based on the personnel projections shown in table I, which indicate the number of people requiring office floor space and do not include construction and maintenance personnel who will not require office space. Table I also graphically demonstrates that technical difficulties in a program do not change personnel requirements.

TABLE I.—*Projected personnel requirement*

	Total personnel
May 1963	546
January 1964	674
July 1964	810
January 1965	975

As of May 1963, the total personnel at NRDS requiring office space was about 546 people. Office space is being provided (1) in existing permanent facilities such as technical operations building in the control point area, (2) in office type trailers, and (3) in temporary quarters such as the ETS–1 control room. The type of office space being provided for the several organizations at NRDS is summarized in the following table:

Table II

Organization	Number of people in permanent facilities	Number of people in trailers	Number of people in other temporary quarters
LASL	35	55	
AGC	13	9	
Westinghouse		30	
SNPO			44
EG&G	131	15	
Catco		45	7
ACFI	82		
APC&I	3	39	
Rocketdyne	2		
REECO assigned to LASL	16	20	
Total	282	213	51

As shown in the above table, 264 people are currently using space in temporary or trailer facilities. However, the current projection indicates that 674 people will require office space by January 1964, or an increase of 128 people within the next 6 months. It can thus be seen that permanent space for 392 (264+128) people should be available by January 1964. Using, as a rule-of-thumb, 150 square feet of gross floor space per person, an additional permanent floor space of (150 by 392) 58,800 square feet should be available by January 1964. It can thus be seen that the 52,000 square feet of floor space currently being planned for the central services building is not completely adequate, and it is obvious that the 10,800 square feet originally requested is inadequate.

Before the decision was made to request that the fiscal year 1963 support facilities project be reprogramed to provide a 52,000-square-foot central services building, serious consideration was given to using trailers on a interim basis. However, an analysis of this alternative indicated that although some "construction of facilities" money might be saved, the high installation and operational costs would result in a very high total cost to the Government. For example, an excess trailer camp was made available by the AEC to NRDS in the latter part of 1962. However, it was estimated that at least $400,000 would be required to place this camp in operation. The trailers would be on a loan basis and subject to recall after January 1, 1964. On the other hand, if trailers are rented from commercial services the average annual rental costs for 300 people would be about $180,000 per year for a 3-year period. On this basis, first year costs would be about $580,000. Although no estimate has been made of the monetary losses due to the inefficiencies inherent in a trailer park setup, any comparison of office trailers versus permanent office facilities must take this into consideration.

Although table II demonstrated why 52,000 square feet of floor space should be available early in calendar year 1964 to accommodate the NRDS personnel expected by that date, additional funds should be provided in fiscal year 1964 to build a second unit to the A. & E. building to house the increase in personnel as shown in table I.

In summary, the above discussion points up the fact that slippages in the program due to technical problems do not affect personnel requirements. The need for additional office space is an immediate problem which can most economically be solved by providing adequate permanent facilities. It should be also noted that the increase in office space requested in the fiscal year 1963 estimate is not an increase in total office space requirements. This increase reflects a need for permanent floor space at an earlier date than originally contemplated.

Slippages in the program do, however, have a real influence on the time when equipment must be available for use. When the fiscal year 1963 budget estimate

was prepared in October of 1961, a substantial amount of equipment was required by calendar year 1964 to meet the program requirements envisioned at that time. Although equipment requirements have not changed, the program slippage will permit a deferment of equipment acquisition. In this particular case, most of the shop tools and equipment, calibration and test equipment, decontamination equipment, and communications and safety system can be deferred until fiscal year 1964. Recognizing that the first engine test stand, ETS–1, will not be ready for operation until about 1965, there is no need for support equipment until early 1965. Allowing 12 months for procurement and installation, funds for this equipment will not be needed until fiscal year 1964.

Mr. KARTH. You have two other budget items here, do you not?

Mr. KLEIN. I will not cover these, but Mr. Woodward will.

Dr. BISPLINGHOFF. Mr. Woodward will cover the Lewis items, Mr. Karth. Mr. Woodward is the Deputy Director of our Nuclear Systems Office in NASA and is Mr. Finger's deputy in this office and he will speak to the three Lewis items that are on our list.

Mr. KARTH. That is a quorum call you just heard. Maybe we can get through this before the second bell. We will have 10 minutes.

Mr. WOODWARD. I want to speak to the three facilities of the Lewis Research Center at the Plum Brook station. As you know, the Plum Brook station comprises about 6,000 acres located near Sandusky, Ohio, and was acquired for experimental test work requiring some degree of isolation. I would like to deal with the facilities in order of their page number in our submission, the first being an engineering building which is essentially an office building and auditorium and cafeteria. The description is pretty clear. The office space is provided at a rate of about 130 square feet per person. The auditorium is estimated at a rate of 10 square feet per person and the cafeteria allowance is about 20 feet per person. These are standard ratios and numbers in accordance with current design practice.

There is a need for this kind of space to house the planned personnel increases and because the existing facilities that were built in 1941 through 1945 as a part of the Army Plum Brook Ordnance Works are temporary and becoming unduly difficult to maintain.

Mr. KARTH. What will the auditorium be used for?

Mr. WOODWARD. For technical meetings, symposia, and various other kinds of meetings that will be attended by over 80 people. They have estimated that they now have need for such meetings in the order of twice a month and, as time goes on, this requirement will increase.

Mr. KARTH. What do they use now?

Mr. WOODWARD. They use part of the cafeteria to provide a capacity of about 80 people.

Mr. KARTH. How many do you usually have attending these meetings?

Mr. WOODWARD. They are estimating again—as I said earlier, and did not make clear—two a month. Over 80 attendance is the estimate.

Mr. KARTH. How many people do they expect to have in attendance?

Mr. WOODWARD. Over 80. That was the breakeven point.

Mr. KARTH. Colonel Gould.

Colonel GOULD. I notice you are providing in this facility 39,000 square feet to accommodate 300 persons?

Mr. WOODWARD. Yes, sir.

Colonel GOULD. This works out to an average of 130 square feet per person.

Mr. WOODWARD. Yes, sir.

Colonel GOULD. When we were discussing a similar building at Ames yesterday a criteria of 200 square feet per person was used. Do you have any comments as to the reason for this variance?

Mr. WOODWARD. No, sir.

Colonel GOULD. What is the basis for providing a cafeteria to accommodate 250 persons?

Mr. WOODWARD. The personnel planned for Plum Brook will rise to about a thousand people as against the approximately 500 on board now. We need more facilities than we now have available.

Colonel GOULD. What is being used now for a cafeteria?

Mr. WOODWARD. I am sorry, I can't give you the exact capacity. It is in the order of 180 but I would like to check that number.

Colonel GOULD. Could you supply it for the record?

Mr. WOODWARD. Yes, sir.

(The information was subsequently supplied:)

The rated capacity of the existing cafeteria is 130.

Colonel GOULD. You state in your justifications that it is considered impractical to upgrade the old wooden structures for long-term use. I certainly agree with that, but why couldn't they be continued in use for 1, 2, or 3 years?

Mr. WOODWARD. They can be. However, we are at the end of such a 3-year period now. We have been in Plum Brook for a number of years and we think we have come to the point where we should not try to keep continuing them for one more year. It is time to change them.

Colonel GOULD. Is Plum Brook officially turned over to NASA?

Mr. WOODWARD. Yes, sir.

Colonel GOULD. When did that take place?

Mr. WOODWARD. It was about 4 months ago, sir, according to Mr. Ulmer.

Colonel GOULD. It couldn't have been that long ago. It hadn't been accomplished when I was out there in February.

Mr. ULMER. The final paperwork was going through at that time. The final transfer action was completed on March 15.

Colonel GOULD. Do you happen to know the value of the existing plant?

Mr. WOODWARD. $25 million original Army, including land. NACA and NASA have put in another $25 million.

Colonel GOULD. $50 million. How much of this is permanent construction?

Mr. WOODWARD. Most of the NASA type.

Colonel GOULD. About half of it?

Mr. WOODWARD. Well, yes; half of it. The Army structures are not permanent, as you know.

Colonel GOULD. You are using trailers out there at the present time, to a certain extent, for administrative space?

Mr. WOODWARD. Three of them.

Colonel GOULD. Are they leased?

Mr. WOODWARD. No. They were purchased.

Colonel GOULD. What do we pay for trailers?

Mr. WOODWARD. Approximately $5,000 each. They will probably be used for approximately 3 years for office space and then will be

turned over for the construction purpose they were originally intended for.

Colonel GOULD. If it is anything other than $300, yes. How far is this building going to be located from the source of utilities?

Mr. WOODWARD. About 150 feet. That tunnel is $150 per foot, sir.

Colonel GOULD. How many parking spaces are going to be provided for $63,000?

Mr. WOODWARD. 315.

Colonel GOULD. What criteria did you use in establishing the number of parking spaces that would be built?

Mr. WOODWARD. I can't answer that question. May I furnish it for the record?

Colonel GOULD. Is it about one space for every two people?

Mr. WOODWARD. The parking lot is to service the auditorium, cafeteria, and office building. There were no specific criteria used. It is our judgement that this number of spaces will be adequate.

Colonel GOULD. What does the item of $75,000 for road extension and intersections consist of? How much road are we putting in here?

Mr. WOODWARD. It is 5,000 feet blacktop and the width would be 22 feet.

Colonel GOULD. That is a very reasonable cost. I think it would work very well at Langley also.

Mr. WOODWARD. We have a different substructure, as you know, at Plum Brook.

Colonel GOULD. The engineering building is estimated at $22 per square foot. A similar facility at Ames is being programed for $19.50 a square foot. One is programed in the 1964 program at the Manned Spacecraft Center for $24.25 a square foot. Now, the cost indexes at Houston are $0.95 and California is $1.05, and $1.05 in Ohio.

Could you tell me why these variances occur?

Mr. WOODWARD. No, sir; I cannot.

Colonel GOULD. Mr. Ulmer, could you answer that question?

Mr. ULMER. I can't tell you why the variances occur in the indexes, other than perhaps the differences in labor costs between the areas. The variances in our estimates occur basically because the estimates are prepared on the experience of the particular center at the time the budget is put together. As you know, the bid prices that come in often are not necessarily in line with what the indexes say they should be.

We find them both on the top and on the bottom of the line depending upon the state of the construction industry in the particular locality at the time we are requesting the bids.

Colonel GOULD. You are speaking of bids and I am speaking of three separate estimates in the fiscal year 1964 program where like facilities are being built with a range of about $5 per square foot.

Mr. ULMER. Yes. The point I was trying to make is that the budget estimate is based on the center's experience at the time they are putting the estimate together. For example, we had a bid recently that was completely out of line with anything that we anticipated. The bid came in considerably lower than our estimate simply because the entire construction industry in the particular area at that time was looking for work. The contractors wanted to keep their men busy, and they sharpened their pencils and come in with very low bids.

The situation can go the other way, too. We have had bids come in $3, $4, and $5 a square foot above our estimate. We do not use these extremes in preparing our budget but we do try to have the budget reflect a fair average of the experience of that center at the time the budget is put together and not necessarily taking what the construction indexes may indicate the bid price should be.

Colonel GOULD. That is all, Mr. Chairman.

Mr. KARTH. I think we are going to have to recess for a while. It is possible for you to come back at say 2:30?

Mr. WOODWARD. Yes, sir.

Mr. KARTH. And, Dr. Kelley, could you do that and maybe we'll finish this thing today? I will see if I can get approval in the meantime.

We will recess then until 2:30 p.m.

(Whereupon, at 12:30 p.m., the committee was recessed, to reconvene at 2:30 p.m., the same day.)

AFTERNOON SESSION

Mr. KARTH. The committee will be in order. Would you like to proceed, Mr. Woodward?

Mr. WOODWARD. Yes, sir. Are we finished with the engineering building? I think Colonel Gould was finishing off with that.

Colonel GOULD. That was all the questions on that project.

Mr. WOODWARD. The next is the experiment assembly test and storage building, also located at Plum Brook, an item of $1.71 million. This facility is needed to assemble the experiments which will be placed in the 60-megawatt reactor at Plum Brook.

I beg your pardon, it is $885,000. When the reactor was designed, it was recognized that a facility of this nature would be needed. However, until we reached the point where the reactor was operable, and we could more clearly define our needs, we delayed requesting such a building. We are now asking for it.

It consists of a mill-type building, with appropriate equipment installed for the assembly and checkout of experiments, including a water pool which is required to stimulate, the environment that the experiment will encounter in the reactor. The reactor is submerged in water. By checking the experiments under water, first we will find out how they work, and whether they are leakproof, and so forth.

Mr. KARTH. Is this similar to the one Texas A. & M. has?

Mr. WOODWARD. It is considerably bigger. It is somewhat similar in that the water is used as shielding in both cases. This is a 60-megawatt reactor, which is considerably bigger.

Mr. KARTH. The reason I mention the Texas A. & M. one is because that is the only one I have seen designed on this principle.

Mr. WOODWARD. I have nothing more to say, sir. If you wish to ask questions——

Colonel GOULD. You are providing a partial basement in this building?

Mr. WOODWARD. That is for utilities, boilers, and so forth.

Colonel GOULD. The justification states there are no available facilities or space in the reactor building at Plum Brook to assemble, test or store experiments. Are there facilities available elsewhere?

Mr. WOODWARD. No, sir; there are not, not of the type we need. There are insufficient and inadequate facilities. However, the reactor is operating now and we are installing experiments. We are now assembling them in a corner of the reactor building. This is not adequate for the bigger experiments that are coming.

Colonel GOULD. Are there no temporary buildings existing that could be used for this purpose?

Mr. WOODWARD. They would have to be extensively modified.

Colonel GOULD. Was a cost comparison made of modifying temporary buildings versus construction of permanent buildings?

Mr. WOODWARD. Not that I know of. This is a special type of building requiring the swimming pool and high bay area crane, and so forth for which existing buildings are not suitable.

Colonel GOULD. Are we providing a new steamplant just to supply this facility?

Mr. WOODWARD. I believe not. I would have to check that to be sure, sir. I think we are leading our services from an existing steamplant through the utility tunnel.

Colonel GOULD. You are asking for a steam line and boiler.

Mr. WOODWARD. Yes, but is this not the kind of boiler that appears in each building as an intermediate heat exchanger?

Colonel GOULD. I don't know, I am asking you.

Mr. WOODWARD. I assume it is. I will have to check it for you.

(The information requested is as follows:)

This item includes the installation of a boiler in an existing boiler room in the reactor complex, and the extension of the steam to the new structure.

Colonel GOULD. How far is this proposed facility from the source of electrical power?

Mr. WOODWARD. It is within 500 feet, I believe, sir. The electrical power source I am referring to is the electrical substation at the reactor building, and this is within 200 or 300 feet of the reactor building.

Colonel GOULD. It is going to cost $30,000 to run 500 feet of line?

Mr. WOODWARD. And connections. There are internal connections included.

Colonel GOULD. I thought that all utilities costs included in project development out to the 5-foot line were included in cost of the building?

Mr. WOODWARD. I am not clear on this. I will have to check for you. This does take some special equipment within the building. I will have to check it.

(The information requested is as follows:)

The $30,000 item includes duct banks where the 4160-volt services must be routed around the reactor building until it can enter the tunnel, and the necessary breakers to go in the existing substation as well as the usual cabling costs.

Colonel GOULD. Is that a correct statement of policy?

Mr. ULMER. That is generally correct, yes.

Colonel GOULD. What do you mean by a "mill" type building?

Mr. WOODWARD. Something like the Butler type building.

Colonel GOULD. Metal siding?

Mr. WOODWARD. Yes.

Colonel GOULD. What is the length and size of the utility tunnel for $75,000?

Mr. WOODWARD. This is a number I am not exactly happy about. I was trying to check it during lunch, and could not. I believe the length of the tunnel is in the order of 300 to 400 feet. This exceeds the $150 number on the other tunnel. I am trying to resolve the discrepancy. I believe it is because this tunnel is a little larger in size at one end.

Colonel GOULD. Are you looking into this cost because you don't have the high water table to contend with here that you have at Langley?

Mr. WOODWARD. It does not agree with the cost per foot of the other tunnel at Plum Brook.

(The information requested is as follows:)

Subsequent check reveals that the tunnel cost per lineal foot is about the same as for a similar item in the Engineering Building cost estimate.

Colonel GOULD. What are we buying for $50,000 in the item of Special Tools and Shop Equipment?

Mr. WOODWARD. This includes standard shop-type tools but more importantly equipment for handling materials and experiments under water in the pool.

Colonel GOULD. Do you have a breakdown of these items?

Mr. WOODWARD. Not with me. I can furnish you one.

Colonel GOULD. Could you supply that for the record?

Mr. WOODWARD. Yes, sir.

(The information requested is as follows:)

The major portion of the money to be allocated to special tools and shop equipment goes for the master-slaves and servo-manipulators for the dummy hot cell located in this building. In addition to the usual small shop tools such as metal saws, grinders, drill presses and the like, special long-handled underwater tools will be necessary for operations in the test pool. Typical universal-use tools of this type are underwater wrenches, pliers, cutters, etc.

Colonel GOULD. I would like to go back to the cost per square foot of the mill-type building, for a minute.

Is this to be slab on grade construction, except for the partial basement area?

Mr. WOODWARD. I am not that familiar with it. I cannot tell you.

Colonel GOULD. Would you provide a narrative description of the structural characteristics of this building, please? It appears to be a little high for the type of building you have.

Mr. WOODWARD. This is a high bay building so that the per square foot cost is higher.

Colonel GOULD. How high is it?

Mr. WOODWARD. It is two stories, in one area. I think it is close to 25 feet high. I am certain this is the explanation for the per-square-foot cost.

Mr. MYERS. It is a basic steel frame building with some insulated paneling with the basic construction.

Colonel GOULD. There is not enough information provided to evaluate the cost. Could you provide a narrative description of it for the record please?

(The information requested is as follows:)

The "mill-type" building construction referred to in the description of the experiment assembly, test, and storage building is the descriptive title used for a steel structure building with insulated, corrugated metal siding. The roof

structure with the metal pan is insulated and waterproofed. This building would be similar to the existing reactor building and the shop section of the services-equipment building. The projected unit cost is based upon our actual costs for similar structures being slightly more expensive than some of the low-bay shops because of the height of the building necessitated by the high-lift crane. An additional item of expense is the special floor treatment (epoxy paint) required to prevent contamination by saturation of the concrete surface.

Mr. WOODWARD. Yes, sir.

Colonel GOULD. That is all I have, Mr. Chairman.

Mr. WOODWARD. The next one is the SNAP–8 Assembly and Spacecraft Checkout Building. Again at Plum Brook.

This is an item of $5 million. This facility is required to assemble the SNAP–8 system prior to its being tested at Plum Brook in the space propulsion facility which was authorized in fiscal year 1963. It is also required to assemble SNAP–8 into its test craft. There are no other facilities like this on the east coast. It is our judgment that it is not a wise thing to do to ship the SNAP–8 system in one piece from the west coast to the east coast without providing some way of checking it before we test it.

Mr. KARTH. Do you have an appropriate facility on the west coast?

Mr. WOODWARD. There are no facilities on the west coast specifically for assembling this system. There are fabrication facilities at the contractors' plants.

Mr. KARTH. So you don't have an assembly and space craft checkout building any place, do you?

Mr. WOODWARD. No, sir; but we do have at the contractors' plants, facilities for assembling subsystems. It is conceivable we could assemble the whole thing on the west coast at the contractors' plants with an additional facility there.

Mr. KARTH. What contractor would this be?

Mr. WOODWARD. Probably Aerojet. However, we are uncertain as to the wisdom of shipping the SNAP–8 system across the country without having some way of checking it on this end. In any event the reactor itself will require separate checkouts after shipment.

Mr. KARTH. When you assemble it at Lewis where do you have to ship it before it flies?

Mr. WOODWARD. If it is assembled at Plum Brook it will be tested at Plum Brook. It is conceivable that we could ship it to the cape with a minimal checkout at the cape.

Mr. KARTH. But you couldn't go from the west coast to the cape?

Mr. WOODWARD. Well, I am sorry——

Mr. KARTH. How about if you did it at the mouth of the Mississippi River. What is the name of that assembly place?

Mr. WOODWARD. Michoud.

Mr. KARTH. That is even closer. What about that?

Mr. WOODWARD. Our philosophy is this; that we should assemble SNAP–8 as close to the point of use as possible. Our first point of use is at Plum Brook. This is why this facility is requested for Plum Brook. The question of what we can do with it down at the cape has not yet been resolved. It will depend a little bit upon our experience with this one. However, our feeling is that what we will need down at the cape will be quite a small scale facility—nothing like this one at all.

This facility includes, among other things, a shielded containment area, so the reactor can be brought up to criticality. This is essentially bringing it to the point where it is almost producing power and then shutting it of. This allows the reactor people to check the physics of the reactor and to make sure it is functioning properly.

We are not sure we need this type of test at the cape. Once we get some experience with it at Plum Brook, our future plans can be more definite.

Colonel GOULD. Mr. Woodward, is this facility a complete entity within itself, or does it depend upon other facilities at Plum Brook?

Mr. WOODWARD. It is a complete entity in itself, in that it will do the job of assembling and checking the SNAP–8 and SNAP–8 spacecraft. It will not test the facility in the space environment at all. That must be done in the large space propulsion facility.

Colonel GOULD. As a followup to the chairman's question, why couldn't this facility be constructed at the Mississippi Test Facility which is en route to the cape from the west coast, then shipped by water from the Mississippi Test Facility to Cape Canaveral in its assembled form much easier than you could from Plum Brook?

Mr. WOODWARD. Our problem is that the people and the facility we want to test it in are at Plum Brook.

Mr. KARTH. How much would it cost to put the facilities and the people down at the Mississippi test center?

Mr. WOODWARD. The space propulsion facility alone at Plum Brook is valued at $25 million. I imagine the total would be well above that.

Mr. KARTH. How long do we expect this SNAP–8 program to last? What are we talking about in terms of time?

Mr. WOODWARD. The SNAP–8 program itself will last through this decade. However, this facility could be useful for other SNAP systems that could be put in the facility at Cleveland.

Mr. KARTH. So we might be talking about a facility that has a useful lifetime of 25 years?

Mr. WOODWARD. It is possible, sir. I think that is a high number.

Mr. KARTH. Let us say 20. Does that still appear high?

Mr. WOODWARD. No, that is a good number.

Mr. KARTH. If we are talking about a 20-year period rather than investing substantial additional funds in an out-of-the-way place, maybe we could do some testing up there, but as the colonel suggests, inasmuch as the Mississippi test site is en route from the west coast, and from there you have nothing but water travel as opposed to rail plus water, plus perhaps some truck—I don't know—wouldn't that make more sense than using the argument that has been used before this committee so often, and in the long run, wouldn't it be cheaper?

Mr. WOODWARD. It is our judgment it would not. I cannot prove it is so, but it is our judgment that in a system as complex as this one we should test it thoroughly on the ground before we fly it; that we should do our assembly under very controlled conditions that are responsive to what we find out is occurring in our test facility; and that the assembly and the test facility should be as close as possible to the people who are going to be operating the program and to the supporting facilities.

Mr. KARTH. Both the assembly and test could be located at Mississippi as well.

Mr. WOODWARD. The test we envision is a full test in the space propulsion facility which is a $25 million facility.

Mr. KARTH. Right. I understand that. My question is that both the test, however, and the assembly could be done at the Mississippi test site, with the proper facilities, of course?

Mr. WOODWARD. With the proper facilities which would be expensive and would duplicate what we already have underway at Plum Brook.

Mr. KARTH. How much more do you think we are going to spend on facilities at Lewis before we are finished with SNAP-8 and the other oncoming nuclear programs?

Mr. WOODWARD. So far as SNAP-8 is concerned, I doubt if there is any more at Lewis other than this. As far as oncoming nuclear electric programs are concerned, the next SNAP system is the SNAP-50. Its facility requirements will depend to a certain extent on whether it is tested at Plum Brook or not.

Mr. KARTH. What is your first blush? I think it will, won't it? If this is the only test facility we have.

Mr. WOODWARD. I would hope it would be tested there, sir.

Mr. KARTH. We wouldn't propose that after this kind of an investment that we build another test facility someplace else, would we?

Mr. WOODWARD. That is right, we would not. In this case, I think this facility could handle the SNAP-50 with relatively minor modifications—such as enlarging the size of the tank for running the criticality test on the reactor. This tank is a $400,000 item to start with, and enlargements certainly aren't gong to run another $400,000. Relatively small changes like this would allow this building to be adaptable to other systems like SNAP-50.

Mr. KARTH. You may be called upon to defend this. I just want to call to your attention the fact that there are some other large requests for moneys for SNAP-8, SNAP-50, SNAP-90. We are going to ask somebody to account for the testimony that has been given, and you understand that, don't you?

Mr. WOODWARD. Yes, sir.

Mr. KARTH. I don't want to be critical, but we would like to have as precisely as possible an estimate of what the overall cost of these programs are going to be because next year comes around fairly rapidly, and the same taxpayers that are paying the bill this year, I suppose, will be paying a good portion of it next year.

Mr. WOODWARD. We have gone through the planning exercise on the SNAP-8 flight program, and the SNAP-8 ground development program. We have a fair estimate of our facility needs. As far as the ground development program is concerned, this facility will take care of our requirements. This facility will also take care of most of the SNAP-8 flight development program needs. The only additional requirement we see is an assembly and checkout facility at the cape.

Mr. KARTH. SNAP-8 and SNAP-50 are going to take care of NASA's nuclear testing program, period.

Mr. WOODWARD. This decade.

Mr. KARTH. Well, 20 years. I was talking about 20 years. That includes the next decade, too.

Mr. WOODWARD. Yes, sir; but to be honest with you, I cannot predict that far ahead accurately. Our large propulsion facility at Plum Brook can handle a SNAP-50 machine. I think the primary remaining facility requirements in the SNAP-8 programs are at the cape for the rest of this decade. From then on I just cannot tell you, sir.

Colonel GOULD. The space propulsion facility you are talking about at Lewis, is this the $25 million project in the fiscal year 1963 program?

Mr. WOODWARD. Yes.

Colonel GOULD. What is the status of that project?

Mr. WOODWARD. I would like Mr. Ulmer to help me on that.

Do you know the exact status of that?

Mr. ULMER. The major engineering design contract has been let.

Colonel GOULD. You haven't actually started construction yet?

Mr. ULMER. No.

Mr. WOODWARD. I was talking to them yesterday. I don't know whether they have broken ground or not.

Colonel GOULD. Is it still in design?

Mr. WOODWARD. The design is well along.

Colonel GOULD. With reference to the SNAP-8 assembly and checkout building, what is going to be done at Plum Brook that cannot be done at Cape Canaveral? Are you going to have a duplicate checkout system; that is, check it out at Plum Brook and again at Cape Canaveral?

Mr. WOODWARD. We hope not. This is a possibility, but it is not a very high probability. What will be done at Plum Brook is to assemble the SNAP-8 system spacecraft, check it out, put it into the space propulsion facility, run it, take it back out, pull it apart, and see what is going on. If by chance something has gone wrong that can be repaired, it will be repaired and put back in the space propulsion facility until we reach the duration of test that we want, which is anywhere from 2 to 10,000 hours. At the cape we do not intend to conduct such an experimental type program. The facility down there will be needed mainly to assembly subsystems and to make sure that these subsystems are assembled properly. There will be no repair capability; there will be no detailed assembly capability. This is the question we have not yet resolved; how much assembly capability do we need? Do we have to start with small pieces or can we ship large pieces?

This we don't know yet.

Colonel GOULD. What is the flight schedule for the SNAP-8?

Mr. WOODWARD. We have no firm flight schedule on SNAP-8 at the moment. We have no firm requirement for SNAP-8 itself. Our feeling is that before we undertake a flight program we should have a pretty good idea of what the application is so that the configuration that we flight test is close to the final design. So we are not setting any flight date at this time. However, we can fly this decade.

Colonel GOULD. You say the first of four flights of the SNAP-8 electric generating system is scheduled for calendar year 1967?

Mr. WOODWARD. Yes, sir; this has been changed since this was written. We are deferring the 1967 flight data. That is as early as

we can fly, but we are not scheduling it until we have an application and a configuration turned up that we need to test. However, the SNAP–8 ground development program is proceeding at full pace. This facility will be useful and needed for assembling the SNAP–8.

Mr. KARTH. What you are saying is you are moving the flight date back from 1967 to some date further in the future?

Mr. WOODWARD. Some later date; yes, sir.

Colonel GOULD. What is the scope of roads and parking area included in this project?

Mr. WOODWARD. Let me check that point.

Parking is for 50 cars. This is relatively small. What was the other part of the question?

Colonel GOULD. And the scope of roads and parking?

Mr. WOODWARD. We don't show anything on roads. We show 1,000 feet of railroad siding which we will use to transport the SNAP–8 system from this facility over to the space propulsion facility, and to deliver parts into this facility. The road cost estimate is $10,000. This includes parking for 50 cars. I don't think there is very much road in here at all. Fifty cars was the figure I gave you on parking lot size.

Colonel GOULD. What is the scope of the powerline portion of this project, $100,000? How many feet of line?

Mr. WOODWARD. One thousand feet of cables and transformers involved.

Colonel GOULD. You speak of a containment vessel. Is this another vacuum chamber?

Mr. WOODWARD. No, sir.

Colonel GOULD. What is it?

Mr. WOODWARD. It is a vacuum chamber to go down to one tenth of a millimeter of mercury pressure. This is practically what could be done with this room with a suitable pump. Its primary purpose is to contain any fission products or anything which might escape from a reactor failure during the test.

The cost is estimated at $460,000, and most of that is in the shielding. The tank itself is very minor. This would not be useful as a vacuum chamber or a space environment simulator at all.

Mr. KARTH. You would have to have radiation protection, though, is that it?

Mr. WOODWARD. Yes, sir; that is where the costs lie, in the thick walls for radiation. The door, for instance, which is a sliding shield door, is estimated at $180,000.

Mr. KARTH. Why do you need a vacuum chamber with such little vacuum capability?

Mr. WOODWARD. If we have an accident within the tank, the initial low pressure reduces the amount of pressure which can build up so that the design wall stresses can be much lower. In addition, any leakage is into the chamber to a pump where you can control your outflow rather than out into the room in an uncontrolled manner. So if the reactor fails in some manner, for example there is a leakage from the fuel element, it will not flow out into the building but flow into the vacuum pump, and into a place where you can trap the products and contain them.

Colonel GOULD. What is included in the "coldroom equipment" for $230,000?

Mr. WOODWARD. That is one I did check. I can check it for you.

Colonel GOULD. Would you provide that for the record please?

Mr. WOODWARD. Yes.

(The information requested is as follows:)

The coldroom equipment is required to simulate space cold environment for the SNAP–8 components prior to their assembly in the complete system. These components would then be assembled in the high-bay area to make the complete package. The point to be made here is that there is no point in asembling faulty components. The successful operation and proving of components is followed by the nonspace checkout of the assembly and after successful assembly and checkout, the package would be sent to the Atlantic Missile Range for firing. It is anticipated, however, that at least one complete assembly would be tested in the Space Propulsion Facility for periods up to 90 days in order to give the best available assurance that the package would work under actual space conditions. The above remarks apply as well to the thermal gradient equipment. Since the components must be subjected to nonuniform thermal heating, they should "prove out" prior to assembly. The equipment would provide, insofar as possible thermal gradient conditions of cold space on one side and sun and earth heat radiations on the other. Heat flow and differential expansion are the problems here.

Colonel GOULD. Your estimate includes $250,000 for a liquid metal loop.

Mr. WOODWARD. Yes, sir.

Colonel GOULD. What does that consist of?

Mr. WOODWARD. That consists of a loop of piping in which liquid metal is circulated, an electric heater to provide heat to the loop, and a heat exchanger to take heat away from it. Its purpose is to simulate on the ground the reactor heat flow into the power conversion part of the SNAP–8.

Colonel GOULD. Have we ever built one of these before?

Mr. WOODWARD. Yes, sir. This is a relatively small job. Based on our experience, these liquid metal loop facilities are horrendous. However, this is a relatively simple one. The purpose of this is to simulate the reactor for the power conversion subsystem tests.

Colonel GOULD. Thermal radiation equipment for $300,000, what does that consist of?

Mr. WOODWARD. I would like to check that for you. I don't have the answer here.

(See previous insert.)

Colonel GOULD. "Health Physics Equipment" for $50,000, could you define that for us?

Mr. WOODWARD. That is standard equipment. Since we have a radioactive source in the building, we must provide the monitoring equipment, the badges, the photographic material, and so forth, to insure our personnel are not experiencing a hazard. This is standard equipment.

Colonel GOULD. I was under the impression that space propulson facility in the fiscal year 1963 program included an instrumentation shop. Why do you need another one in this building?

Mr. WOODWARD. This is a kind of a thing that you like to have in all buildings. One of our problems is the telemetry equipment on the SNAP–8 spacecraft. We intend to do some checkout and some work in this building on the telemetry setups that we will have to use. The telemetry problem is quite difficult. I don't know of any telem-

etry equipment that has yet run in the reactor environment for 10,000 hours, which is what we are requiring. We need to be able to test this telemetry equipment under the conditions of the environment of the reactor for a long time. This is why we think we need an instrument shop of some special capability in this building.

Colonel GOULD. Mr. Woodward, this is a nice round estimate, $5 million.

Mr. WOODWARD. Yes, sir.

Colonel GOULD. Was any consideration given to an addition to the space propulsion facility at a reduced cost in lieu of constructing a new and separate building?

Mr. WOODWARD. We looked into this question briefly and came out with this answer, that making it an addition to the space propulsion facility would not in reality save much money.

The space propulsion facility will be used for a lot of different testing—parts of Centaur, parts of various kinds of rocket engines, parts of various SNAP systems; since it is a large space environmental facility. If we bring in hazardous systems like SNAP–8 we are liable, in the event of an accident to delay or hinder the operation of the tank on other projects. We feel that a wing added on would be compartmentalized to the extent that the money saving would not be too great.

Colonel GOULD. Is it designed as a separate facility because of the hazards involved?

Mr. WOODWARD. The hazards and the fact that the space propulsion facilities will be used for testing systems in addition to SNAP–8.

Colonel GOULD. At the Lewis Research Center it is my understanding that design is supervised by an inhouse capability and construction is supervised by inhouse personnel; is that right?

Mr. WOODWARD. This has been our experience in the past.

Colonel GOULD. You asked for $450,000 for engineering and design services which represents about 10 percent of the project cost.

Are we spending in this case 10 percent for A and E contracts to design this facility?

Mr. WOODWARD. Ralph, can you answer this for me?

Mr. ULMER. I think we will probably have to go that high on certain facilities of this type. It is in excess of what we normally spend for our facilities but it has been our experience in some of these very complicated technical facilities that we do go higher than the normal amounts.

Colonel GOULD. Does this represent about 4 percent for design criteria or are you going to develop these criteria with inhouse personnel?

Mr. ULMER. It will be some of both. It has been our practice in facilities that are handled by our own design staffs that criteria work are often done inhouse supplemented by some outside A and E work.

The percentage is somewhat dependent upon the percentage of work done by our own inhouse people.

Colonel GOULD. What was the design cost experience for the space propulsion facility at Plum Brook, do you know?

Mr. ULMER. I would have to supply that. I don't have that.

Colonel GOULD. Would you supply it for the record?

(The information requested is as follows:)

The obligations for design and engineering on the space propulsion facility at the Lewis Plum Brook facility have amounted to $2,421,064, or 9.5 percent of the $25,500,000 authorized cost. This includes 1.1 percent for the feasibility study and 8.4 percent for engineering design.

That is all I have, Mr. Chairman.

Mr. WOODWARD. That concludes my presentation.

Mr. KARTH. Dr. Kelley, would you come forward and give us the benefit of your knowledge on those things falling under your jurisdiction?

Dr. KELLEY. Yes, sir.

If it is all right with you, I have some slides which I could show as we discuss these facilities.

Mr. KARTH. Proceed in any way you wish.

Dr. KELLEY. All right.

I will take them in the order of the satellite attitude controls systems test facility at Ames first, and then the two Langley facilities, the addition to the vehicle antenna test facility and the Electronic Instrumentation Laboratory, and then the Electronics Research Center.

The first facility is proposed at Ames, the satellite attitude control systems test facility is in fact an attitude control research facility which will enable us to test in a vacuum environment.

This provides a control room to run the test, an instrumentation area to prepare the instrumentation and a model preparation room where we bring the two together before we place them in the vacuum vessel.

The actual test chamber is a relatively small vacuum chamber which would be a unique facility of its kind. We would have, on an air bearing, a test shape or test vehicle.

We probably should broaden the terminology from satellite to include space vehicles where we first begin to require the accuracy that we are researching here using a very precise air bearing as the support.

We can turn the test vehicle around the vertical axis 360° and around the other axes 60°. In this device we can simulate a precise control system in the environment with solar radiation, cold walls, a simulated horizon with which we can test the horizon scanner at the same time along with star trackers and the various control jets, so that we can actually use the equipment that we would be developing or researching for future vehicles.

Now the principal reason for such a facility as this is that as we get into our more advanced vehicles, some of our more advanced orbiting astronomical observatories for example, we will need very, very precise control and pointing accuracy of the whole vehicle, several orders of magnitude better than we know how to do now.

For example, we can point to within several minutes of arc, say point a telescope or space vehicle, point it to within several minutes of arc right now.

As we look into the future we will need to go down to about a tenth of a second of arc or one thirty-six thousandth of a degree.

We do have facilities similar to this on air bearings, that is there are such facilities that exist, but we find the normal disturbances in the air in a regular room begin to disturb it so that we are not sure then whether errors are within the pointing accuracy of the instruments or whether they are due to air currents within the room. We

want to get in a vacuum environment so we can get out the air disturbances and drag. At the same time we want to get the particular heat radiation and cold environments because one of the interesting aspects of these vehicles is that under the various temperature gradients across them the vehicles will bend and distort. All of this feeds back into the so-called control loop, which affects the measuring instruments and devices with which we are trying to tell how accurately we are pointed.

Mr. KARTH. Why isn't this going to be done at Goddard?

Dr. KELLEY. Goddard is our satellite development facility. We are doing research work in attitude control as well as some research work and guidance at Ames.

In other words, this would not be a full-scale satellite such as the type that Goddard would be operating.

This is for information which we would generate from our research centers, Ames being an example here, which would feed into future designs that Goddard would then implement.

Now Goddard, as far as I know, does not propose to have a large chamber to be able to do this for a complete vehicle. At least it is not within the realm of engineering reasonability right now.

The facility we are discussing would be for small test-type vehicles.

In other words, there are vacuum chambers to test vehicles in a static condition right now, to test vehicles in a static condition under environmental conditions and there are some test tables that use air bearings. Here in a small scale way we are combining the air bearing and vacuum environment so we can run a dynamic test in the environment.

We have over the period of the last few years been doing guidance and control work at Ames on a system or subsystem basis.

Mr. KARTH. I thought most of the satellite experimentation was done at Goddard?

Dr. KELLEY. Goddard is responsible for the project management, the system development and specific experiments that go on the satellites.

As far as the technology, they largely depend on the research centers, that is the materials and electronics and guidance and control and so forth.

They are a systems center.

Mr. KARTH. I thought they actually built the satellites.

Dr. KELLEY. They build most of them under system contract and they have built some small ones themselves. These are all for actual tests in flight, they are operational vehicles to go up and get data.

By the time they want to go up and get data with instruments they want guidance and an attitude control system which will give them the required accuracy, for example.

Mr. KARTH. You have some awfully big vacuum chambers and big simulators there, and it appears to me they are doing a lot of testing.

Dr. KELLEY. They do more what we call system testing on the end product, the thing which is pretty well developed, just before it is ready to fly.

It is a different type of testing. I think we got into this problem over the words testing this morning. There is research testing and then proof or product testing.

Colonel GOULD. To follow up on that question, Doctor, why couldn't the research be carried on at the point where development testing is accomplished?

Why couldn't you conduct this research at Goddard instead of Ames?

Dr. KELLEY. I suppose we could reorganize the whole framework and mix it all up.

From a management standpoint, and historically this has proven so not only within the NACA and NASA but other government agencies such as the various military services, it is better to have a focus on research in one of several places and a focus on development in other places.

Mr. KARTH. You say it is better to have a focus on research in one area and then a focus on development in another area?

Dr. KELLEY. I mean in terms of groupings of people and facilities, groups concentrating more on the research side—I am not saying what particular discipline, but I mean in general—and then other centers or groupings more on the development, which is the final end product.

Now there has to be cross flow between these two groups naturally and it is not a completely clean line.

That is why we have research centers and in fact these are the centers, or the facilities of these centers, that we are discussing with you now. The project or space flight centers are interested more in the final development of the end product.

Colonel GOULD. Why can you not modify an existing vacuum chamber that has a solar simulator already installed to do this additional research work rather than build a complete new facility?

For example they just completed a facility at JPL, a very fine one from what I understand.

Dr. KELLEY. I am familiar with the large new facility, which is something we badly needed, but that is to test in the environment, large vehicles.

They intend to put whole vehicles in it. One of the problems they had in the past is that they could not get a whole vehicle in their test chambers.

To go and put in an air bearing type of support here does not seem to make much sense because we only want to test a small device and we want to have it in the chamber for a long time to do various research work and tests on it.

I just does not seem to make sense to put a small device in a great big chamber.

I don't think you would want to modify it, on the other hand, to be able to carry a whole spacecraft.

As I said, this begins to get difficult in terms of the technology. In other words, we can research and do the initial development on the attitude control systems as we have shown here and prove them to the point that then we can put them in the large vehicles and be assured they will give us the accuracy we want.

We don't have to research the whole thing on the actual vehicle.

In other words, I am saying it would be cheaper to do it first on a small scale, which is what we propose.

Colonel GOULD. What is being used to meet this need now?

Dr. KELLEY. Nothing, because the need for this high-control accuracy has only come upon us with the advent of some of the accurate pointing requirements for advanced space vehicles.

It is something like a tenth of a second of arc of control accuracy.

People would have liked to have had that many years ago, but it wasn't really necessary.

Now, if we are going to get off into some of these advanced astronomical vehicles, where for navigation and guidance, for example, we have to have high-pointing accuracy to measure the stars and change of angle between stars. We need to get greater accuracy of measuring and pointing and controlling space vehicles.

So there just wasn't a need for this type of facility before.

Colonel GOULD. Does a capability exist in industry to conduct this type of research?

Dr. KELLEY. This type of facility does not exist, as far as I know.

There are static environment chambers and air bearing test tables but there are no combination facilities.

Colonel GOULD. What type of a Sun- and Earth-simulating device are you going to provide for $150,000?

Dr. KELLEY. I believe that is a carbon arc water-cooled device.

Colonel GOULD. What does it look like?

Dr. KELLEY. It is a carbon arc lamp. You strike the arc and high-intensity light emits.

Mr. KARTH. What does it do? What is the purpose of it?

Dr. KELLEY. To generate heat and light approximately in the spectrum of the Sun.

Also, you notice this has a cold wall on it, as many of these facilities do, because now we can simulate what we call the——

Mr. KARTH. These are the auxiliary parts?

Dr. KELLEY. That is right. That is the Sun- and Earth-simulating device combined—Earth horizon, where you can put a simulated disk so we can simulate horizon tracking.

Mr. KARTH. The total cost of the attitude control systems test facility would be $1,230,000?

Dr. KELLEY. That includes the building and everything else.

Colonel GOULD. You have a reasonable cost for engineering and design services shown here.

Does this indicate you are going to do most of this design with in-house personnel?

Dr. KELLEY. I am not exactly sure of that.

I think it is because it is a fairly straightforward type of construction design and facility except for some of the problems in the air hearing.

I don't know of any particular design-engineering problems.

Mr. KARTH. Can't we put this in some other building? Do we have to build a special building for it?

Dr. KELLEY. The reason for this building is to be able to—we need this type of model preparation area, instrumentation room, control room, and so forth.

The Ames people after reviewing the total allocation of space and other uses they are making of various spaces, recommended it as most efficient to put this in a separate building.

Mr. KARTH. Do you want to go to the next item?

Dr. KELLEY. The next item is the Vehicle Antenna Test Facility at Langley and the addition thereto proposed in this budget. Last year there was in the 1963 budget, an item called "Vehicle Antenna Test Facility," which was composed principally of two anechoic chambers.

An anechoic chamber is a room where you can radiate electromagnetic energy and you don't get it bouncing off the walls. "Anechoic" means without echoes. You can put an antenna or test vehicle at one end and, with a radiation source at the other end, test the antenna pattern and the whole electronic complex around the so-called antenna end.

Mr. KARTH. How much did we provide last year?

Dr. KELLEY. About $1.7 million last year.

Mr. KARTH. This year you decided to build it twice as big?

Dr. KELLEY. No, sir. I might review the history and the need for this.

Mr. KARTH. We needed this last year. I guess that is the simple question.

Dr. KELLEY. The two anechoic chambers—we have two because you cut the walls to different frequencies, that is, the absorbant material on the walls is made to different frequency ranges so if you are going to cover a whole frequency spectrum you need two chambers—was literally proposed last year to get these people in out of the rain. They were doing tests from various pedestals and devices outside.

If you are going to do high-accuracy testing, when it rains you get all kinds of problems plus the fact that in that particular area at Langley there is a high electromagnetic noise environment.

It is on an Air Force base. There are various beacons and navigational facilities.

So we had to get them inside to be able to do accurate and efficient testing and last year these two anechoic chambers were approved plus a small area off to one side, just enough laboratory and office space to be able to operate adjacent.

In looking over the future and particularly when we start getting into some of the laser antenna requirements, we have proposed an addition this year to this facility to make it a reasonable antenna test facility with associated laboratories.

Now all this concerns what we call the front end of the communication device; that is, the antennas, the plumbing, and so forth.

Mr. KARTH. Are they two separate entities, the one you got last year and the one you asked for this year?

Dr. KELLEY. No. In fact, our planning, which is entering the completion stages right now, I believe, shows an integrated building with the money of last year and the money this year.

In fact, we turned around this little small wing with some laboratory space, which was an L-shape and you can see it in the dotted line on the bottom—that was turned around 90° and it seemed just as reasonable to put it up flush and then build the new proposed additions around it in terms of an additional first floor and then a second floor of that same office and laboratory space.

Mr. KARTH. What would happen to your vehicle antenna testing if this was not authorized? Would everything go kaput?

Dr. KELLEY. One of our principal projects is Project RAM, radio attenuation measurements, which would make great use of this facility in the future as well as now.

In fact, this would be our electronic experimental flight test activity in the future as well as now.

Mr. KARTH. So you can get by but you could not do all of the things you would like to do?

Is that about it?

Dr. KELLEY. We could just do very little, particularly when we require more accuracy and I guess it is more sensitive, too, when we get up in the laser frequencies.

By proposing this addition to the antenna laboratory, we are now anticipating the needs to flight test lasers out of Langley.

Mr. KARTH. You mean if you did not get the $1.7 million, money you got last year it would be largely wasted?

Dr. KELLEY. No, I did not mean to imply that.

We would still have two anechoic chambers and some adjacent space.

This would give us a capability, I would call it a marginal capability, with last year funds.

We would also then have no capability to get laser antenna work done.

Mr. KARTH. The $1,714,000 facility authorized last year—what is the status of that?

Dr. KELLEY. We are in design right now. As I mentioned, we combined what we call phase 1 and phase 2 which would go out as a phase 1 and phase 2 A. & E.

The preliminary A. & E. has been completed, as I understand. There are advanced design funds also released for facility planning for the second increment so we can combine the A. & E. for the first and second increments.

Colonel GOULD. Do you have a construction schedule for this project?

When will the construction get underway on the fiscal year 1963 items?

Dr. KELLEY. I don't have the exact date.

I could supply it.

Colonel GOULD. Are you going to hold off starting this project until the fiscal year 1964 program is legislated?

Dr. KELLEY. No, that has not been finally determined, as far as I know, but we could go ahead with our plan, as you can see, either way; because there is enough flexibility in the plan right now. If we get approval we can keep on going with the rest of it.

We would start the anechoic chambers first anyway and if we did not get approval we could just close in the roof on the first floor at the dotted line and not continue.

Colonel GOULD. Did the fiscal year 1963 item include anechoic chambers?

Dr. KELLEY. Two chambers, yes.

The two side-by-side ones.

Colonel GOULD. Anechoic means without echo?

Dr. KELLEY. Right.

It contains absorbent material on the walls so that the radiofrequencies don't bounce around.

Colonel GOULD. Pending completion of the fiscal year 1963 item, what are you using now to carry on this research?

Dr. KELLEY. We are out in the rain.

Colonel GOULD. Come on now.

Dr. KELLEY. Literally. We use outside antenna test facilities just as well as we can get by with them.

Colonel GOULD. You have no buildings in which this research is being carried on?

Dr. KELLEY. We have no buildings where we can calibrate antennas.

As you no doubt know, one of the purposes of an anechoic chamber is to calibrate the antenna test pattern before you fly so that you know what you have and then when you get the test data back you throw in the test pattern and can normalize out the actual test data.

We really have no way of doing this now except in an outside range.

Colonel GOULD. The original laboratory in the fiscal year 1963 program was 14,800 square feet and this addition is for 26,000.

Has the requirement for laboratory space increased three times since you appeared before this committee last year?

Dr. KELLEY. Would you say that question again?

Colonel GOULD. Has your requirement for laboratory space increased by three times since you appeared before this committee last year?

Dr. KELLEY. I am sorry; I meant the square footage.

I was trying to correlate it.

Colonel GOULD. According to the justification books last year the original laboratory that was requested was 14,820 square feet.

Was there a change in plan on that?

Dr. KELLEY. I think that did not include the anechoic chamber.

I think that is right.

Our requirements have increased by the amount of square footage indicated and, as I mentioned, one of the factors here is the light communications laboratory that we would like to add as an adjacent part of the antenna test facility.

These two things seem to go hand in hand.

Colonel GOULD. Are there any other phases of this project beyond fiscal year 1964?

Dr. KELLEY. No; this would complete this entity.

Colonel GOULD. The fiscal year 1964 program includes a launch environment and antenna test facility at the Manned Spacecraft Center in the amount of $7.5 million. This proposed facility also includes an anechoic chamber, antenna range, antenna services, and so on. What is the relationship between the facility at Langley and the one at Houston?

Dr. KELLEY. You will notice quite a difference in cost between the two facilities also.

That is largely for full-scale spacecraft test.

They are going to put full-scale Apollo spacecraft in that particular chamber and run antenna pattern tests on it.

It is a 120-foot-high building, I believe.

Here, again, we are doing the small-scale research calibration for testing. They would expect to get a spacecraft in there, get their antenna patterns, and then get it out and go fly it.

We would expect to have a research test device in ours probably for a considerable length of time running different measurements on it and different tests.

Colonel GOULD. Will this facility at Langley be completed in time to benefit the Apollo program?

Dr. KELLEY. Well, all of our research facilities are for advanced research and technology, which benefit any one of the programs and they all feed into them.

This is not specifically an Apollo facility; but, yes, we expect it would yield some benefit to Apollo.

The RAM project at Langley, for example, already has yielded some potential benefits to Apollo. One of these is the water injection we discussed before with the committee, reducing the communication blackouts during reentry.

This is something that has great interest for the Apollo people.

Mr. KARTH. Are there no test facilities similar to this existing in private industry or other Government agencies?

Dr. KELLEY. There are many anechoic chambers in various facilities throughout the Government and industry.

Mr. KARTH. Does NASA have any?

Dr. KELLEY. Yes. JPL, I believe, has similar anechoic chambers to run some of their tests. These are devices that people use to do calibrations in many cases prior to flight. It is a tool of the trade. There is nothing unique about the anechoic chamber here.

Colonel GOULD. The laboratory and standards calibration equipment are estimated at $150,000 in this project, I believe.

Dr. KELLEY. Yes.

Colonel GOULD. In the fiscal year 1963 program, we had $200,000 for this same type of equipment. This appears to be a considerable amount of equipment over a 2-year period. Could you define for us exactly what this consists of?

Dr. KELLEY. Yes. This equipment, individual units of it, are quite expensive. For example, one of the devices would be an atomochron, an atomic clock, which is used as a standard frequency reference. If you are going to do test work and you want to cover various frequencies, you want to know exactly what freqency you are on. When we are talking in terms of thousands of megacycles, then, of course, this becomes a pretty precise measurement, so these laboratory standards and calibration equipment, plus the so-called counters and dividers and networks that bring the basic reference down to the frequency you want, so you can calibrate at that particular frequency, are quite expensive devices.

Colonel GOULD. The same holds true for laboratory test and shop equipment. I think you are asking for $87,500 this year and last year we included $145,000 for this type of equipment, bringing the total to $232,500. Are these estimates that you show, refined estimates? Do you know exactly what you are going to buy or have you just made a guess as to how much it will cost?

Dr. KELLEY. They are estimates based on experience, largely. We don't necessarily add up all of the individual bits and pieces and come up with a number, because, of course, during the leadtime to build the laboratory, various new devices appear on the market. It is based on an experienced judgment estimate. Much of this

equipment, of course, you can predict. It is standard equipment, such as oscilloscopes and generators.

Colonel GOULD. Has the design on the fiscal year 1964 item been started?

Dr. KELLEY. We are doing the phase I and phase II together on the A. & E.

Colonel GOULD. Are you using fiscal year 1963 advance design funds for the fiscal year 1964 item?

Dr. KELLEY. Yes.

Colonel GOULD. Then the $77,000 item for design and engineering service has already been funded, is that correct?

Dr. KELLEY. To my knowledge, that is correct. The $77,000 advanced funds have been released for facility planning.

Colonel GOULD. That is all I have, Mr. Chairman.

Mr. KARTH. Would you care to go to the next item?

Dr. KELLEY. Yes, sir. The next item is an "Electronic Instrumentation Laboratory at Langley," and I don't think that particular slide is very distinct. This is a copy of the one in the book, which is CF 5–8. At Langley, together with our flight program and from a research basis, as well, we have had extensive effort in the past in the area of electronic instrumentation, and here I might just define instrumentation.

We are talking about physical instrumentation, as opposed to science instrumentation—in other words, trying to measure perhaps some of the more mundane engineering quantities that you need for technology, as opposed to other areas of instrumentation that you need for science.

We are trying to measure heat, density, radiation effects on devices, and so forth. Langley has been in this business and quite capably over a number of years—in fact, Langley is largely responsible for the instrumentation of the X–15. The Langley people participated very heavily in the Mercury tracking network and some of the Mercury instrumentation.

This building is to give the Langley people, many of whom are in subbasement structures with some of their equipment in trailers, to give them a facility so they can progress into some of the more advanced instrumentation that we will need in the future, where we are getting into high temperature measurements, low densities and many engineering measurements that we can think of as we proceed in space, so that they can have access to and use and research with the latest type electronic tools.

That includes microelectronics, and so forth—to be able to use these devices.

Mr. KARTH. How much is office space versus laboratory spaces?

Dr. KELLEY. I think that I have that figure here. It is 24,000 feet laboratory space and 16,000 feet office space. I think that should add up to the total.

Colonel GOULD. You missed it by 16,000 square feet.

Dr. KELLEY. That doesn't include the hall space and some of the other you would include in the gross estimate. These are net laboratory and net office.

Colonel GOULD. You mean to tell me that we have 16,000 square feet of corridors in this building?

Dr. KELLEY. I would have to check that.

Colonel GOULD. You said 24,000 for the lab and 16,000 for the office?

Dr. KELLEY. That is right.

Colonel GOULD. The total building is 56,400 square feet.

Dr. KELLEY. I would have to check those figures.

Mr. KARTH. If you just eliminate the corridor, you have a good building.

Dr. KELLEY. There is also a partial basement, too, in that.

Mr. KARTH. I am not sure you finished your explanation.

Dr. KELLEY. I would be glad to furnish the exact numbers for the record if you want.

Mr. KARTH. Yes, sir; please do.

(The information requested is as follows:)

Floor plan breakdown

	Square feet
Total laboratory space	24,360
Total office space	17,708
Other (halls, stairways, rest rooms, elevator, walls, etc.)	14,332
Total	56,400

Colonel GOULD. How many people are going to occupy the administrative space?

Dr. KELLEY. I can give you a total for the building—approximately 200 people would be in that building, the electronics instrumentation laboratory. That includes those in office space, as well as the technicians who live largely in the lab, as well as the professional researcher who is living half in the office and half in the lab.

Mr. KARTH. Where will all of these people come from?

Dr. KELLEY. Over a 3-year period——

Mr. KARTH. You are not going to empty out another wind tunnel, are you?

Dr. KELLEY. One hundred and eight of these are on board right now at Langley and there would be additional people from some other sources that would go into this building—92 additional.

Colonel GOULD. Where are the 108 people being accommodated now?

Dr. KELLEY. This is largely the Instrumentation Research Division down there which are scattered around in several buildings, including subbasement space and not very well grouped together right now.

Colonel GOULD. What is the relationship between this facility and the one in the next item you are going to discuss, the Electronics Research Center in Boston?

Dr. KELLEY. They are complementary. This activity will be working closer to the flight operations and again, I am talking about research flight test operations, while the work at the Electronics Research Center, in the instrumentation research group included there, will be more on general instrument techniques—in other words, how do you transform a physical quantity into a measurable quantity—something like a voltage or pulse, or digital readout.

This group and our whole distribution of effort, as we discussed with the committee before, the whole distribution of electronic effort in NASA includes groups at various other centers in addition to the new proposed Electronics Research Center. The work would be complementary, because the Langley people would be working closer to the

problem, they would be taking components out and actually flight testing on vehicles and operating payloads with test instruments.

In other words, the flow would go from the Electronics Research Center to the Langley instrumentation people, to the test pad at Wallops, on a research cycle.

Mr. KARTH. Is this $2,085,000 for the electronics instrumentation laboratory, the total cost?

Dr. KELLEY. That is the total cost.

Mr. KARTH. All of these are total costs except for the research center, is that right?

Dr. KELLEY. That is correct. On the title, the "Electronics Instrumentation Laboratory."

I think you said electronics and instrumentation. It is largely devoted, or almost exclusively, to new ways of developing research in instrumentation. But it is largely through electronics.

Mr. KARTH. Where is this "various" located?

Dr. KELLEY. You are talking about the next facility?

Mr. KARTH. Yes. That is the first time I have seen it.

Dr. KELLEY. Various locations but in greater Boston, sir.

Mr. ULMER. That is a heading in the authorization bill, Mr. Chairman. It is used to cover a multitude of facilities that do not have specific locations assigned.

Colonel GOULD. I would just like to ask one general question. Last year, Dr. Kelley, Mr. Wyatt and Dr. Seamans testified to the effect that NASA had to rely quite heavily on industry in the electronics research and testing area. Mr. Wyatt stated:

> We must rely very heavily on outside interest in the area of electronics research.

I am skipping a little:

> This is an area of engineering disciplines where we do rely quite heavily on work by contract with outside electronics groups.

Dr. Seamans then stated:

> There is no question about this. At the time we did establish an Office of Electronics and Control at NASA headquarters to be sure the work we are doing at the Goddard Center, at the JPL and Marshall Center primarily in the electronics area was properly coordinated internally and was not in duplication with work already going on in industry. A great deal of work has been done in the guidance field. There is a danger that our people in NASA centers could repeat what has already been done or what is already going on in this field. We are relying very heavily in industry and to lesser extent, on universities in this area.

Has there been a change in thinking within NASA, as to the requirement for an in-house capability in the electronics research area?

Dr. KELLEY. I replied to that question before at one of the previous hearings, but I will be glad to reply to it again.

Mr. KARTH. I am not sure what you said. Say it again.

Dr. KELLEY. All right. Maybe I can start back a little bit. Yes, we rely on industry and we intend to rely on industry. This is one of the purposes of this particular laboratory. When our office took inventory after we were formed in November 1961, we found that there was a spotty diffused effort with some bright spots of excellence throughout the NASA, but pretty inadequate in a cumulative sense, to meet the future needs. It was about, I think, shortly after the hearings, that we are talking about, that we had some discussions with NASA management, and they recognized the fact that we weren't going to

get from here to there, improving our reliability, and so forth, if we didn't increase our efforts. One of our initial proposals was that we increase our industry efforts over and above what they are now and you are beginning to see the reflections of this in this year's budget, and you saw it in 1963.

To efficiently manage and lead such an effort, we believe that you have to have in-house competent people. You just can't throw the money out and say solve the problem. You have to tell people what the problem is, and you have to express it to them in engineering terms. We believe, as with all of our research centers, that you have to have competent people who are doing enough work, themselves, to get their own hands dirty to be able to lead, in a sense, the effort in this direction, the vast majority of which will be done in industry.

So we intend to increase our industry efforts and the center will be the focal point for us of our total government-industry-university effort in what we call a new branch of electronics, space electronics. So this is consistent—in fact, as I mentioned in the previous reply, it was about that time that our office—this was March of 1962—was directed, in terms of preliminary guidelines for this particular budget we are discussing now, to come up with a plan to implement NASA's required future growth in electronics and guidance and control.

Mr. KARTH. Inasmuch as you had to come up with a plan, I assume you had an official group set up to study this thing and make some recommendations?

Dr. KELLEY. No, I am sorry, I probably used the wrong word. It was a method of implementation for NASA——

Mr. KARTH. Call it what you want. Apparently NASA thought about this at considerable length so I assume they have done some real calculating in addition to what they have already heard in terms of how badly do we need it, where should it be, and all of these other things, and therefore this was done by some official group, wasn't it?

Dr. KELLEY. Yes, sir.

Mr. KARTH. Who were the members of this group? What do you call a group like that?

Dr. KELLEY. There was no separate study staff group set up to do this. This was directed through the line organization and it was directed to the Office of Advanced Research and Technology.

Mr. KARTH. Was this usual or unusual when you are talking about a brand new research center for an agency of the Government.

Dr. KELLEY. We weren't directed to come up with a new research center. We were directed to come up with a plan. In other words, in our discussion with NASA management, we realized that we had to grow, we had to have some method of managing this growth and the 1964 budget was a crucial point—in other words, in fiscal year 1964 we would branch off one way or the other because of the electronic problems we were getting into deeper and deeper.

Mr. KARTH. No official study was made of this, in other words?

Dr. KELLEY. I am not sure what you mean by "official study." There was a continuing review of this problem by our group in NASA.

Mr. KARTH. Who decided we needed an electronics research laboratory?

Dr. KELLEY. The Administrator decided it. We went through——

Mr. KARTH. Then there must have been a number of people that had suggestions or discussion about it. Who were they?

Dr. KELLEY. All NASA——

Mr. KARTH. You just didn't decide this, did you, Doctor?

Dr. KELLEY. No, sir.

Mr. KARTH. Jim Webb didn't just decide it?

Dr. KELLEY. No, sir.

Mr. KARTH. There were a number of people that got together and decided we needed an electronic research lab. Who were they?

Dr. KELLEY. At least NASA senior management. I made a recommendation——

Mr. KARTH. When you say the senior management, who do you mean?

Dr. KELLEY. The senior management basically is Dr. Seamans, Dr. Dryden, and Mr. Webb.

Mr. KARTH. And yourself? You four decided?

Dr. KELLEY. I don't consider myself senior management.

Mr. KARTH. We threw you in as a junior management. Did Dr. Bisplinghoff help to decide the question?

Dr. KELLEY. My initial recommendation was made to him as my superior.

Mr. KARTH. Who else was in it?

Dr. KELLEY. I don't know with whom else the senior management consulted or discussed this. I think we presented a fairly convincing case and there was known to be a need.

Mr. KARTH. You met with the group who discussed this question, did you not, on many occasions?

Dr. KELLEY. I met with my superiors and discussed this, yes, sir.

Mr. KARTH. And all of those people so named are superiors in some form?

Dr. KELLEY. Yes, sir.

Mr. KARTH. Did anyone disagree with you as to the need for it?

Dr. KELLEY. I was asked some very, very intensive questions. My recommendation, which was made late in September, as you know, was certainly not bought lock, stock, and barrel, but the fact I was going to look into that consideration was known in early spring of last year. It was known after March. That was after our guidelines came out. At that time I told our senior management, in terms of the Associate Administrator and my immediate superior, that we were going to look at three alternatives.

Mr. KARTH. Yes, I remember your testimony on this. That is not my question. Of the five of you who sat down and discussed the need for an electronics research center, did any one of the five disagree with you as to the need?

Dr. KELLEY. I think after I got through answering questions, after our initial discussions on it, there was a general agreement that we needed this; yes.

Mr. KARTH. So you sold it to the other four involved, is that correct?

Dr. KELLEY. If you want to put it that way, perhaps.

Mr. KARTH. As to the location, as I understood your testimony, that was your decision, or at least you made this recommendation?

Dr. KELLEY. I recommended a center and then I was asked "If such a center was approved, where would you recommend is the best place to put it?"

Mr. KARTH. And you recommended the Boston area?

Dr. KELLEY. Yes, sir.

Mr. KARTH. Did anyone disagree with that?

Dr. KELLEY. There were some discussions I participated in as to why, and various other areas, but I wouldn't say there was any disagreement; no, sir.

Mr. KARTH. Did anyone have any other suggestion to make insofar as location is concerned?

Dr. KELLEY. Well, I mentioned previously that we had discussions and considered the Northeast area from about—really the electronics——

Mr. KARTH. Who suggested it should be in the Northeast area?

Dr. KELLEY. I said we had discussions on each one of these areas in reviewing this.

Mr. KARTH. You call the Boston area the Northeast area?

Dr. KELLEY. I call Washington to Boston the Northeast area.

Mr. KARTH. What other areas were discussed?

Dr. KELLEY. I think you just have to look at the electronics population in the United States.

Mr. KARTH. Which one of these four suggested a different area, if any?

Dr. KELLEY. I considered all of these areas in my own thoughts and laid all of these areas out in the discussion.

Mr. KARTH. I am sure you did, but I was trying to ascertain whether or not any of the other four had suggested a different location?

Dr. KELLEY. I think, in our discussions that I participated in, it was just a mutual walking across the country in the electronics areas and discussing the pros and cons and these are the areas I mentioned—the west coast, the Midwest concentration of electronics and the Northeast concentration.

Mr. KARTH. There was complete agreement it should be located at the location proposed?

Dr. KELLEY. There was complete agreement it should be located in that area.

Mr. KARTH. This is not my recollection of your testimony earlier, but I don't think there is any sense of us quibbling about it.

Dr. KELLEY. I think this is consistent with my testimony.

Mr. KARTH. It seems to me you said "Yes; there had been some disagreement; after all, there is disagreement in everything."

Dr. KELLEY. I think you asked me about whether there was disagreement as to the need of a center in various elements of NASA.

Mr. KARTH. I think I asked you that question, too. I think you said you convinced everybody there should be.

Dr. KELLEY. I am sorry. The previous question, as I remember in the previous hearing, was "Anybody in the NASA disagree?" and I believe I said, "Well, I would not expect 100 percent agreement on anything."

Mr. KARTH. Well, I haven't reviewed the testimony so my recollection probably isn't as good as yours.

Colonel Gould?

Colonel GOULD. Dr. Kelley, has the site for this center been selected?

Dr. KELLEY. No; it has not.

Colonel GOULD. In a recent letter to Chairman Miller, Mr. Webb indicated that there was some possibility that lands available to the Mas-

sachusetts Turnpike Authority might be made available for this purpose. Is that correct?

Dr. KELLEY. Yes. In fact, we covered this with a press release which says what the letters to Senator Anderson and Chairman Miller say, that we are looking at an interchange of the Massachusetts Turnpike Authority for possible use of air rights over the site location. Now, this is quite a different concept than the thousand acres we proposed originally in the budget. Since we did want to look at it, Mr. Webb wanted to make it public knowledge we were looking at something quite different, but by no means have we made up our minds or selected a site.

Mr. KARTH. What do you mean by "air rights"?

Dr. KELLEY. This is something that municipalities have been doing and the Boston area has already done it in terms of one private center which is erecting a building, essentially on stilts, over a turnpike or railroad to get better use of air space.

Mr. KARTH. In the first instance we needed 1,000 acres. How could we possibly get by with building this thing on stilts over a freeway? I am not sure I understand.

Dr. KELLEY. That is one of the things we want to look into, whether it is feasible or not, and this involves many, many considerations.

Mr. KARTH. I assume under those conditions probably if you built it on the ground and used up only several acres as opposed to a thousand, the difference is in the magnitude of hundreds?

Dr. KELLEY. It means you would have to go more high rise and be more compact in your building, of course, in terms of density as opposed to a conventional research center in which the buildings are more spread out.

Some people say you turn the buildings up 90°. I am not sure whether it is quite as easy as that. That is one of the things we are looking at.

Colonel GOULD. How much real estate is involved in the MTA property?

Dr. KELLEY. I think about 110 acres.

Colonel GOULD. What would this mean in terms of the number of stories that you would have to put on a building of this nature?

Dr. KELLEY. That is one of the things we have to look at. Can you put it in a couple of tall buildings or can you put it in several four- or five-story buildings? You have to look at the particular site and see where you can sink the pilings between the roadways for one thing.

Colonel GOULD. Have you held discussions with MTA on this matter?

Dr. KELLEY. Yes; there have been NASA and MTA discussions on it, with representatives from the MTA.

Colonel GOULD. Would an agreement of this nature require reimbursement from the Federal Government to MTA?

Dr. KELLEY. I don't know what the exact situation on air rights is. I believe they are rented and I don't know for what length of time. The Turnpike Authority actually owns the land and I believe air rights under Massachusetts law are rentable but I am not sure of the legal situation.

Colonel GOULD. I heard recently that the Corps of Engineers has been requested to conduct a feasibility study of the possibility of using this MTA property. Is this correct?

Dr. KELLEY. That is correct.

Colonel GOULD. Have they started the study?

Dr. KELLEY. The corps took a preliminary look at that particular site. In fact, it was shortly after we decided to announce our consideration of this—just enough to let us know from an initial standpoint how hard should we look and what was the feasibility—and their preliminary look convinced us we should take a more detailed look at it, particularly in terms of foundation, pricing. We have a work statement to them, a work order with them to do a study on this particular center.

Colonel GOULD. What funds have been cited to accomplish this study?

Dr. KELLEY. On this work statement their work is reimbursable up to $10,000.

Colonel GOULD. How long is it going to take the Corps of Engineers to complete their feasibility study?

Dr. KELLEY. I think a couple of months, probably no more.

Colonel GOULD. If the MTA area proves not to be satisfactory, are you going to start another feasibility study on other possible areas?

Dr. KELLEY. You mean other areas like this?

Colonel GOULD. I assume you are going to do some advance study work before you enter into the detailed design and layout of a complete installation. Assuming the MTA site doesn't prove satisfactory, will there be another feasibility study beyond that?

Dr. KELLEY. We would continue what we are doing anyway on a number of other sites, which is gathering information and at some point in time, assuming this project is approved, then there would be a site evaluation to pick a particular site. Of course, you have to be accumulating information on topography and substrata and so forth as you move along, which we are doing, which the corps is working on with us.

Colonel GOULD. Your justification indicates that the fiscal year 1965 program will include construction funds for this project. What is your estimated "ballpark" total cost of this facility?

Dr. KELLEY. We have estimated plant value, that is the facilities of about $50 million.

Colonel GOULD. Whether it be a high rise type or not?

Dr. KELLEY. No, this was based on the 1,000 acre campus type. This is one of the reasons we are doing this particular study on the MTA site.

Colonel GOULD. I think this committee would like to know your thinking as to what it is ultimately going to cost since this is the initial increment of this project. If you have changed your mind since the original concept was conceived, surely you have another rough figure you could quote to the committee.

Dr. KELLEY. No, we are waiting for the cost study and report. That is exactly what we are doing it for, really.

Mr. KARTH. We have no design studies at all. I have seen some pretty nice pictuers here and I have gone through the backup and I have seen some pretty well illustrated designs of the other buildings

that you have proposed for the 1964 budget. You have nothing like this at all?

Dr. KELLEY. Could I show you the next picture? I will show you what we do have. We have not gone into detail design of each building. This depends on the site really. This is using our normal center construction. This is the type of layout that you might get.

What we have done is gone into a modular type of plan, as shown in this artist's conception (fig. 315).

FIGURE 315

This is a modular laboratory concept where, depending upon the topography you can combine these in T or L shapes or spread them out any way you would desire according to the particular site. Here you see the different laboratories and buildings and the dot indicates, the first dot indicates the year we would start on that particular facility. You will see there is a progression here. A later increment would be added and I can explain that. For example, an optical communications laboratory—this is a laser research laboratory primarily—we would like to build a building commencing with 1965 funds. However, the state of the art is moving so fast we would not want to build all of that building in that particular year because the building we would build with 1965 funds might be quite different than the one we would build with later funds. In other words, a research facility has to be updated because the art is changing. So our plan takes this into account, that we would then add on another wing,

perhaps, to that particular building with 1967 funds and the total of all such modules is what comes up to approximately $50 million.

Colonel GOULD. Will you have to compress this plan to fund it over a 4-year period?

Dr. KELLEY. The present plan is to fund the buildings over a 4-year period and in this fiscal year requesting land funding. When you look at the leadtimes and so forth, that means we will complete construction by 1969 or 1970, depending upon how we and the corps plan it.

Colonel GOULD. Mr. Chairman, I recommend this chart be included in the record at this point.

Mr. KARTH. Can you make it available?

Dr. KELLEY. Yes, sir; I would be glad to. I will straighten out the Morse code, too, if you like.

Colonel GOULD. Just put a legend on there for the uneducated, so we may decipher it.

NASA Electronics Research Center installation plan

[B=basic module; A=addition]

Facility (functional titles)	Fiscal year funding			
	1965	1966	1967	1968
Microwave radiation laboratory		B	A	A
Space guidance laboratory	B		A	
Electronic components laboratory	B		A	
Optical communications laboratory	B		A	
Instrument research laboratory		B		A
Computer research laboratory		B	A	
Control and information systems laboratory		B		
Energy conversion laboratory	B			A
Qualification and standards laboratory	B	A	A	A
Systems laboratory		B		A
Engineering and administration building	B			

This may have been covered in a previous hearing, Dr. Kelley, but I wasn't present. Your estimate is predicated on $1,000 an acre?

Dr. KELLEY. $3,000 an acre.

Colonel GOULD. $3,000 an acre for a thousand acres and the justification indicates that it is going to be located in the Boston area. Now, land values in that area indicate that for this price range you would be located a minimum of 10 to 20 miles from the Boston area.

When you say the "Greater Boston area," exactly what do you mean?

Dr. KELLEY. We mean, in general, the standard metropolitan statistical area which is the census area, in the 1960 census. To put it in more straightforward terms, it is an area that is within approximately 30 miles from Boston. We are looking at sites generally within that total area but you also have to look at time as well as distance when you are looking at sites in relation to other locations that you might be interested in commuting to.

Colonel GOULD. There is a U.S. Navy Ammunition Depot at Hingham, Mass., which already has been declared surplus and is in the hands of GSA for disposal. It includes 3,500 acres, I have been told.

Dr. KELLEY. The annex to it includes approximately 3,000 acres. We will, as part of the normal site survey, look at all available facilities in the area and we know what each one is.

Colonel GOULD. I would also point out that the U.S. Army has a QM test activity at Maynard, Mass., and some consideration is being given to declaring this property excess.

Dr. KELLEY. I am quite aware of that site also.

Colonel GOULD. I would like to ask this for my own information. You indicated the unanimous decision on the selection of this site was the Boston area. Could you tell us why the Los Angeles area was rejected?

Dr. KELLEY. I probably could put it in terms of why the Boston area was superior, if you want, rather than why the Los Angeles area was rejected. The Los Angeles area was considered but we were looking for a research climate, primarily electronics oriented and in fact the Los Angeles area scores very high in this particular activity. It has a large aerospace industry, for example. This, while it has research aspects, falls more in the development part of the scale—if I take research, development, and production as the three parts of the scale. We were looking for an area that fell more toward the research part of the scale and I think you are familiar with the so-called electronics research environment in the Boston area—the radiation laboratory, the instrumentation lab. This is evidenced by the many large companies throughout the United States who have located their research plants, primarily electronics research, in that particular area. So there is a rather unique electronics research environment both in universities and in industries. The universities, their reputation and their programs, had a very serious impact on our decision. I think you are probably aware that that area turns out the most graduate engineering degrees in the United States, with a great lead at the engineering doctorate level.

Mr. KARTH. Where?

Dr. KELLEY. The Greater Boston area of all of these metropolitan areas.

Mr. KARTH. I am not sure you are right, but go ahead.

Dr. KELLEY. Did you understand my statement?

Mr. KARTH. I think I did.

Colonel GOULD. The Minneapolis-St. Paul area offers a considerable amount of potential in the electronics field. Was this area considered?

Dr. KELLEY. Yes, it was. I am quite familiar with what is in that area.

Mr. KARTH. As a matter of curiosity you happen to know that geography better than others. Where on the scale did they rate?

Dr. KELLEY. We didn't rate them on a scale. In fact, I am personally familiar with the Electrical Engineering Department of the University of Minnesota and Dr. Shepherd who is the chairman of the department. I am familiar with the department and with such companies as Minneapolis-Honeywell. I might add one thing, Mr. Karth, that this is an up-and-coming area in electronic research, no question about it.

Mr. KARTH. Again, I hope nothing happens to it.

Dr. KELLEY. I might add one more figure of merit, if I might, to show you how you characterize a research environment. The National Academy of Sciences' membership, which is a well-renowned institution in the country, the greatest percentage of its members

come from the Greater Boston area—this includes total membership as well as the engineers and physicist category.

Mr. KARTH. You know there are some very knowledgeable people who violently disagree with your theory.

Dr. KELLEY. You mean the conclusion that you would come to as a result of the numbers I expressed?

Mr. KARTH. That is right.

Dr. KELLEY. I am sure there would be, sir.

Mr. KARTH. On every basis upon which you predicated your decision. In fact, there are some people who say—I am not sure they are as smart as you are, but they have fairly good backgrounds—they say this is bad, it is not good. You get hairy about this stuff, you know. What you need is to move off and have a little fresher approach. Everybody starts thinking the same, and you develop a mundane community. I don't know, I couldn't be less well informed on it, so what I have to do is listen to both arguments, the two different schools of thought, so to speak, and then if the determination ever comes down to location, which I hope it won't because I think at first and only you decide something on the basis of need, do we need it, really, and this I think is the question that should be answered in arriving at the decision or coming to the conclusion as to whether or not it should be allowed; although there are many people that think location is extremely important, fortunately, or unfortunately. It happens to be the case, and I suppose deserves some consideration.

As I recall your testimony before the subcommittee, some 3 or 4 weeks ago, it seemed to me that you said in answer to a question you felt the location was just as important as the research center, itself. I wonder if you have changed your position on that at all?

Dr. KELLEY. I remember that particular question and my answer. I believe the question was to the effect that I really wanted a center and the location was not important, was it, and I said that yes, I wanted a research center, but I didn't think the location could be completely divorced—in other words, there were various areas in the country that are satisfactory to a greater or lesser degree, and that the location was not completely divorced from the need.

Mr. KARTH. If it was decided this location was just not acceptable for any number of reasons—let's say because of those experts who disagree with you—you would still want the research laboratory?

Dr. KELLEY. Absolutely; yes, sir.

Mr. KARTH. I just thought we would clear that up if we ever got out of the woods on the other question.

Dr. KELLEY. I am very glad the two issues have been separate.

Colonel GOULD. One final question, sir; Dr. Kelley, the anticipated span of time over which this facility will eventually come into being is about 5 years—fiscal year 1964 for design and acquisition of real estate, and——

Dr. KELLEY. You mean the actual building?

Colonel GOULD. It will be a complete operational facility in 5 years?

Dr. KELLEY. Right.

Colonel GOULD. One year of design and real estate acquisition and 4 years of construction. Much of the determination in this proj-

ect is going to be predicated on feasibility studies which you tell us are going to take 2 or 3 months. Is this correct?

Dr. KELLEY. This particular site. That is only one of many we are considering. You are talking about the M.T.A. site?

Colonel GOULD. Yes.

Dr. KELLEY. Yes.

Colonel GOULD. If this fails you are probably going to conduct other feasibility studies for other sites under consideration?

Dr. KELLEY. Yes, there will be a site selection at some point in time.

Mr. KARTH. Now, wait a minute. Let us quit this business. If after 2 months the Corps of Engineers, or whoever is making this feasibility study, decides it is not feasible, it is not practical, then you have to study some other site, don't you?

Dr. KELLEY. We are looking at many, many other alternatives.

Mr. KARTH. You are doing all of this simultaneously?

Dr. KELLEY. Yes.

Mr. KARTH. Who is doing it?

Dr. KELLEY. NASA, and the corps is reviewing them with us. It is all preliminary. This is not in any sense of the word a site selection, but you have to be gathering data on which you can finally make a site selection.

Mr. KARTH. I think it is absolutely important.

Dr. KELLEY. In fact, much of the available and attractive sites are being thrust upon us.

Mr. KARTH. I would assume you have to beat them off, yes. If you don't watch out you might get sold some expensive real estate.

Colonel GOULD. The point I am trying to explore is that it is going to take you almost a year to determine where this is going to be located, what it is going to consist of, and what it is going to cost. What would the impact be on the NASA program if the authorization and funding for this project were deferred for 1 year?

Dr. KELLEY. It would be a 1-year slip in the facility. If you want to ask what will be the impact on the NASA program, that is quite a different story.

Colonel GOULD. This is what I mean, the impact on the NASA program.

Dr. KELLEY. Well, if we had the choice in this year's budget, and I mentioned this earlier, we feel was an electronic research year of decision as to which way we would have gone, if we had the choice of putting in facilities around at various locations—we call this the Serval Center approach—or of grouping them in terms of a facility, and we chose the latter route. In some sense you perhaps set us back 2 years because we decided not to go the other route which would have appeared in this budget, and then we have delayed this approach another year in turn.

Now, you then have to look at what the center is going to do, and how does this pay off in terms of the program. Well, I hope we have demonstrated the need, and why we have to get working in this particular area of research and whatever reliability problems there are. We estimate that 90 to 95 percent of our unreliability is caused by electronics, so in terms of the dollar cost to the program I think it would be quite substantial. We would hope that the results of this center, not only from its own efforts but from its organization and

focusing of the effort that we contract to industry would be able to yield us results within a year or two and begin to pay off. I would predict that the center, in terms of its salary and overhead and facilities, even if you write off the longer range research contribution, will pay for itself in terms of the reliability factor that it can add to the overall programs.

Colonel GOULD. Can you put your finger on any on-going programs with NASA that will be delayed if this project were deferred for 1 year?

Dr. KELLEY. Will be delayed? We have not tied this into any particular project. If you want to look at schedules and launches, probably none. If you want to look at effectiveness per launch or reliability per launch, quite a bit.

Mr. KARTH. You think that one more laboratory is going to answer all of our electronic problems? Is that what you are saying?

Dr. KELLEY. It is going to allow us to focus our efforts and industry's efforts on the problems which are quite substantial. We have to really get working in this particular area.

Mr. KARTH. So what you are saying is that all of the research that is going on in this area, in private industry, in Government laboratories, and in the universities, is completely inadequate and the answers will be given to the problem areas we now find ourselves facing by building a NASA laboratory? Do you really mean that?

Dr. KELLEY. This is by far the most efficient way of doing it. I don't really know how else you are going to do it if we don't increase our efforts in electronic research——

Mr. KARTH. I think I can tell you several ways I think it would be much more efficient, but I am not sure you would listen. One thing I think we should do, Dr. Kelley, is to find out first, all of the research that is going on in the electronics industry in this country, which I am sure we don't have. I am sure of that, and I think you being an honest man, will admit it. So by saying that just one more laboratory is going to solve 95 percent of the problems that we have in the space field, I think is just about as ridiculous a statement as I ever heard before this committee.

Really, I say this in wanting to be completely and totally objective. With all of the research that is going on in Government laboratories, if we don't have a half dozen laboratories doing research in electronics, I'd be surprised. We have got quite a number of outstanding Government laboratories doing a great deal of work in this area. We have a number of outstanding universities and colleges doing a great deal of research in this area. We have a vast number of very highly touted and well-respected companies doing great research in this area, and to say that just one more Government laboratory will answer our problems, I think is, quite frankly, tantamount to striking this thing from the budget. I really think so.

Dr. KELLEY. Could I make a comment?

Mr. SMITH. Yes, sir; go right ahead.

Dr. KELLEY. We know there is an extensive industry and university effort, and we believe that the laboratory will serve to focus this effort on the particular space problems. It is not going to provide all of the answers, itself. It is going to be able to focus the problem for the people who are going to do the work in industry and universities

with some work being done in the laboratory, itself, and then focus the answers back into the space projects.

Mr. KARTH. Doctor, there are those who say this kind of work should be done at the various centers, where the research can be applicable to the projects that that Center is working on, and they make a very, very strong case. So these are some of the people who disagree with you and others who say we need a separate, a distinctly different type of research facility than we now have, because we now have 50 electronic research centers going on within NASA. We have one at every one of our research centers. I am not complaining, I am just saying this has been called to my attention. They say "Good grief, if we need more electronic research in the satellite field, or in the manned spacecraft field, or whatever field it is, then this kind of research should be going on at the center where the people concern themselves with the problems confronting them in that particular area."

I don't know if this makes a reasonably good argument. I don't suppose it makes a good argument to those who favor the separate center, you know, but, on the other hand, your argument doesn't make much sense to them, either.

The only point I do make, Doctor, and this is what I really object to, someone assuming that we are so naive and so completely unqualified to make decent and accurate and well-founded judgments, that we should be told that unless we have just one more Government laboratory our problems in electronics are going to continue to harass us forever, and that if we do have that laboratory our problems are going to vanish. If it is that necessary, why, good grief, someone should be fired for not having proposed this thing 5 years ago.

This should have been the first thing NASA ever requested. If this thing is so absolutely imperative today, it would have been better to cut off the funds to any one of our other research centers, or maybe all of them, and put all of our emphasis on this thing in earlier years.

I think with the emphasis now being put on it, someplace along the line someone that was responsible for making this determination a long time ago should be fired because he obviously didn't make it.

More important than that, he may have made a determination, but made the wrong one, and decided not to build it until this year. Someplace along the line we have a great need for improvement in management.

Colonel GOULD. One final question. You have included in the project estimate, $2 million for design and engineering. I assume this is all design in this case. What is the leadtime for design on the first increment that will be accomplished for this $2 million?

Dr. KELLEY. This is for master planning and to plan our 1965 facilities.

Colonel GOULD. What is the leadtime?

Dr. KELLEY. You mean leadtime from when to when?

Colonel GOULD. How long is it going to take to complete the master plan?

Dr. KELLEY. To do this work?

Colonel GOULD. Yes.

Dr. KELLEY. About 3 to 5 months. You see, we are working with the corps right now in getting together technical criteria for the particular buildings. And then they will be working in terms of this

master planning and the corps itself may do the master planning on this particular activity. At such times as these funds are available, or would be available, then we would go into a site selection and begin to narrow down on a particular site and design for a particular site.

Colonel GOULD. Are you saying that a complete master plan for an installation of this nature can be laid out to include schedule of existing and required facilities, preliminary costs, utility layouts and costs estimates made in 3 to 5 months?

Dr. KELLEY. This is the initial master plan from which then we would—you are more familiar with this than I am—from which point we would depart into details for our 1965 increment. You are doing master planning all of the time as you go along.

Colonel GOULD. The master plan is the first thing that should be accomplished in any installation. I think this is one of your basic problems with many of the NASA installations. Master plans are made up on a year-to-year basis to cover projects being programed. But you say 3 to 5 months you would have your initial increments of the master plan?

Dr. KELLEY. I would expect that. Let me say enough so we could then begin to zero it on a 1965 facilities plan.

Mr. KARTH. Anything, Doctor, that you would like to add to this thing before we conclude?

Dr. KELLEY. No, sir.

Mr. KARTH. Mr. Myers, anything you would like to add?

Mr. MYERS. No, sir; I have nothing to add.

Mr. KARTH. If not, the meeting is adjourned.

(Whereupon, at 5 p.m., the committee was adjourned.)

1964 NASA AUTHORIZATION

WEDNESDAY, MAY 8, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SPACE SCIENCES AND
ADVANCED RESEARCH AND TECHNOLOGY,
Washington, D.C.

The subcommittee met at 10 a.m., Hon. Joseph E. Karth (chairman of the subcommittee) presiding, in room 214–B, Longworth House Office Building.

Mr. KARTH. The meeting will be in order.

Mr. Gough, are you ready to proceed, sir?

Mr. GOUGH. Yes, sir.

Mr. KARTH. Would you and Mr. Goodrich care to take the witness chairs.

Briefly, the reason the subcommittee found it necessary to ask FAA to testify today is that about a week or two ago we heard from representatives of NASA in the Office of Advanced Research and Technology on the NASA request for some $9 million for research in direct support of the supersonic aircraft.

We noted that FAA, for example, in their fiscal 1964 budget proposal, did not ask for any funds for the supersonic transport, and our curiosity was aroused. NASA explained that the reason they were requesting funds this year was because the organic act gave them the right to engage in all basic research. This subcommittee, I believe, agrees, that as a result of this provision in the organic act it was NASA's responsibility to proceed in this fashion.

Since that time, however, the subcommittee became aware of the fact that some 2 years ago the FAA, as they appeared before the Appropriations Committee, requested a 2-year appropriation for a feasibility study on the supersonic transport. This feasibility study was to answer questions on the feasibility of the Government support for the development of a supersonic transport, especially in the basic research area. Until such a study is completed, and the President makes a national policy decision, this committee questions the wisdom of granting the funds requested by NASA for direct support of the supersonic transport.

For that reason we felt it necessary to call FAA officials before the subcommittee to give us the benefit of their viewpoint.

If you have a prepared statement, sir, and you would like to proceed please do so in any manner you wish.

STATEMENT OF MELVIN N. GOUGH, DIRECTOR, AIRCRAFT DEVELOPMENT SERVICE, FEDERAL AVIATION AGENCY; ACCOMPANIED BY NATHANIEL H. GOODRICH, GENERAL COUNSEL

Mr. GOUGH. Thank you, sir. I do have a prepared statement, and I hope you have a copy there. It has four attachments.

In keeping with your request, as I understood it, when I received it verbally, I have prepared this statement to clarify the points that I think you have just made.

Shall I read it, sir?

Mr. KARTH. If you like; however, if you would like to summarize——

Mr. GOUGH. I think it would be helpful to read it. I consider it very short.

Mr. KARTH. All right, sir. Please proceed.

Mr. GOUGH. Thank you.

In the initial consideration of the supersonic transport question in the executive branch of the Government in this administration it became readily apparent that three agencies within the executive branch had statutory responsibilities, technical competence and background experience directly applicable to the determination of the Government's role and responsibilities in supersonic transport development. These agencies are: The Department of Defense, the National Aeronautics and Space Administration, and the Federal Aviation Agency. In the interest of efficient and expeditious action it was decided that the three agencies would jointly proceed in a cooperative effort in the public interest to make a recommendation to the President with regard to supersonic transport development in the United States. Accordingly, the Secretary of Defense; the Administrator, NASA; and the Administrator, FAA; published a commercial supersonic transport aircraft report in June of 1961, which analyzed the problem and set forth the basic concepts and principles for the joint effort, including a definition of the roles and broad responsibilities of the three agencies in this joint undertaking. That is exhibit 1, and I think you gentlemen have one of those. This was in June of 1961.

(Exhibit 1, "Commercial Supersonic Transport Aircraft Report," issued jointly by DOD, NASA, and FAA in June 1961 is in the committee files. The conclusions of the report are as follows:)

EXHIBIT 1

CONCLUSIONS

The development of a commercial supersonic transport aircraft is now technically feasible. The B–58 and B–70 programs and broad earlier research and experience of supersonic flight from which they evolved provide the United States with a unique capability for developing a supersonic transport.

Considerable research and development effort is required to attain the levels of safety, reliability, and economical performance required for a satisfactory commercial transport aircraft.

The magnitude of the development task and the current financial situation of the U.S. aviation industry preclude its accomplishment on a timely basis solely by private enterprise.

The development and production of a commercial supersonic transport aircraft appears essential to continued U.S. leadership in commercial aviation and is

of increasing importance to our national prestige. Production of this aircraft will afford important economic benefits in its effect on general economic progress, employment, and the balance of trade.

The Department of Defense, the National Aeronautics and Space Administration, and the Federal Aviation Agency are the appropriate Government agencies to jointly organize and undertake a vigorous effort to define a national program for the development of a commercial supersonic transport aircraft. Leadership in this effort should rest with the Federal Aviation Agency pursuant to its statutory authority and responsibility.

A vigorous effort must be started immediately in order to have an operational aircraft in the 1970 time period.

BASIC CONCEPTS AND PRINCIPLES

A well-organized national effort is required to produce an economically competitive commercial supersonic transport by 1970. This effort will require Government assistance and full cooperation between Government and industry.

The Government can utilize the existing technical and administrative capabilities of the Federal Aviation Agency, the National Aeronautics and Space Administration, and the Department of Defense, thereby eliminating the need for additional or duplicate staffs and facilities. These three agencies will cooperate within the framework of their respective statutory responsibilities to provide control and direction for a national program and to facilitate its orderly execution. Under this concept the roles and broad responsibilities of the three agencies would be—

(*a*) Federal Aviation Agency—leadership and fiscal support.

(*b*) Department of Defense (USAF)—administrative and technical support.

(*c*) National Aeronautics and Space Administration—basic research and technical support.

In undertaking a national effort for the development of a commercial supersonic transport, certain basic principles should be kept clearly in mind at all times. These are—

(*a*) The program is one of Government assistance to industry for development of a commercial aircraft.

(*b*) The principle of competition, an important element of normal industry activities, should be employed to maximum advantage.

(*c*) Direct Government financial assistance should be provided only to that point in the development where the aviation industry can carry on in accordance with their normal business practices.

(*d*) The civil air carriers should participate on a continuing basis to provide their requirements with regard to performance, operating, and economic characteristics that they consider essential in a supersonic transport.

(*e*) Maximum feasible recovery of direct Government expenditures should be sought.

ROBERT S. MCNAMARA,
Secretary of Defense.
JAMES E. WEBB,
Administrator, National Aeronautics and Space Administration.
N. E. HALABY,
Administrator, Federal Aviation Agency.

June 28, 1961.

Mr. GOUGH. In order to effectively manage the research and study phase the three agencies agreed to a management plan in which a supersonic transport steering group was established. That is exhibit 2 of September 1961, again signed by Mr. Imirie, Mr. Abbott, and Mr. Halaby. I think you have that one. This is called the Management Plan for the Research and Study of a Supersonic Transport Aircraft.

(Exhibit 2 follows:)

EXHIBIT 2

FEDERAL AVIATION AGENCY,
September 25, 1961.

MANAGEMENT PLAN, SUPERSONIC TRANSPORT AIRCRAFT

In order to effectively manage the research and study phase of the commercial supersonic transport aircraft program, conducted by industry under contract, the undersigned agree to the provisions of the attached plan.

JOSEPH S. IMIRIE,
Department of Defense.
IRA H. ABBOTT,
National Aeronautics and Space Administration.
N. E. HALABY,
Federal Aviation Agency.

MANAGEMENT PLAN FOR THE RESEARCH AND STUDY OF A SUPERSONIC TRANSPORT AIRCRAFT

Purpose

The purpose of the plan is to establish the machinery for management of the research and study effort by industry for the supersonic transport including the organizational functions and responsibilities of the Federal Aviation Agency, the National Aeronautics and Space Administration, the Department of Defense and the U.S. Air Force, with emphasis on the efficient use of congressional appropriations for the supersonic transport.

Guidance

The Commercial Supersonic Transport Aircraft Report of June 1961, approved by the Secretary of Defense; Administrator, NASA, and Administrator, FAA, provides the basic guidelines for preparation of the plan and its implementation.

THE PLAN

It must be borne clearly in mind at all times that the program is one of Government assistance to industry for development of a commercial supersonic transport.

The high level of technical confidence needed by the manufacturers for the preparation of aircraft design proposals has not yet been reached. The need for accelerating essential research in the basic technical areas of aerodynamics, propulsion, structures and systems is an urgent requirement if a U.S. commercial supersonic transport is to be available within the next decade. Therefore, emphasis in the next 12 to 24 months will be given to the conduct of research and study of the critical technical areas contained in appendix II of the above report.

ORGANIZATIONS: FUNCTIONS AND RESPONSIBILITIES

FAA

In the supersonic transport program, FAA by virtue of its statutory authority and pursuant to agreements with the Department of Defense and the National Aeronautics and Space Administration, has basic responsibility for providing overall program leadership and management direction for expenditure of funds appropriated to FAA for supersonic transport development.

Formal coordination and consultation with the Department of Defense and the National Aeronautics and Space Administration will be accomplished through a high level steering group and a working level task group.

SST Steering Group

The plan provides for an SST Steering Group comprised of Mr. N. E. Halaby, Chairman, Federal Aviation Agency; Mr. J. S. Imirie, Department of Defense; and Mr. Ira H. Abbott, National Aeronautics and Space Administration. The steering group will formulate broad policy and give general guidance to the program. They will be primarily concerned with matters of the program involving external governmental relationships with the public, Congress, and special groups. The group will review and evaluate contractor proposals, contractor selection, and fund allocation. Final contractor selection will be made by the Administrator, FAA.

SST Task Group

The task group is comprised of specifically designated representatives of the DOD, NASA, and FAA. It has been functioning satisfactorily for some time and serves as staff and action support to the steering group to coordinate the SST activities of the three agencies. This task group is chaired by an FAA member and its specific functions are—

1. Coordinate plans for Government effort in SST research and development.
2. Recommend policy to the SST Steering Group.
3. Assure implementation through appropriate internal organization actions of the policies approved by the SST Steering Group.
4. Monitor and integrate overall progress of the SST technical activities of the three agencies.
5. Guide and review the preparation of requests for proposal to industry including work statements using appendix II of the June 1961 Commercial Supersonic Transport Aircraft Report as the basis.
6. Review the evaluation of industry proposals and recommend contractor selection and fund allocation.
7. Facilitate the timely preparation of budget estimates with supporting justification for succeeding years' efforts.

The task group will call on and use the specialized skills of the technical staffs of the three agencies and the airlines in performing its assigned functions. Special working groups will be established as required to facilitate expeditious and efficient handling of SST research and development effort. The agencies will assign appropriate representatives to such working groups on a priority basis and for such periods of time as may be required to assure the timely accomplishment of the assigned task. The FAA member will serve as chairman of any working groups which may be convened.

USAF SST Support Office

The primary function of the AirForce SST Support Office is to administer the the research and study effort in accordance with guidance and direction provided by the Administrator, FAA. This Office will be located in the Headquarters, Aeronautical Systems Division, Wright-Patterson AFB.

Technical teams utilized by the Support Office in performance of this function will include representatives from NASA and FAA as required. Technical activities will be coordinated with these agencies to preclude duplication and to insure a fully integrated approach in the contract effort. More specifically, the Support Office will—

1. Prepare requests for proposal from industry and evaluate industry proposals in coordination with NASA and FAA technical personnel.
2. Recommend contractor selection and fund allocation.
3. Conduct contractual services for procuring the research to be undertaken by industry using the supersonic transport appropriations of FAA.
4. Serve as a focal point for industry and Government on contractual matters.
5. Evaluate contractor progress against the provisions of the contract.
6. Implement coordinated technical plans for supersonic transport development.
7. Prepare periodic status reports on contract work reflecting technical progress, major problems, and financial status with appropriate recommendations.
8. Assist in the preparation of budget estimates and justification for next year's work.

FINANCIAL AND CONTRACT PROCEDURES

The funds to be placed under contract with industry by the Air Force are those provided to FAA by congressional appropriation for the supersonic transport. These funds will be transferred from FAA to the Air Force on a "reimbursable basis." The procedures for transfer of the funds will be jointly prepared by comptroller personnel of the two agencies on the approval of this plan.

Procedures used by the USAF will apply in placing these funds under contract.

ADJUSTMENTS TO THE PLAN

It is recognized that this supersonic transport program is unique in terms of Government-industry relationships. It is also recognized that as the program

progresses, and at discreet points where major shifts in emphasis may occur, based on the latest information, changes in the plan may be needed. It is therefore the intent of this plan to respond to the changing needs of the situation and not be bound to an inflexible static system of fixed requirements.

ADMINISTRATIVE SUPPORT

The needs of the groups for administrative support (personnel, travel, office space and equipment) in the accomplishment of the functions and responsibilities contained in the plan will be provided by the organizations concerned and will not be charged to the supersonic transport appropriations provided by Congress.

EFFECTIVE DATE OF IMPLEMENTATION

This plan will be implemented on the date of approval by NASA, DOD, and FAA.

Mr. GOUGH. The DOD representative on this group is now the Honorable Brockway McMillan, Assistant Secretary of the Air Force (Research and Development). The NASA representative is now Mr. Charles H. Zimmerman, Director of Aeronautical Research, and the FAA representative and chairman of the group is the Honorable N. E. Halaby, FAA Administrator. Reporting to this steering group and responsible for planning and coordinating supersonic transport technical and supporting programs within the three agencies is the Supersonic Transport Task Group. Each of the three agencies is represented in this task group by appropriate high level technical personnel. The SST Task Group and the SST Steering Group have functioned in a remarkable spirit of cooperation and have enabled the three agencies to proceed in this joint undertaking with complete assurance that the efforts of the three agencies are completely coordinated and that no duplication of effort exists.

With specific reference to NASA's 1964 budget request for supersonic transport support, it should be first clearly understood that the Commercial Supersonic Transport Aircraft Report referred to earlier defined NASA's role and broad responsibility in the joint effort as one of providing basic research and technical support. This is consistent with NASA's basic statutory responsiblility in the field of aeronautical research and is a role which NASA and its predecessor agency have performed over the years with distinction.

Mr. KARTH. Mr. Gough, that is true. I think the subcommittee agrees that the NASA and the other agencies of Government should do basic research, and one of the agencies of Government should do the basic research so that we don't have too many programs going in parallel and get involved in duplication.

The question I think is in the minds of the subcommittee members—at least it is in my mind—is whether or not NASA at this point should be requesting funds to do research specifically for the supersonic transport project before the feasibility study has been made.

Mr. GOUGH. I think I understand your question, sir, and I would answer it this way: When you talk of the feasibility study I am confused as to which one you mean. Now, the technical feasibility study has been made. It was decided before this report.

Mr. KARTH. Let me be more specific. The study that I understand is underway, but which has not yet been submitted to the President for his consideration, answers the question of whether or not the Federal Government should subsidize industry in the development

of the supersonic transport by at least providing the supporting research. Isn't there such a study underway?

Mr. GOUGH. Yes, that has to do with the economics and the management arrangement.

Mr. KARTH. Has it been submitted to the President?

Mr. GOUGH. It has not yet been submitted. Mr. Halaby would be here this morning if he weren't putting in full time on that work.

Mr. KARTH. I have spoken with Mr. Halaby, and I understand his feelings, and we certainly feel that you can do the job that the subcommittee feels necessary.

My question is until such time as this report is made public—and I assume that at this time NASA is not aware of what the findings might be any more than the administration is aware of what the recommendations might be—why should this subcommittee consider authorizing funds to do basic research which the report might recommend against?

Mr. MOSHER. What is the probable time of that report?

Mr. KARTH. I understand it is in the very near future. Mr. Gough, can you answer that?

Mr. GOUGH. It has been variously stated as from the middle of May to the first of June. This is the economic feasibility and management arrangements for recommendation to the President.

Mr. MOSHER. We will know the recommendations by June 1?

Mr. GOUGH. I hope so, but I am not working on that phase of it. Mr. Halaby is personally handling that.

Mr. MOSHER. May I ask this, Mr. Chairman——

Mr. KARTH. Proceed.

Mr. MOSHER. This is just a recommendation to the President?

Mr. GOUGH. This is Mr. Halaby's recommendation to the Cabinet and the Vice President, as I understand it, and then to the President so that he can make a decision as to how we will proceed.

Mr. MOSHER. That decision will be in the form of a recommendation to Congress?

Mr. GOUGH. Yes.

Mr. KARTH. Let me follow that just one step further. Mr. Halaby makes his recommendation to the Vice President; is that correct?

Mr. GOUGH. Yes, sir.

Mr. KARTH. And the Vice President takes it under advisement, and he makes a recommendation based on Halaby's recommendation and his own advice to the President; is that correct?

Mr. GOUGH. I would imagine so.

Mr. KARTH. How long does this normally take?

Mr. GOUGH. I never have done it before.

Mr. KARTH. Well, there have been instances, I am sure, where recommendations in other areas were made to the Executive. To the best of your knowledge how long has it taken to have decisions made on this kind of recommendation?

Mr. GOUGH. Sir, I don't feel that I am in a position to——

Mr. KARTH. Two months, three months, four mouths?

Mr. GOUGH (continuing). To answer that.

Mr. KARTH. You don't know?

Mr. GOUGH. No, sir; I have never operated at that level or done those things.

Mr. KARTH. Has FAA ever made recommendations of a similar nature to the executive branch?

Mr. GOODRICH. I am not aware of any. At the moment the parallel that comes to mind is the decision to construct the first nuclear merchant vessel, the *Savannah*.

Mr. KARTH. And how long did it take to make a decision on that?

Mr. GOODRICH. I really don't recall the details on that, Mr. Chairman.

Mr. KARTH. The reason I thought knowledge of the time interval would be valuable to the committee is that if it took 4 to 6 months, then the subcommittee could deny the authorization request without really harming the supersonic transport program. If the recommendation did happen to suggest that NASA go forward with research specifically for the development of the supersonic transport and if the administration saw fit to agree with the recommendation, then NASA could apply for a supplemental request.

We could be well into August, September, or October, or maybe even to the beginning of the next session of Congress before a national decision is made; I don't know. This was the purpose of the inquiry.

Mr. GOODRICH. I don't want to anticipate some of the further remarks that Mr. Gough is preparing to make to you, but I think he will address himself in part at least to that.

Mr. KARTH. All right, Mr. Gough, would you care to proceed.

Mr. GOUGH. Thank you, sir.

It is my feeling that it is quite appropriate, proper, and, in fact, necessary that NASA budget for and conduct basic research with respect to the supersonic transport in fiscal year 1964. This is necessary for the continuity of the basic research which NASA has been performing in the joint program in prior years, and is a program to afford optimum utilization of NASA's technical capabilities and facilities in the national interest.

I should like to digress for a minute, sir, with your permission, and ad lib a point here. We need this basic research whether we build a supersonic transport or not. This is the kind of thing that would have been handy to have to make the decision to build a transport 2 years ago if we had had the knowledge in these areas, but over and beyond that we in the FAA are going to have the task of certifying any foreign supersonic transport which is produced, and we must have as much basic knowledgeability as possible to judge them even if we make none.

Mr. KARTH. Then, I assume your personal recommendation has already become firm, and you would recommend to the administration that we proceed with basic research?

Mr. GOUGH. Yes, sir; but I was ad libbing there and giving you my opinion to answer your question. My opinion would be yes, we are way behind, we should proceed. This would be my recommendation to the President, but that would not be based on any knowledgeability of mine on the feasibility economically of doing it, or any recommendation from me as to how they would manage it. From the technical standpoint, it is inevitable. If we don't do it, someone will do it. We are going to go faster. But, you see, we have been in the supersonic business for quite a while. We have a large number of fighters which carry one person. We have bombers which carry three.

Mr. KARTH. If it is so important why did it take 2 years to decide to make some kind of recommendation to the President? That recommendation being "yes" or "no", should or should not the Government engage in supporting research which in effect is subsidizing the aircraft industry in the development of a supersonic jet transport?

If it is so important, why does it take so long to make a recommendation?

Mr. GOUGH. I am again straying into my own personal feeling in this, sir. I don't think it took us so long to make a recommendation. I think we did well in the technical field to foresee——

Mr. KARTH. You said we have been working on it for some time; I assume you mean several years. To my knowledge the Government has been doing work in the supersonic transport area for several years, and now, lo and behold, it is May of 1963 and you are finally going to make a recommendation as to whether or not the Government should start to do research as a form of subsidy to industry in the development of a supersonic transport.

I cannot quite follow. It seems that the cart was put before the horse, but I am not going to argue the point. If it is as important as you think it is, and I happen to think it is important to develop a supersonic transport, why does it take so long to make a recommendation?

Mr. MOSHER. Perhaps I can clarify the point. Mr. Gough just commented, ad lib, that we are way behind. Behind whom, or behind what schedule? What do you mean when you say way behind?

Mr. GOUGH. I meant that we were behind in the degree of activity which we could spend in this area, the degree of knowledge which we might have had had we doubled our research effort to answer many of the technical problems that we don't have the answers to as yet.

Mr. MOSHER. In other words, what you really mean is that there is a long way to go.

Mr. GOUGH. Yes.

Mr. MOSHER. You don't mean that we are way behind some established pace that has been agreed upon?

Mr. GOUGH. No; I meant we should have done this earlier.

Mr. MOSHER. Are we way behind some other group that is doing this? For example, are we way behind France and England in their efforts along these lines, or are we way behind Russia?

Mr. GOUGH. I would say we are behind England and France in that they have made the decision to make hardware. I do not think that we are behind in our knowledge of technical aspects of the problem.

Mr. KARTH. Mr. Gough, if we are behind them in the development of hardware, doesn't it follow that they have already done their basic research? It would seem that development of an aircraft can't proceed until basic research is completed.

Mr. GOUGH. No, sir; you can't assume that; that is not correct.

Mr. KARTH. Then they do things differently there than we do here.

Mr. GOUGH. That is right. There are problems which have to do with the economics of this which are being funded by the national government there, and others have to do with things like noise and what will the country tolerate, and what will they darned well put up with, economy, what will be the fuel consumption, problems of this

kind that go into make up certification that in order to get into the market they are going right on by, hoping there will be a solution, but when they complete their tests and have their airplane, then you will take it.

Mr. KARTH. Do you mean that they are just going ahead and developing the airplane, and then they are going to answer those questions later on if they pose themselves as questions?

Mr. GOUGH. That is right.

Mr. KARTH. Dr. Weaver?

Dr. WEAVER. Mr. Chairman, as I understand it, one of the problems is the selection between a mach 2 and mach 3 supersonic transport, and of trying to decide whether we are going to go as high as mach 3. Further, the British and French are ahead of us and have a good chance of taking away the commercial airline business from us as far as selling transports of this kind is concerned.

Isn't this part of the great problem, that our commercial aircraft industry will suffer unless this research is done?

Mr. GOUGH. Yes, sir; that is a part of it, and it has been commented on at considerable length by Mr. Halaby. It isn't the part that I came prepared to discuss as such, but I would say this, within the state of the known art of airplanes that have been built, they have proceeded to make an airplane. Now, the problem comes up, if it is available will that force our airlines to buy it. Also it means if it is available it has to be acceptable. It must meet our certification. It must meet our requirements for noise, for takeoff, and for approach and landing.

The answers to these questions aren't clear at all.

Dr. WEAVER. Mr. Chairman, it is the same fear that we had when we lost the business to the Caravels and the Viscounts; the same fear that we are going down and down in our aircraft industry unless something happens.

Mr. GOUGH. Yes.

Dr. WEAVER. Also, there is definite value in the knowledge provided to the space program for there is some knowledge gained by learning how to handle planes in the earth atmosphere and at mach 3 that also apply to the control of space vehicles. Therefore, knowledge gained from aeronautical research can apply to our space program.

Mr. GOUGH. There is no question about that in my mind. This is a total process. It goes from the military to the civilian, back to the military, and from our space we benefit, environmental studies, human factors, the space program, they all help us in our calculations with the airplane.

Most important, as I indicated a minute ago, as the military proceeds with their airplanes where performance is the most important factor, there are questions like the life of the piece of equipment, the noise it creates, which aren't tolerable to the present state of economics, so even they are helped by basic research.

Dr. WEAVER. Whether or not it is economically feasible for commercial airlines to fly at this speed, might it still be feasible for the national space program and for military aircraft?

Mr. GOUGH. Yes, sir.

Mr. DOWNING. May I interrupt, Mr. Chairman?

Mr. KARTH. Mr. Downing.

Mr. DOWNING. Our good friend, Mr. Gough, is a product of Langley, NASA, is he not?

Mr. GOUGH. Yes, sir.

Mr. DOWNING. I have seen models on display down there. Haven't they done work on this supersonic transport at Langley?

Mr. GOUGH. NASA?

Mr. DOWNING. Yes.

Mr. GOUGH. Yes.

Mr. DOWNING. What stage is that in now?

Mr. GOUGH. They have made a large number of models of combinations of wings and bodies and powerplant locations in order to determine what configurations produce minimum drag, give maximum lift.

Mr. DOWNING. Well, haven't they decided what configuration is best for the supersonic transport?

Mr. GOUGH. No, sir. They have made a large number of models which from the aerodynamic viewpoint are attractive and efficient, but whether it is technically feasible to fabricate them is another question.

You will recall the problem on such an airplane as the Lockheed 104 when the wing thickness was so small that there was a question of whether you could get the structure in to get strength, that kind of thing comes up even more in an efficient supersonic airplane.

Mr. DOWNING. Thank you.

Mr. KARTH. Unless there is something further you would like to add, Mr. Gough, you can proceed with your prepared statement.

Mr. GOUGH. Thank you. I will try not to interrupt myself.

The 1964 aeronautical budget request was carefully reviewed by the Director, Aircraft Development Service, FAA, and revealed no duplication of effort between the agencies and further indicated that NASA was pursuing the basic role and responsibility assigned to it in the supersonic transport program by the joint agreement among the three agencies.

It may be desirable to indicate in more detail the coordination between FAA and NASA for the fiscal year 1964 programs. The Director Aircraft Development Service FAA wrote to the Director Aeronautical Research NASA on November 27, 1962, transmitting a copy of the FAA Aircraft Development Service fiscal year 1964 budget request for NASA's review and coordination. This letter also requested a copy of NASA's proposed aeronautical research budget for fiscal year 1964. On November 10, 1962, NASA's Director of Aeronautical Research replied to this letter stating that the FAA Aircraft Development Service's budget request had been reviewed by them and that no duplication of effort was apparent. This letter also promised a copy of NASA's fiscal year 1964 budget request for aeronautical research would be forwarded and it was received on December 17, 1962. Both of these letters referred to the thorough and continuing coordination between the agencies with respect to the supersonic transport program. Copies of these letters are attached.

(The letters referred to follow:)

ATTACHMENT I

NOVEMBER 27, 1962.

Mr. CHARLES H. ZIMMERMAN,
Director, Aeronautical Research,
National Aeronautics and Space Administration,
Washington, D.C.

DEAR MR. ZIMMERMAN: In presenting our budget for the fiscal year 1964 for the activities of the Aircraft Development Service we must assure ourselves as well as the Bureau of the Budget and the Congress that there is no duplication of effort between our activities and those of the NASA. Mr. Bates recently discussed this matter with you in a telephone conversation.

The SST program as a joint effort of the NASA, the DOD, and the FAA is completely coordinated at all levels and officially approved through the joint task and steering groups composed of representatives of the three Agencies. I know that you are completely familiar with this program.

The budget for the other activities of the Aircraft Development Service is submitted in the research and development portion of the Agency's budget request under the heading of "Aircraft Safety." This is essentially a development program to bridge the gap between the basic research of the NASA and practical application and use in civil aviation. The primary purpose of this program is to provide the basis for sound and improved safety rules and standards which the Agency is responsible for promulgating. It is also intended to continually advance safety and the state-of-the-art in civil aviation. Informal coordination of most of these programs has been accomplished between appropriate personnel of our respective staffs. Some of the subprograms contemplate a joint effort with NASA. A copy of the budget submission for the aircraft safety activity, together with descriptive material of the programs and subprograms is enclosed. I will appreciate your written assurance that there is no duplication between the programs of the Aircraft Development Service and those of your organization. A copy of your reply will be submitted to the Congress as evidence of our formal coordination with you.

We will appreciate receiving a copy of your proposed program of aeronautical research for fiscal year 1964 for our information and guidance.

Sincerely yours,

MELVIN N. GOUGH,
Director, Aircraft Development Service.

ATTACHMENT II

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION,
Washington, D.C., December 10, 1962.

Mr. MELVIN N. GOUGH,
Director, Aircraft Development Service,
Federal Aviation Agency, Washington, D.C.

DEAR MEL: We have reviewed your proposed fiscal year 1964 program which was enclosed with your letter dated November 27, 1962, with regard to possible duplication of effort.

As you mentioned in your letter, the joint effort of the NASA, FAA, and DOD in the supersonic transport program is completely coordinated at all levels as a continuing task.

As a result of our review of the other activities of the FAA's Aircraft Development Service as outlined in your letter for fiscal year 1964, we conclude that there is no undesirable duplication of effort with regard to the NASA's research program.

As per your request, we will make a copy of our proposed fiscal year 1964 program available to you in about 1 week.

Sincerely yours,

CHARLES H. ZIMMERMAN,
Director of Aeronautical Research.

Mr. GOUGH. This is in keeping with Mr. Halaby's challenge that we make maximum use of Government dollars and a continuing part of my job is coordination of NASA and DOD.

Mr. KARTH. Mr. Ditch has a question at this point.

Captain DITCH. Mr. Gough, after reading the letters, I notice that they both refer to the supersonic transport program, and this implies that the FAA had some money in their budget for the supersonic transport program at that time. Is that in fact the case? Both of them refer to the coordination of the supersonic transport program and they say the budgets do not conflict.

Mr. GOUGH. Let me see if I can clarify what you are talking about.

In additon, in the FAA budget, in addition to supersonic transports we have aircraft development. In my group I have VSTOL I have a possible short haul cargo passenger transport, general aviation safety programs—that is the FAA budget for 1964. There has been no SST budget submitted for 1964.

Captain DITCH. At the time the letters were written there was nothing in your budget for SST?

Mr. GOUGH. No, sir; there isn't yet.

Now, no budget request for the supersonic transport program in fiscal year 1964 for the FAA has been submitted to the Congress.

Mr. KARTH. Had it been submitted to the administration or the Bureau of the Budget?

Mr. GOUGH. No, sir.

Mr. KARTH. You made no request of anyone for funds?

Mr. GOUGH. No, sir; you see the funds we have operated on thus far have been a special supplemental appropriation to determine if we could get the research areas working and to increase this technical feasibility capability pending the time when overall operation of economics would show that it was reasonable to go in the order of magnitude of a billion dollars to build a supersonic transport.

Mr. KARTH. Mr. Gough, if the President's decision is to proceed with a national endeavor, what does FAA intend to do insofar as future funding for the program is concerned? Is the FAA going to ask for a supplemental appropriation?

Mr. GOUGH. Now, sir, I would suggest that what they intend to do is whatever the President tells them, but I don't know that they are going to ask how to do it.

Mr. KARTH. What if the President's decision is in keeping with your personal recommendation, then what do you intend to do?

Mr. GOUGH. I think that is the answer you are looking for in the feasibility report that hasn't been completed yet; yes, sir; that is the one that will tell you whether a careful close look shows that you can do this economically, the airlines could compete and how to manage it.

Mr. KARTH. You don't care to divulge the FAA's recommendation at this time for Executive privilege reasons?

Mr. GOUGH. Sir, I don't know.

Mr. KARTH. I see.

Mr. GOODRICH. I don't think we do know, Mr. Chairman. The study hasn't been completed, and we anticipate a few more weeks will pass before it is.

Mr. KARTH. I see.

Mr. GOODRICH. There are different ideas being explored every day, some being discarded as rapidly as others are being advanced. We haven't come to any conclusions yet.

Mr. KARTH. This report has been under study and review for how long?

Mr. GOODRICH. This particular phase of preparing the report for the President has been under review I think for——

Mr. KARTH. Well, studying and preparing, how long has it been?

Mr. GOUGH. You know the advisory committee's recommendation was sent to the President in December, Mr. Halaby's advisory group's recommendation to proceed.

Mr. KARTH. Well, the report that you expect to send to the President very shortly has been under study and review for how long, when did this later study begin?

Mr. GOUGH. Since December.

Mr. KARTH. December of 1962?

Mr. GOUGH. December of 1962.

Mr. MOSHER. Mr. Chairman.

Mr. KARTH. Mr. Mosher.

Mr. MOSHER. Are there military considerations involved in this study, and is the DOD involved? Does DOD have a role in whatever recommendations will be made to the President, or is this strictly a commercial consideration?

Mr. GOUGH. No, sir; this is an across-the-board consideration, and it has the same kind of across-the-board representation on the study group that these task forces show.

Mr. MOSHER. Then there are military implications in the supersonic transport program.

Mr. GOUGH. I would say there were. I don't think we could have supersonic commercial transportation and the military trying to catch up riding commercial transports.

Mr. KARTH. Which usually comes first?

Mr. GOUGH. It depends.

Mr. MOSHER. Is there any relation between this program and the RS–70?

Mr. GOUGH. A great deal of relationship, yes, the RS–70 is another technical advance on which a lot of basic fundamental data have been produced, and all the technical data of the RS–70 are sterilized of weapons systems data and are made available to the supersonic transport group, so in addition to that the DOD part in the technical and administration of the contracts part has meant that all the money spent by FAA to date has been augmenting the existing military knowledge in these areas.

Mr. MOSHER. Has NASA had a direct role in the RS–70 research?

Mr. GOUGH. Direct role in it?

Mr. MOSHER. Yes.

Mr. GOUGH. I cannot tell you in detail about their direct role, but I know that their wind tunnel facilities and all their basic research had been used by them. I don't recall exactly the connection there, but I do know, for instance, that the study of noise which we are embarking on and which is part of our budget and part of NASA's budget—NASA is furnishing the instrumentation and supervising the flight test program so that when the RS–70 flies there will be a large portion of this data obtained for the commercial interest over and beyond the military.

Mr. KARTH. So, really, insofar as the development of the supersonic transport is concerned, the military working on it in connection with the development of the RS–70. Isn't this a fair statement?

Mr. GOUGH. No, sir; I don't think that is quite true. I think one augments the other. For instance, in the military it is most important that you get high thrust.

Mr. KARTH. Certainly we can agree that the RS–70 is a supersonic aircraft that is going to have greater military application than would a supersonic transport developed jointly by FAA, NASA, and the DOD. Isn't that true?

Mr. GOUGH. For military application?

Mr. KARTH. Yes.

Mr. GOUGH. I am not sure.

Mr. KARTH. I am not in your position, and I tell you, Mr. Gough, I am sure.

Mr. GOUGH. But your concern also is that the Russians could take their transport and put bombsights in it.

Mr. KARTH. There is no question that a civilian transport can be armed. It is, of course, feasible, whether you did it with a .45 or whether you did it with a cannon; it would be armed. I think the gentleman's question was—and I thought it was an extremely good one— does the supersonic transport have some military value? The answer is "Yes," it has some military value or significance, but not nearly so much as the military is accomplishing in their own right by doing research on the RS–70, because this is a supersonic military aircraft, isn't it?

Mr. GOUGH. It sure is, but I think you could add to that.

Mr. KARTH. The RS–70 is being developed to take care of a military mission at supersonic speed, isn't it?

Mr. GOUGH. It sure is, but it is a type, a configuration. There may be others. This is being explored to the extent that if you wish to make RS–70's there may be other types.

Mr. KARTH. And the RS–70 is well ahead of the development of a commercial supersonic transport, isn't it?

Mr. GOUGH. Well ahead of a commercial supersonic transport?

Mr. KARTH. Yes, our supersonic transport, the U.S. supersonic transport.

Mr. GOUGH. Well, it is in the lower mach number regime.

Mr. KARTH. I mean the RS–70 is farther down the road in development, isn't it?

Mr. GOUGH. It sure is, it is ready to fly, but you know it is going to make noise that is unacceptable for any commercial operation, and they would like to know how to make it quiet, and we would like to make it quiet, and it is not going to be economical.

Mr. KARTH. I appreciate that, but we don't have to worry about developing a commercial supersonic transport that is quiet for the military. This is my point. Noise is probably not one of the limiting criteria for military operations.

Dr. Weaver.

Dr. WEAVER. Mr. Gough, from your knowledge on our position with respect to the Russians, where do we stand on this particular program?

Mr. GOUGH. From my knowledge, I don't know that they are making a specific airframe. I have heard that they were. I do know that they are using their military planes operationally to determine something about the programing and traffic problems and use of navigational facilities.

Dr. WEAVER. Then, you have no knowledge on whether they are ahead or behind in the research in this field?

Mr. GOUGH. I have none. When you say supersonic airframe you must remember anything that goes faster than the speed of sound is supersonic, so it would be pretty hard to tell you what area in the higher mach numbers they are working.

Mr. KARTH. Will the gentleman yield? What is the mach capability of the RS–70, or is this classified?

Mr. GOUGH. I don't have this at my fingertips. It is on the order of two.

Mr. KARTH. I thought it was the order of two or three. The gentleman from Colorado says three. So aren't we really talking about the same kind of capability insofar as speed is concerned'

Mr. GOUGH. We are talking about a large airplane that carries a big load and goes a long way, yes.

Mr. KARTH. How much disagreement really exists between NASA, who I understand would like to develop a mach 3 supersonic transport plane, and the FAA who feels that the more conservative approach and therefore the better approach would be to develop a mach 2?

Mr. GOUGH. I cannot agree with that statement. I have heard that and I have seen the press pro and con on it, but as far as I know, no decision such as that has been made.

Mr. KARTH. You would know about any disagreements, wouldn't you?

Mr. GOUGH. I wouldn't call it disagreement, sir. I would call it a matter of discussing opinions on which is more feasible.

Mr. KARTH. All right, if this difference of opinion existed you would know about it, wouldn't you?

Mr. GOUGH. I do.

Mr. KARTH. And does this difference of opinion exist?

Mr. GOUGH. There are opinions—yes. This difference of opinion exists.

Mr. KARTH. So we have to decide on a mach 2 or a mach 3 aircraft before we proceed with too much research. Isn't that correct?

Mr. GOUGH. I wouldn't say that is correct. I think you do your research and learn the fundamentals. From that you decide which you can make and which you can afford to make.

Mr. KARTH. It seems to me we might get into awfully expensive basic research if we are going to study 17 or 18 or 19 different possibilities. That was the only point to my question.

Mr. GOUGH. I don't know how your numbers got so large.

Mr. KARTH. I would assume that there must be some kind of agreement between the various agencies of the Government doing research in this area before further work can be undertaken, and this is the reason for my questions. If you don't feel that a decision on mach number is important, then I defer to your judgment.

Mr. GOUGH. No, sir; I feel that it is very important and I feel we have to have agreement, but you are talking across the board. For instance, we know that it is feasible to make a mach 3 airplane. It is a tough job, but it is feasible, meaning that we think we see a way to do it. We know we can make mach 2 airplanes. We have them. They are flying, small sizes, fighter types. Which you are going to shoot for depends on a lot of other things, and this feasibility report on economics, for instance, is an extrapolation of our past mistakes

into the future. It takes a lot of vision and foresight to see how we can operate better than we have been doing, and it may well be that the very method of ticketing or having offices around the world would add to the economics as much as the aircraft itself.

Mr. KARTH. I think you have answered my question. You seem to be very set on mach 2.

Mr. GOUGH. I am?

Mr. KARTH. Yes.

Mr. GOUGH. No, sir.

Mr. KARTH. Then I misunderstood you.

Mr. GOUGH. Could I have another chance to tell you that I am for mach 3 and above. Let's go!

Mr. CHENOWETH. Mr. Chairman.

Mr. KARTH. Mr. Chenoweth.

Mr. CHENOWETH. Do I understand that the FAA doesn't expect to have an operational aircraft until after 1970? I notice that the Supersonic Transport Aircraft Report, signed by all three agencies says "in the 1970 time period." Is it correct that we are not going to have anything for another 7 years?

Mr. GOUGH. If you take the definition of an operational airplane, for instance this year there will be an RS–70 flying. I feel reasonably certain.

Mr. CHENOWETH. Well, I am quoting now from this statement:

> A vigorous effort must be started immediately in order to have an operational aircraft in the 1970 time period.

Mr. GOUGH. This is a scheduled air transport.

Mr. CHENOWETH. Do you mean it will be 7 years before we get anything of an operational nature?

Mr. GOUGH. I think that is on the high side, a very conservative side at the moment.

Mr. CHENOWETH. Approximately how much is to be spent each year on this program? What is your estimate? Are all three agencies going to be spending some money on it?

Mr. GOUGH. Well, I think it will all be considered one U.S. bill, won't it, regardless of how it is divided.

Mr. CHENOWETH. It will all come from one pocket, but three different agencies will be disbursing the funds. How much will we spend? A billion a year? A half billion? Just what are we going to spend on this supersonic transport, and how important is it?

Mr. GOUGH. I am not even qualified to guess.

Mr. CHENOWETH. Are we just playing around here hoping that eventually something will drop out of the sky, or do we have a target and a goal of an operational aircraft that we are trying to reach by 1970?

Mr. GOUGH. Yes.

Mr. CHENOWETH. Your goal is a mach 3 aircraft?

Mr. GOUGH. Yes.

Mr. CHENOWETH. You have mach 2 aircraft now.

Mr. GOUGH. But not a transport.

Mr. CHENOWETH. How far away are we from a mach 2 transport?

Mr. GOUGH. Sir, I think you are going to have to wait for the feasibility report to get that answer, I wouldn't want to prejudge what that report is going to say, and it answers these questions you are asking me.

Mr. CHENOWETH. But we have the mach 1 transport now.

Mr. GOUGH. You are almost there.

Mr. CHENOWETH. We have practically that. How far are we away from mach 2 and then from mach 3?

Mr. GOUGH. I think we could build both of them right now.

Mr. CHENOWETH. Why don't we do it, then?

Mr. GOUGH. The answer is, of course, that it requires substantial funding to proceed with the development of the supersonic transport. In view of the estimated development cost it is necessary to analyze the problem carefully, which, as you know, takes time. As a technical man I am positive that the United States can successfully develop a supersonic transport and I am impatient to get on with the job.

Mr. KARTH. There is nothing in FAA's budget and we are still waiting on your report.

Mr. GOUGH. Yes, sir.

Mr. KARTH. That is the reason we called you people before this committee. Let me just say to the gentleman, this Congress intends to be very cooperative if we could get some kind of judgment from the agency of Government that supposedly shares in responsibility in the program.

Who makes the judgment if it isn't of FAA and NASA?

Good grief, if we can build them, why are we talking about studies that you haven't even completed? This problem seems so knotty you haven't even completed the study which will make a recommendation to the President of the United States as to whether or not we should proceed.

I think the questioning of the gentleman from Colorado is extremely pertinent. Maybe we are being a little bit overanxious here, but——

Mr. MOSHER. Mr. Chairman, I think Congress in its widsom certainly would never say let's just build them because we can build them. The economic feasibility is an important element that we would like to be enlightened on and he has promised to get this to us by June 1.

Mr. KARTH. I hope the economic feasibility isn't nearly as technical and difficult a matter as the technical difficulty of building the aircraft. That is why I said before that some place along the line we seem to be putting the cart before the horse. I am not sure that I am right, but it comes to my mind, and I express it as a personal judgment.

Mr. GOODRICH. Mr. Chairman, the report which is in preparation right now to the President and the Vice President is designed to answer some of the very specifics that you are asking, just what it will cost year by year, and to try to zero in on a reasonably accurate figure so that the Congress will know what is involved when it passes on a program.

We went through this with our own subcommittee of the Appropriations Committee a couple of months ago, and Mr. Halaby spelled out the problems involved in this study, and I think we have heard from that subcommittee and possibly from other areas of the Congress that there is a great deal of interest in the program.

Mr. Gough's remark a moment ago was intended to be solely jocular, and we anticipate that when the refined estimates, the supportable refined estimates, are available—and as soon as they are

available—they would be forwarded by the President for your consideration and the consideration of any other appropriate committees of the Congress.

Mr. KARTH. Speaking of estimates, rumors and proposed studies, do you know there is a rumor to the effect that the advisory group report has already been submitted to the President, and that it has been returned to FAA because it wasn't comprehensive enough? Is this true? Has this report been submitted once, and then sent back to the FAA?

Mr. GOUGH. I mentioned that earlier. In December Mr. Halaby sent his advisory committee report to the President with a recommendation.

Mr. KARTH. Is that the same report you are now working on?

Mr. GOUGH. Yes, that was accepted and——

Mr. KARTH. I didn't understand it was the same report.

Mr. GOUGH. It said that certain areas should be amplified, particularly the ones that had to do with economics, and that is what they are doing now.

Dr. WEAVER. Mr. Chairman.

Mr. KARTH. Dr. Weaver.

Dr. WEAVER. As far as you know, has any particular aircraft company been selected to do this development?

Mr. GOUGH. No.

Dr. WEAVER. We had heard rumors that one company will be selected for the development of the engines, and the development of——

Mr. GOUGH. No, sir; only this past 2 weeks have the group working on the report been briefed by such people as Boeing, North American, Lockheed, and the engine companies, Pratt & Whitney, Wright, and G.E.

Dr. WEAVER. Then, to your knowledge, there has been no selection of the company that would develop the supersonic transport?

Mr. GOUGH. No, sir.

Mr. GOODRICH. There hasn't even been a decision on the intermix of private industry and Government, or the absence of an intermix, whether industry alone will develop it or Government alone will develop it, whether a joint venture of manufacturers would be the best approach, whether a combination of Government agencies or one single Government agency to the exclusion of others will have jurisdiction of the program.

Mr. Halaby, in a press conference 2 weeks ago, was asked this very question, and he pointed out that there are at least six alternatives that he has heard and read about as under consideration, and his answer at that time did illustrate the number of choices on which decisions must be made.

Mr. KARTH. As I understand Mr. Gough, and Mr. Goodrich, the fact of the matter is that from a technical standpoint we can build these airplanes today but these other basic questions must first be answered before we can go ahead.

Mr. GOODRICH. I would have to defer to Mr. Gough on the technical questions. His vision as an engineer is great and perhaps very hopeful in that regard, and, personally, as a lawyer, I would hope that we can match what any other country or technology can produce, and

that we have the wit to do it, I am sure that we have, but I am speaking as an uninformed layman in that area.

There are other problems, the economic problem alone, and the ultimate economic success, the marketability of an aircraft, and certain technical problems in connection with its use, in connection, for example, with the safety of passengers, and here, again, I am really talking off the top of my head because I am a layman in these areas, all of which have to be refined and defined so that we can be sure that we will have the type of aircraft that will find a market and find an acceptance on the part of the traveling public.

Mr. KARTH. I assume if we build a supersonic transport, it will be a safe one, and not one that will fall out of the sky 10 minutes after it is in the air.

Mr. GOODRICH. These were some of the questions in our minds when you asked us to come here and comment on the desirability of a continuing basic research program, regardless of where we seem to stand at the moment in a decision of how to go ahead, when to go ahead, and in what form to go ahead.

Mr. KARTH. The only reason for this hearing is to permit this subcommittee to use better judgment in considering the NASA request for some $9 million in total funds to do supporting research in the development of the supersonic transport when a study to determine whether or not NASA should become involved has not yet been made to the Administration. This is the reason for the hearing, sir.

Mr. GOUGH. We appreciate that concern, and may I add just one comment. Let us assume—and I wouldn't want this for a moment to go misunderstood, but let us assume just for the same of facilitating your consideration and any help that can come from our comments, let us assume that the United States were not to go ahead. We would still be faced as a government and FAA as the particular agency of this Government, with the requirement to certify the use of a foreign-constructed supersonic aircraft, such as the Concord now being constructed by the British and the French.

Mr. KARTH. If that is the situation, we might as well go ahead and build one. I might say to the subcommittee that it seems to me we don't have much choice as to whether we are going to go ahead and develop an aircraft or not. It seems to me to be a moot question. Even if we don't develop it, and somebody else develops one, we still would have to certify them here, and we have to have as much knowledge as if we built one.

Mr. GOODRICH. That is why the continuing research program in NASA, which is the basic research agency of the Government, is one that for our part we favor very much. The information ultimately produced from these basic research programs will be fundamental to our ability effectively to certificate an aircraft built by another country.

Mr. KARTH. You could not accept the data and all of the other pertinent technical information as to the safety and reliability of the aircraft that would be supplied to you by a foreign manufacturer; is that right? You would have to develop all of your own data and information, and then apply it to a foreign-made aircraft. That seems rather difficult to do. I would assume it is easier to build our own.

Mr. GOODRICH. I am not arguing with that assumption. I wanted to eliminate the possibility that——

Mr. KARTH. I wondered if you would agree with it.

Mr. GOODRICH. Personally?

Mr. KARTH. Yes.

Mr. GOODRICH. Well, insofar as I can express a personal view, I am all for it, but I don't want to presume to speak about considerations and factors as to which I have no knowledge and couldn't possibly judge. I am sure the committee understands there are factors involved in here that go beyond anyone's personal judgment. I mean, I am a home-team rooter, and that is why I say I would like to see us do it if we can.

Mr. KARTH. I would hesitate to recommend to the Congress that we spend huge sums of money just finding out for our own personal information and application the characteristics of a foreign-built aircraft for use in certification when by spending the same amount of money we could build our own. This doesn't really make much sense.

Mr. Chenoweth.

Mr. CHENOWETH. Mr. Chairman, I just want to see if I have the right impression of what I have heard here this morning. My impression is that we are proceeding at a rather leisurely pace in the development of a commercial supersonic transport aircraft. We may have one along in the seventies, but we are not quite sure just what we want, and how we are going about getting it. There seems to be no great hurry and no great concern. It is not a crash program like the moonshoot, and we are just going to play around with this thing for a few years. Is that the correct impression or not?

Mr. GOODRICH. It may be the impression that you have, sir, but I don't think that we meant to leave it with you.

Mr. CHENOWETH. Where am I wrong in that impression?

Mr. GOODRICH. I am not going to suggest that your impression is incorrect on the basis of what you have heard, but my hope would be that within the next few weeks, and possibly months, there would be a firmer basis for a correct impression.

Mr. CHENOWETH. Is it true that nothing has happened up to this time to cause any change in that impression, and that my impression is correct on what I have heard up to this time?

Mr. GOODRICH. I am not sure I would view it the same way as you view it. I do believe there are economic and technical problems in connection with the decision to go ahead on the construction of a supersonic aircraft, the prototype, and the number of models that would be required to test in order to be sure that we have a safe commercial transport.

Those decisions are very far reaching; they involve far greater sums of money than the $9 million involved in NASA's budget item before you today, vastly greater sums, and the administration is proceeding with all due caution, and very wise caution in my opinion, before coming to that decision, and as I see it from where I sit, I have an impression that we are exerting every effort to make that decision as quickly as we competently can.

Mr. CHENOWETH. What would you think about transferring a little of that moon money to this program to speed it up a little?

Mr. GOODRICH. Sir, until a decision is made on the feasibility, and on the other factors involved in the President's study, I think I would defer an answer to that question.

Mr. CHENOWETH. I think perhaps that I would rather see a mach 2 supersonic transport than I would see the shot to the moon right now. I think it would be of more practical commercial value to us. I cannot understand why you are just taking your time and playing around with this. Certainly, there appears to be no aspect of crash program, such as is associated with the moonshot. I think that the supersonic transport is more important to us in many ways than the moonshot. That is my observation.

Mr. GOODRICH. Sir, our agency has no jursidiction in the areas involved in the moonshot.

Mr. CHENOWETH. I understand.

Mr. GOODRICH. The administration has carefully reviewed that program and, as I understand it, is firmly committed to it. That is another area in which I am a home-team booster. I would like to see us do what the others can do and do it better.

Mr. KARTH. The gentleman from Colorado is so practical that at times I find myself in disagreement with him.

Dr. Weaver.

Dr. WEAVER. It would seem to me that the weighing factors are the amount of this research that is going to be of value to our national security in the Department of Defense program, and the value to the NASA space program for the control of space; because, as I understand the situation, it may not be as important commercially to us to have a mach 3 plane as has been talked about, and because there are problems of the sonic boom which affects people in the cities. They are not very happy about what they are hearing now. And they are going to be less happy if this thing has an impact on the local areas. There is also the problem of the value of the 30 minutes saved in going across the country at a speed of mach 3 instead of mach 2. Are we going to want to fly commercially and get there 30 minutes sooner? I understand the supersonic transport is only good for long flights, so we could be in the commerical air passenger situation where we are losing money on it, unless it has national defense value. That would be my evaluation of the program.

Mr. KARTH. I think timesaving becomes more important as you hop from nation to nation rather than from coast to coast within a nation.

Mr. DOWNING. Would the gentleman yield?

I think you have something there. I was wondering whether this isn't more properly a challenge to private industry, itself. We have a military program which is putting up these mach 3 bombers and mach 2 bombers, and from a national defense standpoint that would seem to suffice. Does the Government need to involve itself in a commercial enterprise?

Mr. GOUGH. I am sure, gentlemen, it wasn't the intent at the very outset that the Government would involve itself in the enterprise. It is only a case that it is an order of magnitude of such proportions that no one company could undertake it, and in the interim the Government is stimulating the research and the knowledgeable boundaries to the place where it will be apparent to industry that they can pick it up.

Now, what part the Government is going to play in it I think is subject to this feasibility study. The points you make are very well taken.

Mr. KARTH. You can compare this program, for example, to the Government's participation in communication satellites. The Government has spent huge sums of money in developing communications satellites that can now be used commercially. If it had not been for the Government's expenditure, technology would never have advanced in communications because no company would have been able to afford to do all of the research that is necessary to develop a satellite communications system. Isn't that correct, Mr. Gough?

Mr. GOUGH. I think so from what I have read.

Mr. KARTH. And you are saying the reason we are engaging in research in the supersonic transport area is because of the same reasons that we engage in research in the communications satellite area?

Mr. GOUGH. It is a statutory charge to advance the knowledge of aeronautics, yes.

Mr. KARTH. I don't think the problem is of quite such magnitude in this case.

Mr. DOWNING. Normally, Mr. Chairman, the commercial development will follow the military development. For instance, the military develop a fighter plane and then a passenger plane is developed. Now, if the military build the RS–70 and that is a feasible plane, the next step would be to develop that into a commercial plane.

Mr. KARTH. That was my point earlier in the questioning, and I am inclined to agree with the gentleman that much more of the technology developed or that becomes familiar in the RS–70 program will be applicable to the commercial transport than vice versa. Although I may be wrong, I would think we could almost transfer the total technology and just delete the military hardware and we would have the commercial transport.

Mr. STAEBLER. Mr. Chairman, isn't some of this deliberateness which has been called playing around, but which obviously reflects uncertainty and need for further examination of the problem, pretty well warranted by our experience in the development of the present mach-1 transport planes? We have come perilously close to bankrupting both the transport industry and the aircraft industry by the speed of the development, and by the peculiar nature of the product which delivers so much more capacity but concentrates it in the hands of fewer companies. Isn't this really a revolution in the field that is being contemplated here, and isn't there pretty good reason for a good deep look before we take some irrevocable steps?

Mr. KARTH. I don't think that there is any question but that the gentleman's assumption is correct. If he asked me for an answer to the question, I would say that this is the reason why the subcommittee is attempting to evaluate the need for the $9 million request.

How much can you play around with a project like this? How much money do you waste as you play around with it? I think these are the questions that are before the subcommittee. Would the $9 million or a portion of the $9 million be a waste of funds? Would it be spent wisely? Has the determination been made that NASA should, in fact, proceed to do any research in the area?

If the answer to the last question is "No" and that the answer will be determined in the next few months, I agree with the gentleman that maybe it is well we have not gone into this thing on a crash program. As Mr. Gough said, we could build a mach 2 or a mach 3, but

we have got to determine these other economic questions before we get into the development of hardware. The only purpose I have in asking the FAA to appear today is to assist the subcommittee in formulating an opinion on whether or not the $9 million requested by the NASA for this purpose is indeed justified. That is the purpose.

Mr. STAEBLER. Mr. Chairman, without at all attempting to add anything to the inquiry on the specific value of the $9 million, but putting it in a larger context, isn't there here a little danger of being penny wise and pound foolish?

Mr. KARTH. I think that is what we must decide after we hear all of the testimony. I would hesitate to form an opinion before the testimony has all been taken. That is the reason why witnesses are called before the subcommittee.

Mr. STAEBLER. I defer to the chairman's judgment on that. I think the point is well taken.

Mr. KARTH. I am not sure that you have anything left to say, Mr. Gough, insofar as your prepared statement is concerned. I think we have pretty much anticipated the material remaining in your statement. If you would like to finish reading it to complete the record, please proceed. You may then add anything else that you feel is pertinent to the point, and would help this committee in evaluating the need for the $9 million request.

Mr. GOUGH. Thank you, sir. I would like to read the last paragraph into the record, and I would like to make some other remarks on some of the questions that you have raised in this discussion.

Continuing the prepared statement, no budget request for the supersonic transport program in fiscal year 1964 for the FAA has been submitted to the Congress. Action in this regard is awaiting the recommendation to the President by the three agencies regarding the SST problem and a decision by the President with respect to the required Government action in the national interest concerning a specific program for supersonic transport development. Regardless of the nature and scope of this decision, it is our considered opinion that the continuing program of basic supersonic research proposed by NASA in their fiscal year 1964 budget request is essential and necessary and, further, that this program should in no way conflict with or duplicate any program that may be recommended to the President for further supersonic transport development effort. On the contrary, this basic research effort of NASA will be a vital necessity to future supersonic aircraft development in the United States whether such development is undertaken with Government support or by U.S. industry within its own resources. This fact should be readily apparent from consideration of the past history of NASA and its predecessor agency in furnishing basic aeronautical research data to the U.S. aviation industry. It is our opinion that this basic aeronautical research has been one of the keystones in the foundation that has established U.S. aviation as preeminent in the world.

I would like to mention one thing about the difference between decision and time and that I think Mr. Chenoweth mentioned.

The decision as to whether to proceed depends on many, many more factors other than the technical feasibility of this which you gathered from this effort which is being given to it by industry and by the Government to make a recommendation to the President, but the time that is inferred when we talk about how leasurely we are doing

this, now if we were to build a supersonic transport today and say today we are going to go build it, it still would take 3 to 5 years to build an engine and 3 to 4 years to build an airframe. This is the time requires with an all-out effort.

Mr. KARTH. You don't mean a total of 7 years, do you? Isn't it a total of 4 or 5?

Mr. GOUGH. No, sir; but they have to come together at the end, the engine and airframe. The B–70 is one that was conceived as early as 1956. I think the go ahead, the freezing of the design occurred about that time. Now, I don't think this should be considered a leasurely pace, and I think in view of the magnitude of the problems involved overall for extrapolating to mach 3 if you will, it wouldn't be considered at all leasurely in the technical world to say it would take 7 years to get it into scheduled commercial transport, safeguarding the public. This would mean a year or two of operating it without any payload to speak of, testing.

Mr. KARTH. The airlines probably couldn't buy these planes if we had them on the shelf today. Isn't that the reason we are not in such a big hurry, Mr. Gough?

Mr. GOUGH. I cannot verify whether they could buy them or not because I never did understand this. On the one hand they are always broke, and, on the other hand, they have to buy the foreign one if it is available. You go to hell either way.

Mr. KARTH. I am not sure which way you get there fastest. I cannot say you have helped me much. You haven't hurt me any, but I am not sure this is any clearer than when we started.

Mr. GOUGH. I would like to have another chance some time to improve on this. It is Mr. Halaby's desire that you be perfectly informed on this.

About a month ago I visited Mr. George Miller with him to keep this committee informed on what we were doing in supersonic transport. Mr. Halaby does a splendid job of explaining this, and I am sure he would be here today if he could.

Mr. KARTH. I talked with him on the phone, I understand his problem.

Mr. GOUGH. I assure you also he is a stickler for double-duty dollars.

Mr. KARTH. A question that arises in my mind is why we have to even make a study if we must go ahead either way as the gentleman says. We may as well be developing the airplane and forget about the studies. The FAA budgeted FAA dollars in fiscal year 1962 and fiscal year 1963, for the feasibility studies alone amounted to $30 million, and if we must go ahead either way, it seems to me we better forget about some of these studies and apply this money to research and get on with the job.

Mr. MOSHER. Mr. Chairman, I suppose the nature of the Presidential recommendation which is to be made around June may indicate it would require much more than $9 million, and I assume this $9 million merely represents a continuation of the extensive research that NASA has been doing in this field. If it is an ongoing basic research program, the $9 million may just keep up the pace, leisurely or not, depending on what they are doing.

Mr. KARTH. Apparently that is the case.

Captain DITCH. Their supporting research and technology area carries their long-term research in hypersonic, supersonic, and subsonic aircraft developments as well as the general work in propulsion, structures, aerodynamics, and so forth.

Mr. MOSHER. Do you mean that the general long-term research is all in addition to the $9 million we are talking about?

Captain DITCH. Yes. Of course, there are areas in the general research effort which will have application to the supersonic transport program even though it isn't earmarked now as part of NASA's supersonic transport project. It could have application elsewhere, too.

Mr. GOODRICH. Mr. Chairman, I think it is FAA's position this morning that if the United States goes ahead with the construction of a supersonic transport, the item represented before you will feed into the eventual product, and if the United States does not go ahead with the construction of the supersonic transport the information that this particular project will produce will be vital to FAA in the future in connection with its own certification of any foreign-built aircraft for use in the United States by U.S. airlines.

Mr. KARTH. The President's decision will be made before the funds could be spent. If the Congress authorized and appropriated $9 million, and then the decision was not to go ahead, I assume that the Congress would look with considerable askance on the expenditure of funds for a project contrary to the decision.

Mr. GOODRICH. Sir, I think we do understand that, and that is the reason I wanted to emphasize that FAA does feel that the project would be productive of information very helpful to this Government in its responsibility for certifying aircraft for use by American air carriers in the event that foreign aircraft were produced and purchased by American air carriers. We feel that this project has a relationship to a governmental function that we will be conducting in the future.

Mr. KARTH. Let me ask Mr. Gough, a technical man, this question: I assume you are somewhat familiar with the development of a supersonic transport that is going on in France and England. When would your best judgment cause you to predict that they would have a commercial aircraft of this capability for sale to American-owned airlines?

Mr. GOUGH. Yes, sir; I would like to analyze that in a little detail. You put a lot of qualifications on that, when in my best judgment I would predict they would have one that would meet these requirements.

Mr. KARTH. I am asking about a mach 2 or mach 3 supersonic transport.

Mr. GOUGH. And be an acceptable civil transport of a kind? I can't tell you that date——

Mr. KARTH. Acceptable enough so that their airlines are flying them in normal operations and they are competing with our airlines for international passengers. When do you expect that they will have these airplanes flying in that manner?

Mr. GOUGH. I don't know when they are going to have it because right now the way it is going I don't see them producing one that is going to meet noise requirements. I don't see them producing one at this moment that is going to be as economical as we wish to get, to get the range up.

Mr. KARTH. Let's say they have met the noise requirement, then when would you say they would have these planes flying, knowing what you know about their present development and their present advancement in the state of the art?

Mr. GOUGH. Well, they say that they are cutting metal and this being the case, in 5 or 6 years.

Mr. KARTH. It could be less than that, couldn't it?

Mr. GOUGH. No, sir; 5 or 6 years would be the minimum that they could get one out that they could sell a ticket on.

Mr. KARTH. Are there any further questions?

Mr. MOSHER. I think you have implied a serious doubt that the plane which France and Britain might have available in 5 or 6 years would meet our requirements as to noise and be acceptable in this country. Is that right?

Mr. GOUGH. Of course they would take me to task if they heard me say that. I do. We could go ahead and do exactly as they are doing at this moment. There is no question about that. We would like to do better than this. For that reason we need the fundamental data and research expansion and as long as we can have to increase our knowledgeability to give you an airplane that is really economical, that is really quiet, that is really capable of this range. This is what we would like to do, and we have had this time to do it because the magnitude of the dollars is so great, but I should like to ask you one other thing——

Mr. KARTH. You are the one that is putting all of the qualifications on it. I am not sure you are ever going to develop one under those conditions.

Mr. GOUGH. That could be, but I would like to mention also that the $9 million you are talking about for research, to the best of my knowledge, includes X–15 and the V/STOL work, and the amount assigned to the supersonic transport is $3.7 million.

Captain DITCH. Maybe I can clarify that. The numbers used this morning have been the total supersonic transport project costs, including operations, installations, and personnel; therefore it does appear as a little over $9 million for the supersonic transport project alone. The other NASA aeronautics programs amount to $24 million, $6 million, and $5 million.

Mr. GOODRICH. As to when these planes will first fly, Mr. Halaby, before the Senate appropriations committee last August, testified that the French are shooting for 1966 or 1967 or somewhere along in there for a first flight. They think of putting it into service 3 years later. That would bring us to around 1969 or 1970 in Mr. Halaby's opinion expressed last summer, that is the Concord, the British-French joint venture.

Mr. KARTH. Dr. Weaver.

Dr. WEAVER. One further question. Nothing has been said about the potential market for the sale of these planes. How many planes do you estimate are potentially supported by this $9 million of research? What potential market is there? It, actually, isn't too large a market when you get right down to it; is it?

Mr. GOUGH. The figure that seems to be quoted by people of economic knowledgeability in the field is somewhere between 100 and 200 airplanes.

Dr. WEAVER. How much would it cost a company to buy 1 plane or 10 planes?

Mr. GOUGH. The figure that is quoted is between $20 and $40 million.

Dr. WEAVER. Per plane?

Mr. GOUGH. Yes.

Dr. WEAVER. So it is going to be an economics problem to find out whether it is commercially feasible?

Mr. GOUGH. Yes.

Captain DITCH. Mr. Gough, does the figure that you have quoted as the price of the airplane include research and development cost? I know you are examining the situation both ways, and I want to be sure which figure you are quoting.

Mr. GOUGH. I was grabbing them out of the sky, but I think that is exclusive of development cost. You will recall that there has been talk about how the Government will be reimbursed for this. Now, how that is going to be treated in the economic feasibility report, I don't know.

Mr. DITCH. Then if the Government were to be reimbursed, that price would go up to take care of the reimbursement?

Mr. GOUGH. Well, you are talking in variations of a hundred percent, $20 million to $40 million is a rough guess, if I were going to buy one.

Mr. KARTH. Mr. Randall.

Mr. RANDALL. With that much investment per plane, how does that compare with the average cost of a Boeing 707?

Mr. GOUGH. I think $6 million to $9 million. Wasn't the President's plane $9½ million?

Mr. MOSHER. Plane or planes?

Mr. KARTH. Plane.

Mr. GOUGH. It is interesting that the only people that didn't have any feasibility studies were the Wright brothers, they couldn't get any of these figures.

Mr. RANDALL. Is it intended that the life span of these planes will be in the same as an ordinary jet? What is the useful life of an investment of this kind?

Mr. GOUGH. This is a part of the economic study. The airlines generally expect 30,000 to 50,000 hours of economic life. This is in contrast to 2,000 to 3,000 hours for a military aircraft. Life expectancy is an important part of the research. That has to do with the fatigue.

(Discussion off the record.)

Mr. KARTH. Mr. Randall.

Mr. RANDALL. A compromise arrangement is being investigated, Mr. Downing. A number of military pilots have been lost because of the absence of this new development which we understand is possible. It is a capsule which encloses the pilot which can be thrown out at supersonic speeds and at great heights; a capsule much like a space capsule. In some instances pilots have been able to bail out of high performance airplanes with an ordinary parachute, but were found lifeless when they came down, because of the great stresses placed upon them by their speed through the air. Isn't there such a device that can be used to encase the passengers which can be ejected as a

capsule that would permit a safe landing at supersonic speeds and great heights?

Mr. GOUGH. There has been a great deal of work in this space and survival area. The space people have done a great deal of work for us, in suits, and on the capsule, itself.

Mr. RANDALL. I would be happy to furnish brochures which show how this can be done.

Mr. GOUGH. In the NASA program, on the X–2, there was such an escape capsule and Captain Apt used it when he had difficulty with the airplane. This capsule required that he then get out of the capsule, after he got to lower altitude, and he didn't quite make that.

There are problems like this in the area. The point you make is well taken. You must protect the person in the rarified atmosphere and at the very high speeds, and there is an awful lot of work being done on this, the ejection seats in the 104 and the B–47, and the high-speed capsules that are continuously being worked on by the Air Force and the Navy. At the moment these do not appear to have a commercial application.

There is a lot of fallout data about the environment.

Mr. KARTH. Are there any further questions?

If not, I want to thank you, Mr. Gough, and Mr. Goodrich. We have enjoyed your testimony.

The meeting is adjourned.

(Whereupon, at 11:38 a.m., the subcommittee adjourned.)

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HEARINGS

BEFORE THE

SUBCOMMITTEE ON APPLICATIONS AND TRACKING AND DATA ACQUISITION

OF THE

COMMITTEE ON SCIENCE AND ASTRONAUTICS U.S. HOUSE OF REPRESENTATIVES

EIGHTY-EIGHTH CONGRESS

FIRST SESSION

ON

H.R. 5468

(Superseded by H.R. 7500)

MARCH 12, 13, 14, 19, 20, 26; APRIL 2, 3, 4, 9, 10, 30; MAY 1, 2; JUNE 6, 1963

[No. 21]

Part 4

Including INDEX

For All Parts

Printed for the use of the Committee on Science and Astronautics

1964 NASA AUTHORIZATION

HEARINGS

BEFORE THE

SUBCOMMITTEE ON APPLICATIONS AND TRACKING AND DATA ACQUISITION

OF THE

COMMITTEE ON SCIENCE AND ASTRONAUTICS U.S. HOUSE OF REPRESENTATIVES

EIGHTY-EIGHTH CONGRESS

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1964 NASA AUTHORIZATION

TUESDAY, MARCH 12, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON APPLICATIONS AND
TRACKING AND DATA ACQUISITION,
Washington, D.C.

The subcommittee met at 10 a.m., pursuant to call, in room 214–B, New House Office Building, Hon. Ken Hechler (chairman of the subcommittee) presiding.

Mr. HECHLER. The subcommittee will come to order.

The subcommittee with the longest name, the Subcommittee on Applications and Tracking and Data Acquisition, is meeting this morning to consider the authorization.

In order to make the maximum use of the talent in this subcommittee, I am asking Mr. Roush to chair the portion of the authorization hearings concerned with tracking and data acquisition, Mr. Ryan of New York to chair the portion concerned with communications, and Mr. Davis of Georgia to chair that portion concerned with meteorology.

Without further ado, I will turn the chair over to Mr. Roush.

Mr. ROUSH. Thank you, Mr. Chairman.

Our first witness today is Mr. Edmond C. Buckley, Director, Office of Tracking and Data Acquisition.

We are very glad to welcome you here today, Mr. Buckley; we are looking forward to your testimony.

I believe the questions which will be asked by members of the committee will perhaps be more indicative than my statement of the interest, but we are interested in the requirements of NASA and the relationship of these requirements to the other military and defense establishments.

I believe you brought with you some of your assistants. For the record would you introduce these gentlemen and indicate to the committee their area of responsibility.

STATEMENT OF EDMOND C. BUCKLEY, DIRECTOR, OFFICE OF TRACKING AND DATA ACQUISITION, NASA; ACCOMPANIED BY GERALD M. TRUSZYNSKI, DEPUTY DIRECTOR, AND DAVID WILLIAMSON, JR., CHIEF, PROGRAM COORDINATION

Mr. BUCKLEY. Thank you, Mr. Chairman.

I have with me Mr. Gerald M. Truszynski, the Deputy Director of my office, the gentleman on my right, and I also have with me Mr. David Williamson, Jr., Chief of Program Coordination, and there may be a few questions, particularly in the fiscal area that he may be able to help on.

Mr. ROUSH. I am sure there will be questions. I hope that he might be able to help.

You have a very long statement, Mr. Buckley, and this statement has been distributed in advance to the members of the committee and we are going to ask you, because they have had the opportunity to read and study the statement, to summarize your statement.

Are you prepared to do that rather than to read it in detail?

Mr. BUCKLEY. Yes, sir, I have a summary of about 10 minutes, perhaps 12 minutes.

Mr. ROUSH. All right, you may proceed, Mr. Buckley.

Mr. BUCKLEY. Thank you.

In my prepared presentation I describe the overall task that is imposed on my office, the Office of Tracking and Data Acquisition by the various NASA flight programs and I have described the way we intend to go about meeting that support task.

Now this morning we are going to take up that portion of our required new resources that falls within the research, development, and operations area. The direct or program costs here total $231.5 million. The personnel salaries and field center operations costs associated with the execution of this program bring the total to $261.6 million.

I will confine my remarks to the direct program that is under my jurisdiction. The research, development and operations area covers three sections, three areas of effort in the tracking and data acquisition program.

The first is the procurement and installation of new and replacement equipment at all of our NASA tracking stations, in the Wallops Island launch area, and in the field centers that handle the data processing function for the data that comes in from the various stations.

The second area of effort is the operations of the network stations (which is done by contract); the operations of a communications system that ties the various stations together and to the control centers, both the control center that watches over the network itself to insure reliability and proper operation and the mission control center such as the one at Cape Canaveral, Fla., where the mission people have the proper displays and information in order that they can make the project decisions; and the operations of the data processing lines.

The third area of effort is in the development and test of new or improved equipment, systems, and techniques required by the flight programs.

In the first area I mentioned, that of equipment and components, we estimate $134 million in fiscal 1964. The unmanned satellite program requires major changes in telemetry because of the fact that, as Dr. Newell has told the committee, we are going into a new generation of space vehicles and of satellites that will make many more measurements. In order to make these measurements efficiently and in order to bring the data down in a form that allows automatic computation, the spacecraft are going over to a new telemetry system which has to be matched by corresponding changes in the ground stations. There also will be improvements in the data handling and in the tracking equipment provided at certain stations. For highly elliptical orbits and for the more precise data needed at injection and insertion, we are going to put in a special tracking system at a few of the stations.

The original 16 Mercury stations were modified first to support the longer flights, of which one is just coming up in the near future, and are now being modified for the Gemini flights and will have to be augmented further for the Apollo flights. These changes will, as far as we can possibly do it, build on the original Mercury network rather than starting off with something new, particularly since this network was tried and proven and is an excellent foundation to start on.

Another area of effort that we are expanding is that of processing the data received from the flight experiments. We have set up at Goddard some several reduction lines for processing the data automatically and getting it to the various experimenters whose experiments are aboard the spacecraft. The present reduction line just about keeps up with the rate at which the data is now being received. As we go over to the new generation of satellites, there will be a much heavier data flow and the corresponding processing capability will have to be increased.

The second area I mentioned was that of the operations of the network for which we have a request of $80.5 million in 1964. As new stations become operational, as the coverage time per mission increases, and as the stations handle more and more data (which means more ground equipment associated with it), there will have to be additional operators, additional support, and additional communications services.

The final area of the three was that of supporting research and technology. We estimate $17 million in fiscal year 1964 to maintain a minimum development leadtime in advance of procurement requirements for the ground systems to support our flight missions. We are on a learning curve. We not only are putting operational systems in to do the proper tracking and data acquisition on the ground, but we have to be thinking about where we will be in 2 years or 5 years, and this effort in supporting research and technology allows us to make some improvements, to look at and study the improvements that will have to be made in the network in years to come. The total for this work, by the way, is about 5 percent of the total budget in my area.

The application of these total resources by program is an evidence of the priorities and problems we face. For example, some 50 percent of the total $231.5 million is devoted to the support of the manned flight projects, Mercury, Gemini, and Apollo. About a third supports the unmanned satellite projects, and the remainder is needed to operate and equip the lunar and planetary ground network.

Another way of describing these resources is to examine the probable allocation to the field centers. Some $185 million will go to Goddard Space Flight Center. Goddard is charged with operating, and equipping both the satellite and the manned flight networks with the responsibility for insuring that the proper ground communications network is installed, and with the major scientific data processing responsibility. In contrast, the contract-operated Jet Propulsion Laboratory will require some $25 million for its part in the operation of the deep space network. My own headquarters office will spend about $8 million, covering the contracts with South Africa, the Smithsonian, and Fort Churchill. Wallops, Langley, and the Marshall Space Flight Center require about $4 million each to perform their developmental and operational assignments, and the Flight Research Center needs about $2 million per year to support

the NASA aerodynamic flight test program done with the research airplanes at that Center. You can see, then, that Goddard is a major field element involved in our work. There are over a thousand people there doing the development, design, engineering, scheduling, and supervision required to run the tracking and data acquisition networks for which they are responsible.

I think it is important to stress that the entire $231.5 million that I have been discussing represents industrial procurements for hardware or for services. Our job relies on a host of commercial contractors and upon their ability to perform to the standards we require. Industry as a whole has accepted the challenge of meeting our requirements and has done a fine job of supplying what we must have.

In summary, then, the research, development, and operations portion of our program provides the ongoing operation of our facilities; their modification, maintenance, and augmentation of capability; and the continuing test and prototype development needed to provide adequate leadtime for the future.

That concludes my statement, Mr. Chairman.

(The prepared statement of Mr. Edmond C. Buckley is as follows:)

STATEMENT OF EDMOND C. BUCKLEY, DIRECTOR, OFFICE OF TRACKING AND DATA ACQUISITION, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

INTRODUCTION

Mr. Chairman and members of the committee, the Office of Tracking and Data Acquisition is responsible for assuring that there will be adequate ground support for the various missions of the NASA flight programs. We have to know what is going on in the vehicle far out in space; we have to listen to what it tells us as it makes the measurements that we have sent it out to make; we have to know where it is at all times so that we can correlate its scientific measurements with its location in space; commands must be sent for the spacecraft to perform certain functions or experiments and to assist it to correct any difficulties which may arise; and, of course, in the case of the manned flight, we want to have direct communication with the man for the added information he can pass to us verbally, and so that we can directly discuss his problems and suggest possible solutions. Dr. Dryden has said that we could not exist in space, either from the point of manned flight or from the point of scientific missions, without communication between the Earth and the space vehicle.

In the upper left-hand corner of the first figure (1a), we see these support functions listed as tracking, telemetry reception, communications, and command control. These support the kinds of missions shown on the chart. The first item, tracking, includes the various techniques and facilities for ascertaining just where the spacecraft is, in what direction it is moving, and how fast. It also includes the prediction of where it is going to be in the future; that is, when and where we will have to look for it in order to continue to provide our support when next it appears to a station on the ground.

The second item is telemetry reception which is, of course, the receiving of the coded electrical signals carrying the information to the ground about the condition of the man, in the case of manned flight, whenever we want to know his pulse rate, temperature, etc. Also, we want to know the details about the functions of the systems in the spacecraft, such as information on the oxygen supply, or how the carbon dioxide absorbers are working, how much fuel is left, the conditions of the batteries, whether or not various functions are being properly carried out, such as the pointing of antennas, the actuation of certain valves, etc. To some extent we can think of this function as that of being the copilot on the ground, and even in flying a vehicle like the X–15 airplane we find it most helpful to provide such ground assistance to the pilot. Finally, the telemetering reception, of course, is our method of collecting on the ground the scientific information acquired by the various scientific instruments aboard the spacecraft.

The third support function shown, communications, covers not only the communication from the spacecraft to ground and from the ground to spacecraft, with which you are all familiar because of the Mercury flights, but it also refers to the ground network. This carries information back to a central information

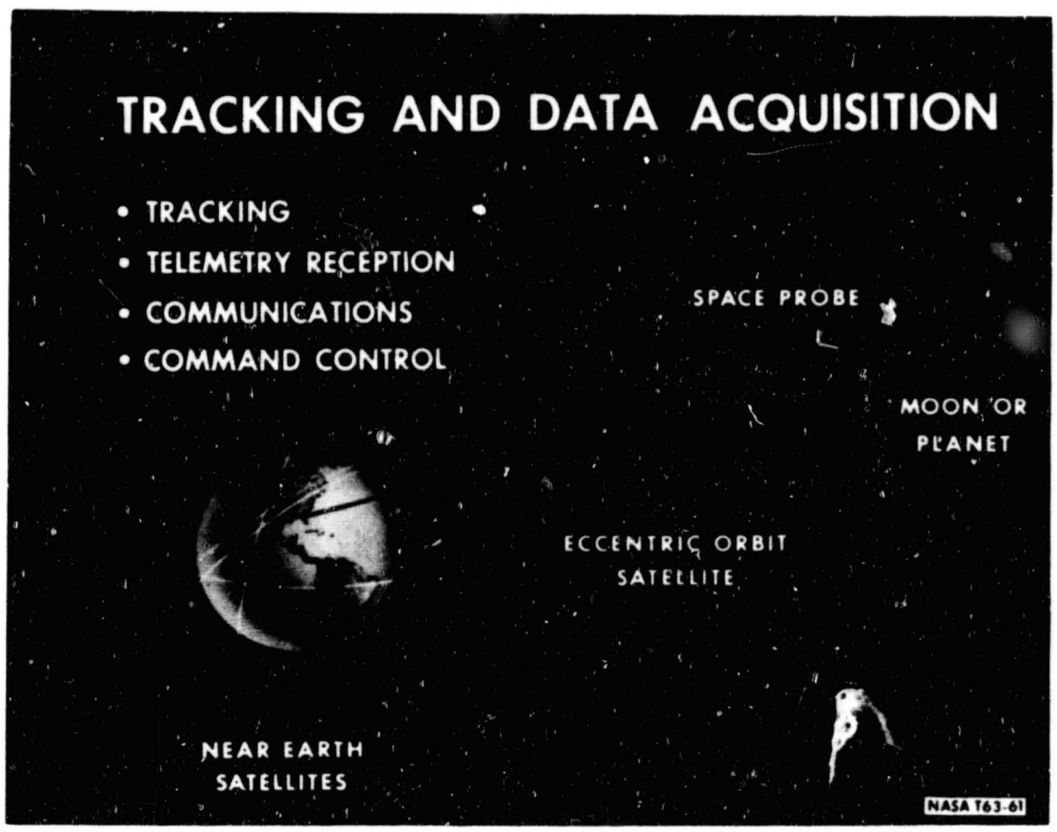

FIGURE 1a

and control center where the well-being of the man, his vehicle, or the scientific apparatus is kept under careful observation.

The last item on the list, that of command control, covers the techniques and facilities by which we maintain operational control or send operating instructions to various mechanisms aboard the spacecraft.

We must provide, then, various facilities on the ground which cooperate closely with the space vehicles. What we provide and where it is placed differs on the different type of missions we undertake. Some of these missions involve flights circling the Earth at relatively low altitudes, and the flights of Mercury or the meteorological satellite, Tiros, were in this class. Such orbits could circle the Earth from pole to pole and, as the Earth turns under the orbit, sooner or later we could see the spacecraft from any point on the earth; that is, it would pass over the whole Earth. However, if these orbits are inclined or tipped, they cannot be seen by locations on the Earth from the higher latitudes, and in the case of Mercury, for instance, they could be seen only from, roughly, places on the Earth that were less than 30° north of the Equator to 30° south of the Equator. If an orbit of low enough inclination were used, 0° for instance, the satellite could be seen only by sites close to the Equator.

Some of the missions involve satellite orbits which carry the spacecraft quite a ways from the Earth, many thousands of miles, and, of course, in some cases this orbit is elliptical as illustrated on the figure, in which case it goes far out from the Earth on one side to what is called its apogee, but comes close to the Earth on the opposite side at what is called the perigee.

Further, we have the case where the spacecraft, subsequent to its launching, attains a high enough speed to escape from the Earth's gravity and becomes a space probe which can go to the Moon or the planets or beyond.

The characteristics and the location of the ground support differs because of these different trajectories, and the next figure (2a), indicates some of these differences. In the case of the manned space flight, we want to keep in very close touch with the experiment, which means that we try to get the information back to a control center quickly; that is, we want rapid data output, with a very

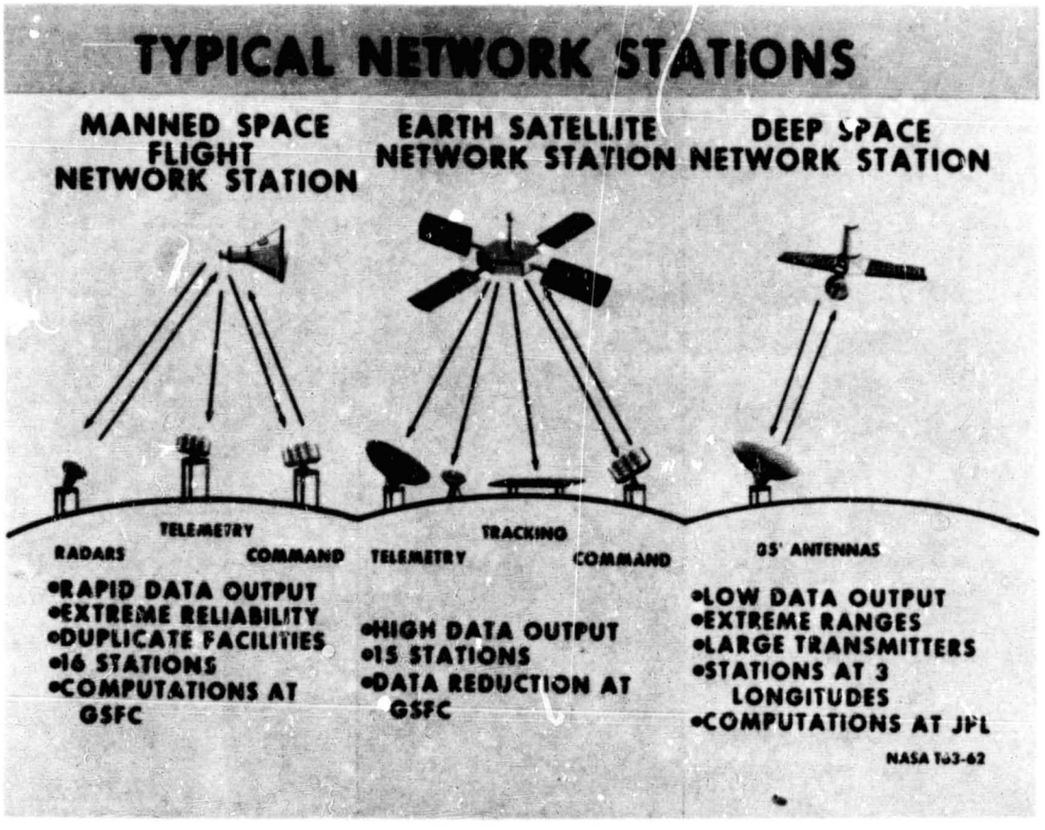

FIGURE 2a

short time elapsing for its evaluation by a control center. It is necessary that we provide extreme reliability if we are going to insure the safety of the man. This results in extra care and planning of the ground support equipment and how they are used, and great stress on training the operating teams. It also makes it imperative to provide duplicate equipment so that, in the event of loss of power or failure of a component at a station, we don't lose touch with the man or the spacecraft except for a very short time. For the manned flight we used a large number of stations, both on land and on ships, around the Earth—some 16 stations, in fact—which allowed us to keep in touch with the man and his craft for, roughly, 5 minutes out of every 15. This was a wise concept because, as you know, the problems which arose in the early Mercury flights made close cooperation between the man and the ground stations imperative. As we acquire more experience, we plan to go longer periods without such contacts, but we will always have to insure good telemetry and communications with the spacecraft at certain crucial points in the trajectory or flight program.

Finally, I have indicated the need for emphasis for rapid calculations, a need for the computing machines to be intimately tied to the stations around the world by reliable communications systems so that we know exactly where the capsule is; we can tell the astronauts just when to fire the retrorockets to come down near the waiting ships, or that we can take necessary corrective actions quickly in the case where the trajectory is not exactly as planned. As a matter of fact, the whole philosophy behind the planning for this network was the emphasis on having accurate data available as quickly as possible at the control center for such decisions as were needed.

The center section of this figure refers to the stations that work with the Earth satellites and particularly with the scientific satellites. The large number of instruments carried results in a high data output from the satellite, and therefore, requires a high capability at the receiving stations on the ground to receive this information. There are some 15 stations distributed geographically around the Earth so that the various types of orbits shown on the preceding figure are properly covered. Again, I have indicated the data processing at Goddard Space Flight Center but, in this case, by far the larger part of the data does not have to be processed as quickly as it is obtained—only that part of the data which is necessary

to evaluate the engineering equipment aboard the satellite, and to evaluate the performance of the scientific instruments.

In considerable contrast is the third area of support, that for the deep space probes. In this case, the spacecraft may have a relatively low data output compared with the Earth satellites mentioned previously. Because it is out at extreme distances, only faint signals are received and we must use large 85-foot antennas to collect and record useful amounts of information from this minute signal. As best we can, we put larger transmitters aboard the spacecraft to assist in sending the signals over great distances, which, as you know, in the case of the Mariner shot which went to Venus and beyond, was over 50 million miles. To give you an example of the amount of energy contained in these signals from deep space, I would like to point out that the Mariner spacecraft carried a radio transmitter which radiated 3 watts of energy, or about the same energy used by an automobile parking light, and this is the signal detected over the Earth-Venus distance.

The station location problem is much more simple, however, as it is possible, when the vehicle is beyond 8,000 to 10,000 miles from the Earth, for three stations placed roughly equidistant around the Earth to keep the spacecraft in sight as the Earth turns under it. Again, I have noted the fact that the data has to be brought to a central location where the computers are maintained, in this case, the Jet Propulsion Laboratory.

Now, the groups of stations doing these various types of jobs, shown in this figure, are sufficiently different from one another either in their equipment or their operational philosophy so that it assists us greatly in the management and operation of the stations to treat them as three networks: One for manned flight, one for Earth satellites, and one for deep space. For purposes of economy, these various functions, when feasible, are placed at one location allowing combined support and communication. For instance, the three deep space facilities are colocated with Earth satellite stations. Furthermore, as we plan the various missions, cross use is made of the stations, wherever needed; that is, they are worked into operation plans wherever they can provide assistance, without limiting them to the use indicated by the network designation. May I repeat again that treating these stations as separate networks is to assist in the operational philosophy and control.

Some details about the present and planned capabilities of the networks will unfold as we proceed in the discussion of tracking and data acquisition support for specific space flight projects in NASA programs. I intend to discuss the support for satellites, for the lunar and planetary program, and for the manned space flight program, in that order.

SATELLITE SUPPORT

For illustration of the support required in the last year for the scientific satellite program, I have chosen two of the six Earth satellites launched in 1962. All six, incidentally, were successful in meeting their objectives. The next figure (3a), will assist me in discussing Explorer XV, the purpose of which was the evaluation of the enhanced Van Allen radiation belt. As a result of the radiation effects produced by the nuclear detonation in space on the 9th of July, Explorer XV was undertaken as a very quick reaction project to obtain data on the changes in the belt of energetic particles distributed in the equatorial toroid about the Earth known as the Van Allen belt. The possible effect of the radiation on manned space flight launches and on other space flight programs had to be determined quickly. As you may know, this radiation may have a damaging effect upon the solar cells which supply the electrical power for most of our satellites, and upon transistors and other electronic components as well, and it also had to be evaluated as a possible hazard to an astronaut in the manned space flight program. In the upper right-hand corner of the figure you will see a rough indication of how this belt surrounds the Earth. The orbit of Explorer XV was designed to allow a survey through this belt and beyond and the orbit indicated in this figure was chosen. You will note that this orbit is an elliptical orbit with 194-mile perigee, the closest point to the Earth, and about 11,000-mile apogee, the farthest point. The orbit was inclined 18° to the Equator. In order to assist us in making decisions about other planned firings, the data was needed very quickly. As is shown in figure 4a, ground stations had to be in the right position to receive telemetered data from the satellites. Since this was a quick reaction project, there was insufficient time to provide a magnetic tape storage system in the vehicle to allow instrument readings to be made at one point in the orbit and a delayed transmission to the ground at another point in the orbit.

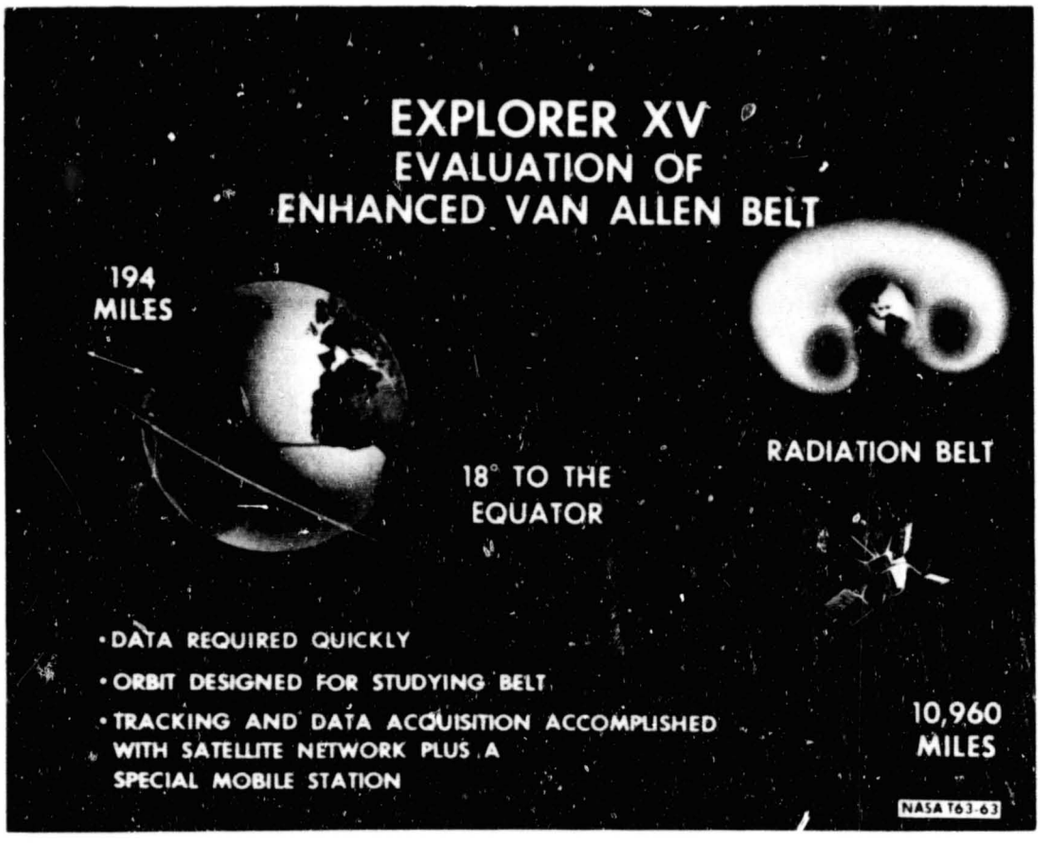

FIGURE 3a

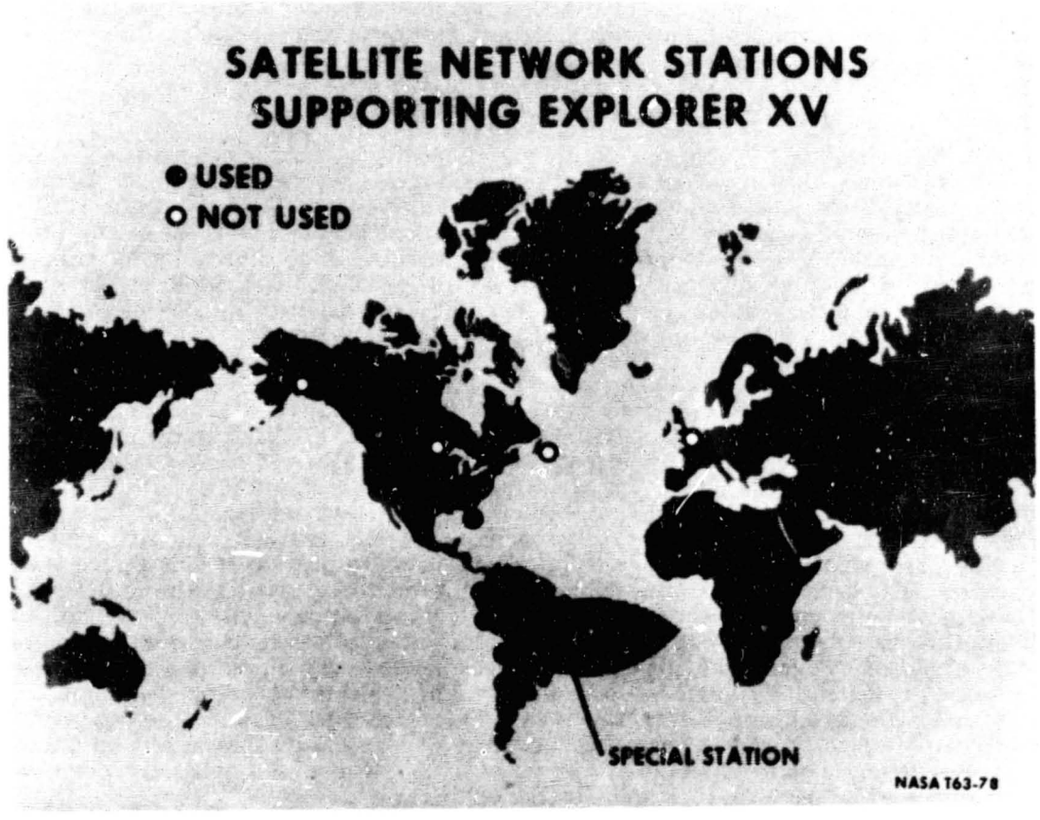

FIGURE 4a

On this figure, the circles show the locations of the network of general-purpose stations used for tracking and for the reception of telemetry from Earth satellites. These have been in use for the last few years and have been discussed in my appearances before this committee in the preceding years. The solid circles are the existing network stations which were used for Explorer XV and the open circles indicate the stations where it was deemed not necessary to receive telemetry data. However, from relatively few observations from other satellites which were already in orbit but not specifically equipped for this type of measurement, it had been determined that there was an area of special interest in the South Atlantic, shown shaded in this figure, where the belt was closest to the Earth because of the magnetic field anomoly. It was necessary to investigate this portion of the belt, but as you will note, none of the existing stations were in a position to receive the data as it was collected during this part of the orbit In slightly over 1 month from the time this requirement was made known, a special van-mounted receiving station comprising the necessary antennas, receivers, recorders, and power supply was assembled and flown to Brazil. During the 1-month period mentioned, were also included negotiations with the Brazilian Government to locate the transportable station in that country. The station has already served its purpose and was returned to the United States during the month of January.

On the next figure, (5a), we show a sketch of the Alouette which was a scientific satellite designed and built by the Canadians and successfully launched on September 28, 1962, into a polar orbit as shown on the left side of the figure.

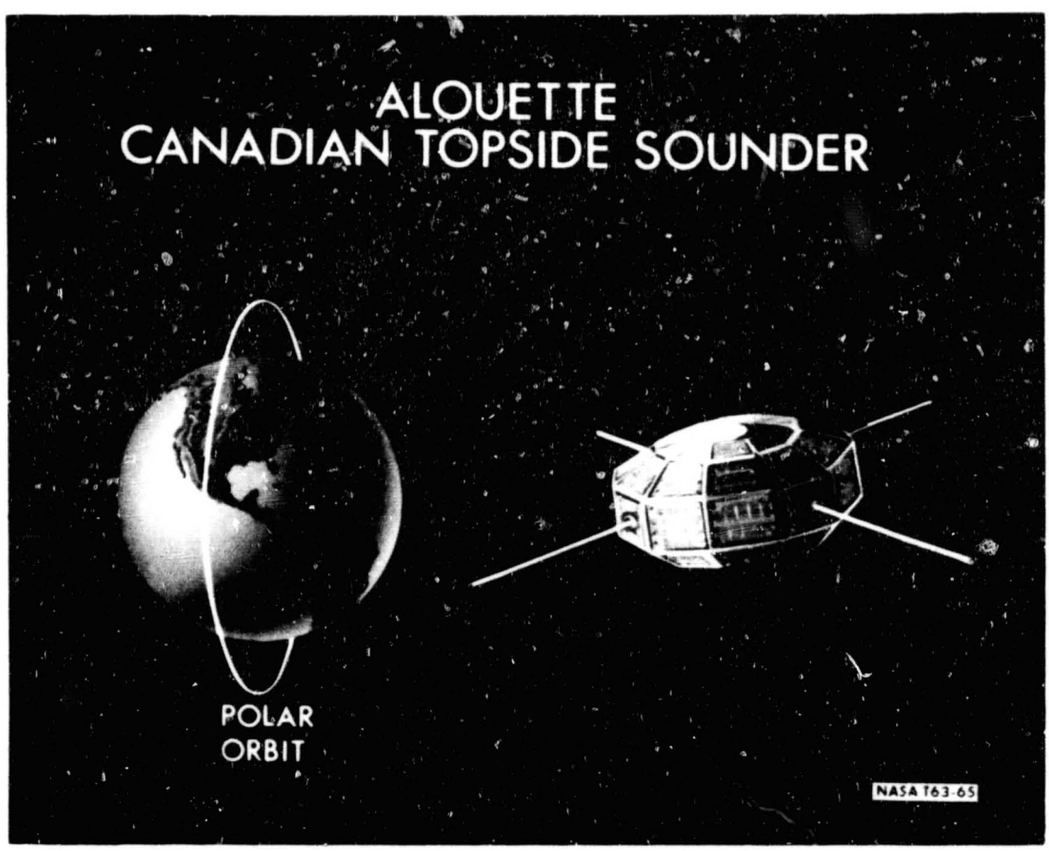

FIGURE 5a

As indicated on the next figure (6a), the job of Alouette was to investigate the ionosphere belt which surrounds the Earth. This is an ionized layer which we have known of for many years and which has a major effect on long-distance radio communications. Successive bounces of radio signals underneath the ionosphere layer are of material help at times on long-range communications, but height and curvature of the ionosphere layer can also play havoc with long-range communications at certain times during the day. The method of investigating the ionosphere, up to now, is roughly indicated in the lower right-hand corner

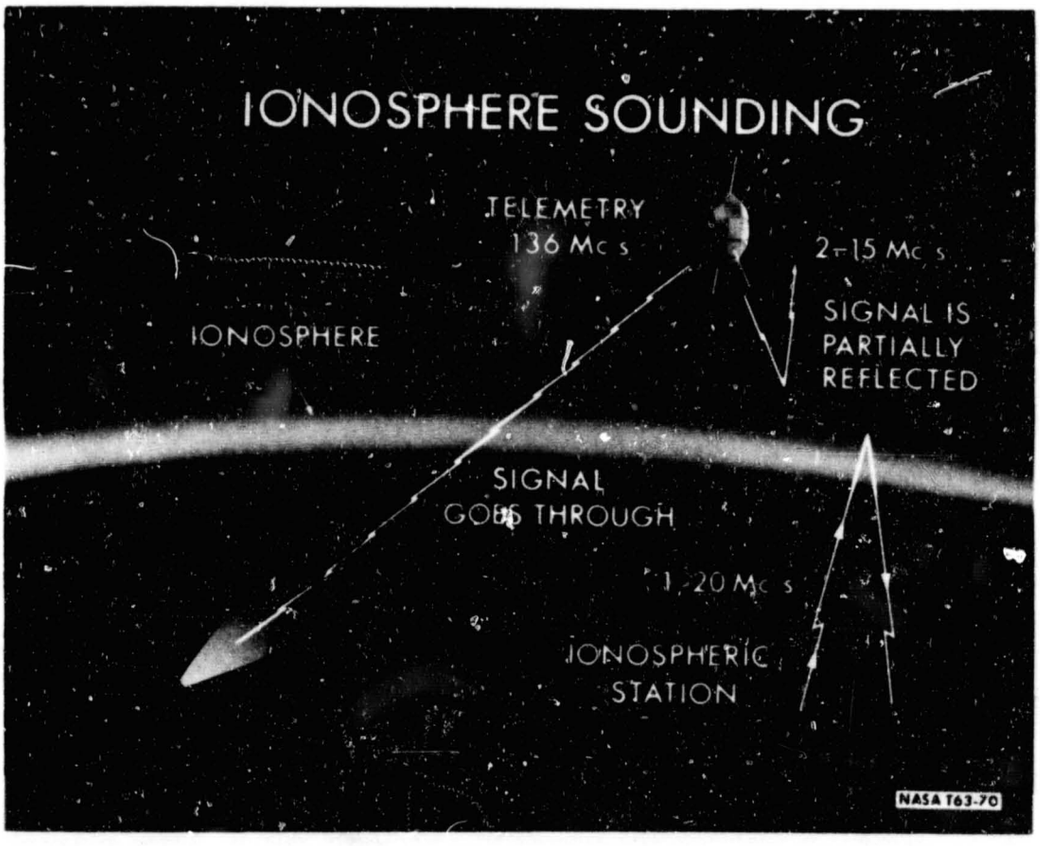

FIGURE 6a

of the chart and it has been to bounce signals off the ionosphere by a ground station. The variations as they are received again on the ground give us information on the height and the characteristics of the ionosphere belt. However, parallel investigations carried on on the top side of the ionosphere belt, using the satellite to transmit and receive the partially reflected signals, would give important information of the thickness and characteristics of the ionosphere belt which could not be obtained by the ground station method. As you will note, the information received by the satellite was transmitted to the ground at frequencies that could penetrate the ionosphere. Thus we could evaluate the amount of reflection from this data and, by proper analysis, the characteristics of the ionosphere could be determined. Because of the need for radio communication in northern Canada and because of the effect on such communications by the ionosphere layer, the Canadians have always had a strong interest and research program in investigating the ionosphere.

In figure 7a we see the participating stations for the Alouette mission, with the black lines indicating the coverage of these stations. Coverage was desired from high, northern latitudes to high, southern latitudes and the circles are the NASA general purpose network stations along the 75th meridian which participated, the squares show the Canadian stations which were used; and the two triangles, one in Singapore and one in the Southwest Atlantic, indicate the stations added by the United Kingdom to assist in Southern Hemisphere coverage.

You will note several things from my presentation on Explorer XV and Alouette which are present to a greater or lesser degree in planning our support for all flight missions. First, we have a basic general purpose layout of stations of which we try to make the most extensive use; second, we are able to modify certain of these stations to meet the peculiar requirements of individual satellites; and, third, additional temporary stations may have to be added because of the peculiar geographic coverage requirements, such as the one station in Brazil for Explorer XV and the three Canadian and two United Kingdom stations for Alouette.

FIGURE 7a

Now let us look at the new scientific satellites presently under development. These are satellites which combine a large number of measurements in order to make a broad and thorough investigation of some aspect of space. The next figure (8a), shows, first, a pictorial representation of the Orbiting Astronomical Observatory and gives an indication of its orbit which is an inclined, very circular orbit at an elevation of 500 miles. In the center of the figure is represented two geophysical observatories, one called POGO for Polar Orbiting Geophysical Observatory, and the other, EGO, for Eccentric Geophysical Observatory. The orbits are indicated with POGO in polar orbit, 600 miles in altitude, and the eccentric orbit of EGO with an apogee of 70,000 miles from the Earth, roughly one-third of the way to the Moon. At that distance, EGO at apogee will appear to move very slowly across the sky, but at the perigee end of its orbit it will race from horizon to horizon like any low-altitude satellite. This results in our planning for EGO involving a combination of the procedures used for low-elevation satellites and those used for lunar or deep space vehicles. On the right side of the chart is shown the satellite known as IMS. The initials stand for interplanetary monitoring satellite and as will be noted from the picture, its orbit is even more eccentric than EGO.

The major problem, shown by the next figure (9a) in providing proper support for the observatory satellites stems from the increased data rate resulting from the sum of the combined experiments. Here we have plotted, as shown at the bottom, a measure of the maximum data rate we have had to meet each year. We have tried to convert this data rate to a concept with which we are all familiar. We use as this measure the equivalent number of telephone circuits which would be required to carry the data. As you can see, in 1958 the extremely simple satellites used in that period had an extremely low amount of information transmitted to the ground, and so recorded on the ground, and this continued through 1959. But as we progressed into 1960, 1961, and 1962, we see there has been a gradual increase, and as we go to late 1963 and 1964, we see that the relative amount of data per unit of time from EGO and OAO is many, many times that of the satellites of 1958 and 1959. In figure 10a, I have summarized the changing requirements of these future satellites. First, as I have mentioned, there is a tremendous increase in the information which will be telemetered down from these spacecraft. This is bringing about a need for automatic processing of the data. By this I don't mean primarily computing, although this is involved, but rather the editing and culling, the conversion to digital form which makes it easier to process

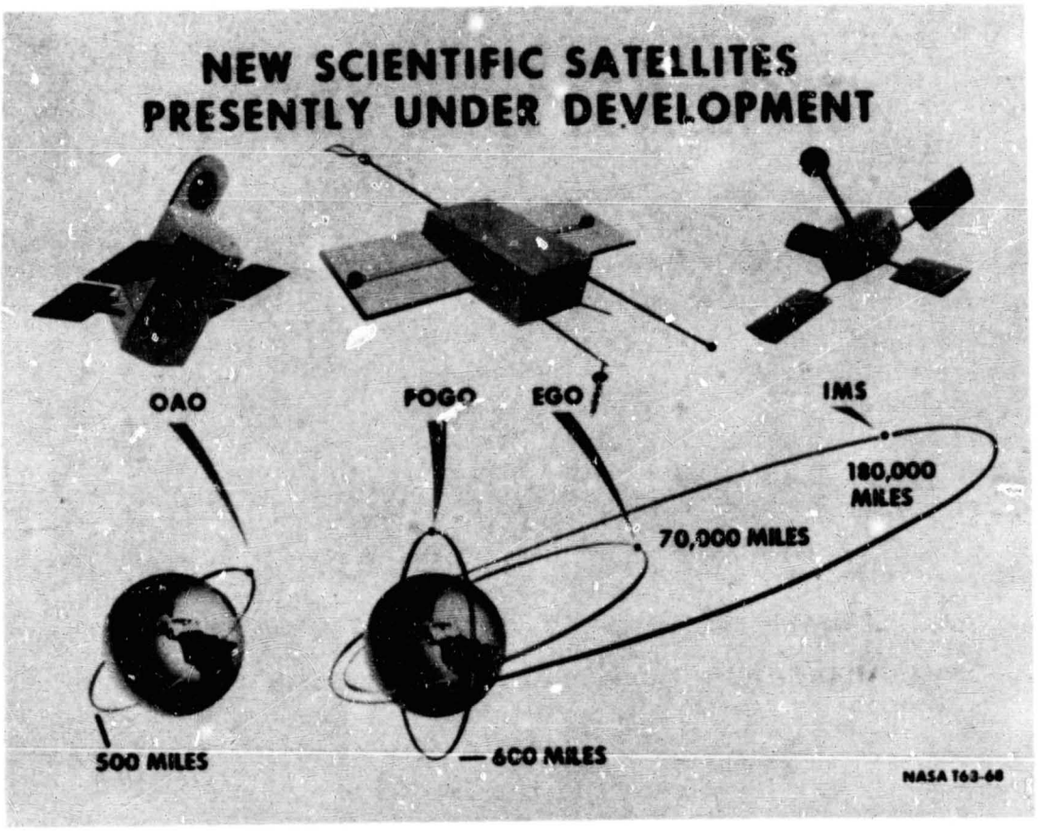

FIGURE 8a

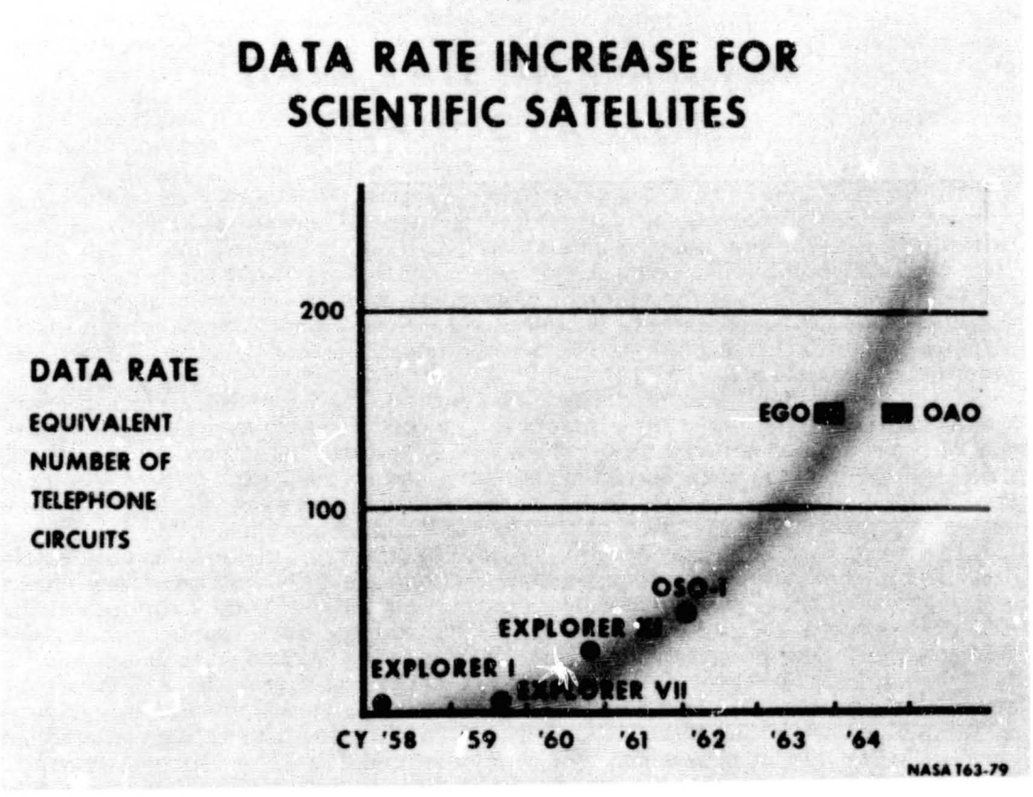

FIGURE 9a

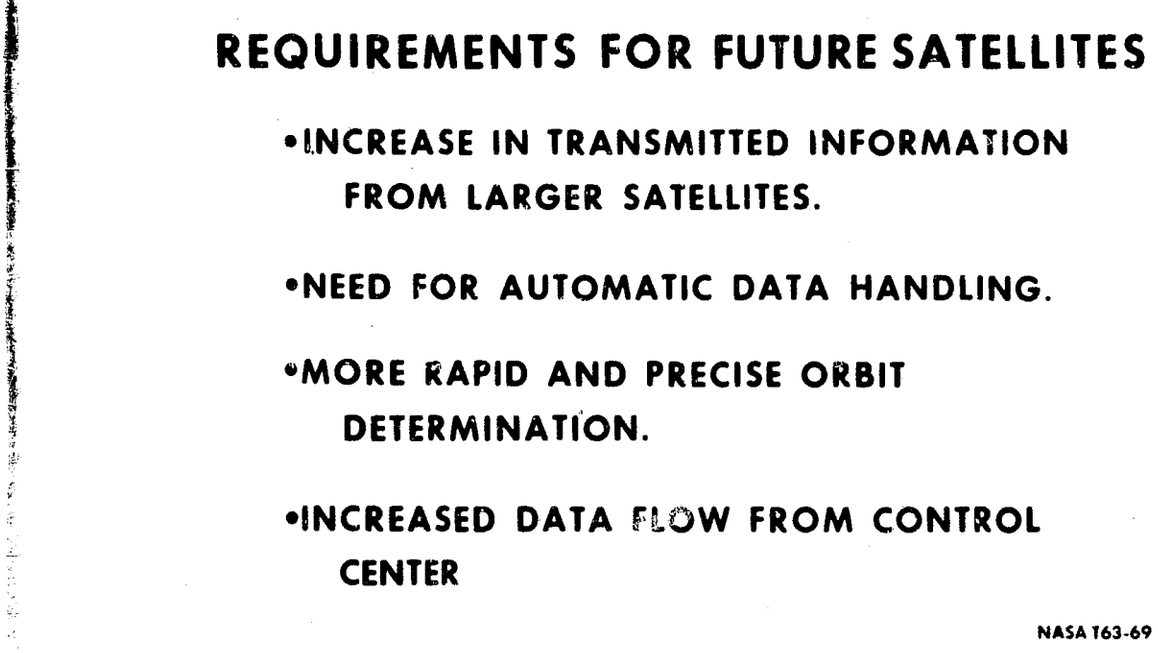

FIGURE 10a

automatically, the separation of one experimenter's data from another, the merging of the data from the scientific instruments with engineering-type data transmitted from the vehicle such as temperatures and attitude, items which the experimenter may need to know if he is to evaluate properly the readings of his instruments. In addition, there is merging with his scientific data the collated trajectory data as computed from the tracking measurements made by the various stations. The result then is a tape going to each experimenter with the data from his own scientific instruments and the other data he needs to evaluate his measurements.

The third item on this chart stresses the need for more rapid and precise orbital determination for the type of orbit to be flown by some of these new spacecraft. The last item points up the increased data flow from the control center up to the satellite; in other words, there will be a greater amount of instructions or commands sent from the control center based on the rapid orbit determination and the preliminary look at the data we have as it goes through the automatic data processing procedure.

There are changes in techniques which we are adopting in order to transmit this increased amount of information down from the future scientific satellites which have the additional benefit of being better adapted to the automatic data processing procedure.

The pulsing on-off electrical signal as it comes down by telemetry, represented on figure 11a, shows a group of pulses which constitute a code which carries the data. This is known as pulse code modulation telemetry. Pictorially, we represent this as being received into an antenna and then brought down through the lower righthand, the particular telemetry equipment which translates this space data into computer language. On this chart, about in the center, is also represented a particular tracking technique which will be used to give us more rapid and precise orbit determination mentioned on the preceding figure. You will note that the output of both this tracking system and the previously mentioned telemetry equipment feed into an electronic data processor and from there into a printer. The data is also fed, as indicated by the arrow, into the communications network which will carry the data to the Goddard Space Flight Center. At both Goddard and at the station a continuous watch is kept over sampled parts of the data and decisions can be made either at the station or at Goddard to send commands back to the spacecraft to change its operating mode, or to turn on automatic equipment, or to make certain engineering measurements within the spacecraft for transmission to the ground to assist in our diagnosis of difficulties or our decisions as to further controls or instructions.

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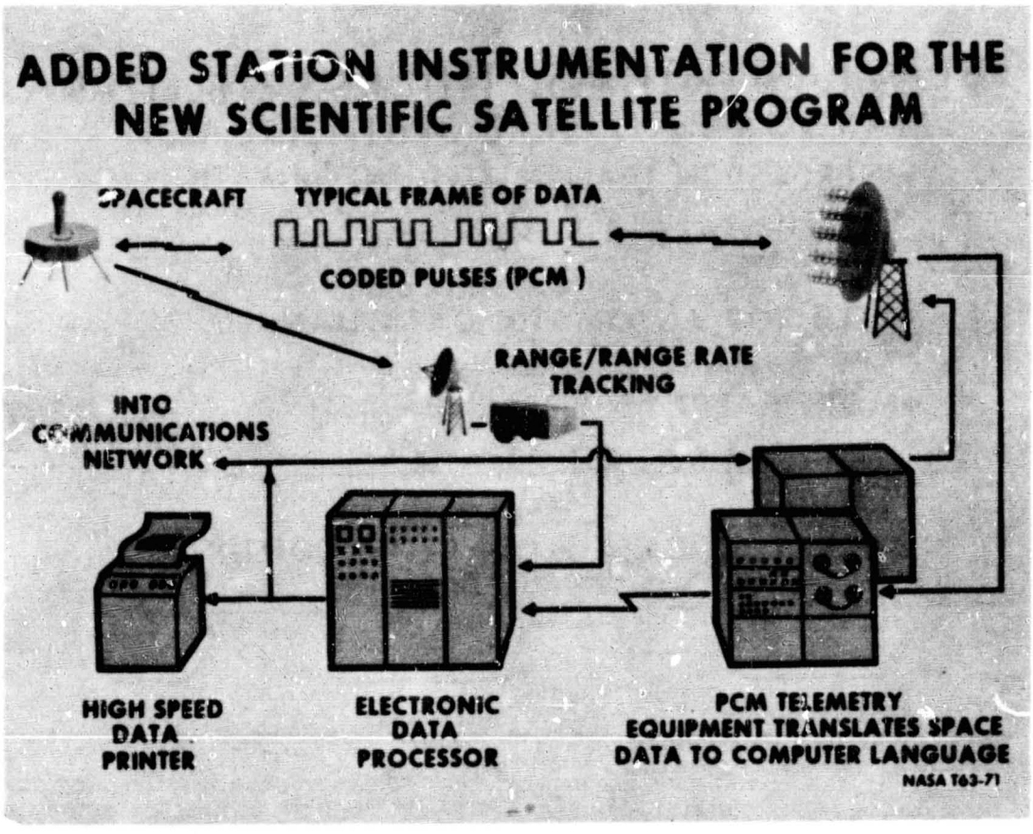

FIGURE 11a

To summarize, then, we have to meet new satellite requirements with new equipment. We are equipping our stations with PCM systems and range and range-rate equipment; we are providing transportable telemetry stations; and we are developing processing systems which can handle the data rate problem.

DEEP SPACE SUPPORT

Now let us go to the next figure (12a) and discuss the various types of deep space missions which impose requirements on the ground system. Spacecraft will be launched to go to the Moon at a distance of a quarter of a million miles and these may be hard or soft landers or possibly lunar orbiters. Others will be going to Venus and to Mars which may either impact or orbit around the planet. And finally, as shown on the bottom of the chart, there will be spacecraft which are sent on long journeys through interplanetary space to investigate what exists in the vast regions between the planets.

Using the figure (13a), I would like to provide some of the background of the requirements laid on the ground system. This shows some of the major steps in a Ranger mission. As the spacecraft is launched and leaves the Earth, it is normally inserted into what is frequently termed a parking orbit; it is then injected into a trajectory which will carry it to the Moon. During injection, both tracking and telemetry are required, and again when the solar panels open and the antenna is deployed, which happens shortly after injection. In this case we would like to be sure that they do open properly and promptly, or that we will have some information that will help us analyze the difficulties in case they do not. All this while, continued tracking will provide information as to what adjustments have to be made in the trajectory to improve the course to the Moon. Based on this tracking data, the necessary adjustments are computed and then commands are transmitted to the spacecraft to cause it to orient itself properly so that when the thrust is turned on for a brief interval the desired change will be accomplished in the trajectory. Still later, in the close proximity of the Moon, commands are transmitted to prepare the spacecraft for the final maneuver.

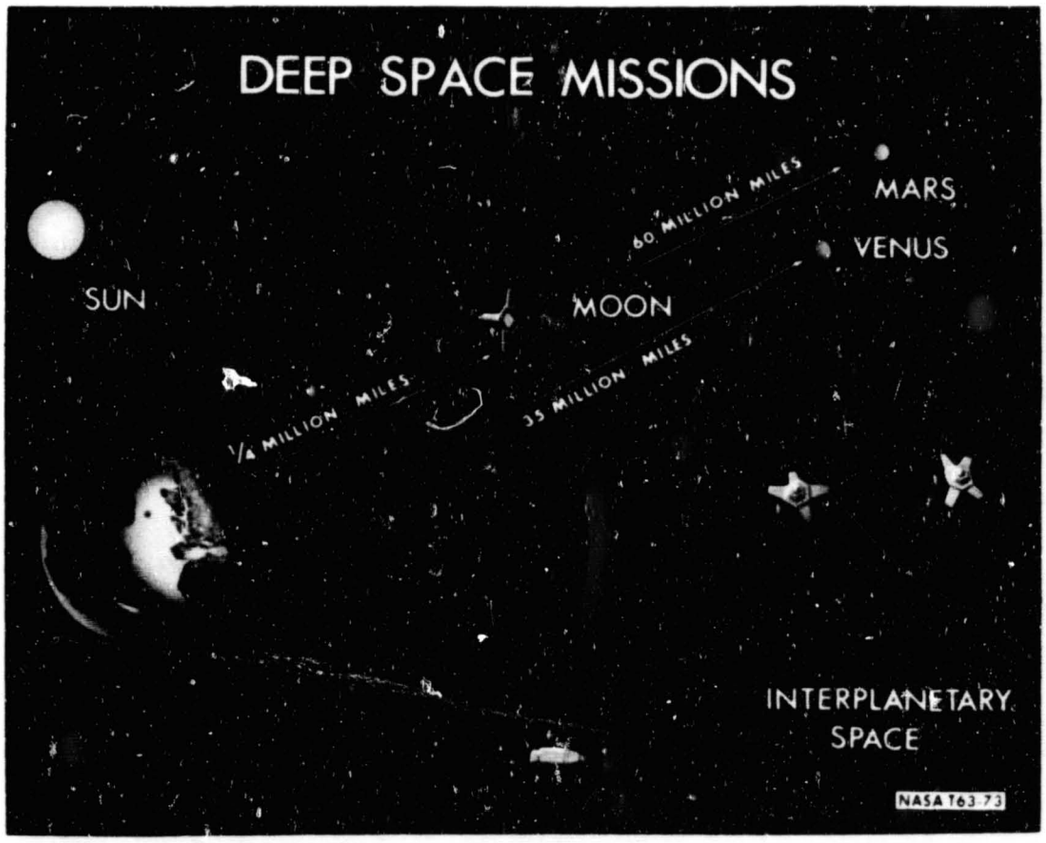

FIGURE 12a

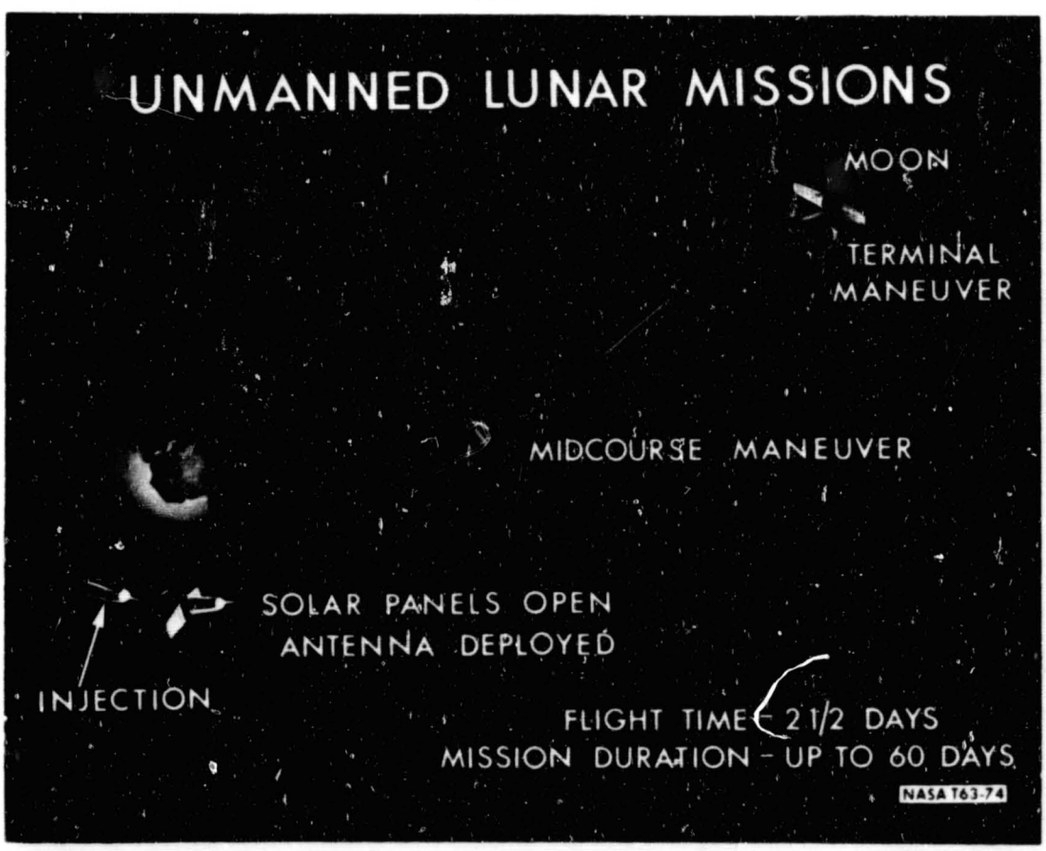

FIGURE 13a

Telemetering and tracking are vital at this phase of the flight. Finally, there is the desired impact on the Moon, with the telemetering being continued during and after landing, for perhaps as long as 60 days. The trip takes about 2½ days and as the flight progresses from the Earth to the Moon, the turning of the Earth requires that first one station and then another provide the desired tracking, telemetering reception, and command.

The field of view of the three stations established for tracking these deep-space probes is represented by figure 14a. The dots indicate our three deep-space tracking stations: one at Goldstone, Calif.; one near Johannesburg, South Africa; and one at Woomera, Australia. The inner circular areas show the range of visibility on objects which are 8,000 miles from the Earth, and the outer circular areas show the visibility pattern on objects at extreme distances. The paths of the Moon and the planets, as seen from the Earth, all fall between the parallel lines.

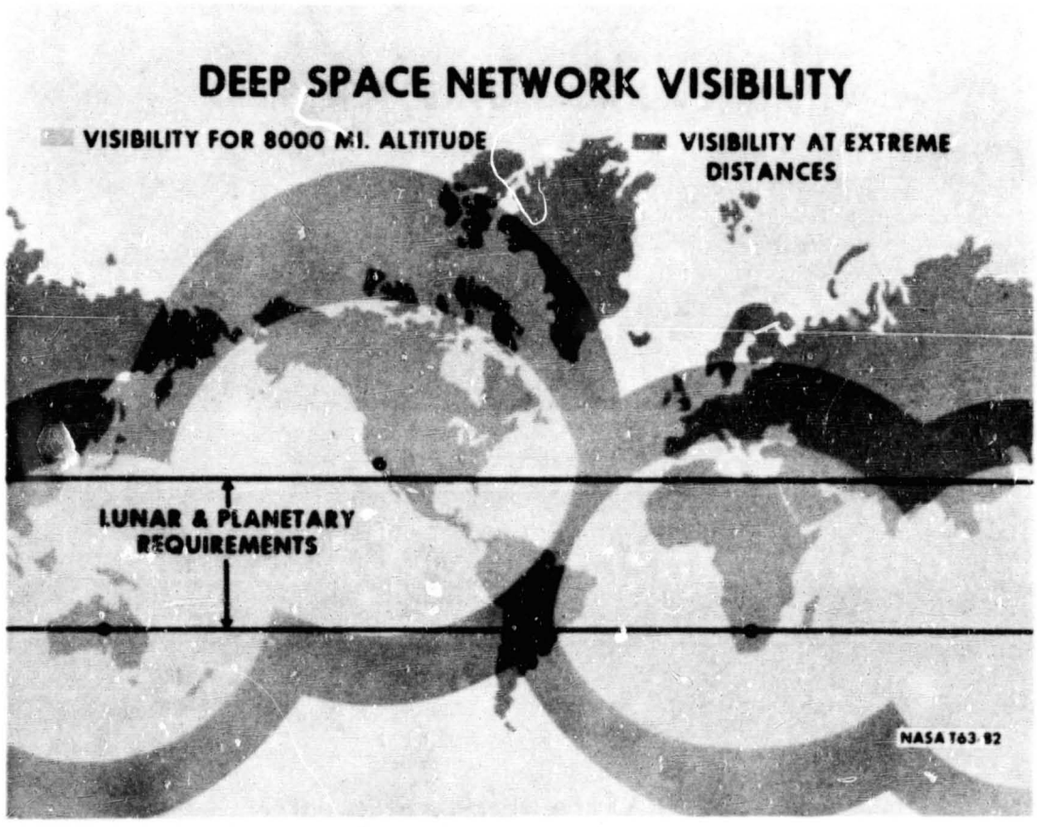

FIGURE 14a

You can see that by the time an outgoing spacecraft reaches 8,000 miles, it is in almost continuous view of one or another of the three stations as the Earth turns; shortly thereafter, and on to the Moon and beyond, the spacecraft is never out of sight of one of the three stations.

With figure 15a, I have endeavored to show the problems faced by the tracking and data acquisition facilities during a planetary mission such as the recent Mariner mission to Venus. Represented are paths of Venus and the Earth around the Sun. You will notice that Venus, orbiting at a faster speed than Earth, on the inside track so to speak, was behind Earth at the time of launch and, in effect, passed the Earth and was ahead of it by December.

The launching took place on the 27th of August and the Mariner spacecraft was first placed in a "parking orbit" around the Earth, pictorially represented on the chart. Further burning of rockets at the correct time speeded up the vehicle and injected the spacecraft into its long trip to Venus.

Now, as I have previously mentioned in discussing the lunar missions, this injection into a trajectory to reach Venus is never expected to be perfect, and

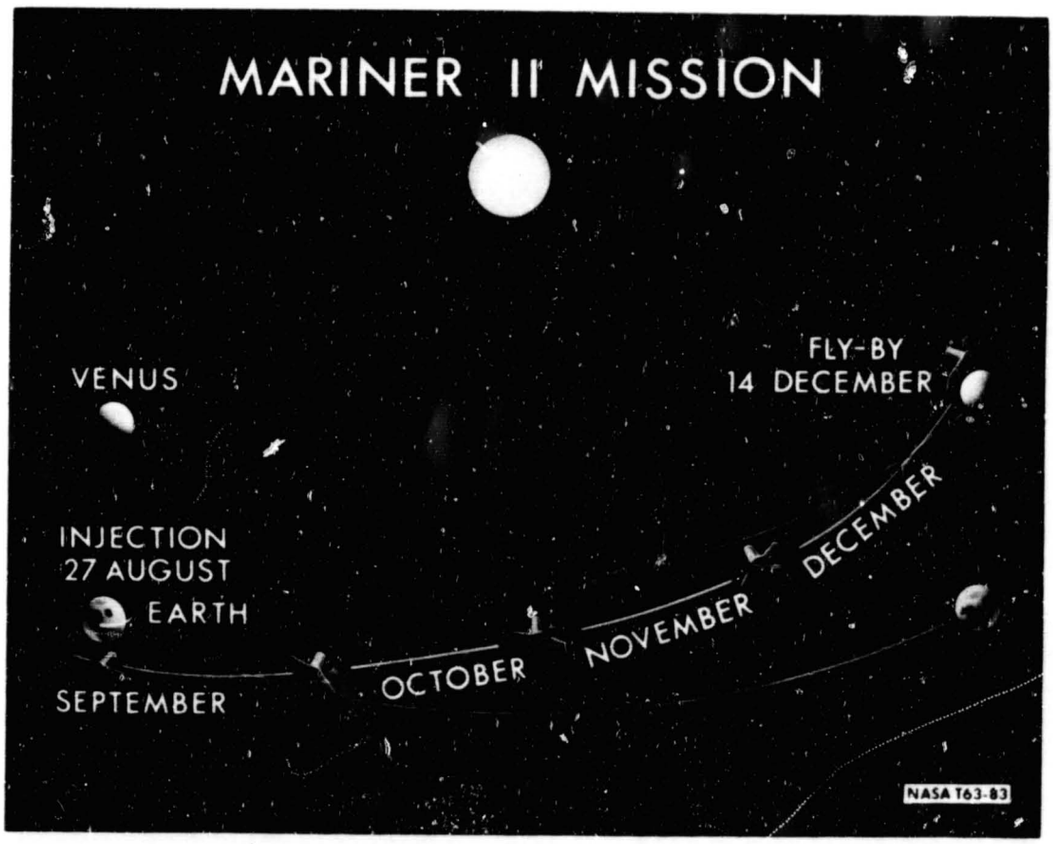

FIGURE 15a

we do in fact always plan to make a path correction after sufficient tracking has been performed to determine just what correction must be applied. In the case of Mariner II, tracking data during the first few days indicated that the spacecraft, if not corrected, would have passed by Venus at 233,000 miles. Therefore, necessary adjustments to the path were computed at Pasadena and on September 4, 8 days after launch, commands were transmitted from Goldstone to the spacecraft which directed it to orient itself in space and to fire its rocket motor for a few seconds so that the proper correction to the path was made. At this time the Mariner was nearly one and a half million miles from Earth. Mariner then continued on its flight through September, October, November, and into December. During this entire period, telemetered data was being received at the deep-space network stations, giving information on the condition and performance of the onboard equipment, and also on the environment, for example, the magnetic fields and charged particles along the path.

Finally, on December 14, Mariner made its closest approach to Venus, passing at a distance of 21,500 miles from the planet. Again, commands transmitted from Earth directed the spacecraft to turn on instruments which would scan Venus to learn something of its temperature, the composition of its atmosphere, and other characteristics. The data obtained from these instruments was continuously transmitted back to Earth. Mariner was 36 million miles from Earth at this time; it took nearly 3½ minutes for the radio signals giving the commands transmitted from Goldstone to reach the spacecraft, and another 3½ minutes for radiotelemetered data to be returned to Earth—a rather nerve-racking period of 7 minutes before we knew whether the commands had actually been received and acted upon.

Up to this time, Mariner had traveled for 109 days, for a total distance of 180 million miles along its flight path. After passing Venus, it continued into orbit around the Sun. We lost contact with it 21 days later when it had reached a distance of 54 million miles from the Earth, and after having covered a total distance of 225 million miles of flight through space.

To receive a signal from a transmitter of only 3 watts at a distance of 54 million miles requires highly sensitive antennas and receivers, and also dictates that the

receiving station be situated in an area of extreme quiet from a radio point of view. Even at that, the amount of information that can be transmitted is low.

Figure 16a outlines our limitations and shows some of the steps we are taking. A large 85-foot parabolic antenna such as is used at our three stations is indicated at the left. With present equipment we can receive medium-quality television at one-quarter of a million miles, the distance to the Moon. This is roughly equivalent to 1,000 telephone circuits; but at 36 million miles, the distance to Venus during the recent flyby, we can receive only about one-twentieth of the information that can be carried by a telephone circuit.

Given the same spacecraft system power, the information rate from Venus is about one twenty-thousandth of the rate from the Moon. We therefore plan some improvements, indicated at the bottom right of the chart. We will, beginning in 1964, convert our deep-space net and the lunar and planetary spacecraft communications systems to the higher frequency S-band operation which is in the 2,200 megacycle region. Since these parabolic antennas focus energy more efficiently at this region of the spectrum, we will improve the gain of the system by a factor of 5.6. By using more sensitive amplifiers, known as masers, we will

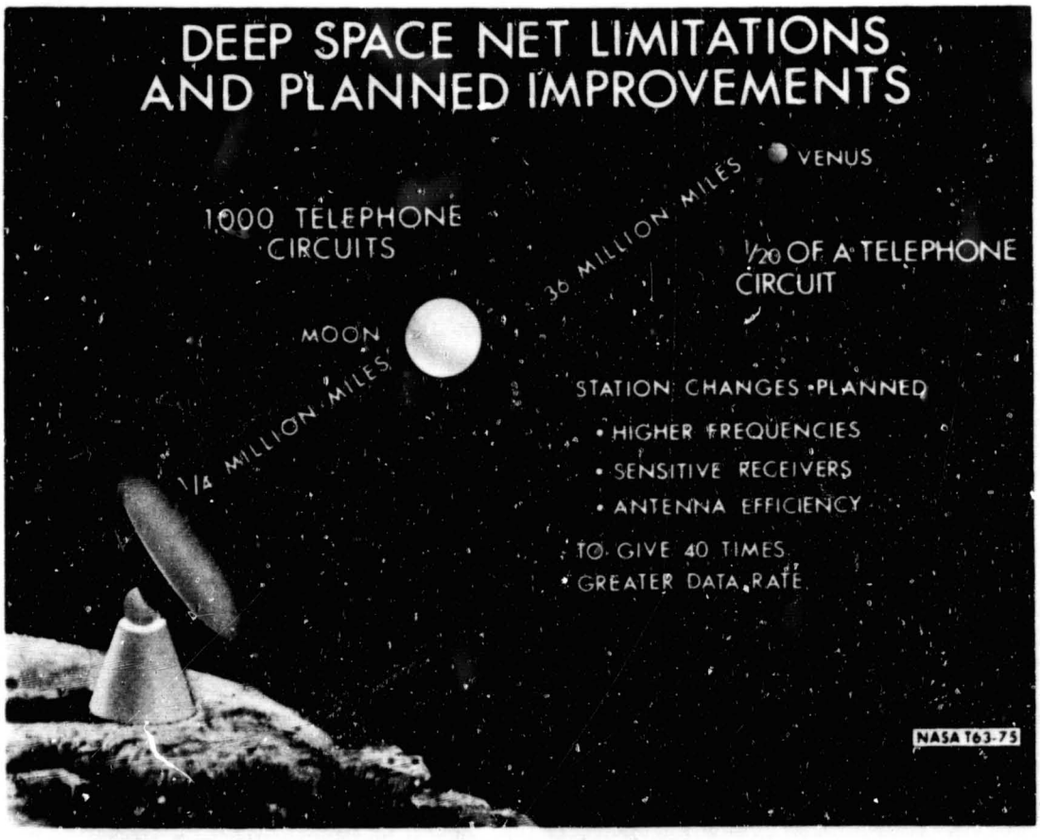

FIGURE 16a

improve by another factor of 5; and by further improvements in the efficiency of the antenna systems, we will get another factor of 1.4. The resulting improvement is the product of these individual factors and therefore gives a total improvement of 40.

All of our deep space programs will benefit from these improvements, including Apollo, and missions to Venus and interplanetary probes such as the forthcoming Pioneer series for investigations related to the International Quiet Sun Year.

Another essential improvement which will benefit the unmanned lunar and planetary programs is a replacement spacecraft prelaunch checkout station in the launch area. This is depicted here in figure 17a. The spacecraft for these missions are growing increasingly more complex. This will be particularly true in the case of lunar and planetary orbiters and landers, which will be called upon to perform a wide variety of complicated observation and measurement functions.

FIGURE 17a

The operation and performance of this on-board equipment must be monitored during an extensive prelaunch checkout, through exactly the same type of r-f communication and telemetry systems which are to be used when the spacecraft is on its way through space. This is the function of this launch-area checkout station. This station will have deep-space-network-type instrumentation, together with adequate display consoles to present information for quick analysis and evaluation by the project director in making the final "Go No-Go" decision prior to launch.

This station will be fitted with a small parabolic antenna which will maintain a two-way link with the spacecraft during the prelaunch checkouts, and also after launch until the spacecraft disappears over the horizon. Now I wish to point out that this station is only for the spacecraft project-peculiar requirements. The launch vehicle tracking and telemetry will continue to be provided by the general-purpose instrumentation stations of the Atlantic Missile Range.

A limited capability for prelaunch checkout is now being provided at Cape Canaveral by a temporary instrumentation setup, installed in trailers, and operating in the 960 megacycle, or L-band, region of the radio spectrum. As I have just mentioned, one of the improvements we have planned for the 1964 and later period is to put the deep-space network on S-band. This new station will be configured for this higher frequency operation and will also be installed in permanent quarters at Cape Canaveral.

This station, together with the new equipment for our other stations, represents our plans to meet the needs of the deep space exploration program.

MANNED FLIGHT SUPPORT

Starting with figure 18a, I will proceed with a discussion of manned space flights, beginning with the three-orbit Mercury mission. The network facilities in the case of manned flight, because the safety of the man is strongly emphasized, vary considerably from the approach used for the scientific satellites and from the approach for the unmanned lunar and planetary missions.

In the first place, we plan for extreme reliability, using backup facilities where necessary. We use stations fairly closely spaced along the orbit as our goal is to talk for approximately 5 minutes out of every 15 with the astronaut and to receive

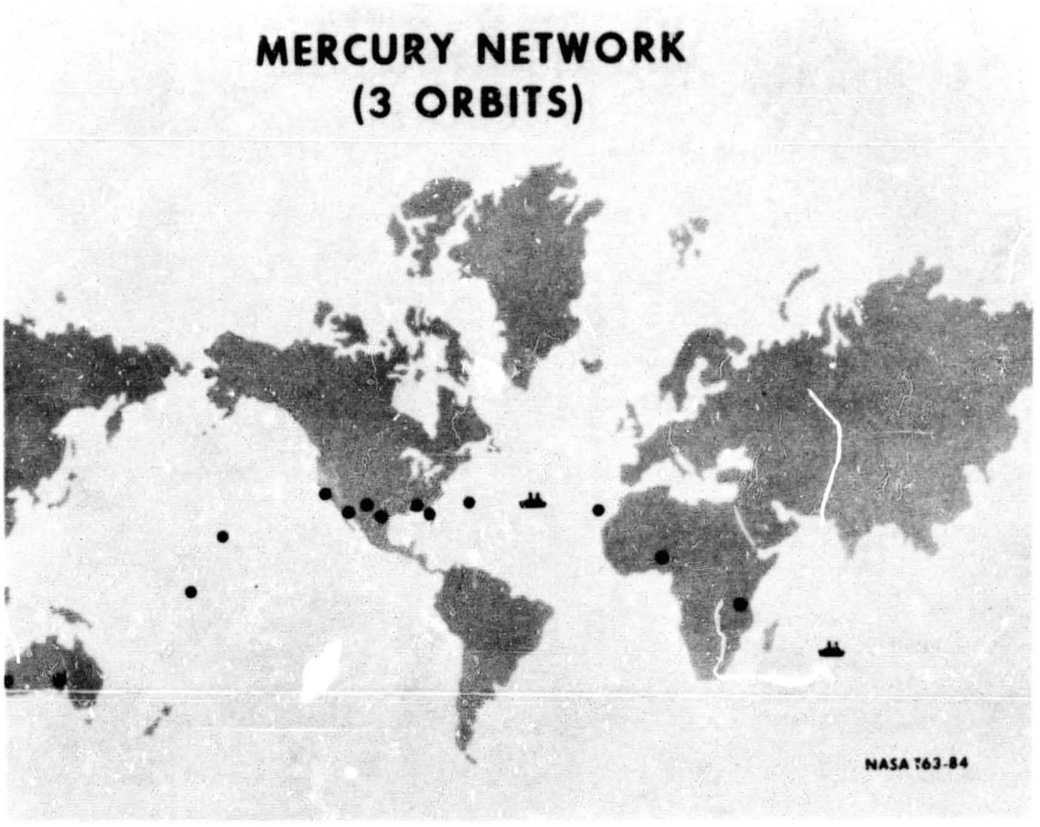

FIGURE 18a

telemetering signals on his condition and the condition of the various systems in the capsule for the same percentage of time. We tie all stations back to the network control center and the mission control center by special communications circuits which bring the data back for immediate calculations at Goddard Space Flight Center and for subsequent evaluation and such decisions as may be needed.

The chart shows the location of the 16 stations. As you can see, we made use of two islands plus one ship in the Atlantic, a ship in the Indian Ocean, and two islands in the Pacific along with the stations in North America, Africa, and Australia. The stations had to be located under the flight path as their visibility allows coverage of only a radius of several hundred miles at the altitude of the Mercury orbit. A wider geographic deployment of the stations was not required because in the time from launch until the end of the third orbit, the earth rotates only 45°.

I believe the soundness of our approach to the ground-support problem for Mercury is appreciated, our repeated support of the Mercury missions with no launching delay or major ground station problem during the orbiting periods constituting a most successful record. This I mention because, as we go to planning for later phases of the manned space flight program, we build on the successful Mercury network and we use the same philosophy and procedures to insure reliability and proper operation.

Progressing to the six-orbit mission as shown in figure 19a, which was, of course, the Schirra flight, it was decided we could get along with stations somewhat farther apart since we had had the previous experience of the three-orbit missions. Our studies indicated that by moving the Indian Ocean telemetering ship closer to South Africa, certain orbits were better covered. We also determined that moving the ship previously stationed in the Atlantic to a location northeast of the Philippines, would obtain the desired capability of receiving telemetering signals and, if necessary, transmitting commands to the capsule in the important area where the retrorockets were to fire to bring about reentry after the six-orbit mission. As you may remember, the tracking was of such quality that we were able to predict the time for retrofiring well enough so that landing was made very close to the recovery aircraft carrier. In fact, throughout

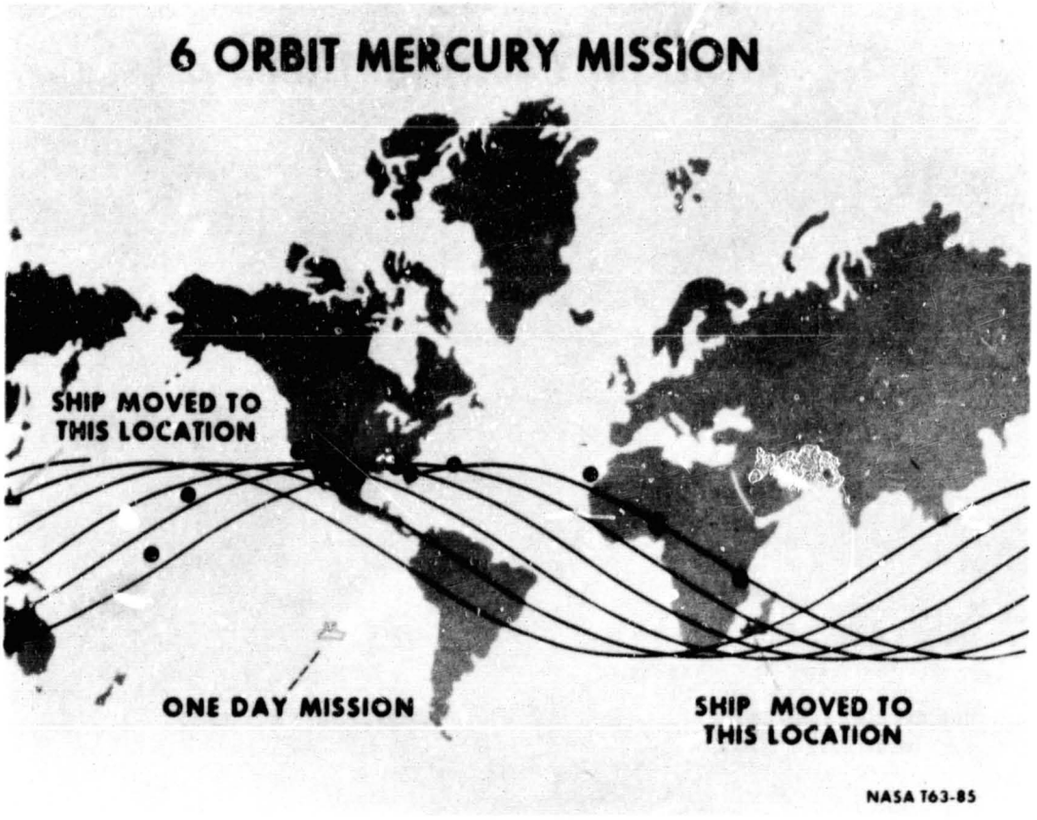

FIGURE 19a

the entire flight comparison of our predictions of the position of the capsule position in space, on a station-by-station basis, agreed with the actual measurements to better than 300 yards.

For the proposed 1-day mission, we have looked over the coverage, orbit by orbit, and have decided that we can get adequate coverage, even though less frequent than on the six-orbit mission, by moving the telemetering ship to a point near Easter Island in the southeast Pacific. The approximate new location is indicated on the chart.

I now would like to discuss the Gemini requirements, using figure 20a, Gemini, of course, being the manned space flight program which will follow Mercury. In this program, as you may recall from previous briefings, an Atlas-Agena will be launched first and a number of orbits later a Titan–II will be used to place the Gemini and its equipment section into orbit close to the Agena. After the Gemini spacecraft makes radar contact with the Agena target, rendezvous and docking will be accomplished by the Gemini astronauts using the onboard propulsion. The tracking and telemetering will be much like that already done for Mercury except in this case simultaneous tracking and data acquisition for two spacecraft must be accomplished. This buildup of the Mercury capabilities, we believe, is the surest and most economical way to satisfactorily support the Gemini requirements.

Figure 21a illustrates the augmentation that will be necessary for a typical Mercury site to provide tracking and data acquisition functions for Gemini. The additions shown by the emphasized areas on the chart include another antenna, more telemetering receivers for the extra telemetering required, equipment and high-speed data processing to allow more critical evaluation of what is going on in both spacecraft, additional equipment for sending commands to the vehicles, and finally, equipment to give the existing radars a target differentiation capability. Thus instrumented, an existing Mercury manned space flight station can perform the radar tracking, telemetry, and command, including the necessary voice communication circuits.

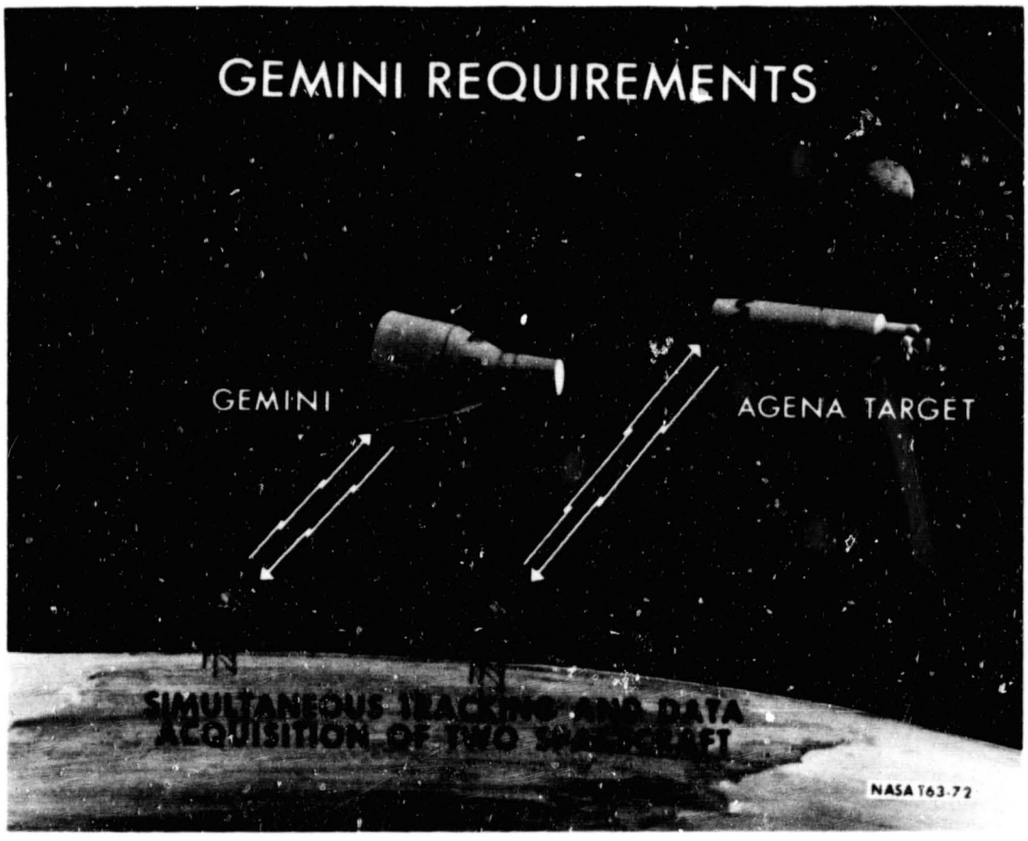

FIGURE 20a

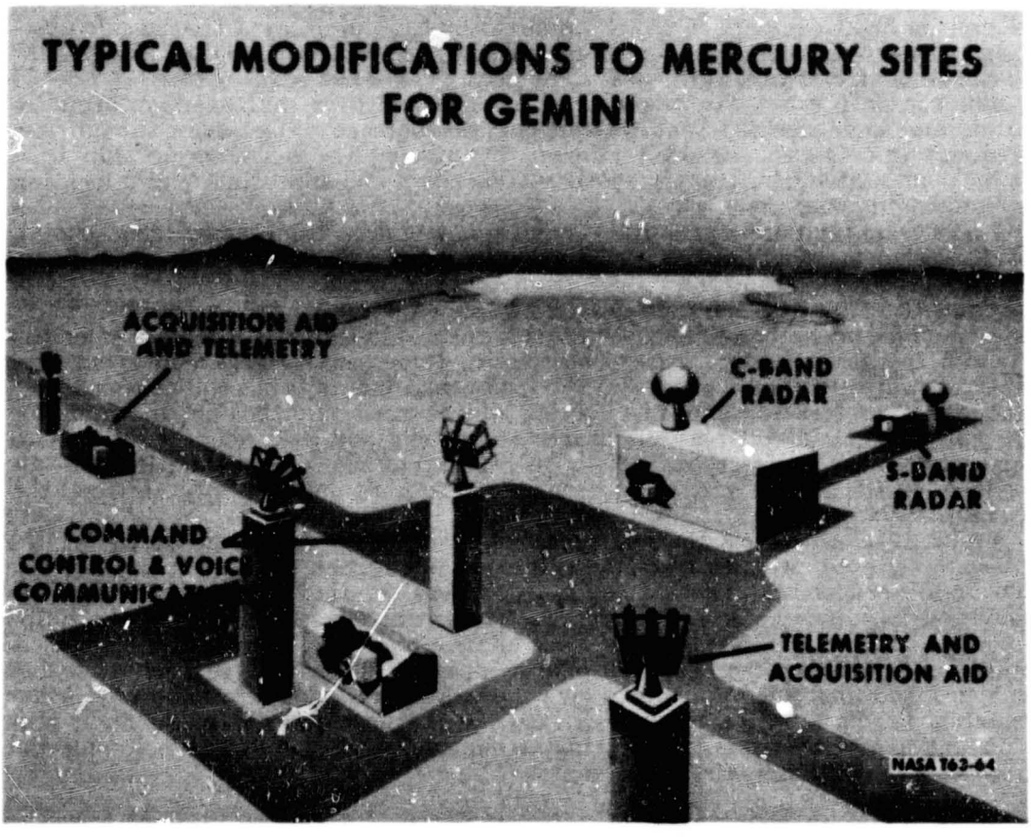

FIGURE 21a

Experience with the tracking and data acquisition for the Mercury missions, plus progress in data handling, has let us plan, as shown in figure 22a, primary Gemini support with much less than the 14 stations used for Mercury, and we have indicated by the filled-in circles and 1 ship that these are the 8 stations which will be augmented for Gemini. Open circles show the locations of existing NASA and DOD facilities which will be used for supplementary coverage of Gemini. These facilities require no augmentation. The station shown at the lower left is now at Carnarvon, Australia, rather than Muchea, for better orbital coverage.

The selection of the station locations and the phasing in of certain of the equipment has been done with careful forethought of the anticipated requirements for the various Apollo missions as will be discussed later. I would like to call your attention to the fact that the ships so far mentioned for the various Mercury missions and for the Gemini mission, as shown, provide telemetering reception, command control to the spacecraft, and communications by voice with the astronauts. They could also assist, if necessary, in abort and recovery, but have not been called on to provide tracking by radars and are not so equipped.

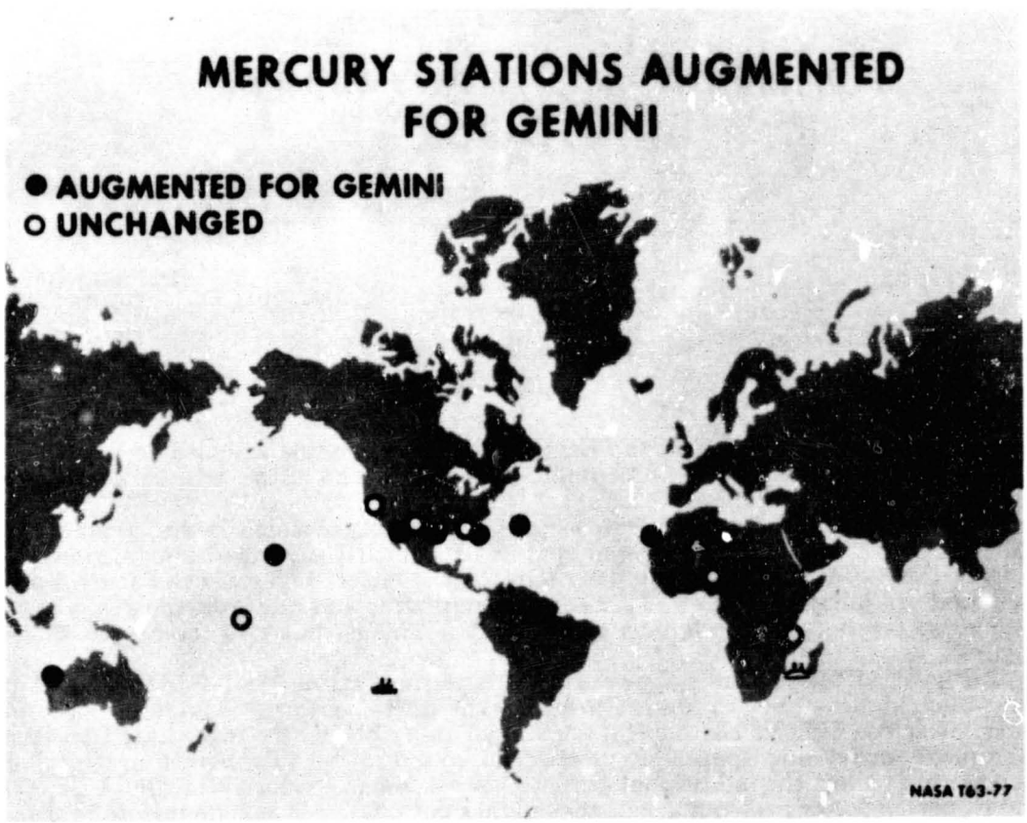

FIGURE 22a

Now, moving to Apollo support, figure 23a shows the Apollo spacecraft and the types of missions on which it will be flown. As you see in the lower right, the Apollo spacecraft will consist of three parts: the command module, the service module, and the lunar excursion module. The command module, along with a basic service module, will be flown in Earth orbits of 100 to 150 miles altitude and for periods up to 2 weeks. Later in the development program, the lunar excursion module will be added; this will be separated during flight and rendezvous and docking practice runs will be conducted. Finally, as shown at the upper right, the lunar missions, using all three modules, will be conducted. In these missions, the Apollo will go into an orbit around the Moon; the lunar excursion module carrying two astronauts will separate and descend to the Moon's surface, remain a day or two for exploration, and then launch to rendezvous with the mother ship orbiting the Moon. The lunar excursion module will then be jettisoned and the return flight to Earth made by the command and the

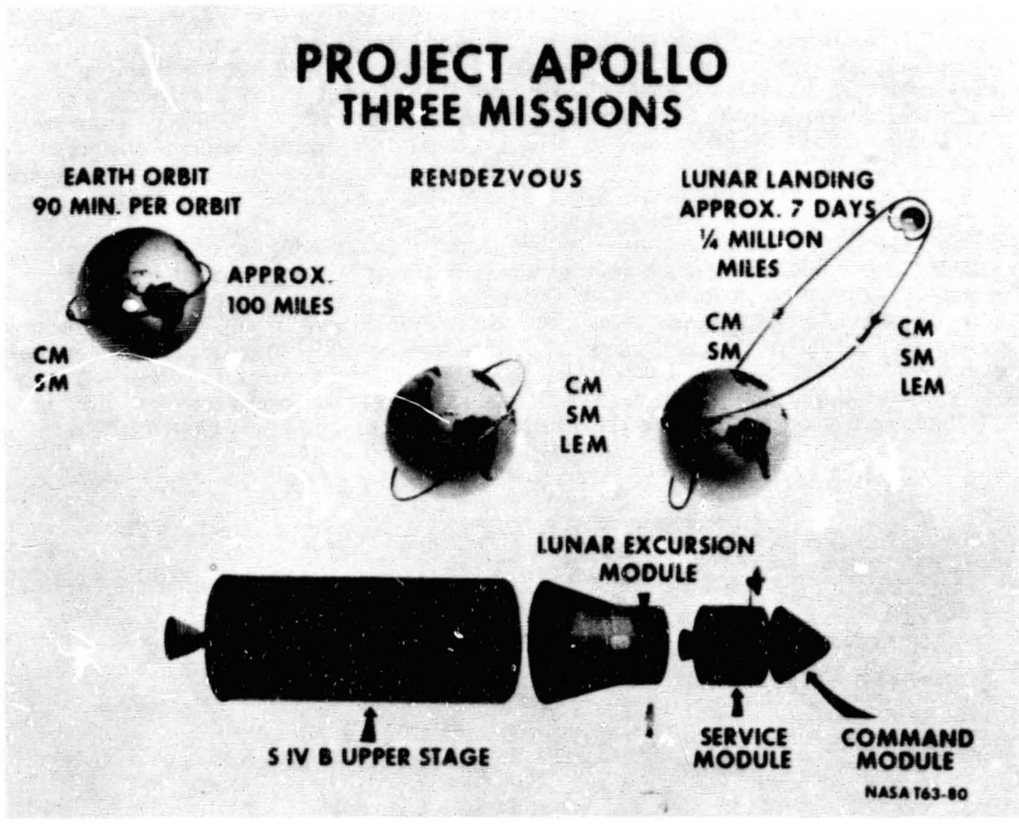

FIGURE 23a

service modules. When near the Earth, the service module will also be jettisoned and the landing made by the command module. The entire trip to the Moon and return will take about 7 days.

At the bottom of the chart you see the S–IVB stage, which is the upper stage of the Saturn rocket. The Apollo spacecraft, which I described above, rides on top of this S–IVB stage. Following launch, the lower stages of the Saturn burn out and are jettisoned; the S–IVB stage then ignites and develops the velocity to place, or insert, the Apollo into Earth orbit. This is shown in the center of the chart.

For a flight to the Moon, however, still additional thrust is needed to develop the much higher velocity required to escape the Earth's gravitational pull. Therefore, after coasting in Earth orbit for one of more orbits, during which time the complete rocket and spacecraft is checked out, the S–IVB engines are ignited again to develop this additional thrust. When escape velocity of about 25,000 miles per hour has been achieved, the engines cut off, the Apollo is injected into a trajectory to carry it to the Moon, and the S–IVB stage is jettisoned.

To provide the ground instrumentation support needed for these Apollo missions, we will make maximum use of the manned space flight network which will by that time have been equipped and used for Gemini. This network will, however, require some further augmentation for Apollo, as shown on figure 24a:

1. Instrumentation ships must be provided to perform tracking of certain critical near-Earth phases of the Apollo flight which will occur beyond sight of any land-based stations.
2. Special instrumentation at several of the network stations must be provided to perform an inorbit checkout of the S–IVB stage prior to the injection of Apollo into lunar flight.
3. Capability for tracking, data acquisition, and command at lunar distances must be provided in the network.

I will describe each of these areas of augmentation in more detail now, in sequence.

To understand the requirement for the tracking ships, we should first have a clear picture of the problem of placing a spacecraft into a trajectory to carry it to the Moon. You recall the flight sequence which I have just described in which

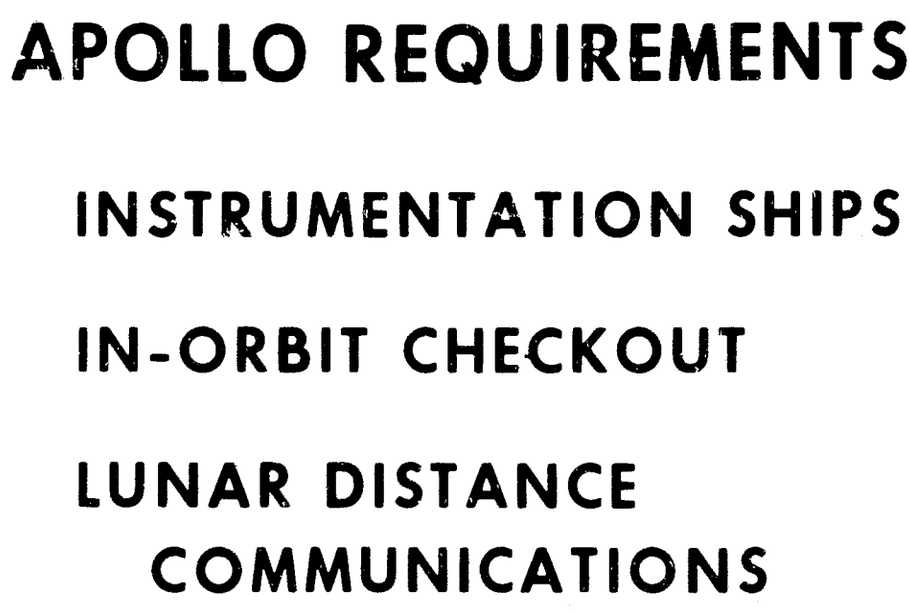

FIGURE 24a

the Apollo is first inserted into an Earth orbit; then after one or more orbits of the Earth, a second burning of the S–IVB engines injects the spacecraft into its flight to the Moon.

Now, this flight to the Moon must follow a certain trajectory. Since the Earth is rotating on its axis, and the Moon is revolving in orbit around the Earth, the specific points over the surface of the Earth at which insertion and injection into this trajectory can take place is determined by the time of day and the day of the month at which launching actually occurs. This necessitates, in turn, that the direction of launch, that is, the launch azimuth, from Cape Canaveral be selected as a function of time. In order to have a reasonable time, perhaps 3 to 4 hours, available during which launching can take place on any given day, a spread of launch azimuths, shown in the next figure (25a), as 73 to 106 degrees, must be used.

The insertion event occurs somewhere over a band approximately 1,800 miles from Cape Canaveral, running across this spread of launch azimuths. As you can see from the map, most of this band is beyond range of land-based radars, and therefore a tracking ship must be used to fill the gap, and will be positioned approximately as shown. Tracking of this phase of flight is essential, of course, because in case of any malfunction, immediate decisions on an abort path must be made based on tracking data obtained, and commands must then be transmitted immediately to the spacecraft. It is also important to obtain early tracking data on a successful mission to allow a description of the parking orbit. This in turn assists stations in the injection area to acquire the signals from the spacecraft as early as possible.

Similarly, the area in which injection into the lunar trajectory can occur will also spread across between the two extremes of the launch trajectories. This is illustrated in the next figure (26a), which shows a typical pattern which the injection area might take. The injection point moves east to west over the marked area as the Earth rotates; in the space of perhaps 3 hours, it will cover a span such as shown on this figure. This is too great a span for a single tracking ship to cover; two ships will be required. This area moves day by day in a north-south direction slowly enough so that the ships can be appropriately repositioned. However, the east-west movement is too rapid for a ship to follow. Now I want to emphasize again that this illustration shows only one of the possible injection patterns. This pattern may have to be broadened to reduce Apollo launch constraints.

Tracking coverage of this injection phase is essential to verify performance of the onboard guidance and computer system and to obtain data for immediate

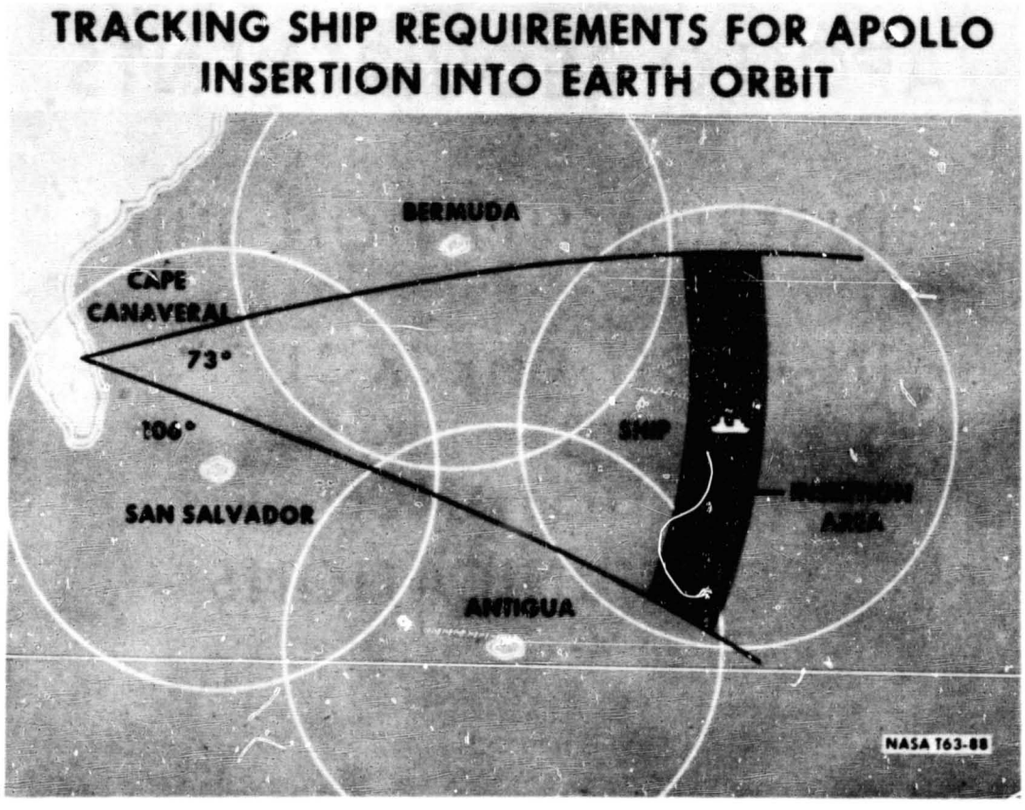

FIGURE 25a

FIGURE 26a

decisions and command transmission to the spacecraft in the event of a malfunction requiring an abort of the mission.

We cannot meet these minimum insertion and injection requirements, therefore, without at least three new instrumentation tracking ships. The procurement of these ships must begin this year because of the very long leadtime involved in modifying the ship hulls and in buying, installing, and checking out the highly specialized instrumentation required for the Apollo mission support.

Now the next requirement I mentioned for the Apollo ground network is shown by figure 27a. This is the need for an inorbit checkout of the S–IVB stage, as well as of the spacecraft, prior to the injection into the lunar trajectory. It should be remembered that this "injection," involving as it does the burning of the S–IVB engines to accelerate the Apollo spacecraft to a velocity sufficient to take it out of Earth orbit, is in many ways as complex an operation as launching a

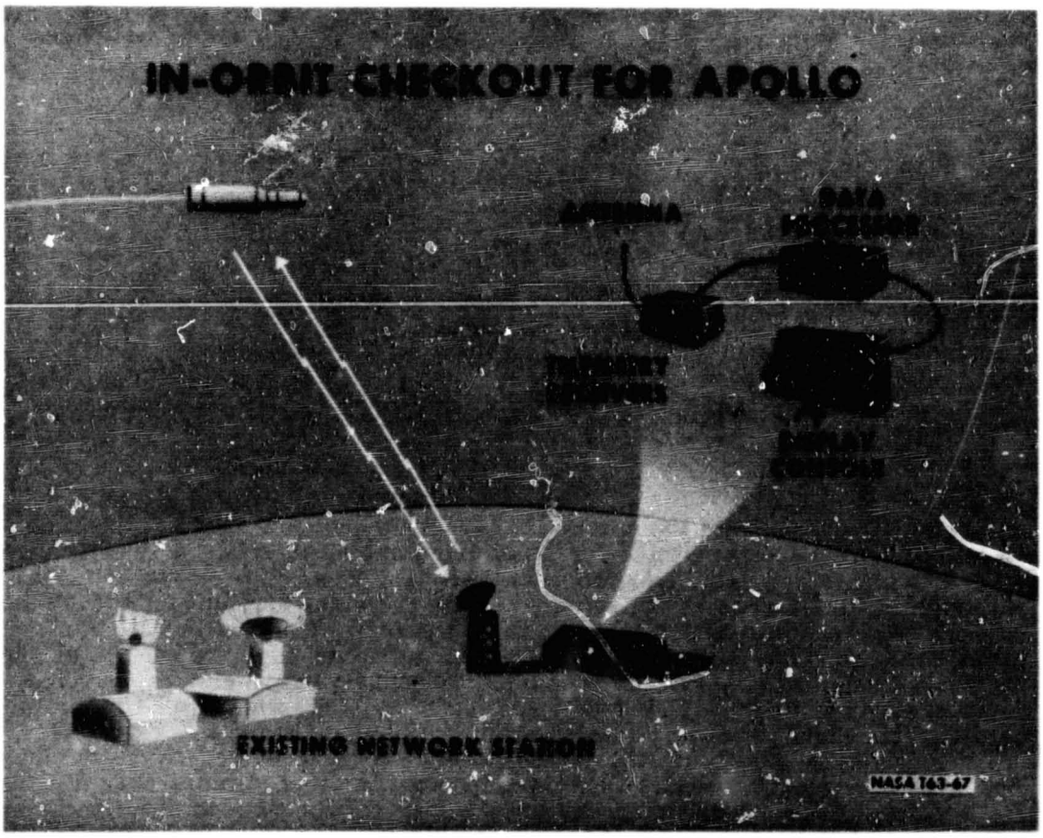

FIGURE 27a

major vehicle from the pad. Therefore, a launch-type countdown is, in fact, needed while the complete Apollo rocket still is orbiting the Earth.

The time for this countdown is limited; the job will have to be done quickly, automatically, and remotely. The information will be telemetered to selected stations in the network at which data processing and display equipment will be provided. The condition of all the critical elements of the rocket will thus be checked and evaluated before committing the Apollo to its lunar flight.

The third requirement, namely, the capability in the manned space flight net for tracking, data acquisition, and command at lunar distances, will be obtained by two more improvements and augmentations. The first of these is illustrated in the next figure (28a). As shown on the left, the present network for Mercury and the planned network for Gemini use three separate radio frequency links between the ground and the spacecraft for tracking, telemetry, and command. The telemetry and command links of these systems operate in a low frequency region, which is not suitable for communications to the spacecraft as it nears the Moon. To communicate effectively at these distances, we must first of all use larger diameter antennas, and secondly, use sufficiently high frequencies so that these

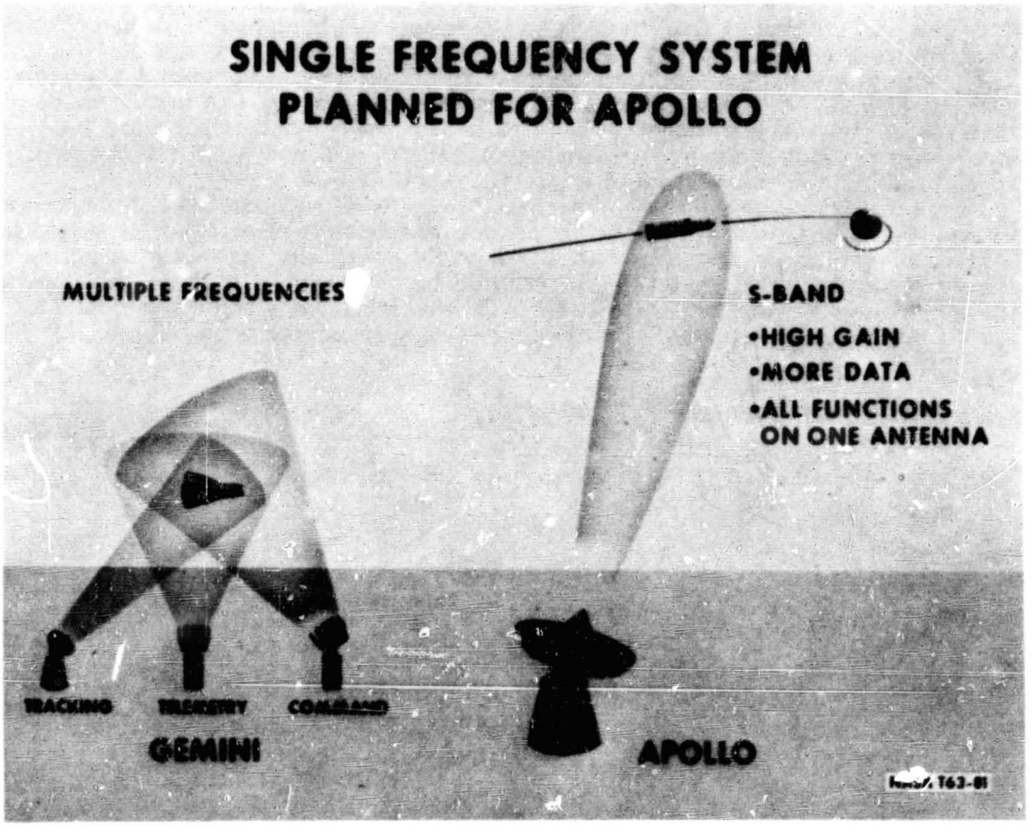

FIGURE 28a

antennas will concentrate the energy into a narrow, efficient beam. The operational radio frequencies selected for Apollo communications fall in the so-called S-band, which is the same band to be used by the deep space network in 1964. Although large antennas will be required at the three new stations for the Apollo network, the instrumentation for the rest of the network used when Apollo is in Earth orbit must be compatible. Therefore, our plans for all elements of the Apollo communications system—tracking, telemetry, command, and voice—envision a single frequency system operating at S-band, which will support all phases of the flight, whether in Earth orbit or at lunar distances.

The next figure (29a), illustrates the coverage to be provided by these three new large antennas, as well as that provided by the other stations covering the Earth orbital phase. The large antennas, which will be 85-foot dishes, will be more or less equally spaced in longitude around the Earth, as is done with the present deep space network stations. The final locations have not yet been selected; however, one will be in Australia, one at a southern European site, and one, of course, in the United States. In emergency, any one of these three stations will be backed up by the deep space network stations located in these same areas, since both the Apollo net and the deep space net will be operational on S-band frequencies.

For manned flight, then, we must provide for completing the Gemini instrumentation plan; we must modify and equip three ships; and we must install the S-band systems at our new and existing stations.

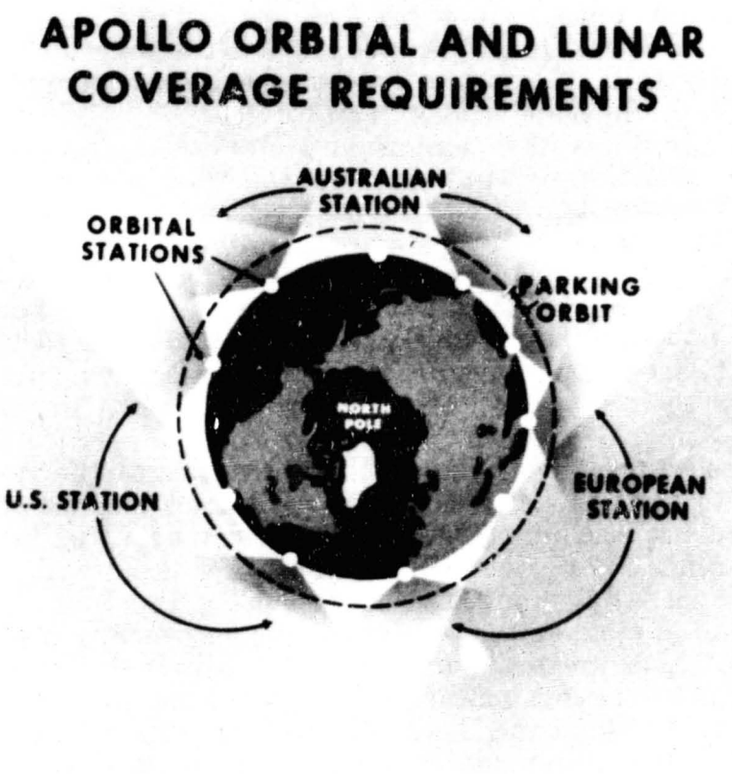

FIGURE 29a

CONCLUSION

This concludes my prepared presentation. I have described the basic support job that tracking and data acquisition provides to all the flight projects in NASA's space effort; I have shown you the way we deploy and use our existing resources; I have described the additional resources required to continue during that job.

I have pointed out the orderly, step-by-step nature of our plans. We are building equipment and facilities that will be flexible and adaptable and can be used for a long time; in fact, in our modifications and improvements to support new missions, we have been able to make excellent use of what we have previously provided and used at our network stations. This is not only an efficient approach, but also it very strongly supports our emphasis on achieving vitally important reliability through the use of tried and proven equipment and techniques.

Finally, I would like to emphasize the vital part that ground support plays in every space flight mission because, whether unmanned or manned, the success of the mission depends on our ability to communicate, to receive telemetered data, to track, and to command.

Mr. ROUSH. All right, Mr. Buckley, I am going to let Mr. Boone, our technical consultant, lead off here, and, of course, any other member of the committee might be interrupting with questions at any time.

Mr. Boone.

Mr. BOONE. Mr. Buckley, would you briefly state how your office locally fits in with the work being done at Goddard, say, or JPL or the launch center at Canaveral, what administrative control you have over those offices, particularly with reference to planning of what they do and how you fit into that picture.

Mr. BUCKLEY. To start at the beginning of the cycle, I guess, my office sends out a request for a budget call and asks them to come in with their idea of a proper budget and the program study that is associated with it. In that call we emphasize the changes in program or the changes in scope that we can foresee.

Each Center may have, and usually does have, supplementary information, in addition to what we have, but they respond to us with an estimated budget and after some negotiations, the program is agreed upon between the two groups.

After the budget is approved, there is an allocation decided on, again by program areas, that breaks down into what each Center is going to do with the various parts that we assign to them. They then start carrying out this program, reporting to us periodically, and we review their execution of the program through the course of the year.

We also watch the technical characteristics of the results of this program to be sure that it is on the right track. In the implementation phase, because our stations are in foreign countries, it is necessary that our office take a very active part in working with the Office of International Affairs and through them to the State Department. We have to take an active part in getting agreements with the foreign countries which are necessary for any additional stations or major changes in the stations or the programs they support.

Mr. BOONE. One thing I was trying to determine is do they establish their own requirements or do you meld these requirements with requirements of other NASA centers to be sure that you only have one tracking network, for example, for a specific job?

Mr. BUCKLEY. All of the tracking requirements go through my office; yes, sir, and we meld these together. In the course of planning a particular operation we immediately look at all of the NASA facilities and see what can be used because there is considerable cross use of the facilities for different purposes, cross use not only of the NASA facilities, but cross use of the DOD facilities as well. Incidentally, this is a bilateral thing because in the last year we supported some 12 DOD launchings with our network stations, and have requests on hand for some 5 right now; the other side of the coin is that we have firm requirements documents provided to the military ranges for some 105 future launchings, and, of those future launchings, there will be some 40 that will require the use of Department of Defense ships.

Now this indicates the crossflow between ourselves and DOD. However, we also use industrial capabilities, and illustrations of that would be the A.T. & T. antenna at Andover, Maine, the I.T. & T. station in Nutley, N.J.; RCA radars have been turned on for our shots and Lincoln radars have been turned on.

Finally there is use of foreign facilities, and one that you are familiar with would be the use of the large 250-foot radio telescope in Jodrell Bank, England, Dr. Lovell's equipment. There is also use of foreign equipment in connection with Project Mercury support in Australia, and use of foreign equipment in the communications program in England, France, Italy, and other countries that will be using their own equipment. This is where the equipment belonging to those countries is used in our programs.

Mr. BOONE. The primary function of your office then is to see that there is no unnecessary duplication, is that right?

Mr. BUCKLEY. That is right; yes, sir.

Mr. BOONE. Are you convinced that this is the case now?

Mr. BUCKLEY. Yes, sir.

Mr. BOONE. And that you are getting maximum utilization of military facilities that exist before going out and buying new facilities?

Mr. BUCKLEY. I think we are getting excellent utilization of the military facilities and there is a tremendous amount of effort that goes into insuring this. For example, there is a large catalog, a few inches thick, that is prepared jointly by ourselves and DOD that covers all NASA facilities and DOD facilities which might be available for such use. Actually, most of the people in my office and the ones doing work such as Goddard does on planning an operation are familiar enough, I think, with most of the DOD facilities so that they don't need this catalog, but this catalog exists so that it can be used in this cross-planning if need be.

Mr. BOONE. Are there other funds programed in the NASA budget for tracking and range facilities?

Mr. BUCKLEY. For what?

Mr. BOONE. Tracking facilities, instrumentation facilities. I don't mean construction, I mean electronic hardware that would normally be under your purview.

Mr. BUCKLEY. There will be, in some instances, project peculiar equipment such as the special equipment needed by Nimbus, perhaps, or Tiros, that goes at the station but is inherently part of a flight project, and that will be carried under the Nimbus or Tiros project. There will be local support activity, such as the support at White Sands which is directly tied to the day-by-day test, operation, and development going on at Houston, that will be carried separately, but the major networks and the worldwide systems are all carried under my office.

Mr. BOONE. Does this mean that Manned Space Flight tells you what they want you to obtain for them from the spacecraft and you take it from that point on, or do they tell you what equipment is needed, or do they buy their own equipment and then tell you what is needed?

Mr. BUCKLEY. No, the procedure is that the Manned Space Flight Center sends the requirements up through Mr. Holmes' headquarters here in Washington and over to me and down to Goddard. In other words, the requirements are generated by the Manned Spacecraft Center in Houston; they do not make the hardware decisions. On the other hand, they have concurrence in Goddard's or my office's decisions as to what hardware will be used, but they lay the requirements out rather than an exact statement of what hardware is to be used.

Mr. BOONE. Do you have any private contractors that assist you in determining what is needed; for example, advisers like Aerospace is to the Air Force?

Mr. BUCKLEY. We have used a number of contractors at times. In the course of the Mercury network planning and development, there were a number of contractors used in the planning, and I believe your question was in the planning area. Aeroneutronics was one, and Lincoln Laboratories was another. At the moment we have a study contract with Sperry, for instance, to study the Apollo trajectories and some interactions between them and the ground stations

and ships to determine exactly where the ships can provide assistance for different types of trajectories.

Mr. BOONE. Are there no funds in this budget request for this type of activity?

Mr. BUCKLEY. Such funds would be under the supporting research and technology area.

Mr. BOONE. They would not be funded in your budget?

Mr. BUCKLEY. They are in my budget. It is one of the three areas I mentioned.

Mr. BOONE. I see.

Mr. BUCKLEY. This is the area that I said was $17 million total, about 5 percent of our budget.

Mr. ROUSH. Mr. Buckley, we are going to start taking this item by item, but considering the amount requested as a whole, in addition to this do you have other funds which have been, say, carried over from last year which are available to your office?

Mr. BUCKLEY. I would like to have Mr. Williamson discuss that area, please.

Mr. WILLIAMSON. The February 28 financial status of our fiscal 1963 program, our current and ongoing program, is about 44 percent obligated, which means written into the form of contracts, and approximately 70 percent, I think, committed.

A "commitment" in our term is a contract not yet signed by both parties. It is a procurement request that has flowed from the technical person at the Center through his financial office for certification of fund availability, is in the hands of his contracting officer, and is in the process of being either written up in procurement form as a purchase order or as a contract for negotiation or for bid. As of today we have fund availability that is not yet completely spent. We aren't at zero. We have another 3 months remaining and about 3 months worth of funds.

Mr. ROUSH. Well, at the end of these 3 months or the end of the fiscal year, have you in your planning considered any amounts that may have been planned or programed for 1963 for use in 1964?

Mr. WILLIAMSON. In terms of expenditures we always do this.

Mr. ROUSH. I am not asking you whether you always do it or not, I am asking you in this particular year whether or not in your budget for fiscal year 1964 you have funds which might be left over from fiscal year 1963.

Mr. WILLIAMSON. Yes.

Mr. ROUSH. And how much and where are they?

Mr. WILLIAMSON. They are in terms of the grand total of $231.5 million. That is the new obligational authority that we are requesting. The expenditure of that money—$231.5 million is the number that we are talking about. I am not dealing here with the salaries and operations of installations.

Mr. ROUSH. Well, isn't this the amount that you are asking for?

Mr. WILLIAMSON. Yes, sir; that is new obligational authority in 1964. The expenditure of that sum takes longer than 12 months. It takes 12 months to write contracts, but it takes the contract several years, in some cases up to 3 years to terminate, and for complete delivery of the equipment to be made and installed, and at that point you are really out of cash.

In other words, we plan on an obligational basis. We did not consider we would have very much unobligated funds at the end of the fiscal year.

Mr. ROUSH. I guess this is my question then: Considering unobligated funds for 1963——

Mr. WILLIAMSON. No; we don't expect to have very much.

Mr. ROUSH. Do you expect to have any?

Mr. WILLIAMSON. The problem here is that of procurement lead-time. History has shown that we have unobligated balances at the end of the year. I suspect that this year, with the upswing in our ability to use money effectively, it will be a very small percentage, indeed.

Mr. ROUSH. How much did you have in unobligated funds at the end of fiscal year 1962?

Mr. WILLIAMSON. I think it was $4.6 million, but I would have to check that for the record.

Mr. ROUSH. Well, is this an unusual amount or is this——

Mr. WILLIAMSON. Our history isn't that long, sir. I don't know whether it is unusual or not. It is a fair small percentage of the fiscal year 1962 program.

Mr. ROUSH. Are you prepared to tell us what happened to this $4.6 million?

Mr. WILLIAMSON. It was obligated in keeping with the program as laid out. This is essentially just a question of time. As you know, we don't actually receive our appropriation until considerably after the fiscal year has gone on, maybe 2 or 3 months, so we are forced, if you will, to take 12 months to spend 12 months' worth of money. This carries you into, say, 3 months of the next fiscal year. If the funds are made available at the beginning of the fiscal year, we consider our program to be based on a 12-month-obligation cycle.

Mr. ROUSH. Well, I think our concern here is that when we have as accurate a budget as possible, and if there are funds carried over to the next year and used the next year, if the same fund was carried over each year it wouldn't make any difference, but if at the end of this year you are not going to have any unobligated funds then apparently more money has gone into the program during 1963 than the Congress intended when they approved your budget. And what I was trying to get at was if there is money, where is it spent, are you reprograming this to other areas and, if so, how?

Mr. WILLIAMSON. We reprogram very little. As you can see by the structure of our budget, sir, a large area of it deals with operations. These are ongoing costs which we must pay—they represent contractors' salaries to a large extent, contract operators' salaries. It is a reasonably well estimable amount and it must be paid out across a time cycle.

As for equipment, the use of those funds is tied, as I said, to the obligation cycle, to our ability to contract effectively. Now contracts do slip; sometimes it takes longer to let a contract than we had planned. Occasionally we are able to let our contracts much more quickly than we had planned. These tend to balance themselves out. We don't buy things that we don't need.

Maybe this is not answering your question on reprograming, but we don't change the program here in tracking-and-data acquisition unless it is required by major changes in the flight program which we are supporting.

For example, if we had proposed to buy a certain piece of equipment in support of a certain satellite flight program at a certain time, and that flight program changed, I think we would be derelict in not reexamining the impact of that flight program change upon our planning. We are a reactive program office in that sense; we react to the flight programing, the flight schedule that we are supporting.

Mr. ROUSH. I believe Mr. Homes the other day suggested that the manned space flight program has—I don't belive he wanted to use the word "slipped," but I will use it, has slipped 6 months. Does your budgeting take this into account?

Mr. WILLIAMSON. Yes, sir; always.

Mr. ROUSH. How is this reflected here in your proposals?

Mr. WILLIAMSON. It is reflected in the timing of equipment procurement, for example. The contracts that we are in process of letting now for the Gemini support equipment, for the ground stations that will be prime for Gemini, are scaled, and therefore their costs are scaled, to the estimated flight date for that project.

These budget estimates go through perturbations, as you know, during the planning cycle and they reflect a point in time flight program position that we are supporting.

Mr. ROUSH. Let's just take this request of yours, item by item now, and I am sure that as we take it up item by item there will be other questions which are more directly related to the general line of questioning that I was attempting to propound at this time.

Mr. RUMSFELD. You don't want any questions at this time on the same subject he has been on?

Mr. ROUSH. I think perhaps as we get into it item by item your question might be more pertinent. If you have one, feel free to ask it, Mr. Rumsfeld.

Mr. RUMSFELD. Good. I would prefer to right now.

Mr. Williamson, what is your capacity? I don't believe——

Mr. WILLIAMSON. I am the Chief of Program Coordination in the Office of Tracking and Data Acquisition.

Mr. RUMSFELD. You used percentages. You said as of March 1——

Mr. WILLIAMSON. February 28.

Mr. RUMSFELD. February 28, you were approximately 44-percent obligated.

Mr. WILLIAMSON. Approximately.

Mr. RUMSFELD. Do you have the dollar amount on that?

Mr. WILLIAMSON. The recorded obligations as of February 28, 1963, were $60.7 million.

Mr. RUMSFELD. Is obligated?

Mr. WILLIAMSON. Is obligated.

Mr. RUMSFELD. Of our total?

Mr. WILLIAMSON. Of our total 1963 portion.

Mr. RUMSFELD. This means that as of a point where we have proceeded through 8 months out of a 12-month period, with 4 months left, you are 44-percent obligated?

Mr. WILLIAMSON. Yes, except if I may suggest, it is not really a 12-month period because the appropriation bill was not made available to NASA at the beginning of the fiscal year in its totality.

Mr. RUMSFELD. Well, it wouldn't have to be in its totality, just the portions you are going to use in the early portion of the year.

Mr. WILLIAMSON. Well, it is not so much the portions you are going to use, it is the authorization for the program that is being undertaken. You don't start into the procurement of new facilities or new equipment without an assurance that the program being supported has been authorized, so your planning actually has a slight hiatus in it until the final bill is available.

Mr. RUMSFELD. I see, and you say you are 70-percent committed. What dollar amount do you attach to the remaining 30 percent?

Mr. WILLIAMSON. It would be 30 percent of our total. I would have to multiply that out quickly.

Mr. RUMSFELD. Which total?

Mr. WILLIAMSON. The total for fiscal year 1963, which is $135.8 million.

Mr. RUMSFELD. That is your total minus personnel and operations?

Mr. WILLIAMSON. Yes, sir; personnel and operations obligated at an almost straight-line level.

Mr. RUMSFELD. Right. I see. So some $40 million roughly is not obligated or committed?

Mr. WILLIAMSON. Yes; that is correct.

Mr. ROUSH. On this point, let us refer to our backup book, on RDO23–1. This is in volume 2.

Taking the totals you were referring to, you referred to the total for 1963 of $135,824,000. Going over to 1963, the $67,302,000 figure, now what does this represent? Is this the amount that was budgeted for that year, is this the amount which was spent and committed that year, or just what is it, and would you tell us in each instance what this is?

Mr. WILLIAMSON. Yes, sir; the $67,204,000 is the program allocation to the Office of Tracking Data and Acquisition. The total of similar numbers throughout the volume here represents the total R.D. & O. appropriation for that year.

Mr. ROUSH. Then for 1962 this figure is not the amount that you spent or committed yourself to spend, is that correct?

Mr. WILLIAMSON. No, sir; this is the program allocation of today.

Mr. ROUSH. Do you have for 1962 the amount that you spent?

Mr. WILLIAMSON. I would have to check, but I believe it is all but $1.8 million of that.

Mr. ROUSH. We would like to have this and we would like to have it quite accurately, and I think in this connection we might say that we would like a more complete breakdown than the general breakdown we have here which we would be requesting from you a little later on anyhow, but we would like to have it for 1962, the estimate for 1963, on the amount that you spent or committed.

Mr. WILLIAMSON. Excuse me, you would like to know exactly how much we have obligated and committed of the $67 million fiscal year 1962 funds and what our plan is for 1963, what our estimate is?

Mr. ROUSH. Yes.

Mr. WILLIAMSON. As of February 28, 1963, the recorded obligations against the fiscal year 1962 program were $61.639 million and the commitments were $64.188 million. The estimated obligations against the fiscal year 1963 program are approximately $128 million and the estimated commitments are $135.8 million at the end of the fiscal year.

Mr. WILLIAMSON. Our plan is, of course, to use the $135.8 million.

Mr. ROUSH. Are there any other questions or comment on this particular item?

Mr. WYDLER. Yes, I would like to understand.

You show for 1962, $67 million here. Now on the summary we have $94,844,000 shown.

Mr. RUMSFELD. Subtract personnel and operation of installations.

Mr. WILLIAMSON. The summary being the President's budget, sir?

Mr. BOONE. No. May I explain that?

This is your last year's budget request, where you showed an estimated $94 million that you would spend in 1962, whereas in your 1964 request you show $67 million. Now the $67 million you said was obligated; is that correct?

Mr. WILLIAMSON. Mostly obligated.

Mr. BOONE. With the exception of $1.8 million. So it would appear that there is a difference of about $20-odd million here from last year's planning against this year's obligation, and I think that is the question he is asking.

Mr. WILLIAMSON. If I may say one thing. In last year's number the break of $67 million versus $83 million was not shown, referring again to page 23–1. The equivalent number is against $83.832 million. If you subtract out the personnel and operation of installation costs that were allocated in the fiscal 1962 column of the 1963 budget, you would come down to a number of $69,817,000.

In other words, the corresponding number last year that we estimated for fiscal 1962 was $69,817,000. This is the equivalent of the $67,302,000. The difference is $2,515,000 in the area of direct program costs.

Mr. DAVIS. I see, that goes back to what somebody said in the hearings last week, that none of these projects include personnel and operation costs and if you tack the personnel and operations costs onto it you get a figure almost the same as $84 million. If you remove personnel and operations costs it comes down to under $70 million.

Mr. BOONE. I think the problem was that the number is really $94 million and not $84 million.

Mr. DAVIS. I thought you said $84 million. The discrepancy then would be the difference between $94 and $83.8 million.

Mr. WILLIAMSON. Yes, of which the actual program difference is only $2.5 million. The remainder of $8.5 million is a personnel and operation of installations difference, and this is a question of the allocation of operations costs against programs.

Mr. RUMSFELD. In answer to Mr. Roush you commented that you nearly always have unobligated funds at the end of the year. Did you mean to say "unobligated" or "uncommitted"?

Mr. WILLIAMSON. No, unobligated. We seldom have uncommitted funds. This is the lag between the time a procurement request is initiated and the time it is actually turned into a contract. If it is turned into a contract after the end of the fiscal year it is carried over as a committed balance.

Mr. WYDLER. Do you have any 1961 funds that are unused?

Mr. WILLIAMSON. No, sir.

Mr. WYDLER. Every penny has been spent?

Mr. WILLIAMSON. Yes, sir.

Mr. ROUSH. Will the information which I requested that you submit clarify this matter for us?

Mr. WILLIAMSON. Yes, it will.

Mr. ROUSH. Let's take these items, item by item, commencing with the supporting research and technology, which is part of the summary and which is taken up more fully in volume 2, RD023–2.

Mr. Buckley, do you have this broken down more for us than we see on this page?

Mr. BUCKLEY. We can furnish a breakdown, yes, sir.

Mr. ROUSH. I understood that you were requested to furnish a breakdown prior to today, is this true or not?

Mr. BUCKLEY. I didn't get a direct request on that.

Mr. BOONE. This is something we discussed earlier. I didn't ask him to submit it, Mr. Chairman, but I did ask him to come prepared to discuss it.

Mr. ROUSH. Can you break it down for us now, telling us what these various items include?

Mr. BUCKLEY. Yes, sir.

Mr. ROUSH. All right, let's do that, taking supporting research and technology, you go ahead and break it down and then later we would like to have this, of course, in a form that we can take with us, study, and understand.

Mr. BUCKLEY. Mr. Truszynski, can you go down through this?

Mr. TRUSZYNSKI. Yes, I think so.

Mr. RUMSFELD. Could we have your capacity?

Mr. TRUSZYNSKI. I am sorry, I am the Deputy Director of the Office of Tracking and Data Acquisition.

I think perhaps the first way to approach this would be to indicate how our program is broken down.

In our operation we, of course, have certain of the NASA Centers who are directly concerned with the major part of our work and these, as you know, are the Jet Propulsion Laboratory and the Goddard Space Flight Center, the primary Centers involved in the major part of our effort.

In addition to this, we have some tracking and data acquisition functions that are more generally project oriented at other Centers, namely the Marshall Space Flight Center and the Langley Research Center.

These represent the major centers that handle our part of the work, and this total of $17 million could be broken down in terms of $6 million at Goddard Space Flight Center in this area, $6 million at the Jet Propulsion Laboratory, $4 million at Marshall, and $1 million at Langley, as I recall.

This represents the break, then, of this total as it is distributed to these Centers.

Mr. DAVIS. Let me be clear on one point. Is that $17 million at the center, 23–2, the right-hand column there?

Mr. TRUSZYNSKI. Yes.

Mr. ROUSH. And you are breaking it down as to places it is being allocated to rather than as it is here, systems study, improvements in existing systems and new systems development?

Mr. TRUSZYNSKI. Yes.

Mr. BUCKLEY. He will get to the other part.

Mr. TRUSZYNSKI. I was doing this to indicate how or where this effort is actually carried out.

Now from a total standpoint basis this break, as we see, is divided into three major technical areas. In the area of integrated systems

study development and tests, this represents such study effort as determining better methods, for example, of orbit computation as we get into higher altitude satellites, satellites that are highly elliptical in nature, with range to thousands of miles apogee and hundreds of miles perigee. This represents a very eccentric orbit and the problems here are ones of the utilizing tracking information to rapidly determine an orbit of this nature.

The characteristics are such that a fewer number of tracking fixes are possible with a long-term orbit of this nature, so effort in this area is needed to determine methods of utilizing the tracking data or of indicating where deficiencies in our tracking coverage are in order to fill these deficiencies and more rapidly get an accurate orbit on these highly elliptical satellites.

Mr. ROUSH. Pardon me, but forgetting for a moment the purpose and intent of this expenditure or proposed expenditure, could you give us a further breakdown of this $2 million? How do you justify this request for $2 million, how was it justified to you and how do you justify it to the Congress? We should not just take a figure out of the air and say this is for a good purpose and accept it. We can't do that.

Mr. TRUSZYNSKI. There is a mechanism for this and it represents a rather detailed breakdown on a task basis for this technical area, whereby the centers actually submit a proposed task wherein supporting research and supporting technology is required.

It is on the basis of these task breakdowns that we, in turn, approve the validity of these against the total program as we see it, and it is the compilation of the pertinent task areas of this sort that we in turn submit as budget requests.

Mr. HECHLER. Well, specifically on this $2 million, could you explain a little bit more pointedly how this operates?

Mr. TRUSZYNSKI. I can give you typical examples of the type of task breakdowns that do come in. For example, we have here a "Trajectory and orbit determination analysis" area. We have a total of $600,000 throughout all of the centers that I mentioned for this area of effort. We have——

Mr. HECHLER. What is that used for?

Mr. TRUSZYNSKI. This is used in two ways. It is used in getting outside contractual study help in the area of computer programs to analyze the problem of orbit determination for things like highly elliptical satellite orbits. It is a study contract type of effort.

Other effort spent is similar study effort to determine the limitations of our tracking systems in this particular type of orbit determination effort. This is directly a problem of analyzing, let us say, our Minitrack system, the basic workhorse tracking system, to determine the deficiencies in this system for certain orbit determinations and in turn to point up what type of additional tracking accuracy is necessary to do the job. This in turn may result in defining an addition to the tracking system that will be required to do this job.

So it is this type of study effort that is required.

Mr. ROUSH. I would like to use this as an example and I would like to get to the specifics on these amounts again. How many requests on these amounts, for instance, came in from these task centers, do you recall them?

Mr. TRUSZYNSKI. Task areas.

Mr. ROUSH. How many came in on this particular item; do you know?

Mr. TRUSZYNSKI. I am not sure I can remember the actual number.

Mr. ROUSH. Do you remember the amount which they all totaled?

Mr. TRUSZYNSKI. Yes; I think in total from Goddard, let us say, where we have allocated $6 million, it was on the order of $10 million that was originally requested. This $10 million was negotiated to a total of $6 million. I don't recall the actual number of tasks.

Mr. ROUSH. Well, that makes no difference. Let's take this $2 million item that we have here. We would like to have that broken down

Mr. BUCKLEY. Mr. Chairman, there is in preparation and it was to be delivered today—we found a couple of corrections to make in it—a volume 5. You have four volumes and there is a fifth one that carries this $2 million and breaks it down further. It breaks the $2 million down, for instance, into four areas. The next item, which is the "Improvements to existing systems," it breaks down into roughly some 12 or 15 areas. Now this has been prepared and it will be over in the next few days. This is the next echelon of breakdown from the one in this book given on page 23–2.

Mr. ROUSH. I am sure we will be glad to see that. I am sure the other committee members wish we had that here today, because it will certainly be helpful in directing our questions to you, Mr. Buckley. You apparently——

Mr. BUCKLEY. This is the book that has that type of breakdown for the whole NASA program. It is not just the——

Mr. ROUSH. I understand that.

You apparently have this breakdown then for this $2 million figure, the four items?

Mr. TRUSZYNSKI. Yes.

Mr. ROUSH. Could you give us that now?

Mr. TRUSZYNSKI. Again the four major areas are: "Trajectory, orbit determination, and data requirements analysis," $600,000; an item of "Systems parametric studies" of $225,000; "Development systems test," $900,000; and "Conceptual system studies" for $275,000. These are the technical area breakdowns of this $2 million item.

Mr. ROUSH. Any questions on that particular item?

Mr. RYAN. I just wondered when you state that there are $600,000 for one study and $275,000 for another study, and $225,000 for another study, with what organization are these study contracts made, and what are the terms of the contracts?

Mr. TRUSZYNSKI. Well, if I may clarify one thing, these are not total contracts, but are groupings of much smaller tasks in each of these general categories. They are not individual contracts by themselves.

Mr. RYAN. Well, let's take the $600,000; can you break that down?

Mr. TRUSZYNSKI. I can give you two examples. We have a $38,000 effort in basic research and mathematical analysis to develop methods of treating the motions of highly elliptical satellites. This represents a specific study task on the order of $38,000.

Mr. RYAN. Who is undertaking that task?

Mr. TRUSZYNSKI. Beg pardon?

Mr. RYAN. Who is getting the $38,000?

Mr. TRUSZYNSKI. I am not sure which particular organization will get this one.

Mr. RYAN. I don't know about the other members of the committee but I think it would be interesting to have a breakdown—and I don't think we should take the time to go over it necessarily item by item, but I think it would be interesting for the committee to know with what organizations these contracts have been entered into and also what goes into this $38,000, what you expect to achieve from it.

Mr. RUMSFELD. I would certainly concur in that.

Mr. TRUSZYNSKI. Again, this is the 1964 request and I was just explaining the method by which we proceed in this program area. We can give you similar information for the 1963 area.

Mr. BUCKLEY. Actually it can't be until after the budget is approved and given to the NASA that those particular tasks could be assigned out.

Mr. RYAN. But you are asking for money and you must have some expectation of what you are going to do with the money or else why are you here?

Mr. ROUSH. This, Mr. Buckley, I think is reflecting the attitude of the committee.

Now the general statements are fine. We have to have those things, but we are interested in the specifics. When we stand on the floor of the House and attempt to justify some of these figures and someone asks well, what are you going to spend $2 million on here for integrated systems study development tests, and Mr. Ryan here says, we are going to spend $38,000 on a certain program, they are going to want to know what this program is.

We have to be able to justify these things, and the intent of our probing here is to be able to justify them, and if we can't justify them and if you can't justify them to us, then of course we have to take a little more drastic action, but we have to be able to justify these, not generally, but I think we are required to do it as specifically as we can within the time that we have and within the limitations of mind and ability here.

Could you supply us a more detailed breakdown of these various items, taking into account the attitude you feel——

Mr. BUCKLEY. We can supply it. I think Mr. Truszynski can go down a list of the items that would be included in the $2 million.

Would you like to illustrate that?

Mr. DAVIS. Mr. Chairman, I have a question that I believe would appropriately come ahead of such a breakdown. What I would like to do is take a moment and ask you specifically about one task that you mentioned, and that was a mathematical study of a highly elliptical orbit.

You said in your judgment that your department, the National Aeronautics and Space Administration, needed the sum of $38,000 to finance such a study in fiscal 1964.

Now how do you arrive at the fact that you need $38,000 for that study, how do you know how long the study will take and how do you know that it won't take a longer or shorter time than that, and who decides that?

Mr. TRUSZYNSKI. This represents the estimate, in this particular case, of the Goddard Space Flight Center on a detailed task basis. They outline this specific item of effort and make an estimate of $38,000, which is primarily a certain number, or fraction of a number, of man-year effort with a particular study group or firm that has the capability of carrying out such an analysis.

Mr. DAVIS. Well, would I be correct in saying that only the people at Goddard would know why they thought $38,000 was a suitable sum for that task?

Mr. TRUSZYNSKI. We, in our capacity of overseeing this, also have to put some judgment on this number.

Mr. DAVIS. Well, can you compute an elliptical orbit yourself?

Mr. TRUSZYNSKI. Personally?

Mr. DAVIS. Yes.

Mr. TRUSZYNSKI. No, I would not be able to compute an elliptical orbit myself.

Mr. DAVIS. Would you know then how long it might take another man to compute one, who could compute it?

Mr. TRUSZYNSKI. I think on the basis of experience as to reasonable effort in this area, we could estimate this; yes.

Mr. DAVIS. Well, how long would it take a man to compute an orbit, say, with an apogee of 2,000 miles and a perigee of a hundred miles, and I guess you will need a given weight of a spacecraft, let's take a hundred pounds

Mr. TRUSZYNSKI. It is not a matter of——

Mr. DAVIS. I don't want you to pass judgment on my question, I just want you to answer it if you can.

Mr. BUCKLEY. Sir, this is not a question of how long it takes to compute the orbit; the problem here is to——

Mr. DAVIS. Again I say I don't wish you to evade my question, either you know or you don't know the answer to it.

Mr. BUCKLEY. Well, this is a study to find out how to do it or to do it better and——

Mr. DAVIS. Well, in my judgement it is a request for $38,000.

Mr. BUCKLEY. Not to compute an orbit but to find out how to do it better.

Mr. DAVIS. I am simply taking the testimony that came to me.

Mr. TRUSZYNSKI. It is not a matter of trying to evade a question at all, but it is the fact that this effort is not really spent in determining an orbit but is an analysis of the orbit determination method that is presently in use and determining its deficiencies.

Mr. BUCKLEY. Can I illustrate?

Mr. DAVIS. Let's go back to the question. Do you know whether $38,000 is an appropriate amount to do the task that you stated was to be done, which was to determine a highly elliptical orbit?

Mr. TRUSZYNSKI. Determine the deficiencies.

Mr. DAVIS. Deficiencies?

Mr. TRUSZYNSKI. Deficiencies in the system of determining such an orbit, sir, using a given tracking system.

Mr. DAVIS. Do you mean that the task is not to determine the orbit but to examine the methods of determining orbits?

Mr. TRUSZYNSKI. Yes, I am sorry if I didn't make that clear at first.

Mr. DAVIS. Well, let's take that amendment then to the answer. How do you know that $38,000 is an appropriate sum for an examination of the methods, the various methods of determining orbits? How do you arrive at the judgment that $38,000 is an appropriate sum of money?

Mr. TRUSZYNSKI. This is a judgment based upon a knowledge of what can be done with a computer for systems analysis, the deter-

mining of the competence of a particular person in this area, and estimating the length of time in which he should be able to decide a problem of this kind. It is a combination of these types of factors.

Mr. ROUSH. Would the gentleman yield?

Mr. DAVIS. Yes, I will yield.

Mr. ROUSH. In this particular instance did you accept the word of a man you considered to be an expert, that this amount of money was needed for this study?

Mr. TRUSZYNSKI. In this particular instance yes, this was the case.

Mr. ROUSH. Do you recall who the individual was?

Mr. TRUSZYNSKI. This would be Dr. Siry at our Goddard Space Flight Center.

Mr. HECHLER. Did he tell you how many people would be involved in this study?

Mr. TRUSZYNSKI. Yes, there is a number for the actual number of man-years there, or fraction thereof, in this particular task.

Mr. HECHLER. And that recommendation seemed reasonable to you?

Mr. TRUSZYNSKI. Yes, it did, in this instance.

Mr. DAVIS. Wouldn't it be more accurate to say that the man was a credible person? You would have to have an esoteric knowledge of the judgment process to know whether the judgment was reasonable or not.

Mr. TRUSZYNSKI. Yes.

Mr. DAVIS. And it is largely a matter of faith or credibility or credulity, let us say, it is a matter of having a good man advising you, rather than being expert enough to know whether his recommendations are reasonable or not?

Mr. TRUSZYNSKI. This is generally the case, yes.

Mr. DAVIS. That is what I was driving at a while ago. Actually, the people up the ladder in NASA, when it comes down to problems of expertise, problems that are known or confined to scientific or specialized engineering knowledge, you are nearly always having to proceed on faith, are you not?

Mr. TRUSZYNSKI. Well, I think that it is fair to say that there is a reasonable technical competence in the NASA headquarters for this very purpose, to attempt to properly judge, as you say.

Mr. DAVIS. Well, Dr. Siry would be one of those of technical competence. You would have to go to Goddard Space Flight Center in many instances to find somebody who could tell you whether $38,000 was a reasonable amount for this task, would you not?

Mr. TRUSZYNSKI. In a task area like this, yes, I think it is fair to say we would accept Dr. Siry's basic judgment and analysis.

Mr. WYDLER. Did you do that?

Mr. TRUSZYNSKI. Yes, this was done in this case.

Mr. HECHLER. Was this done in all of the other cases of the $2 million?

Mr. TRUSZYNSKI. Every task order was reviewed with specific people at the Centers in terms of an analysis of why it was necessary, whether or not it was a reasonable effort, and whether the funding was reasonable. Every task request was reviewed with people such as Dr. Siry at the Center.

Mr. HECHLER. Does the $2 million represent the total amount of the requests, or were there requests for anything more than $2 million?

Mr. TRUSZYNSKI. I am not sure of the percentage breakdown in this area, but on a total basis at Goddard, it was a difference between an amount of $6 million and a requested amount on the order of $10 million. This represents what I call the negotiation in this area.

Mr. DAVIS. I don't wish to belabor my point, Mr. Chairman, but I would simply note that I have listened to as high as 2 hours of debate in the House on whether or not $20,000 was a reasonable amount for painting a garage in the House Office Building.

I simply say that to point up that one need not apologize for belaboring the explanation of a $38,000 expenditure in the subcommittee. But I say what reasons are there for determining whether the methods of computing these orbits needs to be reexamined, what is the fault with the way they compute them at the present time?

Mr. TRUSZYNSKI. This comes about primarily because of the different missions that we are faced with. These highly elliptical orbits are ones that we generally have not been handling in the past, and the existing orbit computation programs are geared to a different class of satellite missions. It is a program change that requires a specific investigation of the capability of the present computer programs to properly compute a rather different orbit than has been handled to date.

Mr. DAVIS. You mean a very elliptical orbit will have task force involved that have not been present in the other orbits that we have been dealing with?

Mr. TRUSZYNSKI. Yes, sir.

Mr. DAVIS. I believe that is all, Mr. Chairman.

Mr. ROUSH. Before we go any further, I want to acknowledge the presence of our full committee chairman, Mr. Miller, and say that we are very glad that Mr. Miller can be with us at this time.

Chairman MILLER. Thank you.

Mr. ROUSH. Would you care to say anything, Mr. Chairman?

Chairman MILLER. No questions.

Mr. ROUSH. Mr. Ryan.

Mr. RYAN. Along this line, in the expenditure of the $38,000 or other similar items, who conducts the study, someone who is hired by NASA and employed by NASA, or is this farmed out to a university, or who gets the $38,000?

Mr. BUCKLEY. May I speak to that point, Mr. Ryan, because I can go back and illustrate it.

As we went into the Project Mercury, here was a case where we didn't know exactly how to compute its orbit. It had never been done with the quality we needed for Mercury. As the man in orbit got to Bermuda, there was the crucial decision to be taken to continue, or to terminate the decisions because if it wasn't done at Bermuda he would come down in Africa. There was also the problem of reentry; there were two or three unknown details about the atmospheric density that would affect his reentry. We first went to Aeroneutronics, Inc., a very large corporation, a subsidiary of Ford on the west coast, who made some studies about how the calculations of Mercury should be done. Subsequently we had Lincoln Laboratory in on this problem and, of course finally IBM was in, not only to pick up the knowledge provided by Aeroneutronics and Lincoln, but also to carry out the details of the programing of the computers, and the details of how it was to be done.

This is a smaller problem, we think, but this is another case where we are going into types of orbits that we haven't handled before. We have had some trouble in the past, in the computation of an elliptical orbit. It took, not long ago, 8 hours; we would like to do it faster than that. The instrumentation we use for other types of orbits is not very good for an elliptical orbit because the vehicle gets way out in the sky and seems to stand still and then comes in and moves apparently across the earth very fast. A combination of instrumentation and an analysis of how to handle the data from that instrumentation is needed. We don't know all that we should at the moment, and so we have decided that we ought to get into this study of how to compute an elliptical orbit better.

Now there is one interesting thing Mr. Truszynski did not mention. Dr. Siry, the man that made the specific recommendation, recently had a group meet with representatives from his parallel position in all of the other Centers, that is, from JPL and Ames, Cleveland, Marshall, Manned Spacecraft Center down in Houston, and so forth, and the various special problems that each group might have in the way of computation was discussed. So Dr. Siry not only has his own experience available when he makes a recommendation like this, but he also has a sort of review board, a committee from the parallel people in all of the other Centers.

Mr. ROUSH. Mr. Truszynski, I believe you were prepared to break these items down for us in detail, is that correct, beginning with the $2 million item, continuing with the $11,500,000 item, and then the $3,500,000 item?

Mr. TRUSZYNSKI. We were prepared to give you representative tasks in this area this morning, yes.

Mr. ROUSH. All right, would you do that?

Mr. WYDLER. Mr. Buckley, I don't think I got your answer to Congressman Ryan's question. He asked who was going to get the $38,000. Who is going to get it?

Mr. BUCKLEY. I don't think we know now. The awarding of this would be some several months from now, and in the meantime we will be looking around to see if anybody has had experience in this, and if so they would probably be the ones that would get to bid on the contract.

Mr. WYDLER. In other words, this request for the $38,000 does not carry a place or a person who is going to do this actual work, as I understand it?

Mr. BUCKLEY. No, sir; and among the possible choices of where it could go would be not only several industrial firms but there are places like Lincoln Laboratory, Yale University, and the University of Cincinnati that are continually investigating the problem of how to make better computations. This stems, incidentally, from the presence at such places of astronomers who have some background in these kinds of computations.

Mr. ROUSH. Have you ever considered asking them to do it for nothing as part of their own research program in the university?

Mr. BUCKLEY. I think that we have had considerable free help at times. I think if we went in and asked somebody to do it I don't think we would ask them to do it for nothing because there is quite a bit of effort, especially for a university. This is quite an effort for a university group to undertake.

Mr. ROUSH. Mr. Rumsfeld.

Mr. RUMSFELD. Yes, Mr. Chairman. Do you intend to request an oral breakdown for each item in this budget? I understood from your previous questioning that we might look forward to receiving a breakdown that had some detail to it rather than simply categories of large amounts of money, and it seemed to me that it might be well to ask some of our general questions in the remaining time this morning and await the presentation of the detailed breakdown.

Mr. ROUSH. It was my understanding that it might be several days before we would get the detailed breakdown that Mr. Buckley referred to, and if we could have a rather rapid oral breakdown, having this testimony in our hands, it would assist us in our deliberation tomorrow and any future date, because this other may be a while forthcoming.

If you have general questions in any of these areas, you are certainly free to interrupt and ask them at any time, but I did feel that we should have something in the record. If you would prefer——

Mr. RUMSFELD. It just strikes me that——

Mr. ROUSH. If it strikes the committee as the more logical thing to do, we might have him submit these items that he has at hand for the record in order that they would be available to us, and then we could proceed with the questioning in the remaining 40 minutes we have.

Mr. DAVIS. Mr. Chairman, to clarify that point just a little bit, I noticed a while ago, that one of the categories of money that we could expect to get in volume 5 of the backup book, for example, was "Conceptual studies," $275,000.

Is that a typical example of the entries that will be made in volume 5?

Mr. TRUSZYNSKI. I think that is correct, yes.

Mr. DAVIS. Then I think from that we still wouldn't hit rock bottom on what the money would be spent for; $275,000 for conceptual studies just doesn't tell you very much.

Mr. RYAN. It gives you a concept.

Mr. RUMSFELD. It just strikes me it is going to be very difficult for at least this one member of the committee to have a good feeling at the completion of these hearings as to how this money is going to be spent when it is lumped in such large pieces throughout the very sketchy presentation in this budget.

Mr. ROUSH. That is the reason we have asked for this detailed breakdown. Another reason is I wanted to get as much of it into the record now as possible.

Let me ask you this, Mr. Buckley. Apparently it is only going to be a few days until this information will be included in volume 5. This information in this area must be available now, at least a great deal of it. You mentioned the fact that it was held up only because of a couple of corrections that were to be made.

Mr. BUCKLEY. That is right; it is available.

Mr. ROUSH. Is this breakdown available now in order that we might have access to it or might have it included in this hearing today so that we can give it thought and study prior to the issuance of volume 5?

Mr. BUCKLEY. Yes, sir.

Mr. ROUSH. Well, let's make this request of you then, that you supply this to the committee and that we make this a part of the record of this hearing this morning.

Mr. BUCKLEY. Yes, sir.

Mr. ROUSH. And supply it as quickly as possible, so that the individual members might be able to give it their individual attention.

(The information requested was supplied to the committee on March 13, 1963.)

Mr. WYDLER. Mr. Chairman, may I inquire?

Mr. ROUSH. Yes, Mr. Wydler.

Mr. WYDLER. I would like to understand something.

Did you say that Goddard had made a request for $10 million in this field, and by "this field" I presume you mean tracking and data acquisition, is that correct, and that you had negotiated the $10 million to $6 million?

What is the method of negotiation? You cut off 40 percent of their request. I would like to know just how you did that, who reviewed that request.

Mr. TRUSZYNSKI. Members of the staff of the office of Tracking and Data Acquisition took the initial task requests of Goddard Space Flight Center in the area of "Supporting research and technology" and reviewed each one with the Center personnel. This resulted in an agreement that certain of these tasks were in fact required, and that this was the year for pursuit by the Center. It was a matter of negotiation from a program standpoint as to the timeliness of the particular task requirement. That resulted in a decrease in the total amount requested.

Mr. WYDLER. In other words, some experts in your office, as I understand it, decided that the $4 million was an unnecessary expenditure for this year, is that right?

Mr. TRUSZYNSKI. Yes.

Mr. WYDLER. Is there anywhere a report that covers these items that were reduced; in other words, that shows how they were reduced and why, in your department, one report?

Mr. TRUSZYNSKI. No, there is no one report of this nature.

Mr. WYDLER. Concerning Goddard now I am talking about, the Goddard request.

Mr. TRUSZYNSKI. No, there is no one report that summarizes this area. Rather it is a product of the meetings that are held with the people at Goddard, resulting in approval of the specific tasks.

Mr. WYDLER. Well, in other words, just so I am clear, your group determined that 40 percent of the Goddard request for this program was unnecessary this year. Is that a fair statement?

Mr. TRUSZYNSKI. Yes, sir.

Mr. RYAN. Would the gentleman yield?

Did you determine it was unnecessary or merely that it did not fit in with the overall budget that NASA was presenting to the Bureau of the Budget?

At some point it seems to me you have to correlate all of these requests that come in, and whether Goddard may think it is necessary or not, in the overall picture of the program, it may be something that you just can't spend money for.

Mr. TRUSZYNSKI. This certainly is a heavy factor.

Mr. WYDLER. One last question. You mentioned something here about man-years. What type of unit is that? Is there a cost for

such a unit as a man-year, is this like a rate? Does it have some particular monetary value to it, a man-year that you have established?

Mr. DAVIS. I might enlighten my colleague. That is a fairly common expression used by the Corps of Engineers and throughout the Government. It is simply a designation of particular effort, one man at work for 1 year.

Mr. WYDLER. Like an hour's work?

Mr. DAVIS. Yes.

Mr. WYDLER. Do you have a monetary value for such a thing as a man-year?

Mr. TRUSZYNSKI. Yes, but this does vary with the area of effort. This is a figure that represents a particular type of technical capability.

Mr. WYDLER. What is that value in this field, in the tracking field? Is there such a figure that you use?

Mr. TRUSZYNSKI. It does vary with the particular function in tracking and data acquisition. A figure for an operational person would be different from a figure for a technically competent research engineer. A figure on the order of $40,000, for example, would represent a man-year's work of effort for a highly competent engineer. This includes all of the overhead that is attached to his particular effort.

Mr. WYDLER. How many categories are there that you use?

Mr. TRUSZYNSKI. Well, I know of two that we use. One is a category of this nature where it is a study effort, and another is in the operational sense where we require operational people for the operation of our stations.

Mr. WYDLER. And the rate for a highly technical study is $40,000 a man-year?

Mr. TRUSZYNSKI. That is a representative number, yes.

Mr. WYDLER. What is the operational figure?

Mr. TRUSZYNSKI. They are lower.

Do you have the man-year figure that is generally used for the operational?

Mr. WILLIAMSON. It is on the order of $8,000 for the man-year proper; the man-year with overhead runs to $15,000 for an operator. So it is 15 versus, say, 40.

The actual source of these man-year cost estimates comes from the contractor who is making his proposal. He will come up with a breakdown of so many—on a research proposal it may be 10 senior professionals, each of which will be working 3 months, and this will be priced out in their proposal, so it is a composite sort of figure, sir.

Mr. WYDLER. You have some standards that you use and these are what you are giving me now?

Mr. WILLIAMSON. Yes, sir; it is on that order.

Mr. ROUSH. Referring to the general category "Supporting research and technology," we observe that in each instance of a breakdown of the first three items, the amounts have jumped and jumped considerably, particularly the second item.

Could you give us a general explanation as to why these jumped, particularly referring to improvements to existing systems?

Mr. BUCKLEY. Well, the requirements being laid on us by the program offices are getting more complex and there should be some ratio, but not a fixed one, between the increasing problems we get and the amount of study we put in to find out how to do it and do it in the future.

Actually, I might say that the increments are down this year in the area of supporting research. It went up from 1 year, from 1961 to 1962 it went up some 35 percent, from 1962 to 1963 about 35 percent, and this year it is going up 7½ percent, if I remember correctly. We can't stand still. We have to put some thought into what we will do to keep up with the flight projects as they change.

Mr. ROUSH. Is there any inclination for the Defense Department in its various programs to lean more heavily on NASA or for NASA to lean more heavily upon the military establishment for their tracking and data acquisition programs?

Mr. BUCKLEY. I think there has been an increase. The Department of Defense has not leaned on us heavily in the past. On the other hand, they do lean on us and this has been increasing.

Mr. ROUSH. Has this contributed to the request for increased funds?

Mr. BUCKLEY. In this area, no, sir. It would contribute slightly in the operational area. If you have a network of stations to cover the lunar and planetary projects, if you shoot the first one, if you shoot a MARINER II as we did to Venus, the stations have to be there to operate. If you shoot a second or third one, the increase in cost is minor, but the stations have to be there before you can shoot the first one. Up until the time they become overloaded, these stations can take on other jobs. This is the area where we support the Defense Department. The load they are throwing on us is minor; it is not enough to add to the number of stations. There is no reaction of the Defense Department's requirements in our "Supporting research and technology," that I know of.

Mr. ROUSH. Any other questions from members of the committee on this particular category?

Mr. HECHLER. Are you able to get any help from the military in terms of tracking? Do you utilize the military tracking network, for example, to try to locate a lost satellite like Syncom?

Mr. BUCKLEY. When we lost touch with Syncom, we immediately took several steps. When we lost radio contact, we immediately alerted the Smithsonian optical group. Through Smithsonian we immediately notify major observatories in the country. Now looking for that vehicle without knowing where it was, we figured out was far worse than looking for a needle in a haystack. It is far worse than looking for a needle on a football field, as a matter of fact. But we made some calculations as to where it might be and alerted major observatories. One in South Africa, as you know, picked it up fairly quickly. We also went to the Department of Defense and asked them to start looking immediately, too. It turned out that in the particular orbit Syncom was in they did not happen to be of much help, but in similar cases in the past they have helped and picked things up quickly.

Mr. HECHLER. Actually, the point of my question was not so much the substance of what happens to Syncom. I was trying to ascertain whether NASA could utilize military tracking networks instead of some of the newer networks that NASA is asking funds to establish.

Mr. BUCKLEY. We make very extensive use of the military equipment. As I mentioned earlier, there are requests for military tracking and data acquisition support out of my office that have been given to PMR and AMR for 105 future launchings. This includes tracking and telemetering and the use of ships and it even goes down to the use of various electronic frequencies. For instance, I happen to

know that there is cooperation needed in six different areas of electronics that we have asked for, with six different frequencies.

Now there are no current capabilities in the Defense Department for tracking anything that is going to the Moon or to the planets.

Similarly, when we started on the Mercury program we, of course, could make extensive use, and did, of the capabilities in the Canaveral area and downrange from it, some use of the equipment at PMR on the Pacific coast, some use of the ships, but in general over the trajectory that Mercury had to go, there were no stations.

There was none on Bermuda, there was none in the Canaries, and none down in Africa, and there was none in Australia and none in the middle of the Pacific at that time, so in order to accomplish the Mercury job we planned a network and put it in.

Mr. HECHLER. Thank you.

Mr. ROUSH. Mr. Rumsfeld.

Mr. RUMSFELD. Thank you. I am interested in knowing the progress, or whether or not there is any application from a military standpoint of the advancements you in NASA are making in antennas and in tracking devices. I am anxious to hear that the advancements that are being made are being given to the military for possible military applications, if there are any.

Mr. BUCKLEY. I think there has been great help in both directions on this. Before we were in the space business, the ranges like Cape Canaveral and PMR had the problem of receiving a lot of telemetering data at their ranges and had gone into a development called a TLM–18, which is a 60-foot dish which tracks the vehicle; there were a large number of those built.

The program eventually required improved equipment. That was about the time that we needed 85-foot dishes and so one or more companies started on 85-foot dishes; I think there were at least two or three companies that started building 85-foot dishes.

Several of these were built and then there was a further improvement in the technique of building them more accurately. They could do a better job, could withstand windloads better, and so forth. The number of companies working in this area is very small. It still is probably only three.

Recently the Department of Defense has been buying some 85-foot dishes, and I know that the know-how that we paid for in getting our 85-foot dishes built has fed back into allowing the Department of Defense to get theirs more easily.

Mr. RUMSFELD. How is this done?

Mr. BUCKLEY. I would say in two ways. First of all, there is a certain number of presentations before technical societies on how to do this, and certainly there is a lot of motion of people back and forth from company to company.

We dealt with one particular company, and the major designers of the antennas, then moved to another company. At this point, the second company suddenly had a very excellent capability that they hadn't had the year before. This is one way that this knowledge gets spread around. I think this is an important way of doing it.

Mr. RUMSFELD. Is NASA doing research on the handling of two satellites on one antenna beam?

Mr. BUCKLEY. I don't think we are. As a matter of fact, seldom are there two vehicles in the same beam at once. This practically never happens, I would say, and, secondly, all of the capability that that antenna has is usually required to get the data from one satellite when you are working.

Mr. RUMSFELD. I see. Thank you.

Mr. BOONE. Mr. Chairman, may I ask one question?

Mr. ROUSH. Yes.

Mr. BOONE. On the $11.5 milllion item you have in 1964, is this purely research work or improvement to existing systems? It's purpose is to provide techniques whereby you could purchase in the following portion of your budget, for example, network operations—this type equipment, if needed.

Mr. TRUSZYNSKI. Yes, this represents an area that is primarily one of what we might call preprototype development of both systems and subsystems, and a considerable amount of this money is expended for equipment and components which, in turn, are used to build up a prototype system in-house in the laboratory.

Working with this system, in turn, provides a basis for future procurement of operational items to put into the network.

Mr. BOONE. This is scheduled primarily for Gemini and Apollo?

Mr. TRUSZYNSKI. No, it is for our entire range of programs. It is in support of all three network requirements, unmanned satellite network, the Gemini and Apollo manned networks, and the deep space network.

Mr. BOONE. Do you expect this number to go down next year?

Mr. TRUSZYNSKI. No, I don't believe I would expect it to go down. This is primarily a function of improving our current systems to where they are capable of receiving and processing greater amounts of information, so it is really directed toward increasing the longevity of our present networks by improving their capability.

Mr. HECHLER. Would this mean the existing systems costs might go down in the future?

Mr. TRUSZYNSKI. I don't believe I understand.

Mr. HECHLER. Well, the heading is "Improvement to Existing Systems." If the systems are improved and given greater longevity, does this mean that the net cost will be reduced?

Mr. TRUSZYNSKI. Yes, I think we would expect the total network cost in the future would go down.

Mr. ROUSH. Is there anything else?

Mr. DAVIS. Mr. Chairman, I have some questions on the prepared statement of Mr. Buckley, if they would be in order at this time.

Mr. ROUSH. All right.

Mr. DAVIS. In the first place, Mr. Buckley, on page 16 of your statement you use the letters "PCM" systems, and I just wanted to know what those letters stood for. The statement didn't give the full words. You say "We are equipping out stations with PCM systems and range and rate equipment."

Mr. BUCKLEY. PCM system is pulse code modulation, and this means that data is carried in the form of pulses and the spacing of the pulse or the length of the pulse is a measure of the quantity of the data then.

This is in contrast with previous types of telemetering which we have been using, which is called FM; this is a cruder technique and

it is an analog type of representation compared with the PCM, which comes up as a digital form. Because it is in this form, this means it is easier to process, it is easier to go right into computers.

Mr. DAVIS. All right.

Now I notice at the part of your statement in which you refer to illustration IV67–1, you say in the center of that chart are represented typical improvements that will be made in your station installation, and I take it that includes the PCM installation as well as the range and range rate tracking facility, is that right?

Mr. BUCKLEY. Yes, sir.

Mr. DAVIS. They are both entirely new additions to your station?

Mr. BUCKLEY. Yes.

Mr. DAVIS. And do they comprise a pretty good percentage of the $11½ million which you list as being improvements to existing systems?

Mr. BUCKLEY. This $11½ million is under the area of "Supporting research and technology."

Mr. DAVIS. I see, and that would not, then.

Mr. BUCKLEY. The "Supporting research and technology" money of last year, or the year before would have led to the choice of the system and the equipment that is going into the station this year.

Mr. DAVIS. Well, now I understand the improvement that will result in a general way from the PCM installation, but what improvement results from the addition of this range and range rate tracking facility?

Mr. BUCKLEY. I mentioned earlier, as did Mr. Truszynski, the problems we had with elliptical orbit tracking. Studies have been made, again similar studies such as we are asking for this year were made during the last year or 2 years, and they indicated that a particular combination of equipment that would put out an electronic signal from which you could get a doppler measurement and count range at the same time would be a marked improvement in the technique you use for the tracking.

Now why do we need it? We need it on these elliptical orbits. We also need it at the insertion and injection points of orbits. As you add thrust to change the condition of the vehicle—as you put it into a parking orbit around the earth, as you take it around the parking orbit and put it into a trajectory that will take it to the Moon, or as you take it out of a trajectory that is going out and put it into another orbit that is far out, such as the synchronous orbit for the Syncom satellite, this system gives more precise data and gives it quickly. It gives it in a form you can use to determine what this transient accomplished. Actually there is a set of equipment like that in Lagos, Nigeria, in connection with the Syncom firing, that measured the trajectory as it went out and was going to go into synchronous orbit.

Mr. DAVIS. When you use the two words "range rate" are you talking about the doppler effect there?

Mr. BUCKLEY. Actually the range rate is the doppler effect, but you can incorporate electronically a kind of counting system that gives you the exact range too. You get both velocity——

Mr. DAVIS. That is what I was coming to next. What does the single word "range" have reference to?

Mr. BUCKLEY. The distance to the vehicle.

Mr. DAVIS. And that is all?

Mr. BUCKLEY. And the range rate, of course, is the velocity of the vehicle, it is kind of a combination of procedural technique that gives you both at the same time.

Mr. DAVIS. I have another question on an entirely different subject. At page 31 of your prepared statement you state—well, at the top of the page you are talking about the necessity of buying two ships, and in the illustration that you give you state that you need two ships and one of several possible injection patterns and how it might be impossible for one ship to be under the point where you might want to change from a parking orbit to an escape or another orbit on, say, another shot, possibly a lunar shot. Therefore you are going to need two ships.

Then further down you say you are going to need three ships. How did that third ship get in there?

Mr. BUCKLEY. We are going to talk more about that tomorrow.

Mr. ROUSH. We have arranged to go into this matter tomorrow.

Mr. DAVIS. All right, I didn't realize. Then I will wait on that.

Mr. ROUSH. Are there further questions on the testimony of Mr. Buckley?

Mr. Boone.

Mr. BOONE. You indicated you intended to purchase PCM telemetry now, and this will replace the FM/FM system you have in place now, I take it?

Mr. BUCKLEY. It will add to it. The FM will stay there.

Mr. BOONE. Are you taking into account further growth in your range system and buying equipment here that will be of more general purpose than FM/FM might have been, or are you sticking specifically to mission-oriented equipment in doing this? In other words, next year will you come back for another bill for an additional modification of the system?

Mr. BUCKLEY. Not in technique. I won't say that there won't be more PCM equipment added to stations where we don't have it, because we are only putting it where we think it is really necessary this year.

Let me see if I can answer your question further. As we put simple satellites up earlier, weight-limited, there was associated with them a simple FM telemeter that could send down far less information.

The plans for not only the observatory class satellites but for the application satellites particularly in the meteorological area, and also the plans for Apollo, all call for using PCM telemetering.

In other words, we are going to go over to a system that matches the plans for the spacecraft for years to come, I hope.

Mr. BOONE. So you don't really anticipate any——

Mr. BUCKLEY. Changes in technique, no, sir.

Mr. HECHLER. Mr. Chairman, I have a press release here from NASA that is headed—

NASA to establish deep-space tracking facility in Australia. U.S. National Aeronautics and Space Administration in agreement with the Australian Government announced today it will establish a deep-space tracking facility about 11 miles southwest of Canberra.

Is this the Far East station that we talked about last year in the authorization hearing?

Mr. BUCKLEY. No, sir; there were two deep-space stations approved last year, and this is one of them.

Mr. HECHLER. I see.

What is the progress on the Far East station? Has the site been selected?

Mr. BUCKLEY. The site has been selected, and through the State Department we have asked the government of the host country for approval, and we are expecting the answer from that country at almost any time.

Informally, we have been told they will approve it. We haven't received word yet. The antenna is already being built for that station.

Can I say something else about the site of the Far East station at the moment? We have a problem, as you know. If we plan to install anything in a foreign country, the foreign country requests that they announce it first. And we respect their wishes in this.

Mr. HECHLER. I understand.

What about the authorizing funds that the Congress voted and appropriated, also, last year for this facility? Are all those going to be expended within this current fiscal year?

Mr. WILLIAMSON. Probably not expended, sir; no.

Mr. HECHLER. What will you do?

Mr. WILLIAMSON. The majority of them will be obligated, however, that is, put under contract. We have already, as Mr. Buckley pointed out, obligated considerable amounts for the antenna itself, the antenna structure, and for the electronics systems that go with it.

Mr. HECHLER. How is that reflected in this budget that you are not actually spending this year? How do you indicate this?

Mr. WILLIAMSON. Well, it is in the "Construction of Facilities" appropriation. As you know, we request and have received full funding for specific construction projects. The funds are available until expended under the terms of the appropriation act. The leadtime of turning an obligation into an actual expenditure sometimes runs 3 years, because the billing cycles of the firms that are involved are really quite long. Final termination of a contract sometimes takes 4 or 5 years before complete and total settlement.

In the meantime the obligation, however, is what allows the firm to proceed, produce work, deliver it to the site, install it, and operate it. The contract itself doesn't terminate and therefore the expenditure is not complete until a considerable legal hassle has taken place at the end.

Mr. HECHLER. You remember last year we had considerable discussion about the cost which seemed to me to be excessively high. Your answer was that the cost was higher because you might have earthquakes over there and you had to build your structures a little bit stronger.

Now would it give away the name of the country if I asked you if you are still worried about the earthquakes? Is your cost still going to be as high comparatively for the construction of this facility?

Mr. WILLIAMSON. I don't think that we have a large earthquake problem at our present site.

Mr. HECHLER. Will your costs then come down to be more comparable to other construction costs?

Mr. WILLIAMSON. We have received very preliminary site-construction estimates. These look to be a little higher than we like. We are going to try to bring them down.

Mr. HECHLER. I certainly hope so, because they always seem to go in one direction, and I thought maybe you had a pretty good defense or excuse last year but now if you don't have any earthquakes, why should they go so high?

Mr. WILLIAMSON. We can't exceed, of course, the authorization.

Mr. HECHLER. We would like you to go below the authorization.

Mr. WILLIAMSON. We always try to be below the authorization and we are attempting to in this case.

Mr. RUMSFELD. I have a question on this subject.

Mr. ROUSH. Mr. Rumsfeld.

Mr. RUMSFELD. Are there sites in foreign countries which you have attempted to secure and failed because the foreign country was uncooperative?

Mr. BUCKLEY. I know of none.

Mr. RUMSFELD. In each country where you wanted a site the country has cooperated, if you decided to go ahead?

Mr. BUCKLEY. Yes, sir.

Mr. RUMSFELD. I have one question which is quite off this subject. You brought Mr. Williamson and Mr. Truszynski to assist you, which, of course, is very normal and proper. Did you bring any other individuals from NASA with you today to assist in this testimony?

Mr. BUCKLEY. No, sir.

Mr. RUMSFELD. Are there any other individuals from NASA that came with you?

Mr. BUCKLEY. Mr. Brown of the Legislative Affairs Office, that is all.

Mr. RUMSFELD. I see, that is the only other NASA employee that came with you.

Mr. BROWN. There is Mr. Sam Keller from Goddard, but the two of us are merely standing by, we are not participating.

Mr. RUMSFELD. You are here but not participating. I see.

Mr. ROUSH. Mr. Buckley, referring to the manned-space-flight network, you have 16 prime stations and I observe that 5 of these are operated by commercial companies, 9 are operated by elements of the armed services, and 2 are operated under an intergovernmental agreement by the weapons research establishment of the Australian Department of Supply.

Do you find it more economical to use the commercial companies for this operation?

Mr. BUCKLEY. In this case it happened that economy wasn't the factor that resulted in the decision. It was necessary in four of the five countries that a civilian scientific organization be the organization that was dealing with the foreign country. This was specifically at the request of those countries, who, in fact, in each case had this written into our agreement.

That is a recurrent problem, as a matter of fact, in some of these countries: Are we really a scientific organization and are we really a civilian group, and so forth. It comes back repeatedly in these countries. In some countries there are always groups that are asking, Is our station really a missile station under another name?

Mr. ROUSH. Are you saying that in some instances you must use a commercial company?

Mr. BUCKLEY. Yes, sir.

Mr. ROUSH. Because of the perhaps political situation existing in the country?

Mr. BUCKLEY. That is right.

Mr. ROUSH. Within this country or within our own jurisdiction or the jurisdiction of the country, do we have any commercial companies operating stations?

Mr. BUCKLEY. Yes, sir; the group of dishes at Goldstone is operrated by a commercial company.

Mr. ROUSH. Do you find this a satisfactory and economical situation?

Mr. BUCKLEY. I think so. First of all, it is a very direct relationship rather than having a couple of intermediate managerial stages.

Mr. ROUSH. Would it be more economical to operate some of those operated by the Department of Defense than by commercial firms?

Mr. BUCKLEY. Well, the Department of Defense, you see, operates them in the end by a civilian company, too, but at times there are some intermediate channels of management. These have not been unfavorable to us, but on the other hand if you are trying to do an important job such as Mercury or Apollo, the manned space flight jobs, I personally believe that direct contract, so that this is one solidly integrated group that is trained for the job and has the responsibility so that every station looks exactly alike, is an important concept in how to run a job like that.

Mr. ROUSH. Because of the House being in session it will be necessary for us to adjourn this committee hearing at this time.

We will look forward to seeing you again tomorrow morning, Mr. Buckley.

Mr. BUCKLEY. Yes, sir.

Mr. ROUSH. We will now adjourn.

(Whereupon, at 12:02 p.m., the subcommittee adjourned, to reconvene at 10:00 a.m., Wednesday, March 13, 1963.)

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1964 NASA AUTHORIZATION

WEDNESDAY, MARCH 13, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON APPLICATIONS AND
TRACKING AND DATA ACQUISITION,
Washington, D.C.

The subcommittee met at 10 a.m., pursuant to adjournment, in room 214-B, New House Office Building, Hon. J. Edward Roush presiding.

Mr. ROUSH. The committee will be in order.

We are 2 minutes late starting this morning. However, the committee is again prepared to hear you, Mr. Buckley, and what we would like you to do this morning is this: referring to the new volume, the backup volume which has just been handed to us, on page 68, we would like to take these various items, item by item.

Now although we did discuss integrated systems study, development, and test, and you gave us the background yesterday on each of those, we would like to take each item and for you to give us a very brief paragraph explanation of the item as it appears here, for example, the $600,000 item on trajectory orbit determination and data requirement analysis, then follow with the $225,000 item.

We would like to have a very brief paragraph explanation of each of these items. The first item will be a little bit of review perhaps. If you could condense what we said yesterday into a brief paragraph, the committee would appreciate it.

FURTHER STATEMENT OF EDMOND C. BUCKLEY, DIRECTOR, OFFICE OF TRACKING AND DATA ACQUISITION, NASA, ACCOMPANIED BY GERALD M. TRUSZYNSKI, DEPUTY DIRECTOR, AND DAVID WILLIAMSON, JR., CHIEF, PROGRAM COORDINATION

Mr. BUCKLEY. Well, we have brought in a breakdown of the $2 million line item. It is broken down in volume 5 into four items, and we have brought in a further breakdown. I believe as requested yesterday, it is now broken down into tasks. I have 10 copies of that breakdown here for you if you would like to have them.

Mr. ROUSH. All right, they will be distributed.

Could you then, Mr. Buckley, in a brief statement explain each of the four major items listed in this category?

Mr. BUCKLEY. I believe so; yes, sir.

Mr. ROUSH. I think we can all appreciate that we are operating under a limitation of time here which is really severe, and we are going to have to move as quickly as we can on these items if we are going to cover the whole field.

Mr. BUCKLEY. As you see from the papers that have just been distributed, we have provided you with a breakdown of the four items and this then adds up to the $2 million item.

You will see here a variety of studies. For instance, we foresee some problems in determining the orbits because of the effect of the atmosphere on the orbit, the effect of the moon or the planets on the orbit; there are various effects that we don't know.

Orbits, then, are not regular. We have a first cut at how to work up the orbits but there has to be more detailed methods worked out for determining some of these, and also there will be effects due to the variations in some of the instrumentation. You might think of them as inaccuracies, I prefer to think of them as limitations, variables introduced by the instrumentation, and these then will affect the orbit determination. This also results in a number of studies.

The second area, one item in the second area is a study——

Mr. ROUSH. You are referring to which item when you say "the second area"?

Mr. BUCKLEY. I am referring to the item "Systems parametric studies."

We have broken this down into two tasks in the papers we have just given you. Radar data coming in from some of the vehicles at high speeds have peculiar reflections and we want to evaluate the radar received data and from this get determinations as to what we need in the way of reflections from the vehicle and develop techniques to obtain this data from the existing radar systems.

The second item consists of a definition of the "ground communications system" characteristics and the data format that will be most efficient for use with the automatic data processors.

You will hear the term "signal conditioners" used; that transposes the data as we get it out of the radars and from the telemetering system into a condition that we can transmit over the communications system back to our control centers in Goddard and in Florida and then reconvert into a condition for the computers, and there are certain optimum ways of doing this. One way would be more efficient than another, so there is $25,000 for a study to determine the better ways of doing this.

The next grouping is classed as "Conceptual systems studies." There will be a determination of the characteristics and operating limitations of several antennas to see if we can, through combinations of antennas that are arrayed together, approach the characteristics of a large parabolic antenna and do this thing probably at lower cost or possibly at better efficiency.

Now this type of study is going on in various places in the country, and our agency is taking a lead part in making such studies, because of the extreme cost of the very large parabolic antennas.

As for the second task, there is always a problem when you move one of these large antennas with the servo systems and the bearings. This has been a severe engineering problem in building all large antennas. There is a possibility of building antenna systems that will be inertialess, or at least will not move; there is a possibility of scanning the sky with systems that don't have the bearing problem.

The last area is entitled "Developmental system tests." This includes the test of protoypes of the ground-based deep space tracking systems, using Venus or Mars as a target to evaluate the combination of systems that will work best when we track spacecraft out to these

distances. As we carry this work out, it is pretty difficult to find a calibration device to try a system against, way out in space. Using Venus and Mars and varying the system on the ground, you have an operating means that you wouldn't have in advance of getting a spacecraft out that far in the sky.

The last task is for aircraft and spacecraft integrated systems tests of a system that Marshal is working on. There is a possibility of using aircraft with the ground systems to get accuracy data on a new tracking system that may be better than some of our present ground-based systems.

This concept of a remote unmanned tracking system has been considered previously. I don't know of any real solution that has ever been used very actively and Marshall wants to try it again. This task covers the job of taking aircraft out to sections that can't be covered by ground equipment.

Mr. ROUSH. Thank you, Mr. Buckley.

Unless there is objection, we will make this breakdown a part of the record.

There being no objection, it will be made a part of the record.

(The document referred to is as follows:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION,
Washington, D.C., March 12, 1963.

MEMORANDUM FOR FILES

Subject: Fiscal year 1964 estimates for supporting research and technology within the tracking and data acquisition program.

The attached list of 15 supporting research and technology tasks represents the effort planned at this time within the $2 million called out for "Integrated systems study, development, and test." All funds requested here are either for contracted study and test effort or for procurement of equipment to permit in-house development work. These estimates cover both new effort and continuation of work begun in previous years.

DAVID WILLIAMSON, Jr.,
Chief, Program Coordination Tracking and Data Acquisition.

Integrated systems study, development, and test	$2,000,000
Trajectory, orbit determination, and data requirements analysis	600,000
Application of DeLauny's method to the problem of determining the orbit of the satellite of an oblate sphere (such as the Earth), to include the effects of tesseral hormonics and lunar and solar perturbations	25,000
General perturbation theory, including the effects of certain zonal harmonic and higher order gravitational perturbations	13,000
Analysis of the constants relating to orbit determination, to provide a computer program that can determine orbits of spacecraft around the Earth and the Moon and in highly elliptical cislunar orbits, using an Encke scheme with Herrick's universal variables	38,000
Influence of perturbing forces on the tracking of orbital vehicles	25,000
Analysis to determine tracking data accuracy using nonlinear treatments	60,000
Postflight analysis of vehicle guidance system data output to determine orbital parameters	40,000
Analysis of orbital data to determine the sources of errors such as those associated with the inonsphere, solar pressure, equipment calibration, and station location; includes analysis of orbit design and selection criteria	306,000
Design techniques and computer program for trajectory accuracy requirements of planned new launch vehicles	50,000
Investigation of the effects of tracking system signal scintillation on computed acceleration data	43,000

Systems parametric studies	$225,000
Test equipment and instrumentation required to support the evaluation of present radar received data, the determination of radar "signature" data requirements, and the development of techniques to obtain this data from existing radar systems	200,000
Definition of the ground communications system characteristics and the data format that will be most efficient for use with remote automatic data processors	25,000
Conceptual systems studies	275,000
Determination of the characteristics and operational limitations of arraying several antennas to approach the advantages of a single very large parabolic antenna without the structural penalties of such a large system	175,000
Investigation of the possible characteristics and potential uses of inertialess scanning antennas for spacecraft tracking	100,000
Developmental systems tests	900,000
Test of prototype ground-based deep space tracking systems, using the planet Venus as a target, to evaluate subsystem interaction and performance prior to incorporation into the operational network	700,000
Aircraft and spacecraft integrated systems tests of a prototype unmanned tracking system for remote locations	200,000

Mr. ROUSH. Does any member of the committee have any questions relating to this particular category?

Mr. Ryan.

Mr. RYAN. Mr. Buckley, could you tell us quickly, going down the first page of the breakdown which you have submitted to the committee, which items are to be contracted and which items are to be in-house? In your introduction you state that the funds are eigher for contracted study or for equipment to permit in-house development work.

Mr. BUCKLEY. Let me go over the items of which I have spoken as a typical case. The first item I mentioned was a continuing one, placed with Yale.

The next one was a continuing one placed with the National Bureau of Standards.

The third one was a continuing one placed with Lockheed.

The next three were new contracts, and because they are new we won't know until after the money is available who they will be with.

The next one is a continuing one with Lockheed. The next two are new, and we have no contractor.

The next one is a continuing one with Langley Research Center, in-house, and this task is asking for the equipment.

Mr. ROUSH. In order to verify where you are when you refer to the next one——

Mr. BUCKLEY. I am at the third one on page 2.

Mr. ROUSH. Referring to which item?

Mr. WYDLER. The $200,000?

Mr. BUCKLEY. $200,000, yes.

The next item, the $25,000 one is a continuing Marshall Space Flight Center in-house.

The two at the bottom of page 2 are both new ones, with nobody designated as yet.

And of the last two on the third page, the first one is a continuing one at Jet Propulsion Laboratory, and the second one as I mentioned before is at Marshall Space Flight Center, and that is a new one.

Mr. BOONE. Mr. Buckley, what percentage of your moneys are contracted out to private industry or to universities.

Mr. BUCKLEY. All of the items in this book represent money that will be spent outside, either by contracts or for purchase of hardware items.

Mr. RUMSFELD. In which book?

Mr. BUCKLEY. In our whole budget book here in the equipment area, the supporting research and technology area, and in the operations area. All of the R.D. & O. money is spent outside.

Mr. BOONE. What percentage then is this of your total request, a rough figure?

Mr. BUCKLEY. Well, exclusive of the personnel salaries, this is 100 percent of the money.

Mr. WILLIAMSON. Of the direct program costs shown in the 1964 request, the $231.5 million, all of that, is spent, as it were, out of house. It is for purchase orders and contracts. The sum for operations of installations and personnel is shown separately on the budget page RDO23–1.

Mr. ROUSH. Mr. Davis.

Mr. DAVIS. As regards this whole $2 million item, would you give us an estimate of how much of the $2 million would probably be chargeable to deep space studies and how much to near-Earth orbit, how much to lunar orbit? Could it be broken down that way?

I know some of these items seem to be purely chargeable to deep space exploration, as I look at some of the detailed breakdown. I just wondered if you for the record could give us your opinion as to what percentage of the $2 million would be chargeable to each of those areas.

Mr. BUCKLEY. I could give it to you for the record. I would have to give you a pretty broad guess at the moment.

Mr. DAVIS. Well, if you would prefer to take a close look at it later and send it in, that will be satisfactory.

Mr. BUCKLEY. I would like to (see p. 2842).

Mr. DAVIS. That will be satisfactory.

Mr. ROUSH. Now, Mr. Buckley, moving to the category which has the heading "Improvements to existing systems," would you give us item by item a brief paragraph explanation of each of these—I should say a paragraph justification, for each of these items?

Mr. BUCKLEY. Yes; I have asked Mr. Truszynski to be prepared to do this this morning.

Mr. ROUSH. All right, Mr. Truszynski.

Mr. TRUSZYNSKI. In this category I think we can say that the total of this is spent in prototype equipment developments, largely in-house, at the four laboratories I mentioned yesterday, the primary ones being the Jet Propulsion Laboratory and the Goddard Space Flight Center, and the other two being the Langley Research Flight Center and the Marshall Flight Center.

In this first item, we are continually faced with the problem of utilizing telemetry information for real time control purposes where we have a satellite that is reasonably complex. This money is spent in determining the types of equipment that can allow us to utilize

information received and processed in the way that provides for an operator control of certain functions on the satellite itself.

These can range from monitoring functions of its particular attitude in space to the decisionmaking requirement for changing some operation of the satellite. This is a continuing requirement, particularly as satellites get larger and more complex. This amount of money is spent in developing prototype equipment which allow us to do this job for a variety of satellites and also deep-space probes.

Mr. DAVIS. Mr. Chairman, I suggest for the record the witness first define the terms here, what it means when it says "conditioning data," "extracting data," and "displaying data."

Just what does that mean?

Mr. TRUSZYNSKI. Yes, sir. The term "data conditioning" is a general term that applies to the processing of the raw information that comes out of a telemetry receiver. This comes out as an electrical signal and must be conditioned or transformed into a different electrical signal that allows a further process to be made on it.

Very often this is a matter of separating individual channels from a large group of total information that is coming down. It transforms the information into a more usable form for a subsequent process.

"Extraction" is extracting individual pieces of information from a large volume that comes down in many channels; this is extracting individual channels for detailed observation.

Once having separated the information, "display" means displaying it in some form that allows an operator to make a decision, based on what he sees. This is display on a meter face or a cathode-ray instrument, some device that allows an operator to see what the information is and then act on it.

Mr. DAVIS. Thank you.

Mr. TRUSZYNSKI. Data-acquisition receiving equipment: We are speaking here of the specific receivers that are part of the ground stations, and the problem here is a continual attempt to get more and more sensitive receiving equipment, as we have satellites that go farther out in space and have more information sent from them. This effort is spent in developing receivers with lower and lower noise figures which allow you to receive very weak signals from extreme distances.

The area of electronic tracking equipment covers equipment development efforts to improve existing systems and subsystems used in obtaining tracking information. Some of these development efforts are briefly described below:

Range and velocity (range-rate) data, derived by receiving reply signals from the spacecraft, will be automatically processed through differing mechanisms to provide greater accuracy when the signals are affected by atmospheric media, particularly at angles near the horizon. In addition, the receiver system will be modified with appropriate new filters to enhance the signal in the presence of noise and to permit several systems to operate in a two- or three-station complex without mutual interference. New designs will be developed to enable the system to be employed for shipborne tracking.

Development will continue on a high-precision, extreme-range tracking system coding to meet tracking requirements for those missions having continuous thrust applied to interplanetary spacecraft. Self-synchronizing techniques are under development for

correlating a faint reply signal with the Earth-generated signal to give greater tracking accuracy and operating distance.

The ground stations which measure angle and angular velocity in tracking Earth satellites, i.e., the interferometer systems, will be modified to improve by a factor of 16 the tracking range capability of spacecraft. This can be accomplished by narrowing the post-detection bandwidth to the order of 0.03 cycle per second from the present 0.5 cycle per second.

The existing ground antenna systems receive single-plane polarized signals. For more reliable operations, the tracking receiver will be modified to receive signals in two planes of polarization and automatically select the stronger signal.

The area of electronic tracking equipment covers equipment development efforts in improving the specific systems we have for obtaining the tracking information. In the types of tracking equipment that follow a target rather than being stationary, this requires improvements in the electronics that actuate particular drive systems that allow an antenna to follow a target automatically. These are good only to certain tolerances, and very often these tolerances are not accurate enough for precise orbit determination, which is required.

Mr. WYDLER. Mr. Chairman, at this point I would just like to ask how much of that amount is going to be spent at the Electronics Research Center in Boston.

Mr. TRUSZYNSKI. None of this is programed for the Electronics Research Center.

Mr. WYDLER. Thank you.

Mr. TRUSZYNSKI. Data handling and processing equipment refers to the equipment and techniques used to extract the information once it is received, and put it into usable form for subsequent analysis. These are developments in actually processing automatically the taped information that is received at our data-acquisition stations. Larger and larger quantities of data are being obtained, and consequently more rapid methods of processing the data to a usable form are necessary.

Mr. HECHLER. Mr. Chairman, is the large amount of data to be processed; does that account for the tremendous jump in amount that you are requesting? I notice that it is over double the amount between 1963 and 1964.

Mr. TRUSZYNSKI. Yes; it is, sir, directly.

The area of command generation equipment: Commands here refer to electrical signals that are sent to the satellite to have it perform certain functions, such as attitude control, turning on and off certain systems in the satellite, or even changing its orbit through an additional propulsion impulse. This particular area refers to the development of equipment to send, not only simple commands, but more complex commands, where we have satellites that require several functions to be performed on a continuing basis, such as the orbiting astronomical observatory, where you are continually changing its attitude to record information from a different part of the sky. Complex command impulses are required to perform a variety of functions on a particular satellite.

Antenna servo drive units: This area is specifically one of improving the drive systems of medium and large antennas. One has difficult problems in driving a large antenna at very, very low rates because of a smoothness-of-drive problem. At the same time you must require

this antenna to track at rather high rates for a satellite that comes directly overhead at reasonably low altitude. This is a problem of increasing the performance of a drive system to lower and lower speeds in some cases for extremely high satellites that look like a space probe, to one of higher rates for reasonably low satellites. It is an extension of the range of these drive systems so that we can perform with one antenna a multiple function in terms of the satellite missions.

Antenna structure and microwave optics is concerned with development of equipment to better energize an antenna. The problem here is one of directing the energy from the feed point into a parabolic reflector in a way to assure maximum energy input in the direction of the satellite. This is a problem of the specific design of the feed, its shape, and how it directs the energy into the parabolic reflector for maximum sensitivity in receiving and for maximum amount of command information on transmission from the ground. As we get larger antennas this becomes a worse problem as we are illuminating a larger area from a certain type of feed. It becomes increasingly difficult to get maximum sensitivity from larger antennas.

The next item, antenna feeds, is directly coupled with the previous one. The antenna feed is the element that transmits large amounts of power directly to the reflector. The problem here is one of configuration, such that you try to minimize the spillover of energy and have it all directed into the reflector as opposed to having some reflected outside of the actual reflector itself.

Calibration of equipment and techniques: In all our stations we have a problem of calibrating the tracking system or the recording systems in a way that, once having received the information, we can in turn take out whatever ground-station errors are involved. We have to determine the deflection of our large antennas as they move from the horizon to the zenith so that we can apply subsequent calibrations of these errors to the data to assure that the tracking fixes that are obtained are not degraded by some particular characteristic of the antenna.

Mr. DAVIS. Well, that is the same thing as when you correct a compass for deviation, isn't it, the same sort of thing?

Mr. TRUSZYNSKI. Yes; it is exactly the same sort of thing. We must know the limitations of the system and be able to put the limitations in as a form of calibration to correct the information.

Timing and frequency standards equipment: this is involved with getting better timing and frequency systems to allow us to correlate our information from different stations so that they do not in turn add errors to an orbit. For example, it is extremely important to know the time relationship of a certain tracking fix at one station with a tracking fix at another station where the data from both stations are used to compute an orbit. The timing of these fixes is a direct limitation of the accuracy with which you can obtain an orbit, and in terms of getting more accurate orbits for experiments such as magnetic field investigations, the timing becomes a limiting factor now in the orbit determination. We must get better methods of time synchronization to a group of worldwide stations, and in this area we are investigating techniques of improving total network timing systems that we now use. There are some promising techniques that can be used, such as very low frequency transmissions of timing information.

Spacecraft and vehicle transponder equipment: the transponder is a device aboard the spacecraft that works in conjunction with a ground station. When we mention that we get range and velocity from a vehicle, this is done by transmitting a frequency from the ground that it is received by a unit called a "transponder" on the vehicle, and in turn retransmitted to the ground. This system allows us, through the use of this return system, to get range and velocity of the vehicle. This item for the development of the on-board transponder equipment is required for getting range and range rate from the larger satellites.

Circuit elements is a category of effort which applies to investigating and utilizing new component developments as they arise. This is specifically concerned with such items as new solid state components and thin film approaches for computer memories. The Centers attempt to utilize whatever new developments in particular circuit elements do arise.

Mr. ROUSH. Generally speaking, is the increase here over and above that which you had last year due to increased requirements, replacing outmoded equipment, or repair of existing equipment?

Mr. TRUSZYNSKI. The increase here is primarily one of improving existing equipment, and it is fair to say it is a direct relationship with the increased amount of equipment that we foresee in the networks by the fiscal year 1964.

Mr. ROUSH. Do members have questions on this category?

Mr. WYDLER. I would like to follow up that question I asked you before.

Now the largest item for electronic tracking equipment here is this $2,250,000 item. Do I understand you correctly, can you tell me where that money is going to be spent, that $2,250,000?

Mr. TRUSZYNSKI. The largest portion is going to be spent by the Goddard Space Flight Center.

Mr. WYDLER. And the balance?

Mr. TRUSZYNSKI. The balance would be at the Jet Propulsion Laboratory. These are the two Laboratories that are directly involved with this function.

Mr. WYDLER. I see. But the Center that you are proposing, the new Electronic Research Center, isn't going to spend any of this money for research and development, is that right?

Mr. TRUSZYNSKI. That is correct. This money is specifically for supporting research and technology directly related to our systems, as opposed to advanced research in systems that are not yet in existence.

Mr. WYDLER. I thought that I kept hearing you say you were trying to improve in various manners the large antennas that you have in operation now, is that correct?

Mr. TRUSZYNSKI. Yes, sir.

Mr. WYDLER. At the same time, if I understand it correctly, under the integrated systems studies program, you are trying to find out if you can't replace the large antennas, aren't you?

Mr. TRUSZYNSKI. This is correct.

Mr. WYDLER. There seemed to be some kind of conflict there. I don't know, maybe there isn't.

Mr. TRUSZYNSKI. We foresee that our large antennas are going to reach an economical limit and we feel this is of the order of 210 feet, which is the type of large antenna we are building now. Beyond

that we feel we must look at other methods of getting increased sensitivity, and the studies in the previous category are directed to methods of increasing sensitivity beyond the present state of the art which we feel is represented by a size on the order of 210 feet.

Mr. WYDLER. In other words, if you got to the point where you would need an antenna to do the job of over 210 feet, then you feel that you would like to cluster these antennas to do the job instead; is that right?

Mr. TRUSZYNSKI. Yes, this is one approach that is possible, and it is a matter of determining its feasibility.

Mr. ROUSH. Mr. Rumsfeld.

Mr. RUMSFELD. In this specific area of antenna development improvement, to go back to a question of yesterday, do you have individuals who are knowledgeable about military needs, participating in these development programs, and, if so, by what method would one of these antenna improvements be transferred to the military, or how would the military be advised?

Mr. TRUSZYNSKI. The military is not directly participating in terms of a day-to-day type of operation. I believe the primary method by which the military is aware of our effort is through summary presentations of the results of such research, either through technical symposiums in which both we and the military participate, or through the published report as the output of any particular study which is available to the military.

Mr. RUMSFELD. Thank you.

Mr. ROUSH. Turning now to page 69 of volume 5, with the heading "New Systems Development," let's proceed to take this item by item, and if you will, please, without sacrificing content here too much, we would like for you to proceed as fast as possible.

Mr. TRUSZYNSKI. This whole category is one of new systems where we see limitations in our present systems and an effort is made to develop prototype equipments for new systems that we foresee having to use.

You will notice that the categories are somewhat similar to the improvements that are directly associated with our present systems. However, they are prototype equipments that we are developing as part of a new system that we see will be needed in a somewhat extended time period, as opposed to improvements to specific equipments that are in the field now.

The technical explanation for these subcategories would be quite similar to what I have just gone through, and the best comment that I can make is that these now are not concerned with the specific network equipment that we now have, but rather concern developing a new system such as the range and range rate system which we plan to put into operation shortly.

Mr. ROUSH. Are any of these particular items specifically designated for any of the new network stations or for existing stations?

Mr. TRUSZYNSKI. No, these are not for a specific station problem. They are for a system problem that can address itself to several stations or an entire network.

Mr. ROUSH. With this explanation does any member of the committee have questions?

Mr. WYDLER. Yes, Mr. Chairman, if I might.

Mr. ROUSH. Mr. Wydler.

Mr. WYDLER. On the item "Electronic tracking equipment," $2,050,000, how much of that item is proposed to be spent at the Electronic Research Laboratory?

Mr. TRUSZYNSKI. None of this money.

Mr. WYDLER. None of this money either?

Mr. TRUSZYNSKI. No, sir.

Mr. WYDLER. Although this is for new systems, is that correct?

Mr. TRUSZYNSKI. Yes, it is for new systems that we have under development, but not yet put into operation.

Mr. DAVIS. Mr. Chairman.

Mr. ROUSH. Mr. Davis.

Mr. DAVIS. I would like to know where the line of demarcation exists as between research and development.

I notice that this category of $17 million is referred to as "Development of new systems," and I would guess that this first category you discussed, "Integrated systems study, development and test," would include quite a lot of pure research, would it not, or applied research?

How do you decide where to draw the line between research and development in making up this sort of budget request?

Mr. TRUSZYNSKI. We try to draw the line between what is more applied or development oriented as opposed to what is research oriented. These are primarily development efforts associated with required improvements of existing systems or required systems that are shortly to be put in, as opposed to pure research.

Mr. DAVIS. Well, now, do you engage in pure research with such things, for example, as lasers? Do you have any such activity going on?

Mr. TRUSZYNSKI. Yes, sir; we have. Our effort is one primarily of determining the applicability of lasers to our job, as opposed to research in improving lasers for the sake of improving lasers, which is a research job.

Mr. DAVIS. Then as far as the 1964 authorization request, I would expect that that would be found, if anywhere, under such things as "Conceptual systems studies"?

Mr. TRUSZYNSKI. Yes, sir.

Mr. DAVIS. That is the sort of place you would find a study on lasers?

Mr. TRUSZYNSKI. Yes. You would find it one more place, down in the equipment item wherein we are examining the characteristics of a particular laser piece of hardware for use on a data acquisition problem. It is an in-house type of investigation.

Mr. DAVIS. Now I just have one further question.

Is there a department of NASA which is engaged in pure research that might feed information and equipment developments into your department, into tracking and data acquisition?

Mr. TRUSZYNSKI. Yes, sir; there is. There is a major program office, the Office of Advanced Research and Technology that is directly charged with this total responsibility.

Mr. DAVIS. And you have a rather close liaison with them, I would think.

Mr. TRUSZYNSKI. Very close, yes.

Mr. DAVIS. Mr. Boone, can you tell me what subcommittee that would come under?

Mr. BOONE. That is Mr. Karth's committee.

Mr. DAVIS. I see.

That is all.

Mr. ROUSH. If there are no further questions, we will go to the item which was designated as "Network operations."

Mr. Buckley, the observation here is that this isn't broken down to any great extent. We have here a major expenditure, $80,500,000, broken down into what appears to be seven different items.

Mr. BUCKLEY. I have a breakdown here, sir.

Mr. ROUSH. Do you have that in a form which can be distributed?

Mr. BUCKLEY. Not today; no, sir, but we can make up copies and bring it in for the record.

Mr. ROUSH. We would like that. We would like to include that breakdown in the record.

If there is no objection, we will direct that it be included in the record.

(The material referred to is as follows:)

Network operations	$80, 500, 000
Satellite network	17, 000, 000
Network operations contractor	10, 300, 000
Australia	500, 000
South Africa	500, 000
Smithsonian	2, 000, 000
Peru	200, 000
Chile	500, 000
Alaska	1, 400, 000
New stations	1, 500, 000
Manned flight network	24, 000, 000
Network operations contractor	12, 400, 000
DOD operations	6, 000, 000
Australia	2, 300, 000
Computer programing	3. 300. 000
Deep space network	10, 000, 000
Goldstone operations contractor	3, 100, 000
Australia	700, 000
South Africa	500, 000
AMR support	300, 000
JPL [1]	5, 400, 000
Launch area instrumentation	5, 000, 000
Fort Churchill [2]	2, 400, 000
Wallops Station services	2, 600, 000
Aerodynamics test range	800, 000
Network communications	16, 000, 000
Engineering services and operations	2, 150, 000
Government agencies	890, 000
Leased circuits—U.S. carriers	10, 320, 000
Leased circuits—Foreign carriers and agencies	2, 660, 000
Data processing and handling	7, 700, 000
Operational supplies	2, 850, 000
Operations and services	4, 850, 000

[1] Task under JPL contract.
[2] Operational cost shared 50 percent with Air Force.

Mr. BUCKLEY. This area is perhaps easier to follow in that it has a precedent from year to year. The cost of station operation is pretty clearly determined by what is going on at the stations and how many there are, and that was the philosophy, I believe, in not breaking it down into more detail. However, I have it broken down here.

Mr. ROUSH. But in looking at this we observe that your request has jumped from over $55 million to $80 million, and that is quite a jump.

Mr. BUCKLEY. Yes, sir.

Mr. ROUSH. Are you prepared to discuss these items, item by item?

Mr. BUCKLEY. Yes, sir.

The first item under "Satellite network" is a large contract currently with Bendix for operation of the satellite network stations. The estimated cost of this kind of service is going from $7.1 million to $10.3 million.

Incidentally, the present Bendix contract includes personnel at 10 stations, plus 1 or 2 portable stations that are in and out of service. We moved one into Brazil in November and brought it back January 4 in order to get some satellite data on the radiation field which was nearer the Earth over Brazil than anywhere else, and this is typical of the movement of the portable stations.

The network contractor supplies all of the logistics support for the satellite net as part of the contract. They assist us in some network planning and engineering relative to the use of the stations. They fly calibration aircraft.

There is one DC–4 and one DC–3 aircraft that have equipment aboard that is similar to the equipment in the satellite, and these fly from station to station to make periodic calibrations of the station from the air.

Since the contractors operate the stations and provide the group that sends the data back to Goddard, there are contractor representatives at the Goddard end of those communications circuits, too, so that they can work together, and if there is any difficulty, they can help clear it up.

There is an estimated contract for $500,000 with the Department of Supply in Australia for operating the satellite stations in Australia, and a parallel contract with a scientific group called CSIR in South Africa also for $500,000.

There is $2 million that would go to the Smithsonian Astrophysical Observatory, under the Smithsonian Institution here, for operating the network of 12 optical stations.

In Chile and in Peru there are a large number of nationals employed at the station. There is a proposed contract for $200,000 with an institute in Peru to provide Peruvian nationals. The University of Chile assists us in operating two stations in Chile, and has a contract that runs to about $500,000 per year that provides the people at those two stations.

We had in 1963 a contract with the University of Alaska that ran to about $1 million, but this work will be picked up by another contractor during the year 1964.

The increase from fiscal year 1963 to fiscal year 1964 can be accounted for by the fact that there is a considerable increase in the equipment being put at the various stations, it is anticipated that the portable stations will receive more use than they did last year, and

the Rosman station will be operational in fiscal year 1964 for the first time.

Because of the complexity of the equipment at the stations, the logistic support is going up and there will be some added use of the calibration aircraft.

Mr. ROUSH. Are you finished with that particular item?

Mr. BUCKLEY. Yes, sir.

Mr. ROUSH. Let me ask the same question I asked before: How much of this is designated for new stations?

Mr. BUCKLEY. I would think about 15 percent. I will have to check that figure.

Mr. ROUSH. You will check it?

Mr. BUCKLEY. Yes, sir. (The figure is approximately $1.5 million.)

Incidentally, I have an answer to your earlier question, Mr. Davis. Mr. Williamson went over the list here while we were talking about other things, and said that 45 percent was for the near Earth and 45 percent was for deep space and about 10 percent was usable for both conditions.

Mr. DAVIS. Thank you, sir.

Mr. ROUSH. I think the members should have an opportunity to ask questions on each of these items, since we don't have a detailed breakdown before us.

Does any member have a question on this particular item?

Mr. Ryan.

Mr. RYAN. Does this satellite network track communications satellites?

Mr. BUCKLEY. Yes, sir. This network tells us where the vehicle and the spacecraft are. It is used for both NASA satellites, some DOD satellites, the application satellites. There is no equipment involved in this network, however, that carries on the communication experiments.

Mr. RYAN. Well, for instance, did this network track the Telstar?

Mr. BUCKLEY. Yes, sir; it tracked it long enough so that the A.T. & T. station could get their equipment checked out and working, and after that they were on their own. But for approximately a month, we were tracking Telstar.

Mr. RYAN. And relaying information to the corporation which owned Telstar?

Mr. BUCKLEY. Yes, sir.

Mr. RYAN. Now was NASA reimbursed for this activity?

Mr. BUCKLEY. That I don't know. But you know we had experiments——

Mr. RYAN. I am just asking whether NASA was reimbursed by A.T. & T. for tracking Telstar for that month.

Mr. BUCKLEY. I don't know.

Mr. RYAN. Can you find out and let us know?

Mr. BUCKLEY. Yes, sir.

Mr. RYAN. And if so, to what extent.

The A.T. & T. Corp. has been billed for $281,213.41 for tracking and data acquisition services through December 31, 1962.

Mr. ROUSH. Would you provide for us a listing of all of the contracts involved in this particular $17 million item? Would you supply that for the record?

(The material referred to is as follows:)

Network operations contract estimates

Network operations contractor	$10,300,000
Department of Supply, Australia	500,000
CSIR, South Africa	500,000
Smithsonian Institute	2,000,000
Geophysical Institute of Huancayo, Peru	200,000
University of Chile	500,000
Rosman, N.C. (new station) operations contract	1,300,000
Gilmore Creek, Alaska station operations contract	1,400,000
Far East station (new station) operations contract	200,000

Mr. BUCKLEY. Yes, sir.

Mr. ROUSH. Are there other questions pertaining to this particular item?

Would you go to the next item, which is the $24 million item, Mr. Buckley?

Mr. BUCKLEY. This covers the manned spaceflight network——

Chairman MILLER. Mr. Chairman.

Mr. ROUSH. Certainly Mr. Chairman. We are happy to have you with us this morning.

Chairman MILLER. You track all space vehicles that come within the range of any of your stations, don't you, if the Russians have one up you track it?

Mr. BUCKLEY. No, sir, our stations—I have got to split this a little bit, if you will be patient with me.

Chairman MILLER. I mean the deep space stations.

Mr. BUCKLEY. The military, of course, have a commitment for tracking everything in the air, and some other agencies of the Government have the responsibility for tracking the Russians. Our electronic stations will track anything that has a cooperating transmitter aboard; in other words, on all of our vehicles that we plan to track, we put a transmitter aboard and if the Department of Defense wants us to track their vehicles they put a transmitter aboard.

The minimum transmitter for the Minitrack system is a very, very small piece of equipment.

Now the optical stations of the Smithsonian Astrophysical Observatory naturally contact vehicles that have no operating transmitter in them. We have prime assignments laid on them to track strictly the items we need tracked.

On the other hand, if they are photographing the sky there are other items that appear in the photographs, so they have other information about bodies that are coming back, as they did about the Russian sputnik which came back in Wisconsin. If it is a Russian satellite, they probably can see it; a Russian deep space vehicle, they cannot.

They could see the Department of Defense vehicles and in some cases the Department of Defense asks the Smithsonian directly, but with our knowledge, for photographs to be taken of their vehicles.

Chairman MILLER. This is all cooperative. You need the assistance, and the Department of Defense cooperates with you in a like manner.

Mr. BUCKLEY. Yes, sir.

Mr. ROUSH. Mr. Rumsfeld.

Mr. RUMSFELD. Would you submit for the record if we do not already have it a listing of how many observatory class satellite launchings are scheduled in the next 3 years?

Mr. BUCKLEY. I could submit that for the record. I don't know it right offhand.

(The material referred to is as follows:)

Major NASA flight projects to be supported by the tracking and data acquisition networks

	Calendar year		
	1963	1964	1965
Satellite network:			
Scientific observatory-class satellites	2	5	7
Scientific Explorer-class satellites	7	11	9
Communications satellites	5	0	2
Meteorological satellites	4	3	1
Other applications satellites	3	4	5
Manned space flight network:			
1-day mission	1	0	0
Gemini	1	5	6
Apollo	0	0	4
Deep space network:			
Lunar missions	3	7	11
Planetary and interplanetary missions	0	3	7
Sounding rocket flights	90	110	130

Mr. RUMSFELD. Thank you.

From what has been said, is it safe to conclude that fiscal year 1964 will be the peak year in the funding of large antennas for NASA's observatory class satellites?

Mr. BUCKLEY. I believe it is safe to say that. I think that is true, yes.

Mr. RUMSFELD. In each of these cases the funding has gone up in these areas this year, but from what has been said it would seem likely that this might be the case.

Mr. BUCKLEY. You notice that there is no construction of facilities, C. of F. items, in here for providing such major facilities for satellites this year. In other words, the funding of last year carried us through, and I don't think that we will pick up major funding for such antennas in the future. I won't say that we won't have some, but I don't think they will be major. This year there is none.

Mr. RUMSFELD. This budget that we are studying includes the funds for the 85-foot antenna in the Far East that we discussed yesterday?

Mr. BUCKLEY. That was approved last year; it was in last year's budget.

Mr. RUMSFELD. So it is not in this year's budget?

Mr. BUCKLEY. That is right.

Mr. RUMSFELD. Thank you.

Mr. RYAN. Before we leave this item, Mr. Buckley, I believe you stated the Bendix contract was being increased from $7.1 to $10.3 million?

Mr. BUCKLEY. Yes, sir.

Mr. RYAN. For this year. How long does that contract run as a contract?

Mr. BUCKLEY. This is a 2-year contract. It has incentive clauses in it—excuse me, the present satellite network contract has not, it is

the manned space net contract that has incentive clauses in it. We will try to write them in any operations contract as it comes up.

The Bendix contract is a 2-year contract. I don't know the expiration date. Mr. Williamson does.

Mr. WILLIAMSON. September.

Mr. BUCKLEY. September of this year.

Mr. RYAN. Now was there any reason for switching the million dollars from the University of Alaska to Bendix?

Mr. BUCKLEY. Well, there were two reasons. I think that the problem of operating that station turned out to be a little different than the University of Alaska thought it was going to be when it took on the job.

I know that they had, for instance, some problems paying employees because they anticipated being able to put employees at that station at a pay rate that corresponded somewhat with their instructors, but they found they were competing with industry and DOD projects in Alaska which have a different pay scale, and so they had difficulty getting the people to operate the station. This is the main reason for dropping away from the University of Alaska, and I think it was a cooperative idea that it be changed.

Mr. RYAN. Will the net cost to NASA be greater because of it being taken over by Bendix?

Mr. BUCKLEY. The contract probably will be slightly greater because of the change in salary levels, but the cost will not go over what we anticipated it should be to run that station.

Mr. ROUSH. Would you go to the next item, Mr. Buckley.

Mr. BUCKLEY. The next line is the "Manned space flight operations." One item here is a contract with Bendix for operating five stations, the stations in Mexico, Bermuda, Canaries, Nigeria, and Zanzibar, and for operating the training site for all our operators at Wallops Island.

All operating crews for these Mercury stations have been taken through the center at Wallops.

Bendix also provides the logistics for the whole net and the calibration aircraft which has equipment duplicating the equipment in the capsule and this flies periodically over all of the stations in the net.

Mr. ROUSH. How much of the item is devoted to this contract?

Mr. BUCKLEY. This is estimated at $12.4 million out of the 24. The Department of Defense receives money for operating stations. This is the partial funding of operations of two ships and reimbursement in connection with operating seven stations, which DOD operates through contractors. The total is $6 million.

Australia is operating two stations now and will be operating a third one during 1964; the estimated contract cost is $2.3 million.

IBM now provides computer programing assistance and other assistance at the Control Center; the estimate for similar services in fiscal year 1964 is $3.3 million.

Those four items then total $24 million.

Mr. ROUSH. Does any member of the committee have questions?

Mr. RUMSFELD. Yes.

Mr. ROUSH. Mr. Rumsfeld.

Mr. RUMSFELD. Would you submit for the record at this point the schedule of manned flights for the next period, your program? (See p. 2844.)

Mr. BUCKLEY. Yes, sir.

Mr. RUMSFELD. What year would you estimate that the budget funding of the manned space flight network, to meet Apollo requirements, would reach its peak?

Mr. BUCKLEY. I think it is at a peak this year, but there will be—it is possible that——

Mr. RUMSFELD. You mean a peak for fiscal 1964?

Mr. BUCKLEY. Yes. We are hoping this is the major part of it. The trajectories, the points where insertion and injection take place, where recovery will take place, and where recovery will be initiated, are under intense and very active study down at the Manned Space craft Center, and I think this may lead to specific requests for coverages that we do not know about at this time, but I think that probably 80 percent of the Apollo network will be completed using the funds in this fiscal year 1964 budget.

Mr. RUMSFELD. I see, so we don't really know what additional flight station will be needed for Gemini and Apollo then?

Mr. BUCKLEY. Excuse me, I am sorry.

Mr. RUMSFELD. Do we know what additional stations will be needed for Gemini and Apollo?

Mr. BUCKLEY. No, we can't, because the studies aren't completed.

Mr. RUMSFELD. This budget included, you mentioned, $2.3 million I recall for the third Australian station.

Mr. BUCKLEY. For the three Australian stations. You see, they have one in Woomera that you have heard about——

Mr. RUMSFELD. This would be for the third?

Mr. BUCKLEY. This contract will be for Australia for operating all three.

Mr. RUMSFELD. I see.

Mr. BUCKLEY. There is one in Woomera, one in Muchea, and one being installed up at Carnarvon.

Mr. RUMSFELD. And what is that cost going to be?

Mr. BUCKLEY. The cost of that station, $8.1 million.

Mr. RUMSFELD. I am unclear why it is necessary to have this new manned flight station at the Carnarvon site when we have two others.

Mr. BUCKLEY. The stations were laid out originally for a three-orbit Mercury mission, and they were laid out with a heavy accent on covering the first orbit of the three. For instance, the station in Nigeria was put in such a position that it was covering the first and second but not the third, and this was done because the problems that would arise as we first flew the man, we felt would arise during the first or second orbit. So the locations chosen for the Mercury stations were only for three orbits, but they emphasized the first and second orbits.

In the case of Woomera, we went down and used a site where the Australians had radars which they were going to allow us to use; it was on the already established Australian rocket range. We went there, of course, with the idea of saving money and getting the station in quickly. However, that station sees the first orbit of Mercury but doesn't see the later ones. It has a very poor glimpse of the second orbit and none of the third.

Now the plans for Gemini and Apollo require that we put the station near the northwest corner of Australia where it is not only more useful for the manned space flight shots but it also happens to be useful for EGO, for instance.

A station in the northwest corner of Australia will be able to support almost any vehicle launched from Cape Canaveral, because most of these will go near that northwest corner of Australia.

Now as we put the station in the northwest corner of Australia, we will decrease the use of the station in Woomera and will phase it out. We also plan to phase out the station down near Perth, at the location called Muchea.

However, during this next year they will all be available for the combined needs of the flight programs. By the year after that Woomera will no longer be a Mercury station and Perth probably will have been phased out. I am not sure of the date on that.

Mr. RUMSFELD. Then from what you have said, am I correct in stating to save money in an attempt to accomplish something quickly you proceeded at a point prior to this to establish two stations which you now anticipate phasing out, and the net result being that it is going to cost more money than had you selected a proper site at the outset?

Mr. BUCKLEY. By locating at Woomera, we saved quite a bit of money because we used a large Australian FPS–16 radar that was on the site, and we therefore didn't have to put one in.

Also, I said that it was desired that the sites emphasize coverage of the first and second Mercury orbits. This emphasis has been dropped now. The peculiar problems that will arise are no longer expected to occur on the first and second orbit.

You might look at this thing from another light—the original requirements for Mercury were that we wanted to talk to the man for 5 minutes out of every 15 he was in the air, and we wanted to receive telemetering not only from him but from the systems in the capsule at about that same rate. As we went to the Schirra flight, which was six orbits, we dropped this down quite a ways, and as we go to the flight coming up, which is a flight that is going to last a day or so, the requirement is down to where they want to talk to him once per orbit.

Now this means a slight readjustment of the stations will do a better job for us for these longer missions.

As it happened, the sites we chose for Mercury support can be used to meet these new requirements of once per orbit pretty readily and we can accomplish this mainly by the relocation of two ships. One ship, for instance, was moved from off the west coast of Africa out to the Philippines for the six-orbit mission, and would still stay there for the 24-hour orbit, and the other ship will be moved to a new location to get this once-per-day requirement.

Mr. RUMSFELD. I appreciate these are difficult decisions and this is hindsight, but do you feel on reflection that with reference to all this talk about a crash program that we have heard and debating whether we have one or not, do you feel perhaps if we programed a stretchout of the expenditure of NASA funds that it might be possible, for example, in an instance like this, to proceed at a slightly lower rate and yet over a period of time save a considerable amount of money by selecting the proper sites at the outset?

Mr. BUCKLEY. Well, the changes in sites that we were discussing are associated with a very major change in the program. I think that we now have to be responsive to the schedules that are laid out and the pace that has been set, and this has been determined at pretty high levels.

Mr. RUMSFELD. Yes, sir.

Mr. BUCKLEY. Our planning this year for putting in what we have to for Apollo is so set that we can accomplish the job without a tremendous speedup. In other words, any delay in getting the funds is going to make it almost impossible to get the stations and the equipment in on time, but with this year's grace we can. We are going at a pace that I think is not wasteful of money, and I don't think that slowing it down further will save any.

Mr. RUMSFELD. You don't anticipate coming back next year or the year after and discussing another major change in program where we are going to abandon this third Australia site and do something entirely different?

Mr. BUCKLEY. I am very sure we won't abandon that site. This has been given very, very careful thought, and we were very, very slow in deciding where to go in order to be sure that we made a correct decision.

Mr. RUMSFELD. Is any consideration being given to location of these three Apollo facilities at a deep space network site?

Mr. BUCKLEY. They will each be associated with a deep space site or close to it.

Mr. HECHLER. Mr. Chairman, may I follow that question?

Is there any way that money could be saved instead of just being associated closely, is there any way that we can accomplish both objectives? I think that was the point of the gentleman's question.

Mr. BUCKLEY. On all manned flight programs we have a requirement that is far more stringent than for our other work. We have almost always tried to do things in parallel or with a backup so that we could be sure that we didn't have a failure in that program.

What we are going to do in connection with the large antennas is to put in, we hope, three prime antennas for the manned space flight projects and use one of the deep-space dishes at each station as the backup. This will be fully equipped for manned flight support, and this will provide the tool that we think is necessary.

In other words, say the one in Australia went out just as the man was going to land on the Moon or take off from the Moon. This would be inexcusable, and so you need a backup at that point, and the deep-space dish will be equipped with the appropriate electronics to be the backup.

Mr. ROUSH. If I may interrupt, I believe we are going to go into this matter in greater detail when we reach the construction phase of our discussion here.

Mr. Buckley, when was the decision made to select the Woomera station?

Mr. BUCKLEY. I think it was in the spring of 1959.

Mr. ROUSH. And isn't there some pressure on the part of the Australians for us to give this station up because of increased requirements on the part of their military and the military of the British?

Mr. BUCKLEY. Yes, sir; that is a point that I omitted. It was convenient for us to go to Woomera at that time because the program for the use of the range in Australia had fallen off appreciably, and this radar did not look as though it was going to have a major workload.

On the other hand, the programs have changed in Australia, so that we were interfering materially with the Australians' use of that

station. As a matter of fact, it got to the point where we could not expect to get proper coverage for Mercury from that station, and we finally had to, at the request of the Australians, send an RCA team down to operate the station because they found they couldn't pick it up and operate it 7 days a week.

By the way, it is a rather complex operation. You see, we run a lot of exercises in connection with Mercury to check all of the stations out and anything we did in the daytime they were always doing at night. This again added to their difficulties of working with us.

On the other hand, if we put our own team in, as we did, they could handle this thing as a run-of-the-mill operation. The Australians' program became a very severe limitation on our use of that site.

Mr. ROUSH. Mr. Rumsfeld.

Mr. RUMSFELD. In this connection there has been a good deal of discussion I believe by Dr. Dryden about cooperation with other countries and participation. Is this an area where we have requested that Australia assume some responsibility, financial as well as from a manpower standpoint, to participate in this exploration of space?

Mr. BUCKLEY. The Australians have volunteered to put in 70,000 Australian pounds, about $200,000, each year to help us on this.

Much of the cooperative program Dr. Dryden talked about is in the scientific area. On the other hand, we consider the cooperation of the Peruvians in working with the station as being part of a cooperative program, too.

The Australians have been very gracious about putting a considerable amount of free effort on our programs, although they charge us direct charges for the station operation over there. There is some assistance we get from them in connection with the management which so far they have not reflected to us, and no price has been put on this, but now——

Mr. RUMSFELD. You say they make direct charges for what?

Mr. BUCKLEY. They make direct charges for the station operations, for the people that they use there, although they then credit us with 70,000 Australian pounds. There are no direct charges for the use of their shops and the use of some transportation and a certain amount of management and supervision they put into our effort over there.

If this gets to be too large a factor I think that this will be reflected in the charges to us, too, but it hasn't been so far.

Mr. RUMSFELD. We were paying rent on the site?

Mr. BUCKLEY. No, sir, we are not paying rent. They donate the site. As a matter of fact, I know of only three sites that we have where the site hasn't been donated by the foreign country. There are three countries where we lease the site.

Mr. RUMSFELD. Where is that?

Mr. BUCKLEY. We lease in Zanzibar, Nigeria, and Ecuador.

Mr. ROUSH. Mr. Wydler, did you have a question?

Mr. WYDLER. Yes, just one question.

What will happen to the antenna at Woomera when you give up the site? Will it stay there?

Mr. BUCKLEY. We were talking about giving up the Mercury site there. We have made no decision about giving up that large antenna that is used on the deep-space network.

Mr. WYDLER. I see.

Mr. ROUSH. If there are no further questions in this area, we are going to have to move right along.

Would you go to the next item, Mr. Buckley?

Mr. BUCKLEY. The next item is "Deep-space network operations," the total is $10 million.

Bendix presently assists Jet Propulsion Laboratory in operating the Goldstone group of antennas. This subcontract is estimated at $3.1 million for next year.

The Australians operate the deep-space stations in that country, through a contract, and the estimate for next year is $700,000.

The same group I mentioned earlier operates the deep-space station in South Africa, and the contract estimate is for $500,000.

Mr. ROUSH. The same group you mentioned earlier being Bendix?

Mr. BUCKLEY. No, I mentioned that it is a group having the initials C.S.I.R. It is a scientific group in South Africa.

Mr. ROUSH. And that figure again was what?

Mr. BUCKLEY. A half million dollars.

Bendix provides assistance to Jet Propulsion Laboratory at Cape Canaveral, and the amount of that is estimated at $300,000.

There is an estimate of $5.4 million for JPL itself. JPL is the contractor, as you know, of the NASA, and so the funds for JPL cover the operation of the deep-space network, which is more than Goldstone, because it includes the management, planning, and engineering in connection with the whole network.

Mr. ROUSH. Does any member of the committee have any questions on any item in this category?

Mr. RUMSFELD. Yes.

Mr. ROUSH. Mr. Rumsfeld.

Mr. RUMSFELD. I would like a schedule to go into the record or the number of unmanned lunar and planetary missions scheduled for the forthcoming period. (See p. 2844.)

I would like to discuss somewhat the same thing we were in the other area as far as the network question. Will the 85-foot antenna authorized for the same longitude as Johannesburg, South Africa, be located at Johannesburg?

Mr. BUCKLEY. We are looking for suitable sites in two or three countries in southwestern Europe rather than putting it in South Africa.

Mr. RUMSFELD. What would be the advantage of that, of a different site?

Mr. ROUSH. I don't mean to limit your questioning, but this will come I think as we get into the construction phase of it.

Mr. RUMSFELD. I see.

Chairman MILLER. If the gentleman will take my word for it, I will say it is political. When we get into the other phase you can get all of the information you want, but I don't think you want it to go in the record.

Mr. RUMSFELD. Fine.

Mr. ROUSH. Are there any other questions?

Would you go to the next item, Mr. Buckley?

Mr. BUCKLEY. The "Launch instrumentation operations," covers two areas, support of the sounding rocket launchings at Fort Churchhill, and the support of firings at Wallops Island, which, of course,

are mostly sounding rockets, but there are also a few satellites launched from Wallops.

The Fort Churchill area is used by both DOD and NASA. It is operated by the Air Force for DOD. NASA pays half of the cost of that operation, and the cost this coming year is $2.4 million.

Wallops, as you know, is on the eastern shore of Virginia and the estimate for Wallops is $2.6 million, covering a number of contracts. RCA operates a radar there. MSTS, which is the Navy group, the Military Sea Transport Service, operates an offshore vessel for telemetering and for recovery, and the cost of that is about a half million dollars a year. The Weather Bureau operates a weather station there. It provides us predictions and analyzes the weather that the satellites are fired through. Bendix provides some assistance for Tiros, which is connected with using our general-purpose antennas there for tracking and receiving telemetering from Tiros, but not the weather pictures from Tiros as it goes over. That is a separate operation and is under the meteorological satellite group, instead of under my office. It is, however, done by RCA. There is an operation by the Bureau of Standards, the cost of which is $50,000 a year, and this is where they bounce radio signals off the ionosphere and predict the conditions of the ionosphere.

There is a group of optical stations down near Cape Charles and down as far as Coquina Beach, near Hatteras, which are used for rockets that are fired up in the air and then come back down close into Wallops, that reach speeds of mach 25, something of that sort. These are tremendously high-speed rockets when they come back in, and the optical stations not only track them but they get the so-called optical signature, the spectrographs on there. From these you can tell what the reentry physics are of the body that is coming back in, why it burns up or what part burns up first.

Incidentally, at Wallops Island at no charge to us is a group of Lincoln Laboratory people and antennas that have been there 2 or 3 years. They get the radio signature from these returning vehicles that we fire for the Department of Defense. We fire them to do research on reentry physics and do some optical tracking of our own, but the same vehicles are then available for bouncing radar signals off, and Lincoln Lab carries on this operation for the Department of Defense.

The total cost, as I said, for Wallops, is $2.6 million. The total Fort Churchill and Wallops then is $5 million.

Mr. ROUSH. Mr. Rumsfeld, were you going to ask him for the scheduled launches for Wallops Island?

Mr. RUMSFELD. No.

Mr. ROUSH. Would you provide the launches that you have scheduled for Wallops? Do you have that?

Mr. BUCKLEY. Wallops Island is a place from which we fire for all branches of the military, for various universities, for ourselves and for AEC, for instance, and a certain number of foreign firings are there. There are two foreign groups firing there now. The best we could do would be a prediction for next year.

Incidentally, the total number of firings at Wallops is about 200.

Mr. ROUSH. All right, if you would supply that we would appreciate it.

(The material referred to is as follows:)

In January 1963, the following rocket flights took place from Wallops Station:
6 weather soundings
23 rocket development tests
1 payload ejection system and electron gun test
1 radar reflection experiment
1 airglow experiment
1 ultraviolet spectrum experiment
1 artificial meteor experiment

In addition, some 226 firings are presently scheduled for the rest of the year, including 9 Scouts. The rate of firing will be approximately 20 flights per month.

Mr. ROUSH. Are there any other questions on this item?

If not, let's move to the next item, the $800,000 item.

Mr. BUCKLEY. This covers the operation of the tracking range that is at and near Edwards, Calif., used in connection with the X–15. It involves a station at Ely, Nev., one at Beatty, Nev., and then a major installation in our own building there at Edwards.

Bendix has at present a contract to provide operational services and the logistics, supplies, and maintenance of equipment. This is a similar contract then for $800,000.

Mr. BOONE. This is in addition to the military there?

Mr. BUCKLEY. Yes, sir.

The X–15, as you know, is carried under the wing of a bomber, up-range, beyond Beatty, Nev., and then is dropped and comes back over these three stations. They are tied together by proper communications so that there are displays and the project people at the various stations——

Mr. BOONE. And the military cannot supply these facilities for you, so you must operate them, is that right?

Mr. BUCKLEY. This group of three stations was put in because there were no military stations that could supply it, that is right, and it has been running since then. I don't know whether the military has put in anything since then.

Maybe you know, Gerry.

Mr. TRUSZYNSKI. No, there was nothing put in.

Mr. HECHLER. I am troubled, Mr. Chairman, as to why the military couldn't operate that.

Is there any specific reason why NASA has to do it?

Mr. BUCKLEY. We put it in to carry out the X–15 program in which, of course, we were responsible for everything but the bomber that carries the flights.

This represents an agreement with the Department of Defense. The network was installed and has been operating under this condition ever since. It could be changed to the Department of Defense. I don't know whether there would be any advantage to it or not. It would just switch over, I think, undoubtedly, to the same contract we are operating under.

Mr. HECHLER. That is all I have.

Mr. ROUSH. If there are no questions, would you move to the next item then?

Mr. BUCKLEY. The next item covers the operational communications network that ties all of the stations together. A large group of contractors are involved on this. I will run down them fairly fast.

This is the communications network that ties together for operational purposes the deep space network and the Mercury network and

the satellite network. Most of the circuits are for teletype service, but there are some voice circuits among them.

The bill from American Telephone & Telegraph Co., which covers services in the United States, to Bermuda, to Hawaii, and to Mexico by telephone, is estimated at $4 million. RCA contracts are estimated at $2.75 million for services to Mexico by radio, a backup to the phone lines whose reliability we are worried about, and for service to South Africa and to Australia. For a network of Western Union teletype circuits in the United States, approximately $700,000. Philco presently provides engineering services on the monitoring of communications circuits and provides assistance in continually metering and assessing the reliability of the whole network. These services are estimated at $1.28 million next year. There are funds going to other Government agencies: to the Defense Communications Agency, to the Army, to the FAA for a circuit from Hawaii to Canton Island, and to the Bureau of Standards, who makes propagation predictions continuously. These propagation predictions, incidentally, are taken into account on establishing the firing time for Mercury. In other words, if they predict, as they did just in advance of the last flight, some magnetic storms that would interfere with communications, we have to be very wary about the flight, and as it happened we just barely missed this condition on the last flight. The total for other Government agencies is $890,000. Other estimated contracts are: Southern Bell Telephone Co., $32,000; Chesapeake & Potomac Telephone Co., $130,000; Hawaiian Telephone Co., $30,000; Overseas Telecommunications Commission—this is a contract with Australia for communications external to Australia back to the United States, $460,000. Internal in Australia it is $750,000. There is a low-speed cable, a very old-fashioned cable, that provides a backup to the radio circuits to Australia, which is the thing that we need in case of a possible complete radio blackout. That is $72,000. There are a few more: For example, British Cables & Wireless, that ties in the Canary Islands, Nigeria, Zanzibar, and South Africa, $449,000; a Spanish radio company, that provides the link between England and the Canary Islands, $47,000; the telephone bill internally in the Canary Islands, $24,000. With other services and operations, that covers the total of $16 million.

Mr. ROUSH. Are there questions on this item?

Mr. Hechler.

Mr. HECHLER. Mr. Chairman, I just want to ask a naive question.

This money that goes to other Federal agencies, what is the advantage of having it appropriated and authorized to NASA, rather than having it go through the other agency?

Mr. BUCKLEY. I have a good answer to that, since it is we that make arrangements with the FAA, for instance, for the circuit from Hawaii to Canton. In the course of planning this and setting it up, it comes up that we should pay them for this service, since we are imposing the workload. I do not think it could be changed.

Mr. ROUSH. Mr. Rumsfeld.

Mr. RUMSFELD. Is it correct to say that with the exception of the $890,000 which goes to other Government agencies that the entire NASA communication network for tracking and data acquisition facilities is leased?

Mr. BUCKLEY. That is right, it is the policy to lease it instead of setting up a very expensive Government communications for a short period. It was determined advisable to lease it.

There is another reason for this in the case of the foreign countries. In many countries it would be very difficult for us to get our own communications setup into them. Our own country is very wary about allowing foreigners to operate radio equipment in this country. Contracting with a group that was native to Nigeria or to Zanzibar greatly relieved our problem of getting communications services there.

Mr. RUMSFIELD. Will mobile stations be developed by NASA or leased from commercial common carriers?

Mr. BUCKLEY. By NASA. I think if we put a mobile set in it would usually be used in connection with a mobile site, and this would be a be a van-mounted piece of equipment that would be a NASA setup. Incidentally, the problem of getting permission to operate such a rig in the country might become bothersome.

Mr. RUMSFIELD. I see.

Mr. ROUSH. Since most of these are fixed charges, why is it that this item has gone up to the extent that it has?

Mr. BUCKLEY. There are more circuits coming on the air. For instance, the meteorological station operation will be moved from the west coast to Alaska and we will be bringing Tiros pictures back over a circuit from Alaska.

There are added voice circuits that have been demanded, required by the manned space flight team. In the beginning we had voice communications only with the stations from Bermuda to Hawaii, but as time went on they decided they needed more voice communications and this was installed in the latter part of last year and will be reflected then in the bill for next year. There were voice communications around the whole world for the last Mercury flights.

Mr. RYAN. Mr. Chairman.

Mr. ROUSH. Yes, Mr. Ryan.

Mr. RYAN. Does the Department of Defense have a communications system which you could use for part of this which you do not use?

Mr. BUCKLEY. We have used some Department of Defense communications. For instance, in the original Mercury shots we used the SAC circuits into Bermuda. Most of the Department of Defense circuits that we could get are leased anyway.

There is a third answer to it, and that is that up to recently, most of the Department of Defense circuits encompass a band across the globe from, say the eastern Mediterranean to the western Pacific, pretty much at the latitude of the United States. In other words, they don't go down into Africa, they don't go down into South America. There were two Department of Defense circuits that we tried to Australia in the beginning, one radio circuit by way of Hawaii to Australia, and another radio circuit through Alaska, Japan, the Philippines, and Australia; there was interference between DOD traffic and ours, and those circuits when we used them did not have the reliability that we needed.

Mr. DAVIS. Mr. Chairman.

Mr. ROUSH. Mr. Davis.

Mr. DAVIS. Do you regard the telephone lines as backup communications and your radio as primary, or is it the other way around?

Mr. BUCKLEY. I made the differentiation, Mr. Davis, between teletype and telephone, which is the difference between sending a telegram and talking to the man.

To try to answer your question, we try to use hard lines if we can because they are more reliable; that is, we try to use the wire circuits in the United States and the cables. As soon as the cable was available to Bermuda we quickly went to the cable instead of using the radio circuits because we had had quite a bit of trouble with that. And, of course, we have to be very careful of the long radio circuits to Australia and South Africa. We have had trouble with them. We would rather use a wire circuit if they existed to Africa and Australia than the radio circuits. If there were wire circuits we would use them, that is the answer.

Mr. DAVIS. Well, the SAC circuit you referred to, to Bermuda was that a wire circuit?

Mr. BUCKLEY. No, two single radio circuits. We had troubles there. The skip distance to Bermuda was such that it was hard to get the realiability in a circuit to Bermuda at the time that we needed for Mercury, which was a higher reliability than the telephone companies provide normally.

Mr. DAVIS. That is all.

Mr. ROUSH. Mr. Buckley, I think it would be helpful on each item as we proceed if you could tell us why the item has gone up. I don't know that there are any which have gone down, but if you could explain to us why they have gone up.

Mr. HECHLER. I found one that went down, Mr. Chairman.

Mr. ROUSH. I am sorry. Mr. Hechler has observed one that went down.

If there are no further questions here, would you proceed to the next item. We are going to have to move right along.

Mr. BUCKLEY. The next group then to go over is "Equipment and components." This is on page 23–11 of——

Mr. ROUSH. Pardon me, did you take care of "Data processing and handling"—the $7 million item?

Mr. BUCKLEY. I am sorry, I didn't mean to skip it.

I find I have no breakdown of that here. I thought I had.

Mr. ROUSH. If you don't have it here you could provide it for the record, if you will, together with a brief statement explaining the item.

Mr. BUCKLEY. Yes, sir.

(The material referred to is as follows:)

The majority of data acquired from the NASA flight projects is processed into a form useful to the experimenter at the NASA Center responsible for the flight mission; it is necessary, however, to supplement this in-house effort with the contractor services. The level of this additional support is a function of the flight schedule and the available in-house capability. Additional contracted data processing services will be necessary in fiscal year 1964 to handle the extra load generated by the increased number of space vehicles planned for launching during the year, especially the large satellites. For example, several equipment complexes to process pulse code modulated information will be put into operation during fiscal years 1963 and 1964 at the Goddard Space Flight Center to cope with the increased data processing workload. The staff to perform the necessary equipment alinement, checkout, calibration, and operation for final processing of the data will be contractor personnel. In other cases, raw data from the stations will be reduced to scientific and engineering terms at contractor-

owned-and-operated facilities. The operations estimates can be broken down as follows:

Procurement of digital magnetic tapes	$2,600,000
Quick look printing services	110,000
Procurement of punched cards	250,000
1107 computer operations	500,000
Computer programing services	1,650,000
Evaluation of DOD satellite data tapes	175,000
Satellite telemetry automatic reduction equipment operations	2,41[illegible]000

Mr. ROUSH. Does any member of the committee have a question on this item?

In moving to this next item, gentlemen, it is apparent that our time is limited and without in any way limiting your time to question on any one of these items, I wonder if it wouldn't be appropriate for us to ask Mr. Buckley to submit for the record, following the pattern we have established, a statement pertaining to each item. Would that be agreeable with the committee?

If so, does anyone have a question pertaining to "Equipment and components, satellite network," which goes from page 69 to the middle of page 70?

May I ask you, can you again break down these items, Mr. Buckley, in the same manner, on the network operations, at least to a certain extent?

Mr. BUCKLEY. You notice the "Equipment components" has seven items, and book 5, which you received, has a breakdown by line item for each.

Now Mr. Truszynski is prepared to speak to the items in any depth that you want and could summarize them.

Mr. ROUSH. If there is no objection we will have Mr. Truszynski's statement concerning each item, similar to what you did before, placed in the record.

Now is there a question on the part of any member of the committee concerning "Satellite network," which totals $22 million?

Mr. BOONE. The contractors that you have do not provide any maintenance, you must provide maintenance spares, and so forth, to them for their upkeep of equipment; is that correct?

Mr. BUCKLEY. You are referring, for instance to the operations contract? No, sir; they supply the logistics as part of their contract.

Mr. BOONE. They do supply the logistics?

Mr. BUCKLEY. Yes, sir.

Mr. BOONE. These are maintenance and spares, equipment that you need within NASA to support this network?

Mr. BUCKLEY. Yes, as part of the operations contract that we discussed a minute ago?

Mr. RYAN. Well, would you yield on that point?

Exactly what does Bendix supply in its contract, more than personnel? Does it supply hardware?

Mr. TRUSZYNSKI. Mr. Ryan, Bendix does supply what is normally called maintenance spares. This is a large variety of small items, spare tubes, and the normal logistic type of items at a station. These are the housekeeping items, normal things to run a station, such as janitorial service and supplies, a variety of items such as this.

The maintenance spares and replacement equipment involved here are the next level of spares and replacements that NASA determines are needed to keep the network.

Mr. RYAN. Where do you purchase them?

Mr. TRUSZYNSKI. In many cases they are specific replacement items for a piece of equipment already existing, and they are procured from the particular firm that manufactures the existing piece of hardware.

Mr. ROUSH. Other questions?

Mr. RYAN. So that in effect you have Bendix and NASA both managing this network, in terms of determining what equipment you are going to supply?

Mr. TRUSZYNSKI. I think it is fair to say that NASA manages this entire operation, including a review of the stock levels of the normal type of supply equipment that Bendix carries. This is under review entirely by NASA.

Logistic support under operations includes housekeeping items such as janitorial services and supplies as well as production type "off the shelf" electronic and mechanical components. These components are common replacement parts such as spare tubes and resistors which are required for the day-to-day operations of the larger pieces of equipment.

Maintenance, spares, and repairs under equipment is concerned with the replacement, refurbishing, and overhaul of major pieces of equipment to restore the designated capability. It also includes the replacement of parts for these major pieces of equipment which have deteriorated by wear and tear but which do not have the immediate day-to-day replacement characteristic of spare parts under logistic support. These replacement parts are usually characterized by a higher unit cost and often require a more selective procurement than the equipment items included within logistic support.

While NASA has the overall responsibility for operating and equipping the networks, individual contractors provide logistic support on an individual station-use basis. However, under the maintenance, spares, and repairs of equipment, the NASA directly plans for and procures such components on a network basis. A typical breakdown of maintenance, spares, and repairs would be the $5,500,000 requested for the satellite network in fiscal year 1964 which was planned as follows:

4 sets of spares and special maintenance tools for 40-foot antennas	$400,000
2 sets of spares and special maintenance tools for 85-foot antennas	200,000
Replenishment of network engineering support items	50,000
2 hydraulic maintenance elevators	50,000
Timing systems replacement	350,000
11 Receiving systems	(165,000)
4 Time standards	(35,000)
Calibration and checkout equipment for above	(50,000)
Power supplies and distribution for above	(100,000)
Additions and modifications to telemetry stations	1,700,000

The introduction of PCM telemetry systems, with signal conditioning consoles and displays, plus the new command and command verification systems will require modification and addition to available space at the Mojave, East Grand Forks, Fort Myers, Alaska, Lima, Woomera, Newfoundland, Winkfield, and Santiago stations. Additional equipment requires both the replacement of generator units and the addition of space for additional generators to meet the increased power needs.

Replacement of plant and facilities and equipment	500,000

A continuing program of replacement of electrical, heating, air conditioning and other utilities at all satellite net stations is now becoming necessary due to the number of years these stations have been operating.

Station system components spares	400,000

With over 12 stations operating in the network, major system equipment such as rack power supplies, buffers, transmission cables, switching assemblies and the smaller antennas require on-site spares to prevent breakdown and unreliable operation.

Replacement of general purpose test equipment	450,000
Experience reveals that replacement of test and calibration equipment is required as a continuing basis at an approximate cost of $35,000 per station. Replacement of such equipments as oscilloscopes, frequency counters, rack-mounted O-scopes, audio oscillators, signal generators, oscilloscope cameras, and minor test equipments are to be provided to minitrack and telemetry stations plus the Alaskan 85-foot station.	
Modular receiver and transmitter spare	350,000
Spares are required at all stations to maintain full operational capability.	
26 replacement paper tape recorders	260,000
Excessively worn and obsolete units at the minitrack sites must be replaced. These units are similar to Sanborn oscillographic recording systems.	
12 replacement magnetic tape recorders	790,000
These are similar to the Ampex FR–600, with a seven-track capability.	

Mr. WYDLER. Mr. Chairman.

Mr. ROUSH. Mr. Wydler.

Mr. WYDLER. Would you just give me an idea. You have an item here of $40,000, payload-simulation equipment. What is payload-simulation equipment?

Mr. TRUSZYNSKI. This is a piece of equipment that generates the same signals that are generated by the satellite, and can be taken to a station. This allows you to check out the station with a signal that is representative of what will be received in the station.

Mr. WYDLER. I understand. Now one last thing.

On page 69 you have "Network operations, satellite networks," that is the $17 million figure. Now we have under "Equipment and components, satellite network," this is the $22 million total. So I have it clear in my mind. What is the difference between this $22 million and the $17 million figure?

Mr. TRUSZYNSKI. The $17 million figure is composed entirely of personnel services, operators' salaries, and the cost of these normal small repair and replacement items that are part of their service for the station.

Mr. WYDLER. Do you mean that represents personnel services?

Mr. TRUSZYNSKI. Personnel services and small amounts of equipment, replacement components. These are tubes, resistors, levels of replacement items.

Mr. ROUSH. The last five items apparently are for new programs.

Mr. RUMSFELD. Which last five?

Mr. ROUSH. I am sorry, referring again to the category "Satellite network," on page 70, the last five items are listed for the first time. They were not listed for 1962 or 1963.

Is this a fact that these are items devoted to entirly new programs we have not been in before?

Mr. TRUSZYNSKI. Yes, sir; that is correct.

Mr. ROUSH. And the major item here is a $3,400,000 item for portable-range and range-rate tracking stations. Is this devoted to one of our new programs or one of our new launchings?

Mr. TRUSZYNSKI. This will be used primarily to support the upcoming observatory-class satellites, such as the EGO satellite, which requires, as we mentioned yesterday, an additional type of tracking for orbit determination. EGO is the Eccentric Geophysical Observatory.

Mr. DAVIS. It is in Earth orbit?

Mr. TRUSZYNSKI. Yes, sir; highly elliptical.

Mr. ROUSH. I think when you comment on each item, keep in mind we are interested in the contractors involved. We are interested also in the reason that the item may have again gone up instead of down.

Mr. Ryan.

Mr. RYAN. Might I suggest that when Mr. Buckley submits his report he also give a breakdown on the number of Bendix contracts and the amounts and what they specifically involve?

Mr. ROUSH. There is no objection.

Mr. Buckley, can you supply that for the record?

Mr. BUCKLEY. Yes.

Mr. ROUSH. All right, if you will, please.

(The material referred to is as follows:)

Active fiscal year 1963 Bendix contracts under Office of Tracking and Data Acquisition jurisdiction—Fiscal year 1963 obligations as of Jan. 31, 1963

Technical services, logistic support, and field operations and maintenance of the electronic satellite network	$3,478,000
Operation, maintenance, and logistic support of the manned flight network (this contract expired Dec. 31, 1962)	5,416,000
Operation, maintenance, and support services for the manned flight network (this contract entered into Jan. 1, 1963)	500,000
Technical services and support of the X–15 High Range	314,000

Mr. ROUSH. Mr. Rumsfeld.

Mr. RUMSFELD. I am mentioning this now because possibly it ought to be submitted for the record separately at your leisure, but in this whole area of equipment components there is roughly a hundred percent increase, and I would like to have some indication of what the leveling-off target is on these funds and possibly what you would anticipate would be the specific fiscal year 1965 request under equipments and components. It has gone from 16 to 67 to 134 million, which is a pretty good growth curve.

Mr. BUCKLEY. We believe that there will be a further increase next year.

Mr. RUMSFELD. Another hundred percent increase?

Mr. BUCKLEY. I don't think it will be a hundred percent. I think it might be 40 to 50.

Mr. DAVIS. Mr. Chairman, if I may, I would like to pose an observation there.

We are dealing solely with tracking and data acquisition and, of course, the responsibility of Mr. Buckley's department is to handle tracking and data acquisition on whatever program we launch as an overall picture in NASA.

Mr. RUMSFELD. Absolutely. I am aware of this.

Mr. ROUSH. If there are no further questions, let's move to this next page or item, "Manned flight network," which begins on page 70 of volume 5 and continues through the middle of page 71. This is a major item and it totals $84 million.

The setup as it is placed in the book, Mr. Buckley, would indicate that there is some phasing out of various programs, and there is the beginning of some of our new programs included in this item. Perhaps you would like to generally comment on this first before we get into the specific items.

Mr. TRUSZYNSKI. The arrangement shown here represents the successive augmentations of the manned flight network for the specific programs that we have been involved with. The manned space flight program started with Mercury, it has proceeded through Gemini and next will be the Apollo, and these breakdowns essentially represent the required major augmentations in that order.

In 1964 this entire amount of $84 million will be the augmentation of the manned space flight network required for the upcoming Apollo program. There is no phasing out of use of the network on these preceding programs, but it represents the successive steps that have been taken to support the successive manned space flight effort.

Now in the 1964 area, this does represent the breakdown in some detail of the specific types of equipment that will be required to handle the upcoming Apollo program.

Mr. ROUSH. There was testimony previously that the Apollo program had slipped 5 or 6 months. Is this reflected in this proposal which you present to us today?

Mr. TRUSZYNSKI. Yes, sir; it is. This proposal represents the best schedule estimates of the manned space flight people.

Mr. ROUSH. And is it up to date as of today?

Mr. TRUSZYNSKI. Yes, sir, it is.

Mr. ROUSH. You would, of course, notify the committee immediately if there was an apparent further slippage or if there was a change in plans which might indicate that the budgeting should be changed prior to the time we present it to the Congress, is this correct?

Mr. TRUSZYNSKI. Yes.

Mr. ROUSH. In this area does any member have a particular question on any one item?

Mr. Wydler.

Mr. WYDLER. I would like to ask you about the landing area instrumentation, the last item appearing, $3 million, what is that exactly?

Mr. TRUSZYNSKI. This money will be used to obtain equipment that will be required to properly direct the Apollo spacecraft in its final landing maneuver. As you know——

Mr. WYDLER. The reason I am raising this is because this is this year's budget, but actually, of course, we don't expect to be landing the Apollo I don't believe for many years to come, do we?

Mr. TRUSZYNSKI. No, that is correct. However, there will be landing exercises starting with the early Apollo tests. As you know, the Apollo program will first have some orbital tests, and while it is true that the landing from the Moon mission will not be for several years, there will be a progressive buildup of tests, including return from orbit.

Mr. WYDLER. This equipment is going to be used this coming fiscal year?

Mr. TRUSZYNSKI. Not this coming fiscal year; no, sir. However, we feel we must proceed with development and with the procurement of this equipment this fiscal year in order to——

Mr. WYDLER. No; the development I understand. This is some kind of equipment you are actually going to buy, though, isn't it? This is a piece of equipment that you are going to purchase this year, isn't it?

Mr. TRUSZYNSKI. Many of these funds of necessity include development in addition to procurement. This is not off-the-shelf type of procurement.

Mr. WYDLER. All right, I understand that. Now let me ask you one other thing:

Is there any possibility that any of this equipment in this particular category, since it will include Gemini, the expense of it might possibly be picked up by the Air Force under your new cooperative program with the Air Force, where they are going to, as I understand it, cooperate with NASA and work with NASA and pick up part of the expenses of this Gemini program?

Mr. TRUSZYNSKI. Mr. Wydler, this item, the 1964 request is all for Apollo equipment.

Mr. WYDLER. This has nothing to do with——

Mr. TRUSZYNSKI. It has nothing to do with Gemini.

Mr. WYDLER. At all?

Mr. TRUSZYNSKI. That is right.

Mr. ROUSH. Mr. Boone.

Mr. BOONE. It seems to me all of the items listed here are certainly 18 months or that order of leadtime, and the latest schedule for NASA shows Gemini and Apollo launches in the fourth quarter of 1963, for example, so have you convinced yourself that these are in consonance with the shoot schedule for Gemini and Apollo?

Maybe you would like to tell us how this fits in with the schedule.

Mr. TRUSZYNSKI. Yes, sir. In terms of Gemini and Apollo differentiations, the manned space flight network is currently undergoing an augmentation for Gemini which will be completed by the time of the upcoming first Gemini flights.

We are speaking here now of the specific additional equipment that is required for Apollo and the way we are approaching this is that there will be a phased installation program such that we will be able to take care of the successive phases of Apollo, which again are broken down in terms of initial orbital flights with a C–1 vehicle, or Saturn I as it is now called, and subsequent orbital flights with a Saturn B vehicle, and then the final flights with the Saturn V vehicle.

This amount of money represents the amount needed for preparation of this total network. We plan to have a phased capability such that we can properly match the specific phases of the Apollo program, for the orbital and final lunar launches.

Mr. BOONE. May I ask then when do you plan to have, for example, all of the data handling and numeric display equipment installed that would be purchased with the $24 million?

Mr. TRUSZYNSKI. This is first required for the latter phases of the Saturn I tests with the Apollo command module. I would have to determine the exact date of that but—this perhaps is a classified date.

Mr. ROUSH. Well, I am sure you can get this information for the committee.

Mr. TRUSZYNSKI. Yes.

Mr. ROUSH. It is apparent that our time is up.

Chairman. MILLER. Mr. Chairman, may I say to the committee on these things, we are meeting here, authorizing money which is the upper limit that can be spent. Before any of this money is spent it has to be appropriated. This is one of the functions of the Committee on Appropriations to determine, whether or not 3 million or a million

and a half or 24 million or 5 million will be immediately spent for this. This is the upper limit for the thing.

Let's not confuse the fact that we are an authorizing committee and not an appropriations committee.

Mr. ROUSH. Thank you, Mr. Chairman.

Mr. RUMSFELD. I think that is a good point. However, recently, the House considered an authorization bill, and each item was approved by the legislative committee exactly as requested with, in my opinion, insufficient discussion. I think that it would be of great value to the members of the Appropriations Committee if these matters were gone over in some detail by the authorizing committee.

Chairman MILLER. I may say to the gentleman that I think this committee has gone over these items from time to time since it has received this authority with much greater care and skill than any other authorizing committee, and there are only two in the Congress. We still have the matter of appropriating the money for these.

Now no one wants to cut you off or to interfere with your right to investigate any of these items, but I just point this out to you, that in this field particularly and in the whole field in which we deal, it is almost highly impossible to predicate today what you are going to spend 18 months, or a year from now, or to get definitive information.

We deal in a sort of nebulous area where we are continually in the dark, and the best we can do is to penetrate this so far as we can. Unfortunately, we have to take a lot of it on faith. That is why we use our oversight authority continuously to make sure that within the limits that we have operated, that NASA operates. That is why you have heard from the very beginning here criticisms in the full committee of NASA's reprograming because we have reprogramed out whole programs that we were at one time ready to go into.

Now I want to tell you that it takes as much courage to scrap a program when you find it is not feasible or not going to be needed, as it does to initiate one.

Mr. HECHLER. Mr. Chairman, I have never seen as energetic or broad a committee chairman as would come to take such an interest in what a subcommittee is doing.

We certainly appreciate it, Mr. Chairman.

Chairman MILLER. Whenever I say that I want the new members to know that it is in no criticism. I want them to satisfy themselves, because that is the only way we can get the basis on which the committee operates.

Mr. RUMSFELD. May I inject something here?

Mr. HECHLER. Let me complete my thought.

I appreciate serving with a subcommittee here which is as energetic and thorough in its work, also.

Mr. RUMSFELD. Well, I would say that this has certainly been the chairman's policy, as well as the chairman of the subcommittee, since I have been on this committee, which amounts to just a few weeks now, and I certainly appreciate it.

Chairman MILLER. Thank you.

Mr. ROUSH. We will have to pursue this matter more tomorrow.

Mr. Buckley, I am wondering did you come prepared with any sort of breakdown on the manned flight network figures which could be distributed today?

Mr. BUCKLEY. None that we can distribute.

Mr. ROUSH. Would you prepare a similar breakdown as we requested for the previous items for the committee?

Mr. BUCKLEY. Yes, sir. (This information was furnished at a later date.)

Mr. ROUSH. And are you prepared to return tomorrow at 10 o'clock?

Mr. BUCKLEY. Yes, sir.

Mr. ROUSH. The committee then will stand adjourned until tomorrow morning at 10 o'clock.

(Whereupon, at 12:06 p.m., the subcommittee was adjourned, to be reconvened at 10 a.m., Thursday, March 14, 1963.)

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1964 NASA AUTHORIZATION

THURSDAY, MARCH 14, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON APPLICATIONS AND
TRACKING AND DATA ACQUISITION,
Washington, D.C.

The subcommittee met at 10 a.m., pursuant to adjournment, in room 214-B, New House Office Building, Hon. J. Edward Roush, acting chairman of the subcommittee, presiding.

Mr. ROUSH. The committee will be in order.

Mr. Buckley, we are prepared to continue our discussion of items included in volume 5 of your backup books. Yesterday we had come to the place on page 71, where we begin the discussion of deep-space network.

Before going ahead with that, does any member of the committee have a question pertaining to any item we have thus far covered?

Mr. HECHLER. I would only suggest, Mr. Chairman, I think some of us will have some questions to submit for written answers, on previous matter.

Mr. ROUSH. Let's follow the procedure we started with yesterday, Mr. Buckley, on this deep-space network, and permit you or one of your assistants here to explain briefly the item, the reason for it, and the reason it is increased, if it is increased, over last year's request. Are you prepared to go ahead in that manner?

FURTHER STATEMENT OF EDMOND C. BUCKLEY, DIRECTOR, OFFICE OF TRACKING AND DATA ACQUISITION, NASA; ACCOMPANIED BY GERALD M. TRUSZYNSKI, DEPUTY DIRECTOR, AND DAVID WILLIAMSON, JR., CHIEF, PROGRAM COORDINATION

Mr. BUCKLEY. Yes, sir. I would like to have Mr. Truszynski carry on that part from yesterday. I have here some of the material you requested we supply yesterday, the breakdown on the "Equipment and components" section.

Mr. ROUSH. Very well. He can distribute it.

In case we did not make a record on this yesterday, the material which Mr. Buckley is now submitting will be made a part of the record, unless there is objection on the part of any member of the committee.

Would you distribute those, please?

Mr. BUCKLEY. This is not all of the material; this is the part that we were able to prepare since yesterday.

Mr. ROUSH. Thank you.

96-504 O—63—pt. 4——7

(The remaining information is furnished below:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION,
Washington, D.C., March 14, 1963.

MEMORANDUM

Subject: Fiscal year 1964 estimates for "Equipment and components," within the tracking and data acquisition program.

The attached documents provide brief descriptions of the line items under "Expansion of network capability" within subject estimates, for the following activities:

Manned flight network.
Deep-space network.

MANNED FLIGHT NETWORK—EXPANSION OF NETWORK CAPABILITY

Data-handling and alpha-numeric display systems (Dahad)

The outputs from the Unified S-band systems described below will feed the Dahad. Dahad systems will be located at all prime stations in the manned-flight network. Input to the Dahad is a wide-bandwidth video signal. The primary subsystems of the Dahad are:

Demodulators.
Data processor and handler.
Displays, including mission, operational, engineering, biomedical and television.
Communication terminal equipment.

The heart of the Dahad is the data processor and handler. This device selects the data for display, generates the data format for communication with the Manned Flight Integrated Mission Control Center, inserts engineering calibration factors and many other necessary functions.

Unified S-band station systems

The present Mercury-Gemini communication system operates at several different radiofrequencies with primary data links in the 225–260 Mc/s. For maintaining adequate communications at lunar distances, it is necessary to use a higher frequency (approximately 2300 Mc/s) where additional capability can be obtained through reduced galactic noise, improved antenna directivity and ultra-low-noise receivers. The communication channel at 2300 Mc/s will be designed to accomplish the following functions.

Data transfer (Earth to spacecraft and spacecraft to Earth).
Voice (Earth to spacecraft and spacecraft to Earth).
Television (Earth to spacecraft).
Tracking (angles, range and range rate).

Besides using the 2300 Mc/s communication channel at lunar distances, it is possible to use it during the orbital and near-Earth portions of the Apollo missions. This is advantageous in that weight is saved on the spacecraft, spacecraft-antenna problems are reduced, additional communication capability is provided, and the manned-flight network is better integrated.

The unified S-band systems will be placed at all prime stations in the MSFN. A typical unified S-band system for use in the orbital and lunar transfer phases of the Apollo mission would include the following major subsystems:

Antenna.
Antenna drives and servo-system.
Diplexer.
Parametric amplifier.
Transmitters and receivers.
Ranging encoder and decoder.
Doppler extraction unit.
Modulators.
Collimation and calibration equipment.

Deep-space station Apollo S-band compatibility subsystems

Three stations of the deep-space network with 85-foot antennas will be used as backup to the prime manned-flight antennas. This cross use of facilities provides an economical solution to providing the required reliability for Apollo mission without incurring the cost of duplicate facilities. However, the deep-space stations do not have all the necessary equipment for the Apollo missions, since

the stations were configured for the unmanned lunar program. Certain portions of the unified S-band system and other manned-flight network equipment must be provided. Among these items are

Antenna modifications (RF and servo).
Receiver modifications.
Additional three-channel receiving system.
Collimation and calibration equipment.
Communication terminal equipment.

Engineering and systems integration

A major effort exists in the integration of the major systems and subsystems described above to provide for a properly and efficiently operating network. In addition, precise test, checkout, and operating and maintenance procedures must be engineered, tried, and documented. This item provides for the required engineering, equipment, and documentation.

In-orbit checkout, data-conditioning systems

In-orbit checkout, data-handling equipment

In-orbit checkout, display-and-status monitoring system

For lunar missions it will be necessary to remotely conduct and reverify vehicle checkout in space after insertion into the parking orbit, and before the spacecraft is injected into the lunar trajectory. This is mandatory to detect any malfunctions or equipment failures or damage which may have occurred during the launch-boost phase. Since contact time with the spacecraft will be limited, this procedure must be performed rapidly and automatically. To accomplish this in-space checkout, data-acquisition equipment; versatile telemetry systems; real-time, data-handling, processing, computing, and transmission equipments; control and command equipments; and equipments capable of displaying and presenting this data in usable format for evaluation by flight controllers are required. Three such systems, installed at selected, established, manned-flight-network stations will be required to execute this function.

Landing-area instrumentation

In order to quickly establish the position of the manned spacecraft prior to landing and recovery, tracking, detection, and display equipments are required at the prime and secondary landing areas. In addition, communication with the spacecraft will be required from paraglider deployment until landing.

DEEP-SPACE NETWORK EQUIPMENT—EXPANSION OF NETWORK CAPABILITY

S-band transmitters and components

S-band ranging systems

Data transmission and processing equipment

Digital data and instrumentation systems

To meet the increased flight schedule for fiscal years 1964 and 1965, S-band exciters, amplifiers, synthesizers, interface equipment, angle encoders, digital systems, etc., will be installed at each deep-space network station to provide a complete and compatible data-acquisition, tracking, command-recording, and processing system. Precision ranging, using S-band frequencies, is required for unambiguous ranging at interplanetary distances. The prototype equipment was developed during the past year.

Klystron and maser amplifiers

S-band traveling-wave maser amplifiers, under development since 1961, will be provided at all stations. The constant vibration on the large moving structure of an 85-foot antenna presented a difficult maser design problem which was overcome in the prototype development completed last year.

Antenna, servo and transmitter modifications

S-band Cassegrain antenna structures were developed in conjunction with the traveling-wave maser amplifier prototype and will be installed on the deep-space net antennas. This ultralow-noise S-band system is expected to provide a minimum listening system temperature of 20° K. Modification to the antenna structures to accept the installation of the Cassegrain cone and servo modifications will be provided.

S-band acquisition aids and equipment

Ephemeris data is provided to a tracking station to aid in acquiring the spacecraft. However, it is still necessary to search the area in which the spacecraft position is predicted. To reduce the search time to a minimum, auto-acquisition input-output buffers, programers and logic will provide for automatic acquisition of receivers in angle acquisition, and frequency acquisition by search or programed modes.

Test transponders and calibration equipment

Test transponders for S-band operations, with functional characteristics of units to be flown on Mariner missions will be provided to each station for operator training, acquisition tests, telemetry tests and related program activity at each station. One unit will be used for system verification and to specify performance of flight equipment in a test-transponder configuration.

Automatic test and checkout equipment

To insure the optimum reliability of the DSIF stations, automatic test and checkout equipment, indicative of the most recent advances in system test procedures methodology and in electronic component design will be provided to the DSIF stations. In addition, precision-reference synthesizers will be installed to calibrate and tune the station transmitters and receivers.

Mobile S-band range and doppler station

A mobile S-band range and doppler station with the ancillary data-handling, communications, integrated test and control synthesizer equipment will be developed and trailerized. This equipment will provide coverage of widely varying spacecraft injection points without providing numerous fixed ground stations.

Magnetic tape recorders

While oscillograph recorders are used for local system evaluation and quick-look data, magnetic tape recorders are used for permanent data records. Separate records are required for low-frequency data recording and for high-frequency data recording. Magnetic tape recorders are required at each station to record the increased volume of data at low frequencies and to provide the high-frequency capability required by the S-band conversion.

Mr. ROUSH. Mr. Truszynski.

Mr. TRUSZYNSKI. The breakdown, as you see on this page, covers 2 fiscal years, and the equipment items that you see listed here represent an increase of capability on the part of our networks to take care of specific requirements brought on by the particular on-board equipments in the space vehicles.

Starting with item, "S-band transmitters and components," a new item for fiscal year 1964, I might say that the major part of the succeeding line items represent different parts of a total system. This system provides S-band capability for the deep-space network. What this represents is an updating of its capability to a different, higher frequency range than has been used in the past, in order to obtain the necessary higher gains required not only to receive information from greater distances, but also to receive greater amounts of information. The succeeding items are all part of what we can call one basic system that is being implemented for the present deep-space network.

Mr. ROUSH. When you refer to the "succeeding items," are you referring to all of that which follows this $1,170,000 item, or just what are you referring to?

Mr. TRUSZYNSKI. I am referring to the major part of the succeeding items, Mr. Chairman. I will proceed down them. I wanted just to point out that the majority of them represent separate parts of a single increase in capability.

Mr. ROUSH. Will you also be discussing the preceding item, $450,000 item?

Mr. TRUSZYNSKI. Yes; as the first one.

Mr. ROUSH. All right.

Mr. TRUSZYNSKI. Specifically, this item is titled "S-band transmitters and components," I should first explain "S-band," which is a name for a specific frequency range on the order of between 2,000 and 3,000 megacycles per second. This line item is specifically for the transmitting unit itself, for this frequency range. It covers the cost of the specific transmitter units that are required to be installed at all three of the present deep-space networks stations.

Similarly, the next item, "Klystron and maser amplifiers" are an additional part of the same overall system capability. The maser amplifier is the unit that is installed at the very front end of the receiving system and is one of the very low noise amplifiers that are being installed into the network to, again, increase the basic sensitivity of these antennas.

The "S-band ranging system" refers to the specific part of this total system which allows us to obtain the distance to the space vehicle. It includes a coding system which allows us to transmit a "range code" to the vehicle. This code is in turn retransmitted from the vehicle to the ground and a combination of the transmitted and received codes allow us to get the distance to the vehicle as it is proceeding out in space.

Mr. ROUSH. Mr. Boone.

Mr. BOONE. Mr. Chairman, there were some funds in this area that we discussed yesterday.

Is this something different from ranging and range-rate equipment?

Mr. TRUSZYNSKI. Yes, sir. The equipment we discussed yesterday was a system for the satellite network. This specific system is a range and range-rate system that is being installed in the deep-space network. It is the same type of equipment, however for a different class of space missions.

Mr. ROUSH. I can see why you couldn't use the instrumentation or equipment for a shallow-space probe for a deep-space probe, but why can't you use the deep-space probe equipment for what I would call a shallow-space probe?

Mr. TRUSZYNSKI. The ranging system itself could be used on either a deep-space mission or a shallow-space mission. The problem here is that the 85-foot antenna system is primarily a deep-space facility. Its tracking rates are low, it is primarily used for tracking extremely long-distance missions, so that its capabilities are not really tuned to the tracking of a very low satellite type of mission. It is also a matter of the station's being an integral part of a total network for deep-space missions. It is not a matter of incompatibility of this ranging system with a satellite, but rather of the network station itself being primarily designed and its equipment attuned to a deep-space type of mission.

Mr. ROUSH. Mr. Wydler.

Mr. WYDLER. Is it a fact these 85-foot antennas can only track one object at a time, is that the fact?

Mr. TRUSZYNSKI. Yes.

Mr. WYDLER. So you couldn't use them for anything else if they are going to be used for this specific project, is that correct?

Mr. TRUSZYNSKI. Yes. These deep-space missions have very long-term coverage requirements. The Mariner is a matter of months on

its way, as you know. And since these missions are very, very few and far between, a maximum amount of data is desired. It is a matter of full-time coverage of a mission of this sort by these three antennas which really represent a single facility.

Mr. ROUSH. Mr. Boone.

Mr. BOONE. Do you have some idea of the utilization time on the 85-foot antenna at Goldstone, Calif., or Johannesburg? In other words, how much available time do you have on these for other uses?

Mr. TRUSZYNSKI. We have a continuing study underway that pulls together this type of information from our operational network. I can give it to you, I think, on a mission basis. I couldn't tell you at this time what percentage of the total time we have, say, available for other missions at this particular time, because it is a rather complicated factor that varies with time and the specifics of the mission.

On a normal Ranger mission, however, the typical time tieup of this network is a matter of 3 weeks to 1 month before launch while the network is being properly prepared for the launch of that particular Ranger mission. There is the mission itself, which represents some 60 hours, or on that order, and then a considerable postflight period of calibration, on the order of 2 or 3 weeks.

So it is the mission time plus the order of 1½ to 2 months that the network is tied up on a particular flight.

Mr. BOONE. It is not feasible, then, to schedule other missions at the same time, so for say one 1-hour period you look at one satellite, and then as the Earth rotates utilize the antenna for another set of satellites.

Mr. TRUSZYNSKI. Generally not in a single 8-hour period, no. This is a matter of the missions having their own particular characteristics, and to support a different mission, such as a Mariner, in a short 8-hour period, might require changes of feed structure on the antenna and calibrations to be carried out that are beyond our capability of doing in an 8-hour period and then having to switch back to a Ranger-type mission.

Mr. BOONE. You are developing broad-band feeds, though, so that you could do this, is that right?

Mr. TRUSZYNSKI. Yes, we are, Mr. Boone. In the S-band, when the network is finally in its S-band capability both Ranger- and Mariner-type missions can be covered without changing the specific feed, that is correct?

Mr. ROUSH. Go ahead, Mr. Truszynski.

Mr. TRUSZYNSKI. The next item, "Data transmission and processing equipment," is that equipment that is necessary to, once the information is received by the antenna, put it into a form that is capable of both transmission back to the control center for insertion into a computer as well as for presentation at the site locally for monitoring purposes, to determine the status of the mission itself.

The "Digital data and instrumentation system" is that part of the system that, once the information is received, puts it in proper format for recording on a magnetic tape system and in a format that is compatible with an electronic computer to allow us then to carry on the subsequent computations at the laboratory.

"Test transponder and calibration equipment" refers to the test items needed in conjunction with a ground network station to perform checkout functions as to its proper operational capability. In gen-

eral, a transponder is similar to the general transmitting unit aboard the spacecraft, installed sufficiently far from the antenna to allow it to energize it, and the total antenna system is checked out through the use of this type of unit.

The "Remote collimation equipment" is that equipment necessary to install on a collimation tower, which is a tower associated with these antennas, again sufficiently far removed to allow us to properly aline the axes of the antenna, reference the axes to some known geographical points in the local area, as well as with the true north line.

"S-band acquisition aids and equipment" refers to that equipment necessary as a part of the total system to allow you to first acquire the target or space vehicle, as it comes into range of the network station. This is a smaller antenna with a broader beam that allows you to search a bigger part of the sky and rapidly obtain the signal from the space vehicle, and in turn the signals from this particular unit are fed into the large antenna, which is then pointed in the proper direction to receive data from the spacecraft.

Our "Mobile S-band range and doppler station" is a unit that will allow us to provide coverage in areas where, during the early phases of a mission, there are no deep-space network facilities capable of actually observing the vehicle. This type of situation arises shortly after launch, between the end of coverage provided directly in the launch area and the point at which the first deep-space network station, which is in South Africa, can see the vehicle. There is a rather long time wherein no information is received. Things happened on previous flights during this no-coverage time period, which we feel would have been extremely valuable information in postflight analysis as to what the failure of the on-board spacecraft system actually was. This station will allow us to provide coverage on a per-mission basis by flying it down or shipping it down and rapidly installing it where it would provide coverage of a critical no-coverage area.

Mr. WYDLER. Mr. Chairman.

Mr. ROUSH. Mr. Wydler.

Mr. WYDLER. Where would be an area like that, where would you place this, between here and South Africa?

Mr. TRUSZYNSKI. On one of the down-range islands of the Atlantic Missile Range. Ascension Island would be a particularly good location, because many of the flights out of Cape Canaveral do come within range of Ascension Island.

Mr. WYDLER. Does this have any connection with these proposed tracking ships that you are proposing?

Mr. TRUSZYNSKI. No, sir.

Mr. WYDLER. Can they do this job, at all?

Mr. TRUSZYNSKI. This is not the type of job we would use a tracking ship for. It is a specialized measurement capability.

Mr. WYDLER. That is what a ship is for.

Mr. BUCKLEY. May I speak?

Mr. WYDLER. I don't want to get into the ships, I know we are going to bring that up specially, but I just——

Mr. BUCKLEY. No, that is a proper comparison. We would never use a ship, nor would DOD use a ship, if there were a possibility of putting in a land station, which is much more simple and economical. So you wouldn't be using a ship for this job if you can get on an island and put such a piece of equipment there.

We are faced with the problem relative to Apollo of coverage over broad ocean area where there is no land. I will talk about that later. So if we can use a downrange island we will do it.

Now this equipment is specifically mated with the equipment in the spacecraft. Incidentally, this is in accordance with the standard procedure that the Department of Defense has used for all telemetry through this range down to Ascension. All their standard facilities are used, but the practice is if there is a spacecraft with special equipment aboard, a special telemetering station is installed to mate with the space station; this is such equipment.

Mr. HECHLER. You have not definitely selected Ascension Island? It is just a probability?

Mr. TRUSZYNSKI. That is right. Just a typical example of the type of place that could provide a location. This is a mobile station and will be actually moved on a permission basis to the location best suited.

Mr. BOONE. Why don't you ask the military to do this for you? It seems to me they have all the basic equipment you need, with some slight modification, and they could do this for you. I am thinking about the typical example you gave, anywhere along the Atlantic Missile Range they have equipment that could be modified to this with ease.

Mr. TRUSZYNSKI. That is, in general, correct. Where data requirements are of a general nature, we do use this capability of the AMR. Wherever a tracking requirement exists, for example, that matches the onboard equipment, this is used.

The difference here is that this is specifically spacecraft oriented type of equipment. It is for only that type of information that is found aboard a Ranger or Mariner spacecraft. As far as the AMR is concerned, it is a one-of-a-kind type of animal, and is quite specialized and doesn't have general-purpose use. Another factor is that it will become part of a total system, that it will be part of the larger deep-space network system.

It is in general more efficient, we feel, to handle it as one of our stations, since it provides rather specialized piece of data coverage. It is not infeasible for the military to do this. However, it represents a rather specific narrow responsibility that in general is better handled as part of the user's system.

Mr. BOONE. Is this to fill in the gap that your deep space network does not provide?

Mr. TRUSZYNSKI. Yes, during the low-altitude postlaunch period, when the vehicle is still in its parking orbit.

Mr. BOONE. Are you suggesting this low data rate telemetry, is this what makes it peculiar to the military system?

Mr. TRUSZYNSKI. No, I am not suggesting——

Mr. BOONE. If it is low enough orbit they can get it with radar.

Mr. TRUSZYNSKI. The radar can provide and is used for tracking. This is a data-reception station, for telemeter information that is required during this postlaunch period. This is not a tracking device.

Mr. ROUSH. Mr. Buckley.

Mr. BUCKLEY. Mr. Boone, I will see if I can help on this.

The telemetering and monitoring equipment, used on the boosters, is pretty much standardized, and we use the DOD facilities on all of these boosters.

Now on the spacecraft, it gets pretty special, as to the, say, switching rate of the telemeter and the associated displays and checkout equipment used to evaluate the spacecraft before launching and on the way down range. This is a common condition; for instance, on Mercury, there was a whole building full of equipment tied right to the capsule, first by coaxial cable, later by telemeter, to evaluate how that was working before and after launch. That was special for the Mercury job, and there will be the same sort for the deep space ones.

Why do we need it down range? We had a case in one Ranger where something happened from the time we last saw it from the Cape and next saw it in South Africa, and could we have ascertained the sequence of events we could have probably found the cause and the probable cure. There is a gap during an important part of the mission. Once it gets out far enough, the stations are on it all the time, but here is a gap that is not covered. So this is adapted particularly to the deep space missions and is in this area because of a blank in the coverage.

Mr. ROUSH. In what period of time, for what period of time, would this blank occur?

Mr. BUCKLEY. You mean in minutes?

Mr. ROUSH. Yes.

Mr. BUCKLEY. Not long. I would think perhaps 15 minutes. But it is hard to equate the minutes and the value of the mission, because if this is where something fails and you can't find out what happened and why, it is pretty hard to go back and make a cure before the next time. You spend a major amount of money sending up the next vehicle.

Mr. ROUSH. Is there any of this equipment that is designed for a one-shot mission, which cannot be used again and again and again?

Mr. BUCKLEY. Do you mean ground equipment?

Mr. ROUSH. Yes.

Mr. BUCKLEY. I know of none, sir.

Mr. BOONE. May I ask one more question?

Mr. ROUSH. Yes.

Mr. BOONE. Could you give us more examples of where you might use that particular type of equipment? That might be helpful.

Mr. BUCKLEY. I only recall that one failure in that area. If we have any more failures, I would be considerably remiss in my job if I had not supplied something to cover it the next time it happens.

I don't think we have had another failure. On the other hand, we have had corresponding failures on other missions and been in considerable doubt as to what happens. I will illustrate with a PMR firing, where the spacecraft went north past Madagascar, where it was inserted into circular orbit and the antennas and the solar panels unfolded. Then something happened in the spacecraft, and we had not provided telemetering at that point. This is where changes are occurring, where things are scheduled to happen, and if something breaks down in the sequence you would like to know what it is. So again we have the problem of putting in a mobile station in the Madagascar area, for a parallel reason. This is for a different type of mission, however.

Mr. ROUSH. Thank you.

Will you go ahead, Mr. Truszynski?

Mr. TRUSZYNSKI. The last two items are the "Magnetic tape recorders", by which the information received is recorded directly at the stations.

The "Automatic test and checkout equipment" is a system that allows us to automate the procedure of checking out one of these complex 85-foot antenna stations. There are a whole series of test procedures that are required during the preparation of a station like this for a flight. These include checks of various subsystems, drive systems, and proper tuning procedures. It is a rather lengthy procedure that we feel can be automated to the point where a considerable decrease in time is required for the preparation of a station for a particular mission.

Mr. ROUSH. Referring back to the "Magnetic tape recorder," in this area generally do you have enough skilled help to make use of all the information that you do record? What I am asking is: Is there a waste in the recording process, a waste simply because there are not enough people to interpret it?

I realize it would be hard to define "waste," where to draw the line. I am asking a general question.

Mr. TRUSZYNSKI. The real analysis of this information is done back at the laboratory as opposed to any analysis of this information at a station. The only analysis at a station is made to assure that the information is being received and properly recorded.

The information itself is reduced into scientific form at the laboratory and then it is the job of the individual experimenter responsible for the onboard experiment to analyze this information, and they are quite expert at this. The skilled help comes from that area.

Mr. HECHLER. Mr. Truszynski, would you explain again what the $460,000 is going to be used for on the tape recorders?

Mr. TRUSZYNSKI. The items in this area are the actual recorders themselves.

Mr. HECHLER. New recorders?

Mr. TRUSZYNSKI. Yes.

Mr. HECHLER. How many new recorders?

Mr. TRUSZYNSKI. About three new recorders.

Mr. ROUSH. It probably is "about," is that right? You say "about"?

Mr. TRUSZYNSKI. It represents a figure between three and four. There are some associated electronics and miscellaneous equipment in that figure.

Mr. HECHLER. It wouldn't be one and a half recorders?

Mr. TRUSZYNSKI. No, sir.

Mr. BOONE. Those are production recording equipments that can be purchased without development, is that correct?

Mr. TRUSZYNSKI. In general these are, yes.

Mr. BOONE. What do you mean, "general"?

Mr. TRUSZYNSKI. Because the recorder itself is an item that can be bought these days. There are additional electronic components required to put the information that comes out of one of these stations in a form the recorder itself can handle. That is why I say "in general."

Mr. HECHLER. How much are recorders these days? Are the prices going up?

Mr. TRUSZYNSKI. I think it is fair to say the prices are going up, sir.

Mr. ROUSH. Mr. Rumsfeld.

Mr. RUMSFELD. How do you intend to let this contract, on what basis? Would it be negotiated, competitive, or what?

Mr. TRUSZYNSKI. For the tape recorders, the specific contract for the tape recorders?

Mr. RUMSFELD. Yes.

Mr. TRUSZYNSKI. Where it is a standard enough type of equipment, it is advertised. If it is a type of equipment that requires some specific modification in terms of its data format it is competitively advertised, and negotiated.

Mr. WYDLER. Those are conflicting things, aren't they? Competitively advertised and negotiated.

Mr. TRUSZYNSKI. Competitively negotiated, I am sorry, is the proper term.

Mr. ROUSH. Are there any other questions on the deep-space-network item?

Mr. RUMSFELD. I have a good many questions on the procurement policies, but I think it might be better to defer them until the completion of this section, because they involve all these areas.

Mr. ROUSH. Let's move to page 27, the category of "Launch area instrumentation."

Mr. Truszynski, are you going to discuss this, also?

Mr. TRUSZYNSKI. Yes. This entire group of items represents equipment required at Wallops Station.

"Photographic processing equipment" is associated with the large amount of photographic instrumentation that is used at this particular station. I believe some of it was described yesterday in terms of the reentry tests which are covered by optical instrumentation, both in the immediate area and on the east coast of the United States, as well as at Bermuda, and on the one range ship that Wallops Island has.

"Range camera equipment" covers specific additions to the optical instrumentation that allows us to record information in the different optical spectrums that are required for the very high-speed reentry tests, to determine more specifically what parts of the vehicle as it reenters are beginning to ablate before others. It is a type of camera equipment that allows us to examine specific parts of the optical spectrum.

"Aircraft calibration and test instrumentation" is involved with equipment installed in an aircraft to provide station checkout for the various tracking stations in the Wallops Island area.

"Antenna system modification": There are some extensions to the present capability that should be provided at Wallops Island in terms of higher gain antennas. In addition, one of the antennas originally procured at Wallops is being heavily used for Tiros support, and the basic programs at Wallops require use of an antenna of this capability. Some of these funds will be used to procure an antenna that will allow coverage of these programs while still maintaining coverage of the Tiros program.

Mr. WYDLER. By modification, you mean actually part of this 240,000 is for purchase of a new antenna?

Mr. TRUSZYNSKI. Yes, sir. Antenna system modification.

Mr. WYDLER. I couldn't help but notice this item goes up 100 percent every year. Can we look for the request to be $480,000 next

year? I notice its progression is exactly 100 percent each year, this request for antenna system modification item at Wallops Island.

Do you notice that fact?

Mr. BUCKLEY. Wallops, by the way—I am sorry you didn't get down there.

Mr. ROUSH. We are going there.

Mr. BUCKLEY. If I may digress for a moment——

Mr. ROUSH. As long as you don't take too long.

Mr. BUCKLEY. It must fire some 200 major rockets and some 200 minor ones in a year to carry on more advanced aerodynamics studies and additional work parallel to that called reentry physics, studying what happens to vehicles when they reach extreme speeds coming in.

It is also used for component checkout. For some of the major satellites, many components such as the folding antennas were checked out there, and also the landing devices and the systems inside the capsule for Mercury.

I mentioned yesterday they were firing for Army, Navy, and AEC. On one job there are 58 cameras installed on Bermuda to support one of the agencies firing from Wallops and we try to use some of our cameras, too.

This is a very actively changing place, and not for things that are planned years ahead. The AEC can come in with something and say, "Can you fire in 3 months?" maybe, and I wouldn't be at all surprised if the antennas had to be adapted and modified for such jobs, because of the complexity of the type of operation.

Mr. ROUSH. Does NASA charge the other agencies or services for the use of this equipment?

Mr. BUCKLEY. No, sir.

Mr. ROUSH. Do they also have perhaps rather similar equipment at Wallops Island?

Mr. BUCKLEY. Not unless it is extremely special for the job.

Mr. ROUSH. Do they charge NASA for the use of this other equipment that might be especially special for the job?

Mr. BUCKLEY. They do not. I can't remember a case. We make extensive use of anything that is there at any time. There is a lot of use of things brought in from, say, Lincoln Laboratory or the universities, for instance.

Mr. ROUSH. Are there any other questions?

The next two items—the $75,000 and $80,000 items—is there anything special about them that the designation given to them would not cause to be self-explanatory?

Mr. TRUSZYNSKI. I don't believe so.

Mr. ROUSH. Mr. Hechler.

Mr. HECHLER. You didn't mention anything on maintenance spares and replacement. Mr. Wydler commented on the 100-percent increase on antenna systems modification. But this item has increased over 100 percent. Could you explain the reason this has been such a staggering increase?

Mr. TRUSZYNSKI. Some of this represents refurbishing the basic installations that have been on Wallops Island for many years now. These are replacements of cable ways for a communications system which extends over a rather extensive portion of the island. These have been installed now for some years and suffer very severe deterioration in that part of the country, where it is immediately adjacent to

salt water, and, as you know, last year there was a rather large storm that caused quite a bit of flooding over some of these areas. This item this year is increased to replace damaged systems.

Mr. HECHLER. Assuming you don't have a storm and everything goes all right, will this replacement investment be enough to take care of it so that we could look for not perhaps a reduction, but at least a plateau in this field of expenditure in the future?

Mr. TRUSZYNSKI. I would certainly hope so.

Mr. HECHLER. I would hope so, too.

Mr. ROUSH. We move to the "Aerodynamics test range." On the first item of $250,000 that appears to be self-explanatory.

Does anyone have a question?

If not, perhaps the next item should have a sentence or paragraph explanation, Mr. Truszynski, if you could provide that.

Mr. TRUSZYNSKI. The only item we have for the "Aerodynamics test range", is to refurbish one of the antenna pedestals that has had some 2,000 hours on it, and that requires considerable work this year.

Mr. ROUSH. You have two stations; one has half as much usage as the other, and you are refurbishing the one that has had the extensive use?

Mr. TRUSZYNSKI. Exactly.

Mr. ROUSH. If there are no questions here, let's move to the next general category of "Communications network." Perhaps this would demand a general explanation for the entire category. The various items seem for the most part to be self-explanatory.

Could you give us a general explanation of this, very general and brief?

Mr. BUCKLEY. Yes. Yesterday I said our general policy is to use leased circuits for communications. But there are various places where a local arrangement is needed, where we have to carry information from one place to another at the ends of the long leased circuits. This can be from shore to ship, as on the Syncom, where the Syncom ship was in the harbor of Lagos, Nigeria, and we had a circuit from ship to shore, and another circuit up to Kano, Nigeria, to cut into another network at Kano, and come back through London. We set up two circuits to that ship for insurance. This type of equipment covers these terminal areas.

The last item, the major one, results from a study that has been going on in an effort to make more flexible use of this communications network that we lease. A switching system of this type is under development and in use by the telephone company in some areas. The studies indicate we can adopt this to our use, and will be able to mix circuits together with such a switching system and probably reduce the cost of our communications. This study continues through this year on how to cut these communications costs.

At the moment we have a switching center of limited capability in San Francisco, and another in London, so that we go to London by cables and then switch into various circuits going to individual stations.

We would like to improve this switching capability and make more cross-use of our circuits.

Mr. ROUSH. Does any member have a question pertaining to the communications network category?

If not, move to the next item on page 75 of volume 5, "Processing and handling." We do have some major items here. It might be well for us to have a more specific explanation of these items.

Mr. TRUSZYNSKI. The first item, "Satellite telemetry reduction system," covers the automatic processing systems required to extract the information recorded on magnetic tape at the network stations. This is electronic equipment allowing you to play the recorded tape into the system and extract from this the individual channels of information that are recorded, and in turn put them into a proper format that allows subsequent reduction by an automatic digital computer. It also provides a means for checking the quality of the information on the tape to assure that information that is not correct does not get processed through parts of the line.

Mr. ROUSH. Does NASA have a similar system now, or is this entirely new to NASA?

Mr. TRUSZYNSKI. Some of these units are in existence, as reflected by the funding in the 1963 column. The fiscal year 1964 funds will cover additional systems to keep up with the data processing load from the increased satellite and deep space probe flights.

"Telemeter off-line processing systems," the next item, is equipment that allows us to process information in a different format than that which we are presently using. As we mentioned yesterday, pulse-code modulation is becoming one of the primary systems we will use in the larger satellites. These systems will be capable of processing this particular type of modulation information from the larger observatory class satellites.

"Special purpose data processors" are small capacity electronic computers that allow us to handle information in a more expeditious and more economical way than trying to use very large computers. There are instances where rapid reduction of information is required to allow us to properly observe how a station or group of stations is working. This type of computer allows us to process a small amount of information rapidly for a specific purpose, rather than putting it through a very large computer program.

"Automatic analog data tape evaluation equipment" allows us to keep a running check on the quality of the taped information, so that we don't run for long periods recording poor data at a network station.

"High speed plotter-printers" are devices used to plot up the reduced information for analysis by the experimenter.

Mr. ROUSH. We omitted the item of "Maintenance, spares and replacement." Is this due to fair wear and tear?

Mr. TRUSZYNSKI. In this case, yes.

Mr. ROUSH. Mr. Ryan.

Mr. RYAN. What is due to fair wear and tear, the omission or the tripling of the amount?

Mr. TRUSZYNSKI. The larger amount this fiscal year is directly a function of the additional amounts of equipment that will be in use.

Mr. RYAN. You have gone from $85,000 in 1962 to $412,000 in 1963 and $1,305,000 in 1964.

Mr. TRUSZYNSKI. Yes, sir. This is about a 10-percent factor for maintenance, spares and replacement for the increased amount of equipment.

Mr. RYAN. What do you predict for 1965?

Mr. TRUSZYNSKI. I think it is fair to say that on a percentage basis it would be probably similar to this.

Mr. RYAN. Tripled?

Mr. TRUSZYNSKI. No, sir; I don't mean an increase in that direction. It very likely could be doubled.

Mr. HECHLER. That is going down, though, if you increase it fivefold, then threefold, and then only twofold, in a sense.

Mr. ROUSH. Mr. Hechler, did you have a question?

Mr. HECHLER. About how much of the data processing and handling would you say would be directly related to the manned flight program?

Mr. TRUSZYNSKI. None of this equipment will be directly related to the manned flight program.

Mr. HECHLER. Thank you.

Mr. ROUSH. Other questions?

Mr. FULTON of Tennessee. I would like to point out the same tendency yesterday and today to skip over maintenance, spares and replacements. It is $15,355,000 for maintenance, spares and replacements, as I rapidly add it. It seems to me that is important enough to warrant more of a discussion rather than skipping over it in each explanation.

Mr. ROUSH. Do you have further questions on this item?

Mr. FULTON of Tennessee. No; I think it has been pursued.

However, Mr. Ryan did ask yesterday a breakdown on one of them, as to what the maintenance, spares, and replacements were, where they are going. Also, a question was asked of what the total volume of the Bendix contracts was in connection with that.

Am I right, Mr. Ryan?

Mr. RYAN. Yes. I think Mr. Buckley was going to provide the breakdown of Bendix.

Mr. BUCKLEY. Yes. We didn't bring it in today, sir. We have not had time to prepare it.

Mr. FULTON of Tennessee. When could we expect that, Mr. Buckley?

Mr. BUCKLEY. Oh, I think very early next week, by Monday.

I would like to speak on this data processing and handling equipment for just a short time.

The amount of data we have collected has gone up by a factor of 10, and the same is expected next year as a result of the observatory satellites. The type of equipment put into use in this last year, but anticipated the year before, is six automatic processing lines at Goddard, and we will put in more this year. So the jump in maintenance, spares, and equipment is very directly associated with the amount of equipment we have doing this automatic job.

Incidentally, on one tape that we collect from the satellite, there may be data from 10, 15, or 20 experiments. We have to cull out a single part of the data—they call it a bursting process, but I would rather call it splitting process—and that becomes a tape for the experimenter, but the engineering data onboard such as the temperature of the vehicle and voltage supply also goes to the experimenter, and that is what these data processing lines do. The jump in equipment used for this sort of thing has been very appreciable.

Mr. ROUSH. Mr. Buckley, would it be possible for you to provide a schedule of the utilization of time on the deep space network over, say, a 6-month period?

(The information requested is as follows:)

Schedule of actual hours of operation for the deep-space network during the period July 1–Dec. 31, 1962

	Goldstone (2 antennas)	Woomera	Johannesburg
July	478	89	77
August	523	168	168
September	1,126	544	545
October	1,217	597	616
November	1,093	540	540
December	1,083	535	535

NOTE.—This actual operating time averages 436 hours per month per antenna system, or a rate of operations of 2.3 shifts out of a maximum of the 4 shifts required for 24-hour-per-day, 7-day-per-week operations.

Mr. BUCKLEY. Yes.

Mr. ROUSH. Would you do that?

Mr. BUCKLEY. Yes, sir.

Mr. ROUSH. If there are no questions directed to these specific items, I believe Mr. Rumsfeld had general questions he wanted to ask in that area.

Mr. RUMSFELD. Yes.

I appreciate you would have to provide this at some later date. I would be very interested in seeing a statement indicating the dollar amounts, as well as the percentage of the total funds, which have been let under contract to firms outside NASA in each of the various types of procurement categories under which you at NASA work.

Now whether it be straight competitive bid, or within the negotiated area—I believe you have one or two different ways of doing it, is that correct?

Mr. BUCKLEY. Yes.

Mr. RUMSFELD. What are they called? One is sole source and one is competitive?

Mr. WILLIAMSON. The bases of contract procurement are basically two: Advertised procurement, and negotiated procurement.

Negotiated procurement is a class you can break down many ways. You may end up with a sole source contract, or with a competitively negotiated contract. Either of these can end up with a fixed-price contract, or end up with a cost plus incentive fee contract, for example.

The breakdown goes into some detail. The total is probably on the order of 15 or 16 different types of contracts. For example, service contracts are different from hardware contracts. Personnel services contracts again differ from construction contracts. Each of these has its own framework and own terms of reference.

There is a report to the Congress, I believe, that covers all of last year's procurement, broken into various categories. We can make a copy available. [A copy was subsequently made available to Mr. Rumsfeld.]

Mr. RUMSFELD. I would like that. Thank you.

Do you feel that under the present situation you are getting the maximum use out of the dollars in the contracts which you are not opening up to competitive bid?

Mr. WILLIAMSON. Yes, we are. You say "not opening to competitive bid." There are some things that cannot be opened to competitive bid, by which I take it you mean advertised procurement, with

detailed specifications where anyone in the industry could bid. There are a great many things not susceptible to this kind of procurement. Services is one.

Mr. RUMSFELD. Right. And will you set out a statement of determinations and findings?

Mr. WILLIAMSON. We are required to by law to make a determination and findings for each one.

Mr. RUMSFELD. Which you fail to put out under advertised bid?

Mr. WILLIAMSON. The Armed Services Procurement Regulation under which we operate is very specific in this matter. We follow it, and have our own procurement regulations that go even further. NASA is required to justify each choice of contract, whatever form it takes.

In the R. & D. business it is very difficult to write advertising specifications for something you are asking a company to invent for you. You are asking them to invent something to perform a job that is still sometimes pretty far in the future.

Mr. RUMSFELD. The Government Accounting Office periodically comes out with instances where there have been situations where properly the contract should have not been handled on a negotiated basis, but should have been handled on a competitive basis, and they point out differences in prices which possibly one service pays as opposed to another.

The papers are filled with this sort of thing. Five and six reasons have come out.

Has NASA ever been involved in any of these to your knowledge?

Mr. WILLIAMSON. I don't know. I don't think so, but I don't know.

Mr. WYDLER. Mr. Chairman.

Mr. ROUSH. Mr. Wydler.

Mr. WYDLER. I might say, the recent report issued by the General Accounting Office does not show anything of that nature as far as NASA is concerned, the report issued for 1962.

Mr. HECHLER. Fiscal?

Mr. WYDLER. They call it the 1962 report. I presume it covers the calendar year operations.

Mr. RUMSFELD. That is all I had at this time.

Mr. WYDLER. Mr. Chairman, may I ask a question?

Mr. ROUSH. Yes, Mr. Wydler.

Mr. WYDLER. Mr. Buckley, what are you doing now in data processing and tracking as far as the Apollo project is concerned? What is planned for this coming fiscal year in this program?

Mr. BUCKLEY. Let's take the tracking case, first, in the stations. You have heard woven throughout the testimony here, the story that we are upgrading the Mercury stations to Gemini condition and will then go from Gemini to the Apollo condition, making such additions as are necessary, not only to the existing stations, but adding to the group of stations as may be necessary. The additions will be the three ships we will talk of in a few minutes, and the three deep-space stations that will be part of a solid integrated Apollo network.

Mr. WYDLER. But these deep-space stations, is their only use going to be for the Apollo project?

Mr. BUCKLEY. If you go after a program of the level of Apollo, the ground system is so important and so vital that you plan it specifically

for that job. Apollo training equipment will be installed at Wallops Island, and everyone going to a foreign station will have to go through this training site.

We will be very severe about the fact that these stations have to be exact duplicates of each other, so if 10 or 30 minutes before launching you have a problem in Nigeria or Zanzibar, that station doesn't seem to the people in the control room to be 5,000 miles away. The communications and your knowledge of the people and the equipment there is such that you are thoroughly familiar with them and you enter into trying to solve their problem with them as though you were right at the station.

This happened, for instance, with 20 minutes to go on the Schirra flight. We had a radar problem in the Canary Islands and immediately the crew at Goddard knew what had probably broken down and was discussing solutions. We had a piece of equipment in the station, not in the building, but about a mile away, that we were able to get and make the cure, and if there was a holdup on the Schirra flight because of this, it wasn't more than 15 or 20 minutes.

We have had breakdowns in other equipment at other stations. The telemetering equipment at Woomera, Australia, has broken down in the last few hours before a flight. We have had difficulty with it in two or three stations 2 hours before pickup.

If you don't have an integrated system for a major program such as Apollo, you are going to be helpless in running it.

Mr. WYDLER. I understand. But this coming 1964 fiscal year, are there items in the 1964 fiscal year proposed budget which are solely directed toward the Apollo program?

Mr. BUCKLEY. Yes, sir.

Mr. WYDLER. Can you tell me what they are? Or are there so many of them that this is impossible?

Mr. BUCKLEY. We have talked about equipment, for instance, that is going to be at those stations. We are going to talk about the ships. We are going to talk about three deep space stations.

Mr. WYDLER. In other words, you will buy equipment in 1964 to be used on the Apollo flights; is that correct?

Mr. BUCKLEY. We will be starting on a program toward getting these stations ready for Apollo; yes.

Mr. WYDLER. And this equipment will only be used for when Apollo is actually in flight?

Mr. BUCKLEY. Not only while it is in flight, but in all the preparation getting ready for each Apollo mission, months ahead of time.

Mr. WYDLER. Do you see the distinction I am trying to draw?

Mr. BUCKLEY. It will be only used in connection with the Apollo program, but not just while it is in the air.

Mr. WYDLER. All right.

Mr. ROUSH. If there are no other general questions, we would like to move, Mr. Buckley, to another category here. We would like to learn about the instrumentation ships now, and this is in volume 4, pages CF13–32.

For those of you who are here as visitors, I should tell you we will reach a point in our discussion when we must go into executive session. Of course, at that time you will have to leave.

I thought I should warn you ahead of time, so there will be no embarrassment at the time.

Mr. BUCKLEY. Mr. Chairman, I am going to use some charts at this point to show where the ships are going to be and indicate the need for them.

In the launchings of Apollo (fig. 1) we have to launch in the right direction at that moment to intercept the Moon's path, even though we approach it at an angle. As the spacecraft leaves the cape and climbs and picks up speed, it comes to the point where we insert it into a parking orbit. The vehicle will then continue around the Earth in a circular orbit and come to a place where we inject from the parking orbit, which is roughly circular, into the trajectory that will go out to the Moon.

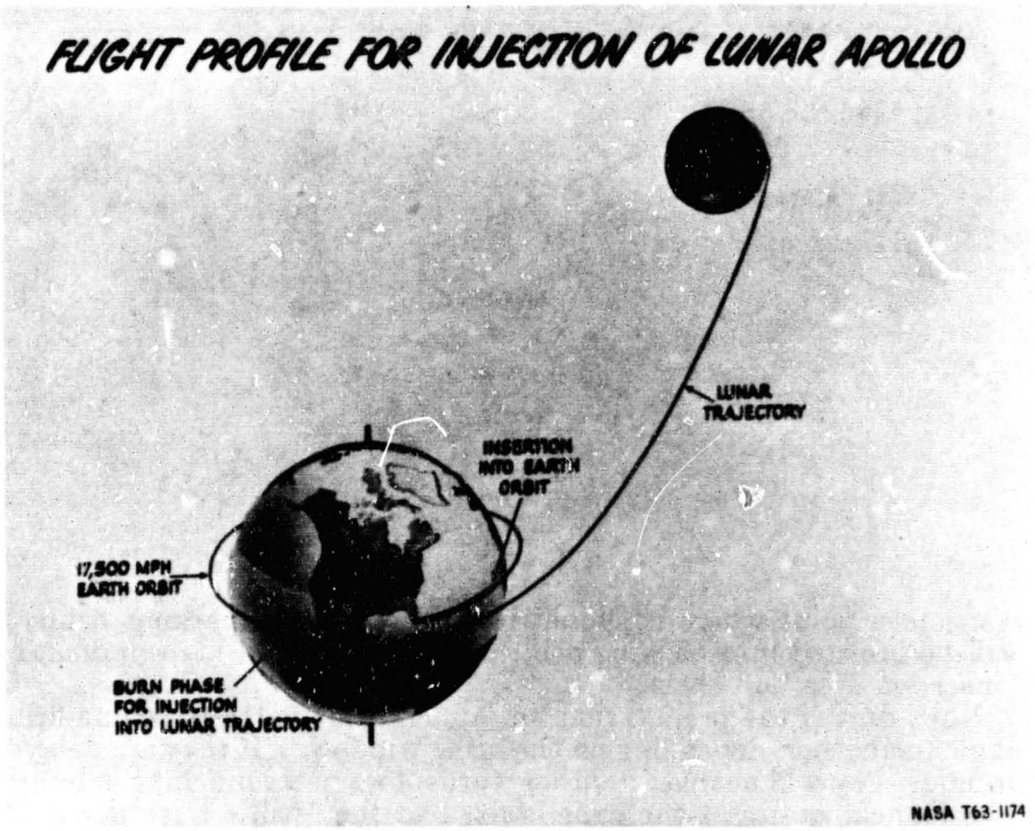

FIGURE 1

The injection point is fixed in relation to the Moon, and the Earth turns under it. Now since the Moon also moves, this point moves as I will show, and this point, relative to the Moon, is in a predetermined position. This, however, is not fixed relative to the surface of Earth. So this point here (pointing) may be at different places here, depending on the time of day or where the Moon is relative to the Earth.

Now I would like to talk about the first part of the mission requirements (fig. 2).

The calculations that have been made show that, in order to get into the right path to the Moon, they may launch from the cape on an azimuth somewhere between 73 degrees and 106 degrees. The calculations they have made so far show that when this vehicle will

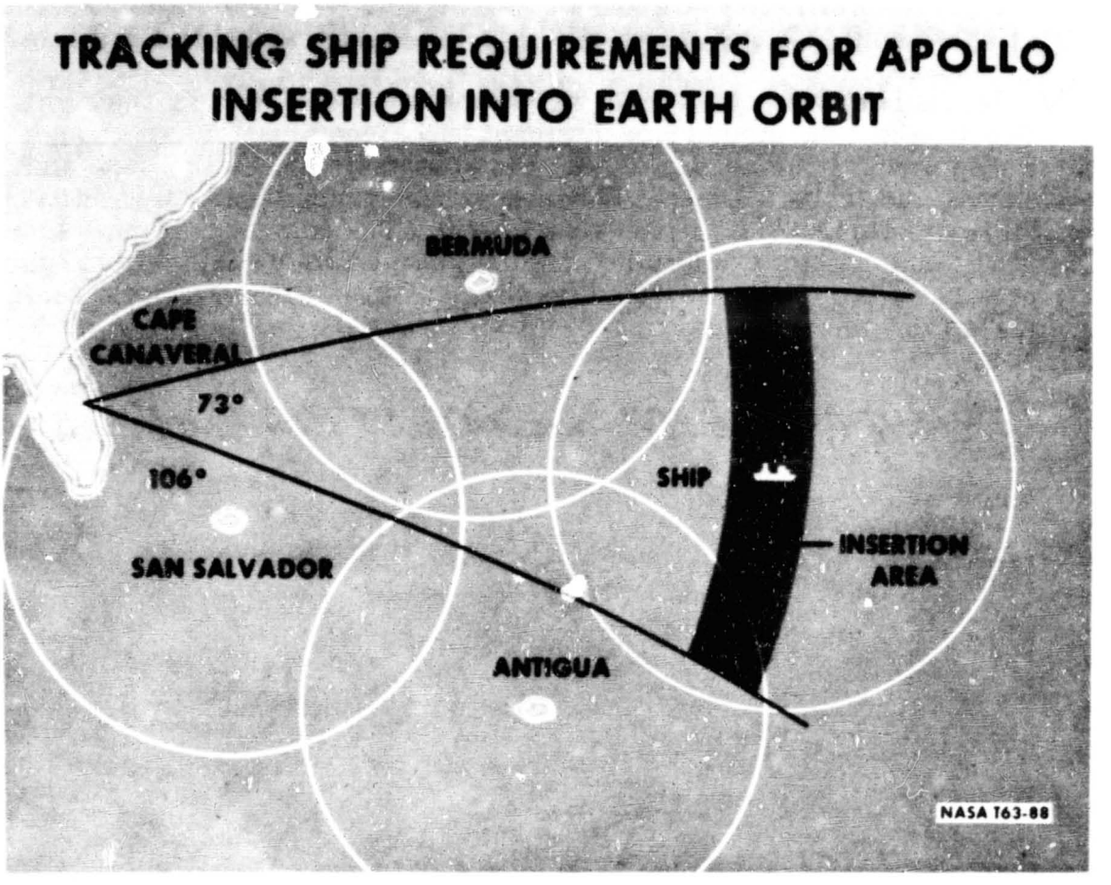

FIGURE 2

come to a point where it should be inserted into a parking orbit, it will be inserted into parking orbit between here and here (indicating "insertion area" on chart).

Now, during the preparation for launch, they move from one firing angle to another, depending on the firing window. If they are delayed an hour they will change, in other words, to a new launching azimuth. The launching site at the cape is fixed so they will adjust the guidance systems to put the vehicle into this path after the launching.

The instrumentation coverage is shown by these circles. Here is the coverage by Antigua, and here is Bermuda. The insertion area is pretty much over the noninstrumented ocean, except for this section.

We plan to put the first of the three ships into this area, and its effective instrumentation coverage range, depending upon the height of the vehicle at that point in its path, is shown by the circle.

Mr. BOONE. Is that a 600-mile-radius circle? And do those circles show radar coverage?

Mr. BUCKLEY. Yes.

Mr. BOONE. It is beacon response——

Mr. BUCKLEY. There will be an S-band system on-board, and there will be C-band equipment, too.

The vehicle, having been put into a circular parking orbit, proceeds around the Earth and at some point must be injected into the path to take it to the Moon (fig. 3). Calculations show it will be done at a

FIGURE 3

point somewhere within black bar shown here in the Indian Ocean; if you fire on a 73° course it will be down here to the right, if you fire on a trajectory between the two, it will be at this middle point, and 106° at azimuth it would occur at the left edge of the bar. So there is a particular point, then, depending on the time of day you fire and the location of the Moon relative to the Earth, that has to be covered by instrumentation.

There is an excellent possibility that, instead of doing this a quarter of the way through first orbit, they will do it on a later orbit in order to give time to check out the vehicle after it is put into the parking orbit.

In fact, there is an inflight checkout system that has been mentioned under "Equipment" just for this. There is just as much of a countdown necessary at this point as there is for a normal launching. You must check out all the equipment through certain sequences to be sure that this vehicle going around the Earth in a parking orbit is ready now to go to the Moon. There are three such checkout stations planned.

It will take some time to check it out, and it may be, one, two, or three orbits later before you leave for the Moon. You may not leave for the Moon after the quarter orbit I mentioned in the first illustration, but only after a first or second additional orbit beyond that (see fig. 1).

Now, assuming that we can take off one full orbit later. The bar of possible injection points I showed you before now moves to the left. Ninety minutes later, to hit the Moon, the vehicle will go up from this new position, or, depending on the launch azimuth, some intermediate position, but the bar of all possible positions moves to here, south of

Madagascar. Going to the chart of the third orbit (fig. 4), if you let it go two full orbits—remember, this right-hand pale outline is a quarter of an orbit, the next is one and a quarter, and this black one is two and a quarter—the locus of the points from which you will inject into a trajectory toward the Moon, is along this path across Africa.

If we come back to the chart of the first orbit (fig. 3), if you are delayed and can't fire today, say, but have to wait until tomorrow, this bar, the loci of the positions here, moves some 250 miles northwest to a position like this, because of the changing position of the Moon relative to the Earth. For a 2-week period it moves north, and then it moves back south again. The east-to-west movement of

FIGURE 4

possible injection points along the bar is equal to the turning of the Earth during an hour and a half, and is roughly 1,000 miles. If you wait till the second orbit, it would be another thousand miles to the west.

Say you were going to shoot on March 25 of a certain year, at 3 p.m. There would come a time 30 minutes later where the Apollo spacecraft would be at this point, and in a position to inject into the path to the Moon.

On the other hand, if you let it go another orbit, this would be half past 4 p.m., and the proper injection point has moved to here, 1,000 miles to the west.

If, however, you are delayed and have to go to March 26, the possible injection points will move up 250 miles north.

The planning that is going on as to what time to launch these vehicles, how to get ready, the limitations of time, already indicates

many constraints. If you narrow down the time in a given day, and narrow down the number of given days, this becomes an exceedingly severe constraint on the mission.

There is a corresponding possibility, and that is injecting from points over the Pacific. The same thing happens. There will be a locus of points shown here by the bar that will depend on the time of day and position of the Moon. That will move, again, east to west, if they decide to go from one to two or three orbits. The checkout time or trouble in the vehicle could readily force them to go from sending it up after 1¾ orbits, to saying "We have to let it go one more full orbit until we verify all the systems." They have to go through a checkout that very much parallels the countdown before the original launching. They figure this can take as much as three or possibly four orbits after launch.

So the earliest they could make it would require injection from some point north of New Guinea. Figure 4 shows orbit 3 here, 3¼ orbits from launch time. The possible injection points then move west as the Earth turns during the 90 minutes between passes from that position to a new one over Borneo.

Now, they are hoping to inject over this area (indicating the Indian Ocean). The studies being made are open to the possibility of doing it in this area (indicating the Pacific). At this point, this is where they are in relation to their studies; this is the problem they are faced with. And since the surface of the Earth is 75 percent water, you are pretty sure you can't get out of the problem of using ships to provide coverage of the injection.

Remember, this ship in the Bermuda area was one ship requirement. We then decided we should request two other ships to help solve the injection coverage problem, which will provide only a compromise solution. It still leaves the project with major constraints. They will try to force their planning to meet this constraint if we can provide the three ships. It constrains them as to how long they can wait after their first planned launch time and how many days they can slip their firing from the assigned date.

Mr. ROUSH. Mr. Wydler.

Mr. WYDLER. What is the time again between the point where you figure it on a certain date, and when you would reach that exact situation again? Is it every month that you could start over again in the same position? In other words, you have your time set at a specific time and hour, and miss it for a reason——

Mr. BUCKLEY. The proper injection point would be back to that exact point in 28 days.

Mr. WYDLER. Twenty-eight days, before you could obtain the exact same positions.

Mr. BOONE. You could wait until the next day and wait an hour and a half later, and still be——

Mr. BUCKLEY. In that case the position has moved north, however, because the Moon has changed its position relative to the Earth.

Mr. ROUSH. Doesn't the ship in that length of time move sufficient distance to be in the proper position?

Mr. BUCKLEY. It can just about move 250 miles in 1 day, except that this would not allow much time to get on position and get checked out and be all squared away.

Mr. ROUSH. You spoke of two ships, but you are asking for three.

Mr. BUCKLEY. One is the area shown on the first chart, you remember the insertion condition?

Mr. ROUSH. Yes.

Mr. BUCKLEY. East of the Bermuda-Antigua line. Then two for coverage of the injection positions that I talked of, and I indicated the probability of their being down in the South Africa area.

There the thought is if you can inject over the South Africa area you have the chance of using the existing DOD station at Pretoria. This would give us three land and ship stations in that area. If you have to inject over some other place you may only have the two ship stations.

Mr. ROUSH. Do you have anything further, then, Mr. Buckley, on a general line, or were you finished with your preliminary statement?

Mr. BUCKLEY. The instrumentation that is on these ships has to be exactly like the instrumentations in all the other stations, and should n't be changed from it. We refer to that as a project-oriented system. You have duplicate equipment and duplicate operations. The operators could move from one station to another and everything would be exactly the same; the procedures and calibrations would be exactly duplicated.

Mr. ROUSH. There is one item that I wondered why it had to be duplicated, insofar as expenditure is concerned. You have $500,000 for design and engineering services for each of the three ships. Why would you have to duplicate that item?

Mr. BUCKLEY. We shouldn't have. And that was a slip in the way this was set up here in the book.

Mr. ROUSH. Would we then reduce the total amount here by $1 million?

Mr. WILLIAMSON. If I may answer that, sir.

Mr. BUCKLEY. Yes, please.

Mr. ROUSH. Certainly.

Mr. WILLIAMSON. We drafted the budget, sir, on a per-ship basis. We could have equally well drafted it on a per-contract basis for three systems. The total design and engineering job is likely to run a million and a half, at least. We could have shown that for all three ships, and, actually, this is a presentation error, I think; not a number error.

Mr. ROUSH. I suspected that. But I thought I better ask about it.

Mr. Boone, do you have a question?

Mr. BOONE. I think on that particular item, Mr. Chairman, you never get three ships that are exactly alike, either. So you are going to have engineering design services on each one of them.

Have you placed these requirements on the military and asked them to give you an idea of whether they can do this for you?

Mr. BUCKLEY. For a little over a year we have been holding meetings on this subject with General Cooper's office in the Pentagon, who is responsible for the general-purpose range ships. We have looked over the inventory of ships together, and as best possible, we have anticipated "use time" of the ships to see whether they would be free to support us or not.

Actually, this is a continuous process since for the last 2½ years or more we have been constantly interweaving ship operations and modification schedules. We have paid for modification of one of the ships, for instance, in order to get it used in support of Ranger. All

other projects but Apollo have laid ship requirements on AMR, totaling some 40 future launchings.

However, these three new ships are only for Apollo. To use DOD ships means you would be taking the ships away from whatever DOD use they were intended for. DOD has ships, but unless they are completely free of other requirements they wouldn't be free for Apollo.

Secondly, they would have to be heavily and completely modified.

As to the amount of time that ships would be used for Apollo: the Mercury ships have been assigned solidly to the Mercury project, with a few exceptions. The philosophy should be that ships are available for other use, if possible. This philosophy was followed in Mercury, but there has been very little free time. One of the ships spent about 352 days and the other about 296 days on Mercury in 1 year. It is not just the hours during which the Mercury spacecraft is up, but the time to get there, the time to wait. For instance, in support of the Glenn flight, we had a ship ready early in December for an anticipated early December launch, and it was February 20 when it was finally fired. The ship had to go back to port and refuel over Christmas, incidentally.

Waiting for the date of assignment, the time to get to where it was going to be used, the countdowns and simulations just ahead of the mission, then the time to get back from the assignment, plus a certain number of modifications, resulted, according to our records, in a use of 352 days on one of the Mercury ships and 296 on the other. We foresee an equivalent problem on Apollo; these ships will be busy all the time.

Mr. BOONE. How many days do you anticipate a ship will be on station for a single Apollo shot?

Mr. BUCKLEY. I would hope 2 to 3 weeks, but probably a month. I mentioned the Glenn flight. As it happened, we didn't have a corresponding problem on the Schirra flight, because that went off pretty promptly.

We had a problem in going from the Glenn flight to the Schirra flight. We didn't know for a while whether it was going to be a three- or six-orbit mission. We brought the ship back to Baltimore to have the second command equipment installed. Then there was the problem, should it go back to its post near Africa for the three-orbit mission, or to west of the Philippines for a six-orbit mission?

We held it in Baltimore until the project people could decide which of the two missions it was and then it took 62 days to go from Baltimore to its post in Manila, counting time by the Panama Canal and resupply in Honolulu as it went by. This is the problem you may be faced with.

We have given consideration and continue to do so to the possibility of resupplying the ships from tankers, particularly MSTS tankers that could bring not only fuel but other supplies to the ship without having to bring the ship to port.

One problem on the ships so far has been the trained electronics team that is aboard; we have had difficulties with these people not having anticipated a life at sea when they went through college to become electronic engineers.

Mr. FULTON of Tennessee. Have you offered any sea pay?

Mr. BUCKLEY. Well, we have not, but they are getting pretty highly paid already.

The ship's operating crew takes this in stride, since this is their normal livelihood.

Members of the electronic teams have resigned, and in the case where the ship was in Baltimore, there was almost a major change in the complement of the group as a result of the long time they had been previously at sea on the Glenn flight. We had quite a little job to get a trained crew back together again.

We do not plan to operate the three new ships ourselves. We have been in touch with the Navy about operating the ships. For instance, a branch of the Navy, MSTS, would be very fitting and have several advantages. One advantage would be that they use civilian crews. We have just gone through a very time-consuming exercise relative to use of the ship the *Kingsport Victory* in Nigeria, because of any possibility of military people being on that ship. The Nigerians were insisting that it be a civilian team completely.

We have considered using the Bureau of Ships in helping plan the modification of the hull and the installation of the electronic equipment that will go aboard.

The MSTS operates our Wallops Island ship, and this is an extremely satisfactory arrangement. In other words, we don't want to operate the ship as a ship. But we do feel it is necessary for us to operate the instrumentation on a ship, so that the whole ground system works together as an integrated system.

Mr. BOONE. You indicated these will be special-purpose ships?

Mr. BUCKLEY. Yes, sir.

Mr. BOONE. That means if you are to use them beyond the Gemini-Apollo situation you have to remodify these ships again; is that correct?

Mr. BUCKLEY. Well, there should be general-purpose telemetering aboard, providing it doesn't cost too much or take too much space. The radar aboard would be usable at times for other jobs. Apollo will be their primary responsibility. Within the schedule allowance they will be available for any other jobs, if the necessary equipment is aboard; and if it doesn't compromise the ship too much, or raise the cost too much, we plan to put equipment aboard to make it adaptable to other missions.

Mr. BOONE. Does General Cooper's office in DOD specifically know your requirement? You indicated you talked to them.

Mr. BUCKLEY. We have been meeting with them at least once a month and letting them know everything we knew about our need for ships. In my office, as a matter of fact, there is an Air Force officer on assignment to us, and he is one of the team who has been meeting with the DOD. They knew all that we knew, progressively. The thing is, you can't always wait for the full definition of the problem.

There is another aspect to this, dealing with the use of this word "requirement." When a "requirement" is put on a range, at this point you have decided in detail what you want to do, and the range picks it up and carries it out. Since the Apollo support ships are still a planning job, this couldn't be put on the range requirement, though the use of all other ships but the Apollo ships has reached a stage where there has been a requirements document sent to the range.

Mr. BOONE. Do you know when your planning would be firm on this, so you could ask them if they could meet the requirements?

Mr. BUCKLEY. I think it might be 3 to 6 months.

Mr. BOONE. They have not specifically told you, then, that they could not meet your need in this case?

Mr. BUCKLEY. I understand and believe they are prepared to support our requirements for the ship.

Mr. ROUSH. That doesn't quite answer the question, Mr. Buckley.

Mr. BUCKLEY. You get into quite a juggling process at this point. They have no ships available right now to meet the NASA's need. The question is, Can they go through juggling, or will they have to get a ship from reserve storage, such as up the Hudson or James River, and then put it through the modification process especially for this job? They have no directly applicable ships, I believe. The amount of equipment that will have to be on board this ship for Apollo will use up a great deal of the ship's space.

Mr. BOONE. Wouldn't it be cheaper for the Government to modify one of their ships, instead of going out and buying three additional ships?

Mr. BUCKLEY. I personally believe after many meetings with General Cooper's office that there is a very serious shortage of instrumentation ships in the country, because we have always had a great problem in getting ships for this purpose.

We have had great difficulties in planning ship support for Ranger, difficulties in planning ship support for the Schirra flight, and I think we will have similar difficulties for future operations. We ran into a problem in getting ships for the Schirra flight. We bumped into the Johnston Island tests on that case, making it very difficult to get ships. The ships made available for that flight were chosen at the last moment during the last 3 or 4 weeks, and we had major problems in checking them out for that job.

Mr. ROUSH. What would have to be done to the ships used in the Mercury flights to prepare them for use in the Apollo flights?

Mr. BUCKLEY. The ships for the Mercury job have only a telemetering installation. On the ships there is the usual representative of the astronaut group who talks with the astronaut in the air, and there is a systems man aboard who is very knowledgeable on the Servo mechanisms, fuel use, and valves, all the devices on the spacecraft. They have communication gear on board that I think could be used, and acquisition aids that help to pick up signals and direct the telemetering antennas.

As we go to Apollo there will be far, far more sensitive telemetering of a different type required because they are bringing down far more data.

Mr. BOONE. This telemetry is essentially why the Air Force is buying two new ships that have not yet been delivered?

Mr. BUCKLEY. The two new ships, *Aris I* and *Aris II*, were deliberately configured for the reentry tests where you fire up in the air and come down in the area between Ascension and the cape. They have an X-band, an L-band, and two C-band radars aboard. From the point of view of electronics, there are two of each. They double up some. There is a weather station aboard, also, that is for these tests. In other words, these ships were also configured for a particular, special purpose. Incidentally, it is a long jump from a ship with all that equipment aboard configured to that test, to a ship that has Apollo equipment aboard.

Mr. BOONE. The telemetry would be essentially the same, though; wouldn't it?

Mr. BUCKLEY. The telemetering would be up to the point where you split it off and modify it to go into the correct displays, and so forth, which is a very essential part of the gear, too.

The ship, from the point of view of Mercury or Apollo, is essentially a small mission control station.

Mr. BOONE. Under certain circumstances, under one set of circumstances you wouldn't even need a South African ship, would you, but just an injection station off Bermuda somewhere?

Mr. BUCKLEY. If you could constrain the launch to the particular day of month and the hour when the moon would be in the right position, that is right, you could use the station in Pretoria. But this gets down to practically telling the people after all the years of effort and money they have put in that they can only launch between 3 and 4 o'clock on a particular date, and I think this is far too much of a constraint on Apollo.

Mr. BOONE. What is the altitude of the orbit over Johannesburg?

Mr. BUCKLEY. Between 100 and 150 miles; this is not a settled item yet.

Mr. ROUSH. Back to the Mercury ships we used; who owns those, or who operates them, has them under their jurisdiction and control?

Mr. BUCKLEY. The ships are operated by DOD. The equipment on board is operated by RCA, the subcontractor to Pan American, working for the Air Force.

The ships until recently were operated as ships by the Suwannee Steamship Co.; in the last few months they have been transferred to another company for operations.

Mr. ROUSH. Specifically, why cannot these ships be used for this?

Mr. BUCKLEY. Well, first of all, they are far too small for all the Apollo gear. Between the crew's quarters, the air conditioning that is associated with a lot of electronics equipment, and the electronics equipment itself, these two Mercury ships already are pretty full. I believe the Mercury ships will continue to be used, still, during the Apollo missions. Remember, these ships have no tracking equipment aboard. And the main problem here is to get tracking data.

Incidentally, I did not mention the reason why the ship was to be in this area to watch the injection. As the Apollo vehicle receives added thrust to put it into the trajectory that takes it to the Moon we have two major problems: Has it been given the right amount of thrust and is it going in the right direction, and the associated problem of watching over this new and very heavy type of engine in there: Did it perform as desired? Did it give the full thrust?

If, the spacecraft doesn't perform properly, the tracking from the ships is needed to solve the abort problem. Also, if you don't insert into orbit correctly, you have to figure out what to do next and where to bring the man down.

This is the tracking problem these ships are needed for. I should have told you that when I talked about the charts.

Mr. ROUSH. How long will it take to finish these ships and have them ready for use?

Mr. BUCKLEY. We figure 2 to 2½ years, with a checkout time of 6 months.

Mr. ROUSH. Approximately when is our first shot on which they would be used? Would it be generally—could you give it to us generally?

Mr. BUCKLEY. I can't do that, I am sorry.

Mr. ROUSH. All right.

Other questions?

Mr. FULTON of Tennessee. Mr. Chairman.

Mr. ROUSH. Mr. Fulton.

Mr. FULTON of Tennessee. I wondered as to the increased cost of the use of Military Transport Services, as compared with the Navy.

You mentioned one instance where the country objected to the use of military personnel aboard the ship.

Mr. BUCKLEY. You asked about the cost, first?

Mr. FULTON of Tennessee. Yes.

Mr. BUCKLEY. I think the costs are fairly comparable between the various methods of operating the ships, and there is no serious difference between them. That is to answer the first part of your question.

Yes; we have had quite a problem about whether there were military or civilians aboard a ship. As it happens, MSTS uses civilian crews, which we figure will get us into foreign ports without any difficulties. In one case there were probably 8 to 9 months of negotiations with one foreign country, and the pile of paper resulting from our negotiations to get that ship in there is about a foot and a half high.

In other words, if you are going to plan for Apollo support and don't know where you are going to put in for fuel and supplies, you ought to plan an approach that won't have any major restrictions.

Mr. WYDLER. Is it also true that on return of these ships—the return of the Apollo mission—you might need these ships?

Mr. BUCKLEY. This area of planning is going on but is less advanced than the part I have discussed. Some ships are almost certainly going to be needed in connection with the reentry. And at this time we have no information on where such ships should be positioned.

In other words, our asking for the three ships is a compromise and intermediate position, because I am sure there will be more ships than that needed. We are asking for the three we are sure of. I personally think there will be more ships needed as the studies develop, and possibly then we will have to see what the future would be.

In this case, Mr. Boone, I think we would continue to use, and probably try to convert, Department of Defense ships. This would be a later solution as you get further down the wire.

I left out one other item, Mr. Chairman, and that is that the problem of having land stations in foreign countries is becoming continuously a little more difficult. In this morning's paper there was an article about the problem of having a Navy communications station in Australia, though we have our NASA stations in Australia. There is a difference between a military station and a civilian station. But we foresee, and Mr. Webb has made quite a point of this in talking to us at various times, that the difficulty of getting land stations in foreign countries is going to increase.

So once again we feel it is necessary, if we are going to do the Apollo program, to have ships ready to support it.

Mr. FULTON of Tennessee. I think that is even more an argument for the Navy to participate in this program.

Mr. ROUSH. Would it be possible for you, Mr. Buckley, to direct an inquiry to the Defense Department and specifically ask them if they can meet your requirement?

Mr. BUCKLEY. Yes, sir.

Mr. ROUSH. Would you do that?

Mr. BUCKLEY. Yes, sir.

Mr. ROUSH. Concerning the cost of these ships, I think this is a matter which is of concern to the committee, not that we feel we are spending too much on them, but that perhaps your estimate here is not a correct estimate and that next year you will be coming back and telling us "Well, we underestimated here by quite a bit and we are going to have to have considerably more."

This is particularly true, because we happen to have the figures on these two Air Force ships which are being developed. We realize there are some differences, but it seems basically the two are about the same, and they are spending more for two ships than you plan to spend for three.

Mr. BUCKLEY. Well, those ships are far more complicated, as I indicated to some degree. We have lists of the equipment aboard those ships, and——

Mr. ROUSH. Which ships are you referring to?

Mr. BUCKLEY. The two Air Force ships.

Mr. ROUSH. All right.

Mr. BUCKLEY. They are far more complicated than our ship will be. In other words, there is much equipment that is extra to our need on those ships.

We have gone to the Bureau of Ships and to three possible contractors and discussed ship costs and broken them down to how much it takes to modify ships, how much to put on radar of a certain size and how much to put on telemetering equipment. We think we have gone to most of the knowledgeable people in this area, and we have pretty consistent estimates as to how much it takes to make the crew modifications, air-conditioning modifications, raceways, and so forth, install equipment, install radar, to modify the hull in the first place, and therefore we think this is a fair total price for three ships that we have come up with.

There have been, I believe, estimates given by the Defense Department for ships at various times, so that people have been able to make a comparison between our requests and these others. I first compared it with the two Air Force ships that are now building, and now I have compared it with some plans that have been made at various times on lesser ships.

From this variety of approaches we have come up with the present cost estimate.

Now, Mr. Truszynski has looked into this in some further detail, if you would like more detailed answers on some of the cost elements.

Mr. ROUSH. We are going to have certain questions which we submit in writing, because of time limitations here. I am sure that will be included. This is also going to pertain to the other construction items that this particular subcommittee has the responsibility of looking into.

(The requesting letter follows with the prepared response from NASA:)

MARCH 21, 1963.

Mr. PAUL G. DEMBLING,
Director, Office of Legislative Affairs, National Aeronautics and Space Administration, Washington, D.C.

DEAR MR. DEMBLING: The Subcommittee on Applications, and Tracking and Data Acquisition has completed its hearings on the tracking and data acquisition portion of the NASA budget request. However, the subcommittee has found there are a number of additional questions it would like to have answered. These answers will be included in the record.

Attached is a list of questions which pertain to this portion of the budget and which I believe were unanswered in the hearing. The committee is most anxious to have your reply by April 5 so that these questions can be considered in its deliberations on the budget.

Thank you very much for your help in getting this information for us.

Sincerely,

W. H. BOONE,
Technical Consultant.

(The questions with NASA's response are as follows:)

1. Has NASA discussed in detail the tracking ship requirements for the Apollo mission with the Department of Defense and based on these requirements and/or other factors has the Department of Defense stated that they do not have the capability to meet this requirement?

NASA has been discussing tracking ship requirements in support of manned space flight missions with the Department of Defense for over a year. These requirements have dealt with (a) the operational needs that NASA foresees in integrating tracking ships into a worldwide Apollo ground support network and (b) the general technical configuration of the equipment aboard these vessels to match the system characteristics of the manned spacecraft and missions. Actual metric, location, and schedule requirements cannot be known in detail until considerably more study and mission profile effort has been completed by the Apollo project group. The NASA forwarded a formal inquiry to the Department of Defense requesting whether or not three tracking ships were available within the national inventory to be committed to Apollo support as their top-priority primary function. We were informed that the existing national inventory of instrumentation ships cannot support this requirement.

2. If for technical reasons DOD cannot meet the NASA need, have they estimated how much it would cost to modify their ships to supply this need and what is the estimate if available?

The underlying reason that DOD cannot meet the NASA need is that there are not enough tracking ships in the national inventory. The Department of Defense, therefore, has not been requested to estimate the costs of modifying their existing instrumentation ships. The need of the National Aeronautics and Space Administration can only be met by the addition of at least three instrumentation ships to the national inventory.

3. Has NASA completed negotiations for the three vessels required and do they have assurance that the vessels will be made available to them? If so, what is the availability date?

NASA has not completed negotiations for the three hulls to be modified in fiscal year 1964. Informal assurances as to hull availability have been offered, but no selection could be made until a NASA authorization bill so permits. The actual transfer of hulls to NASA will be a simple matter of an exchange of letters between NASA and the Maritime Commission.

Telemetry station (p. CF 13-46)

4. Can existing facilities be continued in use to meet Gemini and Apollo needs? If not, why?

Some of the existing Mercury telemetry and associated equipment will be used in support of Gemini and early Apollo. It will have to be augmented by considerable additional instrumentation including PAM/FM/FM equipment and PCM equipment, the latter requiring some 14 to 20 racks of added components. The Apollo program will require expanded command, communication, data processing, and display equipment which will require additional space. While Gemini and Apollo equipment comprise the bulk of the equipment to be housed in the proposed facility, the existing Scout telemetry (currently housed in trailers) will also be installed in the new facility. The existing prefabricated structures cannot accommodate the augmented and new equipment since they were originally constructed to support only the Mercury project.

5. What makes the cost per square foot for these buildings in excess of U.S. costs?

Unit costs ($37.50 per square foot) are higher because:

(a) The design includes a water catchment system on the roof (draining into a subsurface cistern) to obtain potable (rain) water.

(b) The above, plus provisions for the possible later addition of a second floor, results in heavier and costlier footings, columns, and beams on the first floor.

(c) Sectionalized removable floor panels are used to provide a subfloor space in which to locate cable runs, etc.

(d) Similarly, false acoustical ceilings concealing air-conditioning units and utilities contribute to increased costs.

(e) All materials (cement, coarse aggregate, lumber, etc.) must be imported from the States.

(f) Labor costs in the skilled construction trades are approximately 25-percent higher than continental United States.

These same factors account for the $31 per square foot cost of the generator building, which also contains a bridge crane capable of handling the diesel generators.

6. How much is involved in grading, excavating, and soil compaction?

Grading, excavation, and soil compaction costs are estimated as follows:

Strip topsoil and seeding	$2,000
Excavation	18,500
Backfill and compaction	4,600
Blacktop paving (1,200 sq. yds.)	5,500
Foundation grouting	4,400
Total	35,000

The Town Hill site is a high and steep coral (limestone) hill containing numerous subterranean cavities typical of limestone country. These are not large (small boulder size) and are due to the leaching action of rainwater.

A large amount of hand labor is used for stripping topsoil, sidehill excavation, backfilling and compaction cavities, and grouting the foundation subsoil bearing surfaces.

Blacktopping (bitumastic) costs $2.50 per square yard for a 3-inch cover in the States, excluding cost of grading and subsoil preparation. The $4.50 cost in Bermuda reflects both increased labor and material costs.

7. Utility and fire alarm systems appear excessive. How were these estimates completed?

The utility system includes a drilled well 250 feet deep to provide somewhat brackish water used as cooling water in the generating plant and in the sanitation system.

The septic system provides the internal plumbing and external tanks and extra large field designed for 40 people.

The utility connections at $56,000 include the following:

(a) Rainwater catchment and underground storage: 55,000-gallon capacity	$36,000
(b) Treatment (pumps, piping, etc.)	14,000
(c) Portable water storage: 20,000 gallons (3-day supply)	6,000

The fire alarm system estimate was based upon a response from a local contractor and provides a three-wire sensing and alarm system for the original one-story building with built-in capacity for possible future expansion.

8. The design and engineering services are excessive to normal fees. How was this estimate computed and was the Bureau of Yards and Docks considered in performing their work?

Design and Engineering Costs include:

(a) Drawing and specifications.

(b) Construction contract administration.

(c) Onsite supervision and inspection.

(d) Fee.

Construction costs are estimated at $562,000. The $38,000 estimate for A. & E. services is less than 7 percent and is not excessive considering the onsite inspection function included.

The assistance of the Bureau of Yards and Docks has been used in the past for NASA work on Bermuda. As recent as January–April 1963 the local resident engineer for BUDOCKS handled the minor construction on High Point in connection with the SNAP–10A program in which NASA is supporting the Atomic

Energy Commission. However, since there is no firm project until congressional action is completed, Bureau assistance has not yet been solicited in implementing this proposed new telemetry station.

Support facilities (p. CF 14-1)

9. Does the launching schedule for future firings justify additional facilities at Wallops Station? How many shelters are available and how many new shelters are proposed?

There has been a consistent increase in the number of multistage rocket firings from year to year.[1] For example, even at this early date, the calendar year 1964 schedule for this class of vehicle only shows 2 Astrobees, 10 Javelins, 2 Ram-B, 6 Trailblazer, and 9 Wasp II vehicles. Other experiments are in the planning stage. There are two tubular launchers (launch area 4 and launch area 5) available to handle this class of vehicle. A third launcher (launch area 2) can be used occasionally but requires a waiver of safety requirements due to its location and design, and more over interferes with the sounding rocket program. A launch schedule of this magnitude for the year, from only two launchers, is impossible due to the constraints imposed by weather, moon cycles, optical coverages, sun cycles, local and down-range clearance problems (maritime and aviation) which often hold a rocket on the launcher for extended periods—up to several weeks duration. There have been occasions when prolonged delays have resulted in the loss of a launch window, requiring dismantling and removal of the rocket, with the associated risk of derangement of internal systems and possible structural damage, in addition to the cost of removal and subsequent reassembly. The existing congestion in blockhouse No. 3 will become operationally limited when the controls for the second Scout pad (under construction) are installed. It is considered necessary to build another launch-control center to relieve this congestion by transferring launch area No. 5 controls from blockhouse No. 3, and to service the new proposed pad. The proposed facility will not only meet operational requirements but also permits the economies inherent in the dual pad-single blockhouse concept.

There are presently two mobile enclosures which are conversions of van trailers, and are used in launch areas 1, 2, 3, 4, and 5. With the vehicle in a horizontal position (on the launcher) the shelter is positioned to enclose the upper end, usually payload and upper stage only. Two additional enclosures are proposed—one for existing launch area 5 and another for the proposed new launch area 6. These retractable shelters will fully enclose the vehicle (rockets plus payload) and personnel during assembly and checkout procedures on the launcher. Extremes of temperature, moisture, and high winds have a deleterious effect on the solid-propellant fuel grain, staging interface connections, payload electronics, and batteries. A vehicle's residence on the launcher varies from 2 days to a matter of weeks; therefore, launcher environmental enclosures contribute significantly to the probability of success of the experiment.

10. The site development and utility installations appear to be a separate expenditure not necessarily to accommodate a new building and appears to be a civil works project. Was it coordinated with the Corps of Engineers and do you have estimates from the Corps of Engineers for this work?

The beach protection system is designed to not only conserve for future use the entire southern end of Wallops Island but to protect the southern flank of existing facilities from progressive erosion and eventual encroachment by the sea—a process that has already started with the cutting of two small inlets across the end of the island. The design of the beach protection system is based on the continuing recommendations of the Beach Erosion Board of the Corps of Engineers. The system consists of a steel sheet-piling bulkhead running the length of the beach to be protected and a wooden groin system spaced at suitable intervals (400-600 feet) extending out to sea at right angles to the bulkhead. The bulkhead protects the beach against direct wave action pounding whereas the groin system interrupts lateral currents eroding the beach. This latter action not only prevents erosion but builds up the beach as sand is dropped out of suspension when the current is arrested. Behind the bulkhead a dyke is constructed to various elevations and base widths, depending upon the intensity and frequency of the storms against which it is desired to protect the beach. The Wallops design will withstand the maximum storm intensity which is likely to be experienced based on a survey of the past 40 years of experience. Cost esti-

[1] As indicated in the NASA budget estimates, current and planned programs based on the Javelin Journeyman-Trailblazer class of vehicles have saturated existing facilities.

mates were derived from recent construction of this type along the center section of the beach front. Unit costs of steel sheet piling in place (per linear foot) and of the groin system are relatively standard and readily available to design agents. The cost of fill for the dykes, however, poses a problem due to the lack of suitable material close at hand. In the case of Wallops, suitable material is found in the marshland to the west of the island under a layer of organic material which must first be removed, and which was pumped by hydraulic dredge to the beach area. The Corps of Engineers furnished representative unit costs to be used in evaluating bids. These are adjusted to localities and to the general economic level of activity prevalent at the time of bidding.

11. What are the future plans for the area to be restored?

The continuing role of Wallops Island in supporting space programs clearly indicates that many of the components and devices developed for lunar and planetary explorations, and scientific satellites will be flight tested from the island. The Mercury capsule abort and recovery systems, antenna deployment systems (Alouette), nuclear power-generating devices, etc., are representative of the type of testing which will be continued from the island. It is expected that large space-erectable structures will likewise be test-flown, requiring larger vehicles which in turn will necessitate additional and heavier launch complexes. The southern end of the island is the only real estate available, as the overflight problem posed by nearby Assateague Island restricts the area to the north for many launch purposes.

A definite pattern has been established by past experiences which indicate that out of the numerous new vehicle and spacecraft studies continuously under review, a few result in actual development hardware requiring flight testing. For example, the Aerobee 300 rocket is under development, for which Wallops is presently modifying a launch facility for evaluation purposes only. When this vehicle is added to our rocket family we may require another launch tower which would be logically located in the south area.

12. Facility construction and modifications appear to be excessive for launchings of vehicles such as the Scout. Justification is requested for these costs.

The cost of facility construction and modifications is based on the following estimated cost breakdown:

Facility construction and modifications	$785,000
Launch control center (3,600 square feet at $120 per square foot)	430,000
Site preparation	65,000
Building	295,000
Escape hatch and blast doors	15,000
Lights, air conditioning, heat and power	55,000
Assembly shop (11,000 square feet at $24 per square foot)	265,000
Pad (300 by 280 feet)	90,000

The launch control center is estimated at $120 per square foot. This estimate is based on the cost of a rocket storage building of 1,560 square feet constructed in 1957 plus estimates for power, air conditioning, blast doors, and an escape hatch not included in the rocket storage building. It is of the igloo type covered with earth, costing $102,700 when constructed. Updating the price would make this building cost approximately $128,000 today; thus making the cost per square foot approximately $82. This building has no lighting, power, mechanical ventilation, plumbing, heating, communications, blast doors, or escape hatches. The inclusion of these features in the proposed launch control center raises the unit cost to $120 per square foot. This cost compares favorably with that for a control center on Cape Canaveral. While vehicles are considerably larger at the cape, separation distances are also greater thus attenuating the overpressures to which the structure must be designed. Wallops on the other hand is a long narrow island where long separation distances would result in large areas of scarce real estate being rendered useless for any other purpose than providing separation distances.

At $24 per square foot the cost of the assembly shop is not considered excessive. Using $15 per square foot as basic unit cost for concrete base and blockwall construction, and adding plumbing, electrical, and ventilation costs, results in the $24 per square foot unit price. At Cape Canaveral, where humidity and other ambient conditions are more severe, costs for similar structure vary between $31 and $50 per square foot.

With concrete in place (including form work and reinforcing steel) costing approximately $70 per cubic yard, the $90,000 for the pad is not considered excessive.

Deep space network launch station (p. CF 6–59)

13. In accordance with the NASA-DOD agreement of January 17, 1963, this appears to be a requirement that should be supplied by the DOD. Has DOD been asked to supply this function?

The deep space net launch station will use specialized instrumentation essentially identical in function (but not in power and sensitivity) to that used at other stations of the deep space network. The instrumentation system is designed specifically for compatibility with the S-band transponders used in the various unmanned spacecraft (Mariner, Ranger, Surveyor, Pioneer) for lunar and planetary exploration: it must also provide for demodulating and displaying telemetry data received from the transponder, during the prelaunch checkout and countdown, so that full information for a final go-no-go decision is available to the project director. It will also be utilized for early initial coverage on first pass with the south Africa deep space net station. Under the terms of the NASA-DOD agreement of January 17, 1963 (sec. IV–C), each agency is responsible for the ground support equipment required for mission-specific functions directly associated with the preparation, launching, and in-flight control of its space vehicle, regardless of the area in which the equipment is located. It is in accordance with this provision that NASA provides facilities such as this DSN launch station and, therefore, DOD was not requested to furnish the facility.

14. Do you plan to utilize other facilities of DOD at Cape Canaveral in this network?

The DOD facilities at the cape are primarily for general-purpose range support and are utilized extensively in support of launch-vehicle data requirements which can be handled by such general-purpose range facilities. These do not, however, provide the special-purpose capability which is required of stations of the deep-space network. In particular, it is necessary in the deep-space system to use a two-way mode of operation, involving a certain specific frequency offset between ground transmitter and spacecraft transmitter. This two-way system is essential for transmittal of commends and verification of command reception and action, for measurement of precision Doppler, and for certain other specific functions involved in command, control, and telemetry reception from the spacecraft. This in turn requires that the entire communication system of ground station and spaceborne transponder be treated as an integrated system. The general-purpose DOD facilities were not intended to meet such a requirement, and therefore cannot be used as a part of deep-space net.

15. The costs generally throughout this item appear excessive. Justify.

An examination of costs for similar laboratory-type buildings at Cape Canaveral and other U.S. locations employing hung acoustic tile ceilings and elevated or "floating" floors to facilitate electronic installation indicates a variation from approximately $30 to $50 per square foot. Consequently, this facility at $35 per square foot is considered representative of the cost to be expected for such construction.

16. Is maximum utilization of DOD and other NASA facilities being made to reduce costs for this function? For example the DOD has large antennas, data-handling equipment, and precision ranging and Doppler equipment available. Are these existing and planned NASA equipments efficiently utilized?

NASA provides and installs only such equipment which is not available in the general-range-support capability. Since the DOD facilities at Cape Canaveral are not compatible with the deep-space net system, as explained in the previous two items, they cannot be utilized to serve this launch-station function. However, the existing and planned NASA facilities are felt to be very effectively utilized to serve their primary function. In addition, in the planning of these various facilities, every effort is made to insure as broad a general-use capability as possible within the cost limitations and without detracting unduly from the effectiveness of accomplishing the primary function of the facility.

17. What projects require this installation?

All unmanned lunar and planetary projects operating at S-band will require this facility. These projects presently include Ranger, Mariner, Surveyor (lander), Surveyor (orbiter), and Pioneer.

Manned-space-flight data-acquisition and tracking facility—CF 13–43

18. How far have the negotiations for sites for the three manned-space-flight data-acquisition and tracking facilities gone? When do you expect to complete negotiations for each site? What is the anticipated date of completion of each facility?

No formal negotiations have been conducted for sites for the three manned-space-flight data-acquisition and tracking facilities. NASA does not consider it

appropriate to do this until authorization to proceed with the project is granted by the Congress. However, in all station planning and siting, consideration is always given to anticipated future needs so that tracking and data-acquisition equipments can be colocated to the maximum technical extent possible. For example, the sites now being investigated for the fiscal year 1963 deep-space and data-acquisition facilities in Australia and Western Europe provide for suitable areas and terrain features which could accommodate additional antennas when and if such were required and authorized. This does not imply that land is acquired in addition to that initially needed, but that sites are chosen whenever possible to allow for potential expansion. In this way NASA hopes to reap the benefits of having multiple facilities located in the same areas in order to save on roads, general logistic support, and personnel operating costs.

To the extent considered technically feasible, these facilities will be colocated with existing NASA facilities or in countries in which NASA facilities now exist. Immediately upon congressional authorization, negotiations will be initiated officially through the Department of State, and are anticipated to be completed by about November 1963.

These facilities are anticipated to be operational by mid-1965.

19. Since this is a backup system, have all other possible facilities been investigated for use?

The three manned-space-flight, 85-foot tracking and data-acquisition antenna facilities are the prime stations that will be used entirely in support of the lunar phase of the Apollo project rather than backup systems. As pointed out in the justification book, these three stations will be closely interconnected with the existing deep-space network stations; NASA hopes to avoid having to build six prime stations for lunar Apollo by using three of the existing deep-space stations as backup. The backup philosophy indicated here is based on the requirement that the Apollo spacecraft and its crew must be in constant communication with the earth during the entire lunar mission. There are no facilities existing today that can provide two similar, independent, yet interconnected deep-space facilities at each of three ground locations separated by 120° longitude.

20. If available could not DOD or NASA ships be stationed to provide this function?

Since the major facility item in the prime manned-flight stations for the lunar mission is an 85-foot-diameter antenna weighing some 300 tons and standing approximately 140 feet high, it is not possible to mount such equipment on a ship.

21. Why would these stations not be located immediately adjacent to existing stations to reduce construction and housekeeping costs?

As indicated in the justification book, it is planned to locate these three prime stations at existing deep-space facilities. It is felt that considerable savings can be made in the areas of road and utilities construction by this approach. Operations costs, on the other hand, are a direct function of the number of personnel required to operate any specific equipment and therefore the location of a facility has less bearing on its operation costs.

22. Do you not have sufficient backup facilities at Goldstone to eliminate the need for a station on that longitude?

There are two 85-foot-diameter antennas at the Goldstone station; these are being and will continue to be utilized heavily in the unmanned lunar and planetary programs. The manned-flight net station proposed for construction in the United States would become the third at that approximate longitude. This station would be "prime" for Apollo lunar missions; it would be backed up by one of these existing deep-space antennas in exactly the same fashion as at the two oversea locations, each of which also has two deep-space net antennas.

23. Are the construction costs based on actual experience in former installations? Justify and give comparison with former construction.

The cost estimates for the manned-flight net are based on the construction of the two antennas at Fairbanks, Alaska; the two antennas at Rosman, N.C. and the antenna to be constructed in Canada. However, the manned-flight net antennas will have a great deal of equipment in addition to that provided at the above-mentioned stations which increases their estimated cost by some $2 million, depending upon the electronic sophistication of the station used for comparison. The basic structures are essentially the same—some buildings vary in size depending upon the equipment to be housed.

24. Give a breakdown of site development and utility installations.

Final selection of the sites for these antennas has not been made; consequently, a more detailed breakdown of the site development and utility installations costs

than that shown in the justification book cannot be made at this time. These are:

Site development and utility installations	$415,000
Site preparation and roads	100,000
Power-generating equipment	220,000
Power-distribution systems	45,000
Water and sanitation systems	50,000

Mr. ROUSH. It is quite possible after receiving your answers, that we will have to call you back. We will, if it is necessary, of course. But these items will be brought to your attention, that is, the questions will be brought to your attention, and we would expect answers to these, because we don't have time to go in to them today.

We have only a couple of minutes here, and unless a member of the committee has a question that should be propounded now I think we will go into executive session.

(Additional data submitted by NASA for the record is as follows:)

NATIONAL AERONAUTICS
AND SPACE ADMINISTRATION,
OFFICE OF THE ADMINISTRATOR,
Washington, D.C., May 16, 1963.

Hon. J. EDWARD ROUSH,
Member, Committee on Science and Astronautics,
House of Representatives, Washington, D.C.

DEAR MR. ROUSH: Pursuant to the authorization hearings on the question of NASA instrumentation ships, I would like to offer for the record the attached concise statement of our position on this matter.

Sincerely yours,

ROBERT C. SEAMANS, Jr.,
Associate Administrator.

NASA STATEMENT CONCERNING FISCAL YEAR 1964 BUDGET REQUEST FOR THREE APOLLO INSTRUMENTATION SHIPS

The Apollo project shares with several military programs the highest national and industrial priority. Any delay in the orderly progress of the program would not only be costly in dollars but would impair our national prestige.

An essential element in the success of the lunar landing mission will be the integrated tracking, communications, and command network equipped with instrumentation peculiar to the Apollo mission. One of the specific functions of this network will be to cover the insertion into orbit and the injection into lunar transfer of the Apollo spacecraft. These events will occur over water, and will require shipborne stations. The highest practicable degree of standardization of equipment throughout the network is needed for maximum operational responsiveness and mission safety.

The tracking of the Apollo mission will require, as a minimum, essentially the full-time availability of three ships. NASA has, therefore, included in its fiscal year 1964 budget request, presently before the Congress, three such tracking ships at a total estimated cost of $90 million.

The essentially full-time requirement for three ships is based upon a minimum of 45 days (15 days in transit; 30 days on station) of actual support per flight mission on a flight schedule of six missions per year; ship maintenance and repair time of 30 days per ship per year; and an allowance of 60 days per ship per year for equipment modifications and tests and technical crew training.

When the additional factors of schedule changes and mission revisions are considered, it is evident that anything less than full-time availability of three ships would involve the risk of delaying the program.

On April 2, 1963, NASA asked the Department of Defense if it could provide, within its existing or planned inventory, three full-time ships for Apollo support. On April 3, the Department of Defense answered: "It can be stated now that the Department of Defense does not have sufficient resources to commit three instrumentation ships for the full-time exclusive use of the Apollo program."

The Department of Defense proposal that five general-purpose ships be instrumented for the Apollo mission, and that ships be made available out of this pool

on a part-time basis for Apollo support, will not meet the NASA requirements. Assigning three ships to Apollo, while at the same time providing adequate support for DOD and NASA missions other than Apollo, will require the addition of three tracking ships to the national inventory.

Plans for the reentry phase of the lunar landing mission have not yet been finalized. When they are, it is most likely that a requirement for additional ships, beyond the three requested in fiscal year 1964, will become apparent.

Current plans call for meeting the Apollo ship requirements under the most economical schedule. Modification and instrumentation of three existing reserve fleet hulls must start in late 1963 in order to have ships available for operational training when needed in 1966. Our plan is to stagger delivery of these ships by 3-month intervals; this will permit the shipyard and instrumentation contractors to minimize personnel requirements and, in turn, the overall cost. Full authorization and funding are required in fiscal year 1964 to meet the Apollo schedule while realizing the advantages of scheduled procurement.

(Additional data submitted by NASA for the record is as follows:)

MAY 28, 1963.

Mr. PAUL G. DEMBLING,
Director of Legislative Affairs, National Aeronautics and Space Administration, Washington, D.C.

DEAR MR. DEMBLING: Additional questions have arisen in the deliberations of the Subcommittee on Applications and Tracking and Data Acquisition concerning the NASA fiscal year 1964 authorizations. It is requested that information be forwarded to the subcommittee no later than June 4, 1963, in response to the questions that follow on items of concern to the Office of Tracking and Data Acquisition. Your reply will be included in the record of hearings.

1. A list is requested showing the stations comprising each of the tracking networks; that is, the satellite network, the manned flight network, and the deep-space network. Those stations now under construction and planned should be described, giving the estimated completion date and the percentage completion at this time.

2. Four antenna facilities similar to the three manned space flight facilities requested this year were authorized in fiscal year 1963 at $5 million. What additional costs are involved to require $7 million expenditure at this time?

3. Previous testimony on the solid state switching system for communications network indicated that there would be a savings in communications costs if this system were purchased. What will be the magnitude of yearly savings brought about by the use of this system? Is there a standard nonsolid state device available and if so what is its estimated cost?

4. The committee requests a breakdown of each item under the heading "Data processing and handling" with an explanation of the increases over fiscal year 1963 funds?

5. The subcommittee is concerned that the facilities construction under its preview must conform to established design criteria and standards of the General Services Administration, the U.S. Navy Bureau of Yards and Docks, or the U.S. Army Corps of Engineers and must be constructed on an austere basis similar to other Government agencies. Have similar standards been adhered to in the design of the telemetry station, CF–13–46, manned space flight tracking facilities, CF–13–43, the meteorological laboratory, CF–3–17, and support facilities, CF–14–2?

6. The committee has been informed that the Alaska tracking facility has blue ceramic tile used in its construction. Is this true and does this conform with established standards for this type facility? Will all of the large tracking stations utilize these same standards?

Sincerely,

W. H. BOONE, *Technical Consultant.*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION,
Washington, D.C., June 3, 1963.

Mr. W. H. BOONE,
Technical Consultant, Committee on Science and Astronautics,
House of Representatives, Washington, D.C.

DEAR MR. BOONE: The attached information is forwarded in response to your request of May 28, 1963.

Sincerely,

PAUL G. DEMBLING,
Director, Office of Legislative Affairs.

Enclosure.

1. NASA TRACKING AND DATA ACQUISITION FACILITIES

All stations operational except as indicated.

MANNED SPACE FLIGHT NETWORK

Cape Canaveral, Fla.
Coopers Island and Town Hill, Bermuda
Grand Canary Island
Kano, Nigeria
Zanzibar
Muchea, Australia
Woomera, Australia
Canton Island
Kauai Island, Hawaii
Point Arguello, Calif.
Guaymas, Mexico
White Sands, N. Mex.
Corpus Christi, Tex.
Elgin Air Force Base, Fla.
Carnarvon, Australia (80 percent complete; operational December 1963)
Rose Knot, Quebec telemetry and command ship
Coastal Sentry Victor, telemetry and command ship

Fiscal year 1964 request

Europe (85-foot antenna; operational mid-1965).
United States (85-foot antenna; operational mid-1965).
Australia (85-foot antenna; operational mid-1965).
Tracking ship No. 1, operational March 1966.
Tracking ship No. 2, operational June 1966.
Tracking ship No. 3, operational September 1966.

SATELLITE NETWORK

Electronic tracking stations

College, Alaska
Fairbanks, Alaska (85-foot antenna)
Fort Myers, Fla.
Quito, Ecuador
Lima, Peru
Santiago, Chile
Antofagasta, Chile
Winkfield, England
Mojave (Goldstone) Calif.
Woomera, Australia
East Grand Forks, Minn.
Blossom Point, Md.
St. Johns, Newfoundland
Johannesburg, South Africa
Rosman, N.C. (85-foot antenna, 95 percent complete; operational August 1963); second Rosman antenna system (20 percent complete; operational, August 1964)
Southeast Australia (65 percent complete; operational July 1964)

Optical stations

Villa Dolores, Argentina
Woomera, Australia
Curacao, Netherlands West Indies
Naini Tal, India
Shiraz, Iran
Mitaka, Japan
Arequipa, Peru
Olifantsfontein, South Africa
San Fernando, Spain
Jupiter, Fla.
Maui, Hawaii
Organ Pass, N. Mex.

DEEP SPACE NETWORK

Goldstone, Calif.
Woomera, Australia.
Hartebeesthoek, South Africa.
Fiscal year 1963:
Southern Europe (10 percent complete; operational January 1965).
Canberra, Australia (25 percent complete; operational October 1964).
Fiscal year 1964: Goldstone, Calif. (advanced antenna) (12 percent complete; operational February 1966).

Fiscal year 1964 request

Cape Canaveral launch station (operational October 1964).

Sites have been selected by NASA for all authorized stations; in several cases, the cooperating government has not either officially entered into an international agreement or has not yet made public announcement of the site selection. For this reason, some of the stations under construction are identified only by general location.

2. Manned Space Flight Data Acquisition and Tracking Facilities

In fiscal year 1963, authorization was requested for four NASA antenna facilities: two deep space network stations at $5 million apiece, a satellite network station at $6 million, and a second antenna for the Rosman satellite network station at $3.5 million.

In fiscal year 1964, NASA is requesting authorization for three manned space flight network stations at $7 million apiece. These are much more comparable to the fiscal year 1963 $6 million satellite network station than to the $5 million deep space network stations, in that the basic antenna mount will be of the X–Y rather than Ha-Dec type and the complete electronics required for manned flight support approximate the cost of those needed to support the large unmanned satellites.

The $1 million difference in cost of the two types of stations is entirely a factor of the manned flight program requirements. The antenna itself will be more expensive since it will be built as a Cassegrain rather than prime-focus parabola. The Cassegrain configuration is necessary to operate at maximum efficiency in the S-band frequencies that the lunar Apollo missions will use. Since these antennas will be used to support manned space flights, they must be sturdy and reliable enough to operate without environmental constraint; this requires extra structural strength and heavier gear systems. Tolerances must be held to a minimum, since the antennas will have to track accurately at both high speeds for the orbital portion of the flight and at low speeds during the lunar approach. Accuracy and reliability requirements, then, serve to increase the antenna cost. The electronic systems required by manned flight missions include an accurate ranging system not included in the basic cost of the satellite network station as well as a very different transmitter system that must handle both voice and command data

3. Solid-State Switching System

The present switching system in use at the Goddard Space Flight Center is composed of two semiautomatic solid-state electromechanical units. The system is leased from common carriers at a cost of some $300,000 per year. The system has a capacity of seventy 60-word-per-minute teletype circuits.

The automatic solid-state electronic system proposed for procurement in fiscal year 1964 will have a capacity of 184 such teletype circuits as well as twenty-four 1,000-word-per-minute high-speed data circuits. This system can be leased from common carriers at approximately $900,000 per year or can be purchased for $1.8 million.

To increase the existing rented system capability to 184 teletype circuits alone would increase the annual lease costs from $300,000 to $850,000, and would not provide for any high-speed data circuits. The electromechanical systems cannot handle 1,000-word-per-minute data traffic.

The purchase of an automatic solid-state electronic switching system will effect economies in system maintenance and operations personnel in that 30 percent less people will be required; building space in that only half the presently used area is needed by the compact modular equipment; and direct cost in that the purchase cost is only twice the annual rental cost and the system will be in use for many years.

There is no vacuum-tube or electromechanical switching system that can handle high-speed data. The proposed solid-state electronic system is made up of entirely standard components listed in the "Federal Supply Catalog."

4. Data Processing and Handling

During the period from early 1962 to the present time, data processing requirements have caused an increase in the number of processing "lines" from two to a total of about seven which will be operated and maintained during fiscal year 1964. The increase in satellite data rates, plus the increased use of PCM telemetry in the current and planned satellites, will require approximately four PFM processing lines and three PCM processing lines. Under the demanding workloads for "in orbit" satellites, plus the requirement to rerun previously processed tapes (in order to extract additional data previously not recoverable due to limitations of equipment), the data processing systems must be provided with various analog and digital equipment and other components as replacement and spares. Therefore, a considerable increase in cost is anticipated to maintain the data processing systems to meet program requirements.

In order to provide STARS equipment for the processing lines required to handle the satellite-produced data, four complete systems are being incrementally funded in fiscal year 1963 and fiscal year 1964. These systems are required to augment the processing lines already in use to maintain processed data output at appropriate and required levels.

A description of the new equipment to be procured is attached.

EXPANSION OF NETWORK CAPABILITY

Satellite telemetry automatic reduction systems (STARS).—The larger scientific satellites will possess on-board digital systems capable of storing great quantities of required data. This results in a vast increase of data flow and subsequent need for expansion of data handling facilities. The STARS system consists of digital processing and handling equipments which operate automatically at preprogramed modes to reduce and print out the above data at very high speeds. Such an automatic system is considered necessary if data is to be reduced on a timely basis.

Telemeter off-line processing system.—The observatory class of satellites have very high data rates which even when processed by STARS require an inordinate amount of machine time. Preliminary processing of this data in the telemeter off-line processing system will greatly diminish or eliminate unusable data and allow for more effective use of the large automatic reduction system.

Special purpose data processors.—Many experiments produce raw data which cannot be processed by standard means. The special characteristics of the rubidium vapor magnetometer (planned in the OGO series) requires a special device to translate frequencies from telemetry signals into digital numbers with high accuracy and precision. A special processor is required to display spectrograph star patterns and TV scans, as translated from telemetry signals from the OAO satellites.

Automatic analog data tape evaluation equipment.—This equipment will be capable of automatically sorting out and evaluating improperly recorded telemetry tapes. This increased capability is necessary in the face of the rapidly increasing number of tapes required to be handled.

High speed plotter printer.—This machine is necessary to more nearly equate the speed of printing with computer speed. Present equipment dictates a several hour delay in printing following the completion of a computer program.

5. Construction Standards

Pending the implementation of NASA-wide design criteria and construction standards, all NASA facilities will continue to be designed on an austere basis using the established criteria and standards of the Army Corps of Engineers, the Navy Bureau of Yards and Docks, and the General Services Administration. The facilities in the NASA fiscal year 1964 program have not yet been designed but their planning and cost estimates reflect the use of such established criteria and standards.

6. Alaska Tracking Facility

The operations building at the Alaska tracking and data acquisition facility is built of glazed brick, not ceramic tile. Glazed brick or a similar material is required to assure proper temperature and humidity control inside the building to protect the expensive and highly sensitive electronic equipment. The operations building at the Rosman station is similarly built of glazed brick.

Glazed brick is available in a variety of colors, including a clear glaze, at no differential in cost; blue was chosen both for the Alaska and for the Rosman facility.

In each construction project, the individual station and equipment requirements are taken into consideration before designing and building the facility. The most appropriate and economical approach is chosen in terms of location, available materials, and operational needs. Construction techniques therefore can vary depending upon these factors but the standards do not.

(Whereupon, at 11:50 a.m., the subcommittee proceeded to executive session.)

1964 NASA AUTHORIZATION

TUESDAY, MARCH 19, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON APPLICATIONS AND
TRACKING AND DATA ACQUISITION,
Washington, D.C.

The subcommittee met at 10 a.m., pursuant to adjournment, in room 214–B, New House Office Building, Hon. Ken Hechler (chairman of the subcommittee), presiding.

The CHAIRMAN. The committee will come to order.

This morning as we commence hearings on NASA headquarters operations, we are pleased to have with us Dr. Robert C. Seamans, Jr., Associate Administrator of NASA.

I think in any operation of this magnitude this committee and the full Congress are deeply concerned with the full justification for the total amounts authorized.

I guess one of the administrative prices that has to be paid for rapid expansion is far more personnel, and I know that you dislike as much as the Congress does the necessity for more personnel, yet it is the responsibility of this committee and of Congress to analyze and scrutinize as thoroughly as possible the personnel and headquarters estimates submitted.

We are considering about half a billion dollars in this area, which amounts to about 10 percent of the total NASA budget.

Before you commence your formal testimony, Dr. Seamans, I would like to place in the record several tables on the comparative number of NASA employees, along with their grades and salaries, as compared with other Federal agencies. These tables have been prepared by the Legislative Reference Service at the request of this committee, by C. Edward Wise, Jr., and copies, of course, will be made available to NASA. They will also be in the record.

(The tables referred to are as follows:)

TABLE I.—*National Aeronautics and Space Administration*

	1961 actual	1962 actual	1963 estimated	1964 estimated
Total number of permanent positions	17,077	22,156	28,547	32,500
Full-time equivalent of other positions	78	644	858	917
Average number of all employees	15,949	19,493	26,571	32,294
Number of employees at end of year	17,471	23,686	29,147	33,100
Average GS grade	9.5	9.8	10.0	10.0
Average GS salary	$8,112	$8,279	$9,030	$9,122
Average salary, grades established by Administrator, NASA	$6,498	$6,640	$6,686	$6,708
Average salary, ungraded positions	$16,776	$17,071	$18,181	$18,181

Source: Budget for fiscal 1963, p. 748; and budget for fiscal 1964, p. 785.

TABLE II.—*Atomic Energy Commission*

	1961 actual	1962 actual	1963 estimated	1964 estimated
Total number of permanent positions	7,417	7,571	7,659	7,720
Full-time equivalent of other positions	111	109	111	125
Average number of all employees	6,826	6,794	6,987	7,265
Number of employees at end of year	6,846	6,863	7,152	7,330
Average grade, grades established by AEC	9.0	9.1	9.3	9.3
Average salary, grades established by AEC	$7,926	$8,089	$8,811	$8,993
Average salary of ungraded positions	0	0	0	0

NOTE.—Not included in this table are employees under allocation account.

Source: Budget for fiscal 1963, p. 659; budget for fiscal 1964, p. 693.

TABLE III.—*Agricultural Research Service*

	1961 actual	1962 actual	1963 estimated	1964 estimated
Total number of permanent positions	15,886	16,670	17,821	18,100
Full-time equivalent of other positions	1,104	1,214	1,261	1,158
Average number of all employees	15,235	15,926	17,124	17,520
Number of employees at end of year	17,263	18,059	18,790	19,530
Average GS grade	7.7	8.0	8.0	8.0
Average GS salary	$6,624	$6,717	$7,182	$7,193
Average salary of ungraded positions	$4,477	$4,547	$4,582	$4,676

Source: Budget for fiscal 1963, p. 85; and budget for fiscal 1964, p. 91.

TABLE IV.—*National Bureau of Standards*

	1961 actual	1962 actual	1963 estimated	1963 estimated
Total number of permanent positions	4,137	3,484	3,692	3,947
Full-time equivalent of other positions	197	176	200	215
Average number of all employees	3,398	3,545	3,811	4,065
Number of employers at end of year	3,755	3,873	4,090	4,372
Average GS grade	8.3	9.1	9.1	9.1
Average GS salary	$7,507	$7,856	$8,408	$8,516
Average salary of ungraded positions	$5,708	$5,955	$6,100	$6,100

Source: Budget for fiscal 1963, p. 219; and budget for fiscal 1964, p. 216.

TABLE V–A.—*Department of Defense—Army: Research, development, test, and evaluation*

	1961 actual	1962 actual	1963 estimated	1964 estimated
Total number of permanent positions	15,136	16,199	14,057	14,178
Full-time equivalent of other positions	36	59	55	59
Average number of all employees	14,622	14,037	13,356	13,380
Number of employees at end of year	14,681	14,818	13,726	13,512
Average GS grade	8.8	8.2	8.3	8.3
Average GS salary	$7,420	$7,080	$7,459	$7,479
Average salary of ungraded positions	$5,378	$6,125	$6,150	$6,160

Source: Budget for fiscal 1963, p. 272; and budget for fiscal 1964, p. 291.

TABLE V–B.—*Department of Defense—Navy: Research, development, test, and evaluation*

	1961 actual	1962 actual	1963 estimated	1964 estimated
Total number of permanent positions	25,399	25,877	26,030	27,359
Full-time equivalent of other positions	50	45	45	39
Average number of all employees	23,958	24,851	25,387	25,590
Number of employees at end of year	24,063	25,432	25,665	26,480
Average GS grade	9.1	9.3	9.3	9.3
Average GS salary	$7,870	$7,993	$8,589	$8,589
Average salary of ungraded positions	$5,852	$6,013	$6,022	$6,022

Source: Budget for fiscal 1963, p. 273; and budget for fiscal 1964, p. 293.

TABLE V–C.—*Department of Defense—Air Force: Research, development, test, and evaluation*

	1961 actual	1962 actual	1963 estimated	1964 estimated
Total number of permanent positions	23,479	26,611	24,438	27,854
Full-time equivalent of other positions	35	47	60	60
Average number of all employees	23,091	23,233	24,012	27,385
Number of employees at end of year	23,199	23,555	24,096	28,054
Average GS grade	8.1	8.2	8.2	8.1
Average GS salary	$6,958	$7,117	$7,667	$7,594
Average salary of ungraded positions	$6,400	$6,598	$6,780	$6,869

Source: Budget for fiscal 1963, p. 275; and budget for fiscal 1964, p. 294.

TABLE V–D.—*Department of Defense—Advanced research projects agency (ARPA): Research, development, test, and evaluation*

	1961 actual	1962 actual	1963 estimated	1964 estimated
Total number of permanent positions	82	84		
Full-time equivalent of other positions	1			
Average number of all employees	74	81		
Number of employees at end of year	80	84		
Average GS grade	9.1	9.7		
Average GS salary	$8,264	$8,721		
Average salary of ungraded positions	0	0		

Source: Budget for fiscal 1963, p. 277; and budget for fiscal 1964, p. 297

TABLE VI–A.—*National Institutes of Health—General research and services*

	1961 actual	1962 actual	1963 estimated	1964 estimated
Total number of permanent positions	343	188	315	394
Full-time equivalent of other positions	6	8	12	15
Average number of all employees	306	148	259	348
Number of employees at end of year	347	178	297	379
Average GS grade	6.4	7.1	7.5	7.5
Average GS salary	$5,866	$7,196	$6,964	$7,058
Average salary of ungraded positions	0	0	0	0

Source: Budget for fiscal 1963, p. 407; and budget for fiscal 1964, p. 436.

TABLE VI–B.—*National Institutes of Health—Biologies standards*

	1961 actual	1962 actual	1963 estimated	1964 estimated
Total number of permanent positions		206	265	297
Full-time equivalent of other positions		4	4	4
Average number of all employees		196	224	271
Number of employees at end of year		207	249	287
Average GS grade		6.9	7.4	7.4
Average GS salary		$6,030	$6,654	$6,595
Average salary of ungraded positions		$3,821	$3,898	$3,898

Source: Budget for fiscal 1963, p. —; and budget for fiscal 1964, p. 437.

TABLE VI–C.—*National Institutes of Health–National Cancer Institute*

	1961 actual	1962 actual	1963 estimated	1963 estimated
Total number of permanent positions	1,351	1,283	1,313	1,336
Full-time equivalent of other positions	76	64	62	65
Average number of all employees	1,200	1,153	1,257	1,312
Number of employees at end of year	1,328	1,291	1,325	1,350
Average GS grade	6.4	6.7	6.7	6.7
Average GS salary	$5,876	$6,057	$6,354	$6,413
Average salary of ungraded positions	0	$3,843	$3,949	$3,949

NOTE.—Not included in this table are employees allocated to Veterans' Administration.

Source: Budget for fiscal 1963, p. 408; and budget for fiscal 1964, p. 438.

TABLE VI–D.—*National Institutes of Health, mental health activities*

	1961 actual	1962 actual	1963 estimated	1964 estimated
Total number of permanent positions	701	820	1,113	1,255
Full-time equivalent of other positions	79	111	82	82
Average number of all employees	728	859	1,074	1,182
Number of employees at end of year	885	1,036	1,168	1,306
Average GS grade	7.5	7.7	8.1	8.1
Average GS salary	$6,691	$6,798	$7,401	$7,464
Average salary of ungraded positions	0	0	0	0

NOTE.—Not included in this table are employees allocated to St. Elizabeths Hospital.

Source: Budget for fiscal year 1963, p. 409; and budget for fiscal year 1964, p. 439.

TABLE VI–E.—*National Institutes of Health: National Heart Institute*

	1961 actual	1962 actual	1963 estimated	1964 estimated
Total number of permanent positions	837	634	755	762
Full-time equivalent of other positions	15	12	15	21
Average number of all employees	742	577	643	682
Number of employees at end of year	772	632	729	753
Average GS grade	7.1	7.1	7.4	7.4
Average GS salary	$6,367	$6,388	$6,969	$6,974
Average salary of ungraded positions				

Source: Budget for fiscal year 1963, p. 410; and budget for fiscal year 1964, p. 440.

TABLE VI–F.—*National Institutes of Health: National Institute of Dental Research*

	1961 actual	1962 actual	1963 estimated	1964 estimated
Total number of permanent positions	181	234	262	272
Full-time equivalent of other positions	3	5	5	5
Average number of all employees	160	218	248	257
Number of employees at end of year	192	241	269	277
Average GS grade	6.5	6.5	7.2	7.3
Average GS salary	$5,859	$5,842	$6,591	$6,637
Average salary of ungraded positions				

Source: Budget for fiscal year 1963, p. 411; and budget for fiscal year 1964, p. 441.

TABLE VI–G.—*National Institutes of Health, arthritis and metabolic disease activities*

	1961 actual	1962 actual	1963 estimated	1964 estimated
Total number of permanent positions	549	591	653	655
Full-time equivalent of other positions	9	21	19	15
Average number of all employees	504	529	565	580
Number of employees at end of year	510	579	633	580
Average GS grade	8.2	8.2	8.4	8.4
Average GS salary	$6,980	$6,985	$7,629	$7,642
Average salary of ungraded positions				

Source: Budget for fiscal year 1963, p. 412; and budget for fiscal year 1964, p. 442.

TABLE VI–H.—*National Institutes of Health, allergy and infectious disease activities*

	1961 actual	1962 actual	1963 estimated	1964 estimated
Total number of permanent positions	593	644	760	710
Full-time equivalent of other positions	10	7	7	7
Average number of all employees	571	617	677	702
Number of employees at end of year	603	647	708	708
Average GS grade	6.4	6.6	7.0	7.0
Average GS salary	$5,897	$6,001	$6,456	$6,600
Average salary of ungraded positions	$4,448	$4,444	$4,855	$4,621

Source: Budget for fiscal year 1963, p. 413; and budget for fiscal year 1964, p. 443.

TABLE VI–I.—*National Institutes of Health, neurology and blindness activities*

	1961 actual	1962 actual	1963 estimated	1963 estimated
Total number of permanent positions	458	563	729	755
Full-time equivalent of other positions	30	26	44	43
Average number of all employees	450	517	660	715
Number of employees at end of year	516	615	798	903
Average GS grade	6.8	6.7	7.0	7.1
Average GS salary	$6,184	$6,133	$6,637	$6,679
Average salary of ungraded positions				

Source: Budget for fiscal year 1963, p. 414; and budget for fiscal year 1964, p. 444.

TABLE VII.—*Atomic Energy Commission—Personnel compensation* [1]

Grades and ranges	1962 actual	Number	
		1963 estimated	1964 estimated
Special positions at rates equal to or in excess of $20,000	27	27	27
Grades established by the AEC equivalent to GS grades:			
GS-18	26	35	35
GS-17	53	61	60
GS-16	96	91	97
GS-15	390	435	441
GS-14	709	803	848
GS-13	840	905	958
GS-12	703	683	700
GS-11	554	534	508
GS-10	42	41	40
GS-9	513	483	482
GS-8	200	197	198
GS-7	460	454	442
GS-6	776	780	775
GS-5	1,061	1,067	1,083
GS-4	683	649	657
Grades established by the AEC equivalent to GS grades:			
GS-3	239	192	183
GS-2	48	47	43
GS-1	12	7	6
Ungraded positions for scientific and technical personnel, established under sec. 161d, Atomic Energy Act of 1954 as amended	91	113	126
Ungraded positions at hourly rates equivalent to less than $12,845	48	35	12
Total permanent	7,571	7,659	7,720

[1] Source: The Budget of the U.S. Government, fiscal year ending June 30, 1964. Appendix, 1195 pages, at pp. 1135–1136.

TABLE VIII.—*National Aeronautics and Space Administration—Personnel compensation* [1]

Grades and ranges	1962 actual	Number	
		1963 estimated	1964 estimated
Special ungraded positions: Administrator and Deputy Administrator	2	2	2
Special ungraded positions established by Administrator, NASA:			
$20,000 to $21,000	54	60	60
$18,000 to $19,750	154	182	182
$16,500 to $17,750	158	195	195
GS-18	1	0	0
GS-16	4	5	5
GS-15	1,033	1,548	1,832
GS-14	1,514	2,236	2,717
GS-13	2,028	2,889	3,571
GS-12	2,193	3,182	3,524
GS-11	2,022	2,881	3,209
GS-9	1,506	1,934	2,446
GS-8	31	36	41
GS-7	1,596	1,940	2,220
GS-6	445	559	675
GS-5	1,175	1,564	1,938
GS-4	1,104	1,339	1,538
GS-3	821	1,055	1,159
GS-2	112	115	121
GS-1	1		
Grades established by Administrator, NASA:			
NASA 1–14 ($3,994 to $13,291)	619	647	652
NASA 1–12 ($2,829 to $9,360)	456	503	522
NASA 1–13 ($2,579 to $8,965)	5,203	5,662	5,879
Total permanent	22,156	28,547	32,500

[1] Source: The Budget of the U.S. Government, fiscal year ending June 30, 1964. Appendix, 1195 pages, at pp. 1151–1153.

The CHAIRMAN. Once again it is a pleasure to welcome you again, Dr. Seamans, and you may commence with your prepared statement.

STATEMENT OF DR. ROBERT C. SEAMANS, JR., ASSOCIATE ADMINISTRATOR, NASA, ACCOMPANIED BY ALBERT F. SIEPERT, DIRECTOR OF THE OFFICE OF ADMINISTRATION, DeMARQUIS D. WYATT, DIRECTOR OF THE OFFICE OF PROGRAMS, DON D. CADLE, DEPUTY DIRECTOR OF OFFICE OF ADMINISTRATION JOHN D. YOUNG, TO BECOME DIRECTOR OF THE OFFICE OF ADMINISTRATION, ROBERT J. LACKLEN, DIRECTOR OF PERSONNEL DIVISION, MELVIN S. DAY, DIRECTOR OF OFFICE OF SCIENTIFIC AND TECHNICAL INFORMATION, AND GEORGE J. VECCHIETTI, JR., DEPUTY DIRECTOR OF THE PROCUREMENT AND SUPPLY DIVISION

Dr. SEAMANS. Mr. Chairman and members of the subcommittee, the supporting witnesses for my presentation are Mr. Albert F. Siepert, Director of the Office of Administration, on my right, Mr. DeMarquis D. Wyatt, Director of the Office of Programs, on my left, and Mr. Don D. Cadle, Deputy Director of the Office of Administration as of April 15 of this year.

Mr. John D. Young, who will become Director of the Office of Administration on April 15 when Mr. Siepert becomes the Deputy Director of the Launch Operations Center in Florida, is also present.

In addition, Mr. Robert J. Lacklen, Director of the Personnel Division; Mr. Melvin S. Day, Director of the Office of Scientific and Technical Information; and Mr. George J. Vecchietti, Jr., Deputy Director of the Procurement and Supply Division are here to answer questions you may have which bear on their areas of responsibility.

The purpose of today's hearing is to present NASA's personnel and operation of installations program for fiscal year 1964. This program is of great importance involving $560.3 million of research, development, and operations funding. Its conduct determines the effectiveness of a major segment of scientists and engineers, and consequently is receiving detailed attention by general management.

PERSONNEL

The unique team of Government personnel which NASA has built in the period of the last 5 years is certainly one of the Nation's most valuable resources in terms of scientific and technical competence and creative ability. Since this team is coupled with the great know-how and research and development skills of the Nation's aerospace industries, we are confident that the United States will forge ahead to become preeminent in space if the manpower, funds, and facilities requested by the President in the fiscal year 1964 budget are authorized and appropriated by the Congress.

We are still in the process of expanding the NASA team to meet the needs of our projects and programs as they mature. In fiscal year 1964, we are requesting 3,953 additional permanent positions to aid in the direction, monitoring, planning, execution, and administration of the civil space program.

This growth of 28,547 estimated end of year strength in fiscal year 1963 to 32,500 in fiscal year 1964 is an increase of about 16 percent while by contrast our budget request for funds increases about 55 percent from fiscal year 1963 to fiscal year 1964. The budget estimate for personnel compensation and benefits is $319.5 million.

Within the executive branch, manpower utilization is receiving increased attention. As I am sure you are aware, the President has placed special emphasis upon keeping the total manpower requirements of the Government at the minimum level consistent with national policy and the requirements of the Nation's far-reaching program.

This emphasis is especially apparent in a recent project throughout the executive branch to strengthen agency manpower utilization procedures and systems. During this project, NASA explained in detail to the Bureau of the Budget the management procedures which are now used and the integrated system we are developing to assure that manpower is not wasted and to identify the manpower requirements of the future.

It may be of interest to the subcommittee to review with me for a moment how personnel requirements contained in the fiscal year 1964 budget were obtained. The problem we faced was to link the direct personnel requirements of each individual research and development project and program and then to derive the supporting personnel requirements at each installation. In other words, the requirements were built from the bottom up.

The job was complex because each program office within headquarters implements programs and projects at many installations. The system we used was for each program office to work with the installations to establish which projects or parts of projects were to be implemented at each location. Each installation director was then charged with the task of determining with the program offices the numbers of direct personnel who would be needed to conduct the effort within the scheduled time frame, dollar parameters, and method of doing the work (in-house, by contract, or mixed in-house and by contract).

To determine direct personnel requirements, the installation directors considered not only scientific and engineering manpower, but also other direct types such as procurement specialists, financial managers, and contracting officers who would be needed within the project teams.

Direct personnel needs were then totaled and the installation directors were asked to study the requirements they would have for supporting personnel. Supporting personnel include overhead categories such as administrative services, shops, and general management who are required to support the operation of the installations, but who are not identifiable with specific projects.

Total requirements by installation were then forwarded to headquarters where they were consolidated and reviewed. Review teams were sent to each of the installations to study the methods, factors and judgments used in arriving at the manpower requirements, and these teams assisted the Deputy Associate Administrators responsible for installation matters and me in our analysis of the data submitted. Finally, consolidated estimates were forwarded to the Bureau of the Budget for further review and final decisions on the level of our request to you today.

In the budget justification books which you have, the results of the process I have been discussing can be found in volume I with the installation presentations, and volume II under each of the R. & D. programs and projects.

You will notice in volume I that the part each installation plays in each project and program is described and the direct and support manpower requirements identified. In volume II, the installations and manpower working on each program and project are indicated. The results are summarized in volume I under the heading "Personnel Cost."

I would like to submit for the record the table in this section entitled "Staffing Requirements."

(The table referred to is as follows:)

STAFFING REQUIREMENTS

The estimates submitted for the fiscal year 1964 support a proposed end of year staffing level of 32,500 permanent employees, an increase of 3,953 over the anticipated level for the current fiscal year. A summary by installation is as follows:

	Fiscal year 1962 end year	Fiscal year 1963 end year	Fiscal year 1964 end year	Increase
NASA Headquarters	1,360	1,900	2,300	+400
Ames Research Center	1,674	2,025	2,309	+284
Flight Research Center	524	575	593	+18
Goddard Space Flight Center	2,414	3,200	3,700	+500
Langley Research Center	3,770	4,025	4,296	+271
Launch Operations Center	333	800	1,200	+400
Lewis Research Center	3,678	4,658	5,128	+470
Manned Spacecraft Center	1,620	3,196	3,980	+784
Marshall Space Flight Center	6,194	7,062	7,492	+430
North Eastern Office	----------	30	40	+10
Pacific Launch Operations Office	6	15	22	+7
Space Nuclear Propulsion Office	40	106	160	+54
Wallops Station	407	465	530	+65
Western Operations Office	136	440	500	+60
Electronics Research Center	----------	50	250	+200
Total, permanent positions, end of year	22,156	28,547	32,500	+3,953
Reimbursable	−140	−106	−104	+2
Direct	22,016	28,441	32,396	+3,955

The procedure that I have described for estimating manpower assures that our request for manpower is as accurate as possible in a research and development program. It should be recognized that the state-of-the-art of estimating manpower needs for this type of program is not a science, and that it requires mature judgment at all management levels.

To achieve program objectives, a research and development manpower utilization system must also allow flexibility to cover cases in which unforeseen problems arise or breakthroughs are accomplished ahead of schedule.

In this regard, two things should be pointed out in candor. First, our experience shows that conscientious manpower planning has always led us to underestimate our needs by a small percentage. This is true because we have not been able to foresee all of our needs, and in some projects we have not known in advance how many people were needed to manage properly and monitor the effort.

Second, our talented managers must be provided with resources of all types—manpower, facilities, and dollars—to do their job successfully.

Therefore, we have put the budget together to show this interrelationship and to encourage executive and congressional branch reviewing authorities to view our requests in the same way.

In the program execution phase we emphasize manpower utilization also. We approve projects for implementation based on total resources requirements, and we follow up with reporting systems, some of which are fully operational and others which soon will be, to produce utilization data by location and project. These data are reviewed by installation directors, program offices, and my staff to assure that manpower is being utilized in a manner which will produce the best program results.

Further, it should be noted that our manpower requests relate not only to numbers who must be available, but also to types of skills required. Our recruitment program is directed to finding specific numbers of specific types of people.

For example, of the total NASA permanent staff of 32,500 people requested in the fiscal year 1964 budget, we estimate that we will require approximately 11,300 scientists and engineers, compared with about 9,200 in fiscal year 1963, or about 36 percent of the total NASA staff. These personnel are among the hardest to recruit.

In addition to our requirements for NASA scientists and engineers, about 62,000 scientists and engineers will be required by NASA contractors to carry out the fiscal year 1964 budget program.

Therefore, a total of about 73,000 scientists and engineers are required in fiscal year 1964, which represents approximately 5 percent of the total national requirements for scientists and engineers.

If the biological and medical scientists are deleted from the NASA requirements for both in-house NASA and contractors, approximately 72,500 scientists and engineers will be needed which is approximately 5.5 percent of the total national requirements for engineers, mathematicians, and physical scientists.

Still a further way of looking at the requirements is to determine how many of the total of 72,500 scientists and engineers in these categories would be involved in research and development effort. It is calculated that approximately 66,400 would be involved or approximately 12.9 percent of the national requirement.

I would like to be able to give you the figures on the percentage of the available supply of scientists and engineers these requirements represent. However, estimates in this regard vary widely and major efforts are getting underway in other agencies of the Government to try to determine the facts.

Another question which is sometimes raised concerns the source of NASA's recruitments. In a recent study made by NASA, scientific and engineering hires made during a period from July 1, 1961, to September 30, 1962, were canvassed to gain a detailed insight into the workings of the NASA recruiting program.

The results of this study show that approximately two-thirds of those hired by NASA came from States where the aerospace industry is concentrated. These States include Alabama, Ohio, Virginia, California, Maryland, Texas, Florida, Pennsylvania, New York, and the District of Columbia.

On the other hand, it should be noted that 49 States contributed people to the NASA staff in this period, and that six people were recruited from foreign countries.

From the results of this study, other factors were apparent. For example, approximately 27 percent of the people hired during this period were first prompted in their interest in NASA by a friend who was already a NASA employee. Almost 6 percent were interested in NASA by family, professor, or teacher. Over 25 percent were hired as a result of interest generated by NASA recruiters, our paid advertising program, our recruiting brochures and college placement offices. About 12 percent came from interest created through news stories, and approximately 24 percent through various other stimulation factors.

The results also indicated that about 3 percent of the scientists and engineers hired had doctoral degrees, 14 percent held masters degrees, and more than 80 percent were the recipients of bachelors degrees. In addition, over three-quarters of the people hired were in the top half of their college class.

During the period studied, the greatest source of scientists and engineers was other Federal organizations. NASA recruited 33 percent from this source. Over 32 percent were recruited from industry, while colleges and universities supplied almost 24 percent.

In relation to hires from industry, the top three companies from which people were obtained were all undergoing reductions in force during this period and in some cases NASA was asked to recruit by the companies. Only 10 companies supplied more than 20 people each to the NASA team while 275 other firms supplied the remainder.

In relation to college and university hires, only 30 of the 321 recruited were teaching at the time of their employment by NASA. A total of 220 colleges and universities supplied personnel for the NASA team, and of the 17 who supplied the most, 9 were schools which had cooperative student-training programs with NASA.

From these statistics, it is clear that NASA's team is not being built at the expense of the competence of our industries, colleges, and universities.

One of the parts of our personnel program I would like to single out is the employee-training program. In fiscal year 1961, 1,626 NASA employees were involved in advanced training, graduate study, or in our cooperative, apprentice, summer student, or correspondence programs. In 1962 this number had grown to more than 3,700, while it is estimated that about 4,100 will participate in the program in fiscal year 1963 and nearly 4,900 in fiscal year 1964. The cost estimate for the training program in 1964 is $780,000, or approximately $160 per person, which seems to be very low in comparison with the value of the program.

OPERATION OF INSTALLATIONS

The second part of my statement regards NASA's request for $240.8 million in operation of installations funds. The activities in this category are reviewed and approved within the executive branch in accordance with Government-wide "object classes" or types of supporting costs common to all agencies. These object classes include travel, transportation, rents, communications, utilities, printing and

reproduction, other services, supplies and materials, equipment, insurance claims, and indemnities.

Operation of installations includes funds for two categories of activities. The first consists of supporting activities necessary to operate NASA's installations and to support its personnel.

The second category consists of agency programs which are conducted at the headquarters level to support total agency objectives. Examples of this latter category are NASA's scientific and technical information and education programs, some international programs, general quality assurance and reliability programs, and the security program.

I would like to review a little of NASA's history in the supporting costs area and our general management philosophy in the control of these costs. As you will recall, NASA used to have three appropriations: "Salaries and expenses," "Research and development," and "Construction of facilities." Within the "Salaries and expenses" appropriation, funds were appropriated for the pay and benefits of NASA personnel and for certain other object classes of supporting costs. In addition, further supporting costs were budgeted under the title of support of plant in the research and development appropriation.

As NASA began to emphasize the identification of the total costs of projects, we found that, during the transition period, from NACA to NASA, many items which were program and project related were being included in the supporting accounts.

Following our reorganization of November 1961, which set up the present program office structure, the effort to identify these items was accelerated in order that program offices would have control of the total dollar resources for their projects. The task of realining the supporting accounts was aided by the consolidation of the "Salaries and expenses" and "Research and development" appropriations into a single research, development, and operations appropriation in the fiscal year 1963 budget.

We are continuing this effort in NASA. For example, before the fiscal year 1963 funds were released to implement the program, several million dollars were identified in this category and were transferred to the cognizance of the headquarters program directors for utilization in their projects.

We are now at the stage where detailed instructions are being drawn up to define precisely those items that should be included in requests for operation of installation funds, and these definitions should be in general use within the agency by the time the fiscal year 1964 funds are released by the Bureau of the Budget for NASA's use.

Among these definitions, there are some major cost items which are considered to be supporting because of the difficulty of managing them under the many separate projects and programs in which the items are utilized.

An example of this is computer rentals. It is quite possible to identify the projects and programs which are supported with each computer and to charge the expense against these projects and programs. However, since most computers are rented and since they support many projects, it is more efficient, from management's point of view, to fund and review them in one place in the operation of installations

budget. This example alone accounts for about $35 million in our fiscal year 1964 operation of installations budget.

There are other examples which could be cited such as leased lines for project data transmission and propellant procurement. The advantages of this consolidation in specific cases appear to outweigh the disadvantages of not identifying total project costs.

The other activities which should be viewed separately are those at headquarters which support the total NASA mission. Within the total headquarters operation of installations budget of about $40 million in fiscal year 1964, nearly $28 million is in support of this type of activity.

To take some examples, the Assistant Administrator for Public Affairs in headquarters has cognizance in fiscal year 1963 of $15 million of operation of installations funds. In fiscal year 1964, the amount requested for these special activities increases to $20.1 million.

Within this $20.1 million in fiscal year 1964, the Office of Educational Programs and Services is planning to conduct special activities at an estimated cost of $10.7 million. The space mobile program requires about $2 million. The purpose is to provide information on a wide basis to teachers and students about the civil space program of the United States.

Teacher training institutes, seminars, and workshops are conducted and educational publications are produced and distributed to teachers and students to help in the implementation of school courses related to the aerospace sciences.

The cost of these programs is estimated at about $1.6 million in fiscal year 1964. These programs also provide information to reply to the many thousands of requests which come from the general public. In this respect, approximately 5,000 requests for NASA educational publications are processed each month.

Educational audio-visual programs require about $2.4 million. Films are planned in such fields as physical sciences, earth sciences, life sciences, the mathematics of space science, and celestial mechanics. Video tapes, kinescopes, audio tapes, slides, and visual aids pertaining to NASA programs and activities are also developed for distribution to schools, colleges, educational television stations, and the general public.

The exhibits program is estimated at $4.4 million in fiscal year 1964 for design, construction, transportation, and renovation of NASA exhibits. During 1963, it is estimated that approximately 2,200 requests will be received from domestic and foreign sources for space program exhibits. Approximately 890 of these requests can be scheduled under current manpower and budgetary plans. Also, within the $20.1 million fiscal year 1964, the Office of Scientific and Technical Information needs $9.4 million. This amount includes $6.5 million for the contractor operated documentation program.

Scientific reports generated by NASA and by the aerospace industry are rapidly increasing in volume, and these reports must be abstracted, indexed, and distributed. Technical publication needs are estimated at more than $2.3 million for technical reviews, state-of-the-art monographs, handbook and data compilation, and industrial information reviews.

This program started in fiscal year 1963 to satisfy the requirement of providing scientists and engineers with publications containing the latest aerospace technical information in readily usable form.

The technical services program will require $440,000 in fiscal year 1964, and deals with technical translations, reprints, and preprints of articles and materials and with the operation of the NASA library programs.

Other programs to support the general agency mission in fiscal year 1964 include inventions and contributions awards ($110,000), patent and procurement training ($160,000), long-range interdisciplinary studies ($1.5 million), cooperative programs with foreign countries and international organizations ($550,000), reliability and quality assurance contracts ($2.7 million), dissemination of advanced research and technology findings ($150,000), NASA security program ($2.7 million), and national recruitment advertising ($250,000).

In conclusion, activities supporting the total agency mission and those which support projects and programs but which are retained in operation of installations for management purposes total better than 25 percent of the operation of installations request for fiscal year 1964. The balance is required to operate NASA's installations and to support its personnel.

With the help of my staff I will now attempt to answer any questions you may have.

The CHAIRMAN. Thank you, Dr. Seamans.

I am particularly pleased that you went into some detail on how your personnel requirements are obtained. Perhaps it might be useful to start with personnel. Have you had a head count lately? How many people are actually working for NASA now?

Dr. SEAMANS. I can give you the exact number, I am sure. It is 26,665 at the close of last month.

The CHAIRMAN. And how many will be expected to be on the payroll at the end of the fiscal year?

Dr. SEAMANS. 29,147, and in that number we include the temporary employees, and these are broken down into two parts, the cooperative employees—employees who are working with us on a cooperative basis with universities, as well as some of our summer students who will be coming aboard in June. The permanent position figure is 28,547.

The CHAIRMAN. Would you have a figure on how many military personnel are assigned directly to NASA?

Dr. SEAMANS. It is approximately 200, and this is broken down into those who are——

Mr. SIEPERT. 210 were on board as of February 28.

Dr. SEAMANS. And these break down really into two categories, those who were assigned for missions, for jobs that are within the NASA framework, and those that come to us through the ROTC, a large number of which are at JPL.

The CHAIRMAN. Any questions by members of the committee at this point?

Mr. Rumsfeld.

Mr. RUMSFELD. For the record you indicate that by June 30, 1963, you are indicating 29,147, is that correct?

Dr. SEAMANS. That is the total personnel. The permanent personnel is the figure in my testimony, 28,547.

Mr. RUMSFELD. What do you anticipate on June 30, 1964, using that same base of 29,147, what do you include there as temporary employees?

Dr. SEAMANS. 33,100, and of which 32,500 are the permanent employees. The on-board figure as of the end of February is 26,665 total positions.

Mr. RUMSFELD. Would you repeat the figure for 1964?

Dr. SEAMANS. Sorry, on February 28, the actual on-board was 26,665 people; the total at the end of 1964, permanent 32,500, the total including all employees, 33,100.

The CHAIRMAN. Well, you actually intend then to recruit prior to the end of this fiscal year nearly as many additional employees?

Mr. WYATT. About 2,500 yet to go this year. We are requesting an increase of 3,953 more next year.

Dr. SEAMANS. We are taking about a little bit under 2,500 between now and the end of the fiscal year. It should be remembered, of course, that the month of June is a very heavy month, with many people coming to us from colleges. People that we have already in part recruited and are continuing to recruit during the winter and spring come aboard during the month of June.

The CHAIRMAN. This would be only about 25 percent of that amount, though, 500?

Dr. SEAMANS. Well, it is about 25 percent of the total recruitment for the year that I gave in my testimony.

The CHAIRMAN. I see.

Mr. SIEPERT. There is another element involved in our figures too, Mr. Chairman, and that is there is a turnover factor on the existing staff. Our total recruitment efforts to date for this fiscal year involve 4,222 people. To meet the goals that we are talking about here, we need to recruit another 1,547 people according to our figures.

Mr. RUMSFELD. What is the overtime policy at NASA?

Dr. SEAMANS. Well, to begin with, there are cases where overtime is absolutely essential. For example, on the Mercury problem last year, getting ready for the manned flight, there was very heavy overtime on the part of the task team down at Canaveral who were preparing the Mercury capsule and getting ready for the flight operation.

We also used overtime in connection with the Saturn project, which carries a DX priority.

It is our belief, however, that excessive overtime over a long period of time can cause a diminution of effort rather than an increase in the amount of work done.

We also feel that it is very hard on families when members of the family are working excessive hours, so we attempt to minimize overtime and only use it in those cases where it is absolutely necessary in order to meet our scheduled objectives.

Mr. RUMSFELD. Do you have any figures on overtime in, say, fiscal 1962, compensated and not compensated?

Dr. SEAMANS. I can get them. I don't have them directly at my fingertips. My recollection is it runs around 10 percent. (In fiscal 1962 it was $11.9 million, the estimate for fiscal year 1963 is $14.2 million and for fiscal year 1964 the estimate is $16.7 million.)

The CHAIRMAN. Dr. Seamans, are your remarks directed only to industrial contractors or civil service?

Dr. SEAMANS. I was talking entirely about civil service, although the general policy carries over to the industrial contractors, and they

can only work overtime when specifically approved by the contracting officer.

Mr. CHAIRMAN. Mr. Davis.

Mr. DAVIS. Mr. Seamans, I noticed about the fourth line from the bottom on page 9, that you were giving examples of your rentals, and you said this example alone distorts our 1964 operations and installations budget by about $35 million. I notice in your oral testimony you said it accounts for about that much.

I am assuming that both words are correct. Am I correct in this assumption, that the word "distortion" merely refers to a method of accounting in which more is chargeable to headquarters operations than really should be?

Dr. SEAMANS. That is the point. We have these computers at every one of our centers, there is a complete breakout in volume 1 of the location of the different computing machines and the cost of operating them, but we have pulled it all together in one account and the total amount is $35 million, so you can say that this does in effect distort this particular account because in actual fact the computers are used on a project basis.

There are a large number of computers used for the man-in-space program. Four 7090's located at Goddard work, not full time on the program, but a large time.

Mr. DAVIS. Your point is, if you took the time of allocating the cost of the computers to this project and program you would be wasting money, in effect. It is just an exercise in bookkeeping that it is unnecessary to go through.

Mr. WYATT. That is correct.

Mr. SIEPERT. It would be the same requirement for the computers. We would just be parceling the cost out among the projects, rather than showing the total computer cost in one spot.

Dr. SEAMANS. And we would reduce the operation of installation budget from $240 million down to $205 million.

Mr. SIEPERT. But with an increase on the project side to compensate for it.

The CHAIRMAN. May I suggest that now we are on computers that we talk about computers, and then to preserve continuity in the hearing that we go back to personnel until we have exhausted all our questions on personnel.

Inasmuch as the gentleman has brought up a question about computers, I wondered if there were any other questions in this general area.

As you recall, last year the subcommittee went into considerable detail on the relative advantages of purchasing or renting computers. I wonder if NASA has made a study since that time or can give us the results of any investigation as to what the best way to go about this in the most economical and expeditious fashion?

Dr. SEAMANS. I will lead off on this, and then I would like to ask Mr. Siepert to discuss it in more detail.

Our overall policy is to both rent and buy computers. We feel that we should rent somewhere around 60 to 70 percent of the computers. This gives us a flexibility to shift over to new models without extra cost to the Government.

As you know, the computer technology is changing very rapidly, going from tubes to transistors, and other solid state devices. Also

our requirements are rapidly changing, and consequently we need the flexibility that could only be achieved by renting a large number of the computers.

However, we also know that certain of the computers will be used for long periods of time, and if we own a computer for 4 to 5 years, we will write off the cost in comparison with operating on a rental basis, and consequently it is the part of good sense to purchase somewhere around a quarter to a third of the computers.

Now our experience during the past year is the item that I would like to have Mr. Siepert discuss if he will.

Mr. DAVIS. Excuse me. Mr. Chairman, may I inject this?

What amount of money in this budget is for computer rental and maintenance and ownership, how much of this budget? What is the dollar figure?

Dr. SEAMANS. Well, I believe, that is the $35 million figure.

Mr. SIEPERT. That figure, Mr. Davis, is the computer rental figure. It is not the figure for the operational costs in terms of manpower that may actually operate the machines or program the applications that go on it. I don't have that figure but it is a substantially larger figure.

Mr. FULTON of Tennessee. What about the maintenance and spares?

Mr. SIEPERT. If a computer is on rental, the rental in all cases includes the maintenance, the repair and servicing of the machine, and it includes the operating time for the use of the machine, but it does not include the manpower actually to operate the machine in a serviceable condition.

If we purchase a computer then, of course, we have to enter into a maintenance contract with the manufacturer to keep the machine in operating condition.

Mr. DAVIS. Another preliminary question or two.

Now are your vacuum tube computers obsolescent by this time, or are they still operational?

Mr. SIEPERT. They are rapidly going out. This has been the major problem that has delayed plans of most agencies, including ours, to go extensively into the purchase of equipment.

The field has known for 4 years at least that the transistorized or solid state computer would take over and not only provide better equipment but also cheaper to maintain in that the vacuum tube computers required extensive air conditioning and high electrical load factors, built into the physical facilities. So it made sense not to buy those.

Mr. DAVIS. Well, now let me ask this: Are digital computers replacing analog computers?

Dr. SEAMANS. I would say that I can't give you the exact figures but by far the largest percentage of our computers are digitized. The analog computer is useful in those cases where actual equipment is to be harnessed in with the flight mechanics, if you will, so that we can simulate on the ground the boost phase, and the orbital injection of a particular space vehicle, and in cases where we are not sure of the dynamic parameters of the equipment, it is very helpful to actually connect the servo valves and amplifiers and various sensors in with an analog computer and actually run through the mission.

This is also particularly helpful when we have a man at the controls. However, the analog computer is not as precise, you cannot carry out your computations to any degree of accuracy, and consequently for precise orbital computations, for the kind of calculations that are needed in determining whether to abort a Mercury flight or not, it is imperative to use a piece of digital equipment.

Mr. DAVIS. Well, then would you say that maybe 75 or 80 percent of your computers are digital computers?

Dr. SEAMANS. I think it is higher than that. I can't give you the exact number, but it must run around 95 percent of the large computers.

Mr. DAVIS. And what percent of your computers that you rent and own are solid state?

Dr. SEAMANS. We can give you that figure. I don't happen to know it myself. All of the 7090's and 7094's are transistorized. The IBM 704 was not fully transistorized. We can put that in the record. I would hazard a guess that over 50 percent are now transistorized.

(The information requested is as follows:)

Of the 133 computors in NASA, 124 or 93.5 percent are solid state.

The CHAIRMAN. Dr. Seamans, are you familiar with the GAO study which concluded that it would be cheaper to buy than to rent?

Dr. SEAMANS. I am not familiar with that study. I am familiar with the Bureau of the Budget study of about a year ago.

Perhaps Mr. Siepert is familiar with the study.

Mr. SIEPERT. I think the study to which you are referring was made in cooperation with the Bureau of the Budget.

Dr. SEAMANS. That is the same study then.

Mr. SIEPERT. They took one or two typical kinds of computers, I think one was a, let us say, a medium-sized computer, and a large one, and they developed general criteria for the agencies to consider in determining when it was in the public interest to buy versus rent. I believe the figures are that if a machine is going to go past 4⅓ years, together with at least a shift and a half of operation on the machine, it is clearly in the interest of the Government to buy the machine.

The CHAIRMAN. Have you altered your policies any since that study?

Mr. SIEPERT. Yes, we have. We have not gone all of the way that the study to which you refer might indicate, largely because of uncertainties in our own mind as to what the technology in this computer field will bring us in the next 5 years.

However, where IBM and Remington Rand and others have developed a stabilized computer that we are quite sure will have an application either at the installation or somewhere else in NASA, we are doing our level best to buy it. This again means we need to find the money as a capital investment rather than a rental, in order to do it.

The CHAIRMAN. Are there any other questions on computers?

Mr. WYDLER. Yes.

Mr. RYAN. Yes, Mr. Chairman.

The CHAIRMAN. Mr. Wydler.

Mr. WYDLER. I will yield to Mr. Ryan.

Mr. RYAN. I understand you intend to spend $35 million on the rental of computers in the next fiscal year.

Dr. SEAMANS. That is correct, Mr. Ryan.

Mr. RYAN. And from what corporation or corporations do you rent these computers?

Dr. SEAMANS. Well, that is listed in volume I. You will find there that IBM represents the largest percentage of computers.

Mr. RYAN. Do you have the page?

Mr. WYATT. OC23-3, at the back, the very last tab.

Mr. SIEPERT. While you are looking for that I might comment, there are 10 manufacturers who have some appreciable share of the business.

Mr. RYAN. Could you list those 10?

Mr. SIEPERT. Advanced Scientific Instruments, Bendix, Burroughs, Control Data, General Electric, Honeywell, IBM, Autonetics, RCA, and Remington Rand.

Dr. SEAMANS. And of that number, IBM has 52 percent of the business.

Mr. SIEPERT. This compares with the total Government-wide IBM calculation which is 66 percent.

Dr. SEAMANS. And in the total computer population in the country we believe it is 74 percent.

Mr. SIEPERT. Next largest is Control Data Corp., with 9 percent, Autonetics with 8¼ percent, General Electric with 6 percent, and it goes down.

Mr. DAVIS. May I ask for clarification of the percentage figure that was given just a minute ago. Do you mean NASA has 74 percent of the computers or IBM supplies 74 percent of the total computers?

Dr. SEAMANS. Computers in this country.

Mr. DAVIS. Well, what percentage of the computers in the country does NASA have, it would be a lot smaller than that?

Dr. SEAMANS. Oh, very much smaller because we are a small part of the Government.

Mr. SIEPERT. I don't think we have that figure.

Mr. DAVIS. I think it would be pretty hard to get up, too. Could you hazard a guess as to how your computer population compares with the Department of Defense?

Mr. SIEPERT. Oh, considerably smaller. Again that information we could get for you and would be happy to supply it.

Mr. DAVIS. I would appreciate it.

(The information requested is as follows:)

	Total computers	Rented	Owned	Percent rented
NASA	133	110	23	82.6
DOD	750	662	88	88.3

Mr. SIEPERT. The three figures we used are that IBM has slightly over half of our computer applications, the Government has two-thirds of its applications on IBM equipment totally, and that includes our portion of it. They have almost three-fourths of the total business in the country as a whole.

Mr. RYAN. This is rental?

Mr. SIEPERT. Yes.

Mr. RYAN. What about purchases, with whom do you deal?

Mr. SIEPERT. Excuse me, I stand corrected, Mr. Ryan. These represent what brand manufacturer we are using, regardless of whether they are owned or rented, so both purchases and rentals are in the figures.

Mr. RYAN. Do you have a breakdown distinguishing rentals from purchases?

Mr. SIEPERT. I don't have it here. We can get it for you. I want to be sure I understand the question. Do you mean get the percentage of our own computers, what brands those are versus the others?

Mr. RYAN. Yes, your own contracts.

Mr. SIEPERT. We can get that, yes, sir.

(The information requested is as follows:)

	Rented	Owned	Total
International Business Machines	67	2	69
Remington Rand	1	1	2
Radio Corp. of America	1		1
Autonetics Division, North America Aviation	11		11
Control Data Corp	5	7	12
General Electric	7	1	8
Minneapolis-Honeywell	3		3
Burroughs	1	2	3
Bendix	1		1
Advanced Scientific Instruments	1		1
Others	12	10	22
Total	110	23	133

Mr. WYDLER. Mr. Chairman.

The CHAIRMAN. Mr. Wydler.

Mr. WYDLER. Are all of your leases for these computers for 1 year?

Dr. SEAMANS. Yes, I believe they are.

Mr. WYDLER. That is all I have.

The CHAIRMAN. Mr. Fulton.

Mr. FULTON of Tennessee. You mentioned you would consider purchasing additional computers if the money was available. Could you not use the same methods that private industry use in a rental purchase agreement?

Mr. SIEPERT. We do seek a rental purchase option in negotiations with computer manufacturers, provided that purchase option will not cost the Government a substantial sum of money, and most of the manufacturers give us quite a good break on that, so this does permit us after a year or two, if we know the computer is going to remain with a kind of application and be satisfactory for our use, we are in a position to move in and purchase it.

Mr. FULTON of Tennessee. Have you used this method, have you purchased any computers after having rented them for, say, 2 years?

Mr. SIEPERT. I don't think our experience in trying to move into the purchase end of this is that long. We are only really ending our first year operating under this present arrangement.

We have set up in the headquarters a two-man staff of specialists in computers to work with the field centers in seeing to it that they do adopt good business judgment with respect to their purchase or lease of the computers. We think this will help pay off on an item this expensive.

The CHAIRMAN. Mr. Boone.

Mr. BOONE. Mr. Siepert, you mentioned that 4½ years was the crossover point for purchase or rental of computers. Does this apply for both business-type machines as well as scientific machines?

Mr. SIEPERT. That is partly the problem, because the study they made was primarily on administrative-type applications, which we do feel are more predictable in terms of the machine having a continuing use.

This is a less comfortable assumption in the use of a computer in tracking, say, earth-orbiting satellites.

Mr. BOONE. This equipment you have listed on OC23–3, does this include both types of computers?

Mr. WYATT. Out of the 133 computers that we have only 7 are assigned full time for administrative purposes. The rest are either used wholly for scientific purposes or a share of their time is on scientific data calculation. We only have seven that are strictly full-time business machines.

Mr. BOONE. I notice in the first item, NASA headquarters, for example, 1401, you only operate one shift. From a look at these figures, it appears that the second and third shifts are certainly much cheaper. How do you arrive at whether you operate second shift, third, shift, or you buy another machine?

Mr. SIEPERT. The reason for this only being on one shift is this is one of our very recent acquisitions. It has only been in operation since, I believe, February 1 of this year.

The applications that are projected on it were studied before we got the machine in order to be sure that we actually had a machine operation that would involve more than one shift of operation. I think you will find that as our experience builds up this will become a multiple-shift operation too.

Mr. BOONE. Do you think the third shift buys you very much in this?

Mr. SIEPERT. No, I do not, but I think the break is between one shift and two shifts—on the IBM equipment the second shift only costs you 40 percent of the figure that the first shift costs you. So you see the more you run it on that second shift, the cheaper your overall costs are.

Mr. BOONE. The scientific operations lend themselves better to shift operations than the business machines?

Mr. SIEPERT. I would say yes, as a generalization. I think the primary thing on the scientific computation is that you staff on the multiple-shift basis in order to get very fast return of the data where decisions and studies depend upon it.

As a case in point, the Marshall Space Flight Center, which has a very large computer operation, could not begin to do its test work on the schedule it does if it didn't have multiple shift operation. They will run a static engine test, and I believe now they are taking as many as a thousand measurements on their multiple engine tests, and all of the data will be back in the hands of the Test Division the next day, so they just run right around the clock.

Mr. BOONE. You do expect then that the second shift will be utilized more and more as we move forward in the program?

Mr. SIEPERT. Yes, sir.

Mr. BOONE. We noticed the other day in the Tracking and Data Acquisition hearings that they also funded for rental of computers.

Are there other programs that fund for rental of computers in the NASA budget submitted?

Dr. SEAMANS. I believe the reason that it shows up that way is because it is a contractor operation.

Mr. BOONE. A contractor operation?

Dr. SEAMANS. Yes.

Mr. BOONE. So this should include all of the computer rental that NASA is paying for in 1964?

Mr. SIEPERT. In our installations, yes.

Dr. SEAMANS. Where a computer is located in one of our centers of at headquarters. If there is a computer at one of our contractor's plants, it is obviously not included here.

Mr. BOONE. Certainly.

Mr. SIEPERT. Or at a tracking station it would be a contractor cost and therefore it would be in tracking and data figures, which you saw.

Mr. BOONE. Do you contract out for computer work and data reduction to some corporation?

Dr. SEAMANS. Well, I believe in one case the operation of our space science activity in New York City we are operating that computer on contract. The computer itself is owned by the Government. We purchased the IBM equipment. It is located there in New York City, but I think the programing and operation is done on contract.

Mr. SIEPERT. I would like to amend Dr. Seamans' statement. There are several areas where we have found this was the best way to do it.

The Government has furnished the equipment either on purchase or on lease, and we have contracted to a computer organization to develop some of the soft work, that is, the programs that go on the machine, and actually operate the machines, delivering a finished product to us.

We have done this in the Computer Laboratory in Marshall, on the administrative applications in the Launch Operation Center, and at the Goddard Space Science Institute in New York. I don't know of any others, but those are all substantial contracts.

Mr. BOONE. Did you indicate before how much money is involved in 1964 for the purchase of new machines, is that included here?

Mr. SIEPERT. I did not indicate that, and I can't put my finger on it.

Mr. CADLE. The only one scheduled for purchase now is a 1410 IBM machine at Manned Spacecraft Center.

Dr. SEAMANS. Is that Mission Control Center?

Mr. CADLE. No, this is basically a business application machine.

The CHAIRMAN: What kind of machine?

Mr. CADLE. IBM 1410 a business application machine.

Dr. SEAMANS. We are thinking of purchasing 7094's which will be included as part of that complex, but that is 1963 funded.

Mr. CADLE. Yes, sir.

Mr. BOONE. Are the computers in the Manned Space Flight Centers for Mercury-operations, will they be utilized in the Apollo program?

Dr. SEAMANS. Yes, those computers show up at Goddard. They are used for both scientific data reduction and for the conduct of the world tracking net, including the Mercury net.

Now during the first flights of the Gemini we will still use the first tracking, same communication, and same computers at Goddard. However, once the Mission Control Center is in operation at Houston, we will only use the computers at Goddard to check out the tracking stations around the world, but will not use those computers except as backup for the actual orbital calculations during a flight.

However, the computers will still be required at Goddard for the increasing scientific load resulting from the various geophysical and astronomical observatories that we will be launching this year and next year.

The CHAIRMAN. I don't think Mr. Davis realized when he asked the question that he was going to set off this chain reaction, but I think this has been a very useful discussion as to policy in the use of computers.

I think now in order to preserve more continuity in these hearings, perhaps we could take up in the backup book that section entitled "Summary by Object Classification of Personnel Services and Operation of Installations," which immediately follows the tab "Classification by Object Class."

Starting with "Personnel compensation," you have requested $298,487,000 for fiscal year 1964. I wonder, Dr. Seamans, if you would care to make any preliminary comments on a matter that we will probably have a chance to go into later concerning the average GS grade of NASA employees. Turning to this compilation prepared by Legislative Reference the average grade of NASA employees is GS–10, which is the highest average grade of any agency in the Government. Likewise, the average salary is $9,122, which is considerably above the average salary of any other agency in the Government.

Dr. SEAMANS. Well, I do not have a full comprehension of what each agency of the Government requires so I cannot discuss completely how we compare with other parts of the Government.

I certainly have found that at the NASA we are looking for a reasonably rare commodity, as I discussed in my testimony, namely people who are qualified either to carry out or to supervise scientific and technical effort.

We also need, in order to carry out our programs, support people in a wide number of areas who can help establish quite sophisticated reporting systems, who can assist in the approval of major projects and supervise the building of large facilities.

This all takes highly qualified personnel. I don't want to get into the position of saying that other agencies don't have major responsibilities, they do, but our scientific and technical personnel are of the highest caliber, and this may at least in part account for the fact that our salaries are higher on the average than other agencies.

Perhaps either Mr. Siepert or Mr. Wyatt would like to comment on that.

Mr. SIEPERT. Well, I think one of the elements that affects our grade structure is that this is a large agency but its function is much more cleanly described as being research and development than probably any other agency.

We have no other function to perform. The material that is going to submit for the record for these various agency research, testing, and evaluation functions includes some functions which are—I

hesitate to use the word, it might be misunderstood—more routine than a purely research and engineering development operation. This will have a tendency to deflate the grade structure a bit for the other agencies.

The second element, looking ahead to the future in NASA, is that it is predictable that the kind of program that we are engaged in will require an increasing proportion of our total staff to be individuals who have requisite technical training and experience.

This means that if you were to compare our situation with 1958 when we took over the NACA Laboratories, it was entirely an in-house research program. This meant that for every scientist and engineer, he was backed up by a shopman and a laborer and perhaps a clerical type individual. These were low grades and they had a tendency to depress the average grade salary.

As you move now into our program where 90 percent of our work is not in-house, but is in terms of contracts with industry, this puts a high premium on the organization building an increasing number of technical monitoring people and responsible executive people to handle and administer the contracts, so what you get over a period of time then is less of this clerical and supporting personnel structure. This will have the tendency to raise the grade average a bit more than some of the other agencies.

The CHAIRMAN. Yet I would point out according to this table which I will make available to you that in 1961 the average GS grade was 9.5, estimated 1964 was 10. So it actually has been high over the period as well as moving up.

Mr. SIEPERT. Yes, it is moving up slowly.

The CHAIRMAN. It is moving up, but still it was even high during that early period.

I notice on page 7 of your statement, Dr. Seamans, that you mentioned that NASA recruited 33 percent of its scientists and engineers from other Federal organizations, is that correct?

Dr. SEAMANS. That is correct.

The CHAIRMAN. On this point I wonder if you have any comparative figures. Do you have to pay these people more when you recruit them from other Government agencies in order to get them away from those agencies?

Dr. SEAMANS. The attempt is to always have them come to NASA at the same salary that they held when they were in the previous agency.

Mr. SIEPERT. We have a slide on that.

The CHAIRMAN. I wonder if you have detail on that. It would be helpful to the committee to know in just a little bit more specific detail.

Dr. SEAMANS. We have a slide that summarizes this information that we would be happy to discuss with you.

Mr. SIEPERT. This information, I might say, is a result of our having made a study of every new professional person that we brought on board during this very large buildup.

We wanted to find out where they had come from, were their qualifications as good as we already had on board, were we raiding some areas, what was our promotion experience as opposed to lateral transfer, and we found that two-thirds of the Government appointees were lateral transfers without promotion.

The few teachers that we hired were paid in line with others at advanced technical levels, and when we hired a teacher he made more money when he came with us, but we have other figures to show that less than 1 percent of our total recruitments came from the teaching side of the academic world. Twenty-two percent came from the student body, so we were very careful not really to deplete the teaching reservoir of the country. Almost two-thirds of those who came from industry came at the same or lower salaries.

Now the detail is on the next chart.

Now you will notice this is a little hard to read because it has a great deal of information in it, but we have a hard time really figuring the exact same salaries, because there are differences in what is considered compensation in industry versus ours, so we said we will consider the same salary, if a person makes neither plus or minus $500 over his current grade. We haven't found that people will leave for a $500 difference.

You will notice in the Government that 60 percent of all of the folks here came to us in the same salary bracket.

Now in industry you find 38 percent came to us at the same salary, 24 percent came at a lower salary—I am talking salary now, not fringe benefits, because the fringe benefit would be over and above that, if there were a bonus plan or anything of that sort, and 37 percent came to us from industry at a promotion, $500 or more.

Thirty-seven percent of those who came from the Federal Government came at a promotion.

Are there any questions on that?

The CHAIRMAN. This chart will be available for the record in typed form, will it not?

Dr. SEAMANS. Yes, we will submit it for the record, Mr. Chairman.

(The information requested is as follows:)

Salary differential upon transfer to NASA

	Industry	Teachers	Non-teaching facility	Other Federal	Other NASA	Non-profit organization	No response and other	Total
Lower NASA salary:								
Percentage	24.4	6.7	3.5	2.2	0.8	14.0	6.6	11.7
Numbers	272	2	1	25	2	7	5	314
Same salary (±$500):								
Percentage	38.4	13.3	28.6	60.6	67.4	32.0	15.8	49.3
Numbers	429	4	8	693	163	16	12	1,325
Higher NASA salary:								
Percentage	37.2	80.0	67.9	37.2	31.8	54.0	77.6	39.0
Numbers	415	24	19	425	77	27	59	1,046

NOTE.—¾ of the Government appointments were lateral transfers.
The few teachers hired were paid in line with others of advanced technical levels.
Almost ¾ of industry hires came at the same or lower salaries.

The CHAIRMAN. Does this include both scientists and engineers and other type personnel?

Mr. SIEPERT. This is restricted to those employees who came to us who had professional requirements. That is, they were scientists or engineers at the B.S. degree level or higher. It does not include clerks or accountants.

The CHAIRMAN. What about administrative personnel without particular scientific or engineering——

Mr. SIEPERT. We did not run a special study on that. I think we can get some information for you, but we did not check that.

The CHAIRMAN. I think, it would be helpful to the committee also in addition to your so-called professional personnel to have some figures on administrative personnel insofar as lateral transfers from other Government agencies are concerned.

Would that be possible to obtain for the committee?

Mr. SIEPERT. I would like to check. I would rather not make a commitment that I can supply that in a very short period of time, but we will do our best, and may I inform the committee staff how soon we would have it for you?

The CHAIRMAN. I think that this would be very useful to have.

Mr. SIEPERT. We will do our best to get it.

(The information requested is as follows:)

Salary differential upon transfer to NASA headquarters for the period July 1, 1961, through Sept. 30, 1962—Administrative professional personnel

	Total	From outside Government	From other NASA centers	From other Federal agencies
Lower salary:				
Percentage	(4.5)	(13.5)	(5.3)	(1.5)
Numbers	12	5	5	2
Same salary (±$500):				
Percentage	(51.6)	(56.8)	(45.3)	(54.7)
Numbers	139	21	43	75
Higher salary:				
Percentage	(43.9)	(29.7)	(49.5)	(43.8)
Numbers	118	11	47	60
Total personnel	269	37	95	137

Dr. SEAMANS. Let me say if I may, Mr. Chairman, that we are very sensitive to the problem that we could create for other agencies of the Government, and I can remember one specific case where we had acquired a number of people from a particular Department of Defense project and there was concern expressed that if many more came to NASA this could hurt the project.

We discussed this with the project director in the Department of Defense and agreed that we would not recruit any additional people from this particular segment of the DOD.

The CHAIRMAN. Yes, I think there are two things to be concerned about, of course, not only the possible pirating that you mentioned but also we don't want to make NASA a nice happy hunting ground for people that just want to move on to higher salaries.

Dr. SEAMANS. That is correct, and that is why as a matter of policy we attempt to affect lateral transfers and only have an increase in salary when it is justified on a promotional basis.

The CHAIRMAN. Have you made any analysis of the one-third who went over to transfers at higher grades from other Government agencies? I believe you had a figure there that two-thirds were lateral.

Mr. SIEPERT. An analysis in what regard? Do you mean as to what kinds of jobs they went to?

The CHAIRMAN. Yes, and where they came from, and why it was necessary to give them higher salaries.

Dr. SEAMANS. Just as a person within NASA should have an opportunity to move ahead and obtain a greater responsibility, so this should happen between agencies of the Government, but it has got to be clearly an increase in responsibility if there is to be an increase in salary.

The CHAIRMAN. Mr. Fulton.

Mr. FULTON of Tennessee. Mr. Chairman, in this breakdown, I would also, with your permission, like to request that we be given the percentages of the Negro personnel employed by NASA in the administrative offices.

Mr. SIEPERT. In administrative as contrasted with the total?

Mr. FULTON of Tennessee. The total NASA.

Dr. SEAMANS. We do have the total breakout. We have the total for the NASA. As of December 31, there were 702 Negro employees out of a total of 25,667. That comes out to 2.7 percent.

In NASA Headquarters, we have 123 Negro employees out of a total of 1,701, for a percentage of 7.2.

We can give you the total for each one of our centers if you wish.

Mr. FULTON of Tennessee. I would like to have it, if you please.

(The information requested is as follows:)

Employees as of Dec. 31, 1962

	Total paid employees	Total Negro employees	Percent of Negro to total employment
NASA total	25,667	702	2.7
NASA headquarters	1,701	123	7.2
AMES	1,825	41	2.2
Flight research	568	9	1.6
Goddard	2,858	106	3.7
Langley	4,007	169	4.2
LOC	604		
Lewis	4,177	151	3.6
Marshall	6,844	47	.7
Manned spacecraft	2,392	45	1.9
Wallops	430	5	1.2
Western operations	261	6	2.3

The CHAIRMAN. Mr. Wydler?

Mr. WYDLER. Yes.

Dr. Seamans, on this comparative chart that we have been given, NASA is shown with an average GS grade of 10. Is that according to your figures?

Dr. SEAMANS. I believe it is accurate.

Mr. WYDLER. On this same chart, we are shown that the Atomic Energy Commission has an average GS grade of 9.3. Wouldn't you say that those two agencies are rather comparable as to the degree of——

Dr. SEAMANS. Yes, but I wouldn't say they are exactly the same. We operate somewhat differently from the AEC. For example, in their figures, I don't believe you will find the operation of Los Alamos, Livermore, Argonne, all of which are operated by universities on contract to the AEC.

Mr. WYATT. It is my understanding that the AEC staff is largely a contract organization, rather than civil service. The bulk of their scientific work, as Dr. Seamans indicated, is done by contractual

employees at Los Alamos, Livermore, Argonne, and such laboratories, and these do not show as personnel of AEC.

Mr. WYDLER. Do you mean they would have a smaller percentage of scientists on their staff; is that what you are saying?

Mr. WYATT. On their actual staff, because where we take one of our research laboratories which make up a center, such as Langley or Lewis, in the AEC operation this is a contract with a university and does not show as an employee of the AEC. It would be analogous to our JPL contract, which does not show as part of the Government payroll.

Mr. WYDLER. Well, let me ask you this now, this is asking you about some other agency, but possibly you can give me some explanation of this. I don't understand it.

According to this chart I have been shown, the Department of Defense, in the Research Test and Evaluation Department, showed a 1963 estimated GS grade of 11.9, which would have been greatly in excess even of what you are requesting now, but it shows that for 1964 down to 6.6. Is there any reason for that?

Mr. SIEPERT. I would like to comment on that. I think those particular figures need additional study and explanation.

I had the opportunity to look at that table and it is apparent what is given there is not the experience for the Department of Defense as a whole. That is a figure, 11.9, of eight individuals, eight positions in all, who were a part of Dr. Brown's office in the Office of the Secretary of Defense, which coordinates all of the research, development, and evaluation, but is in no sense the total function.

Now I can't conjecture how the average grade goes down to 6 except that you will notice that he goes from 8 positions to 56 and may well be rounding out a substantial recordkeeping kind of operation, but that is pure conjecture on my part. I would have to say that is not a figure which is in any sense comparable to what we are talking about.

The CHAIRMAN. It would be much more comparable to utilize the figures for Army, Navy, or Air Force.

Mr. SIEPERT. Yes. The Navy figure is 9.3, I think, on the chart that you have there, as an average grade, and that includes a substantial number in Navy. I think there were 27,000 employees shown in their figures, so that does include a substantial part of their program called R.D.T. & E.

Again you will find their figures, however, include, I believe, a substantial number of people who are in effect on things like the inspection end of their hardware development systems.

I know that we found this when we ran a study one time of their scientists and engineers, and found that in their population they included a number of people, for instance, who worked in the Brooklyn Navy Yard in connection with appraising the actual production and fabrication of ships. I don't know whether that is higher or lesser paid than the average that we have, but I suspect that it might be less.

Dr. SEAMANS. I would like if I could just to come back to the point that I attempted to make earlier, that we in NASA feel as a matter of policy that we must have highly qualified scientific and technical people if we are to manage properly such a massive undertaking as we are now embarked upon. We feel that if we do not have this in-house competence the whole program will be poorly

managed, that we will make improper decisions from a technical, and scientific, as well as administrative standpoint, and that it will end up as a very inefficient and costly operation, but we feel that it is definitely in the Government's interest to have highly qualified people, both in headquarters and in the centers.

Now obviously this can be overdone, and we are not saying that everybody in NASA should have a doctor's degree, but we must have at all levels in our NASA structure highly competent people.

Mr. WYDLER. I agree with you on that, Doctor, of course this goes for the other agencies of the Government as well. There is nothing peculiar about NASA in that regard. The Atomic Energy Commission certainly has the same problems, but it does seem that NASA is setting their standards higher than any other agency of the Government in this regard.

Isn't that a fair statement?

Dr. SEAMANS. Let me say one thing first. We are somewhat unique in NASA. We aren't saying the other agencies are conducting their business incorrectly but we as a matter of policy are making all of our contracts, essentially all of our contracts, out of our centers where we are also conducting in-house technical and scientific work.

We feel that in this way we can better manage all manner of programs, be they small research contracts or very large development contracts, and this is a difference between our agency and the Department of Defense and the AEC.

Mr. SIEPERT. There is one other trend I think that may make us a bit unique.

The grade structure of the other agencies is a grade structure that has been built up over a substantial period of time. In other words, those do not represent new or rapidly growing functions. Most of those organizations build up their staffs, if they have field laboratories, making the staff completely self-sufficient, that is with civil service personnel.

We have had to build up to meet this program at a time when personnel numbers were scarce, and as a management policy in the agency we decided in the beginning when we were setting up a new center to contract out routine services which responsible business could take care of very well for us. For example, our civil service grade structure in a place like the Marshall Space Flight Center will not include the people who run a motor pool. Those are low-GS-grade personnel, because the entire motor pool operation from the beginning has been put out on competitive contract.

Mr. WYDLER. Well, maybe I would understand this better if you would tell me who and how are these grades set by and how are they set, who does this actually.

Mr. SIEPERT. The Civil Service Commission issues what are known as classification standards.

Mr. WYDLER. I understand how we get the grades in the first place but who now in NASA is determining what grade should be given to what job?

Mr. SIEPERT. We have personnel officers in each of our field centers who have delegated responsibility to allocate a given job to a grade based upon the functions of that position compared to the specification that the Civil Service Commission gives us.

Mr. WYDLER. In other words, do I understand you to say that these were all reviewed by the Civil Service Commission?

Mr. SIEPERT. Each job is not postaudited by the Civil Service Commission. The Civil Service Commission, however, does make an inspection audit of agencies on a cycle basis, and we just went through a complete inspection by them in this last summer, and their general approbation of our classification structure was evident.

Mr. WYDLER. Who does this in NASA itself?

Mr. SIEPERT. Personnel specialists.

Dr. SEAMANS. These specialists report functionally to the Personnel Office, which is headed by Mr. Lacklen, who reports to Mr. Siepert.

Mr. WYATT. One other point, Mr. Wydler, that may have a bearing on comparative grades. That is, I would judge from the way the statistics have been discussed, that the military statistics do not include the officers in the functions assigned by the military.

You see, all of our people are civil service, whereas you take a military R. & D. establishment, you will find a large number of technical officers assigned in the technical side and in the management side. I would judge that the general effect, if you could include them at a comparative GS grade, would be to raise the average grade of the Military Establishments.

They don't assign so many enlisted men but they do assign large numbers of officers for the administrative and technical direction.

Mr. WYDLER. Could I just ask one final question:

Would you have any idea, for instance, if NASA's average GS grade was 9 instead of 10, what the difference in total cost would be?

Mr. WYATT. Approximately $25 million a year would be my guess.

Mr. CADLE. Could I make one additional comment, Mr. Wydler. There is one additional factor which hasn't been brought out fully which affects our average grade.

In addition to the comments Mr. Siepert made in terms of contracting-out functions, such as motor pools, guards, janitors, things of this type, there is an additional factor which has a heavy impact here, and that is that the Department of Defense in fiscal year 1964 will have 5,525 individuals working on NASA contract management, construction management and quality and reliability effort.

In other words, the inspectors on all of this effort and the people who are doing the contract management, of course, are relatively low-average grade. These are in the Department of Defense in many cases, and they do this work for us and we will reimburse them for these people.

Now these costs are costs which are going to affect our average grade because the average of these 5,525 people is quite a low average. If they were figured in with ours it would bring our average down substantially.

The CHAIRMAN. Dr. Seamans, I would like to ask you one general question. The 11,300 scientists and engineers which you estimated are going to be recruited have caused some people to make the statement that this will result in NASA siphoning off from other essential parts of the Government, the scientific community, and the economy, so many scientists and engineers in proportion to the product that we can produce that eventually it will hurt not only the economy but NASA.

I wonder if you could comment for just a minute on this general statement?

Dr. SEAMANS. Well, this is a matter that must be considered very thoughtfully and we have paid a great deal of attention to this matter in our overall management decisions in NASA.

We have attempted to determine what the requirement is for NASA both within NASA and on contract, in comparison to the total national requirement, and that is the reason that I included those figures in my testimony because it is so important to evaluate what we are doing with our most important commodity; namely, people in this country, particularly in the scientific and technical area.

We, of course, feel that the program that we have is of such importance that it justifies this level of expenditure of these valuable talents. However, we realize that it is not a limitless supply and that we have a responsibility to both upgrade the people that we have within NASA by having them involved in various training programs, as well as working with universities to build up the national supply and, as I attempted to stress when I appeared here in front of the full committee several weeks ago, we feel that the people that are now receiving their impetus or their drive, their challenge from the space program, will as time goes on over their total professional career carry out very valuable and important assignments in other than space objectives.

The CHAIRMAN. Mr. Roush.

Mr. ROUSH. Mr. Chairman.

You don't pay overtime at all grade levels, do you?

Mr. SIEPERT. No.

Mr. ROUSH. Where is the break?

Mr. SIEPERT. Well, as a matter of law no overtime compensation can be paid above GS–15. In other words, excepted positions that we have are not entitled to any compensation.

We operate on the same basis as applies to all GS grades, that overtime is paid when it is directed; that is, directed by the supervisor, and it is paid for an individual up to grade 9 at the regular overtime rates. This is time and a half.

As you move up higher, say, a GS–12 or a GS–13 person will get a decreasing rate of overtime pay because he is paid at the GS–9 rate for his extra hours, so that as a practical fact when you get up to GS–14 or GS–15, you don't earn much money by overtime.

The second factor to be kept in mind is that we are quite, let us say, reluctant to enter into directed overtime for our senior professional staff. We find that they do the job with really an inner motivation and they work the hours and we do not pay them.

Mr. ROUSH. Is there any other compensation which comes to them by way of days off?

Mr. SIEPERT. The law does provide a compensatory leave arrangement, but as a matter of NASA policy there is no point in our trying to bolster the morale of our people with that idea because the compensatory time never comes.

Mr. ROUSH. I was only wondering if there are enticements in the NASA setup which are not present in the Department of Defense which would cause some of these people to come over of this sort.

Mr. SIEPERT. The enticement, quite frankly, is the most exciting work in Government. That is what they tell us.

Mr. ROUSH. Thank you.

The CHAIRMAN. In your prepared statement, Dr. Seamans, you referred to "other stimulation factors."

Any other questions?

Mr. CADLE. I do have an answer to the overtime, the question that came earlier in the session.

In fiscal year 1962, overtime and holiday pay, these are hours spent in overtime or on holidays, we paid out $11.9 million. In fiscal year 1963, the estimate is $14.2 million. In fiscal year 1964 it is $16.7 million.

Dr. SEAMANS. What is that on a percentage basis?

Mr. CADLE. Of the total? I will have to do that in my head.

It is $11.9 of $163.9 million.

Dr. SEAMANS. So it is under 10 percent.

Mr. CADLE. Well under 10 percent.

Mr. RUMSFELD. We have switched three or four topics here, and I have two or three questions. One is on overtime.

There have been instances not in NASA, that I have heard of, but in other departments, where an individual obviously of a lower GS rating has been continuously working overtime and the net result has been that he was paid more than would possibly have been paid to two individuals, or a rate very close to that, had they worked out a little different kind of compensation schedule and added employees.

I recall in one instance it was a chauffeur who was working a tremendous amount of overtime on a regular basis. For example, are there chauffeurs working in NASA?

Dr. SEAMANS. There are people in NASA who work part as chauffeurs and in part have other assignments, such as in the mailroom. But I would say this is the kind of situation we would never countenance if we knew about it. I don't know of any situations where this would occur.

The CHAIRMAN. Sort of in-house moonlighting?

Mr. RUMSFELD. My second question goes right back to the topic we were talking about before overtime.

Within the past few days there has been a statement by one of the officials at Argonne which has been highly publicized in the press around the country, which basically is in line with what the chairman raised as a question, but is slightly different.

His concern, and I appreciate you people are down here to justify a budget, but if you can step aside and be objective, do you feel that there is any danger—and this is basically what he articulated—because of this push toward the Moon and toward space, in moving along too slowly in some pure and some basic research areas, so that a very serious imbalance will result in a period of years?

Dr. SEAMANS. Let me say that we believe that we are objective here. I will attempt to continue to be objective.

We do have within NASA a lot of basic work going on, particularly in universities, that is not directly related to the manned exploration but is of long-term consequence. We feel that this is an extremely important kind of activity for this country, not just in space but in many different fields.

I myself do not believe that we are attracting people to the extent that we are hurting these other activities. This is a very difficult thing to judge, I agree.

Mr. RUMSFELD. Well, his point was broader than simply personnel. It involved the expenditure of funds. I think it is an intergovernmental dispute as to where the money should be spent, should this

much be spent for space or should more be given, for example, in his particular case to Argonne.

Dr. SEAMANS. I would think that would depend on what he intended to do at Argonne. I don't know what his role is there. He is unidentified. But this would obviously have to be reviewed on its merits. Argonne has some very important assignments.

Mr. RUMSFELD. There have been a number of requests for improvement in disseminating, in compiling scientific information. Do you feel that at some point in the future if the Government and other interested groups of people are able to facilitate this accumulation and dissemination of scientific information that this would conceivably decrease the number of individuals working within NASA as well as other governmental agencies?

Dr. SEAMANS. Well, obviously the better the communication between the various individuals working in a particular field, the more efficient is the work, the research, because each can draw on the work of the other, so the dissemination of information is extremely important.

I attempted to stress that in my testimony this morning. We have an office set up at NASA on an agencywide basis for this purpose. Mr. Day, who is in charge of that, is here and would, of course, be happy to discuss this with you in detail.

However, it is not an easy objective to achieve because it involves both having the information available on a timely basis and, second, it involves cataloging of subjects that are difficult to catalog. It takes very great skill to so deposit the information in your library that it can be brought out on call, if you will, by others who are interested, but we are making a very major effort to do this.

In the past, the NACA was able to do this in an unmechanized way. One of the aircraft companies could telephone somebody here in what was then NACA headquarters, and ask for information on a particular kind of wing configuration. That person would know which particular laboratory or center in NASA was working on this line. He could call them on the phone and have them send all of the information to the particular company.

Now we have grown to the point where you can't do that any more, and you have to have a centralized activity for this purpose.

The CHAIRMAN. We have a lot of ground to cover on personnel yet, and I wondered if any of the members of the committee had questions which related to personnel compensation and personnel benefits before we get into travel and compensation.

Mr. WYDLER. I do, Mr. Chairman, if nobody else does.

The CHAIRMAN. Mr. Wydler.

Mr. WYDLER. You say that you are requesting about 4,000 additional permanent positions this year. Can you tell me what was the original request for permanent positions from your various projects and programs, the heads of your various projects?

Dr. SEAMANS. It was in excess of that figure.

Mr. WYATT. If I recall, Mr. Wydler, we are asking for a year-end strength of 32,500, the requests originally received from the field centers were up around 36,000 to 37,000, and we trimmed it back.

Mr. WYDLER. 36,000 or 37,000.

Mr. WYATT. That is year-end strength. We are asking for a year-end strength of 32,500, so it was about of the order of 3,500 or 4,000 more that were requested by the centers in their raw requests.

Mr. WYDLER. So you cut that request figure in about half, is that correct?

Mr. WYATT. Yes, a little over half.

Mr. WYDLER. And in turn you submitted this to the Bureau of the Budget?

Mr. WYATT. Yes.

Mr. WYDLER. Did they cut the figure you submitted?

Mr. WYATT. Yes, we asked for 1,000 more than appears in the budget request.

Mr. WYDLER. So they cut your request by 1,000?

Mr. WYATT. Yes.

Mr. WYDLER. In turn was that cut at all by anyone else in the executive department?

Mr. WYATT. No, sir.

Mr. WYDLER. All right, that is all the questions I have.

Mr. ROUSH (presiding). All right, are there other questions in this particular area?

Mr. Boone.

Mr. BOONE. I would like to ask Dr. Seamans to tell the committee how many total personnel including contractor—I do not mean supporting contractors like the Bendix contract, but JPL and others, are involved in NASA work.

For example, you have 28,547. JPL contributes directly day to day to your end of it. How many others do you have that contribute day to day to your endeavor?

Dr. SEAMANS. Well, JPL is the only group that we have working with us that are essentially on a level with one of our own centers. They have currently just a shade under 4,000 people.

Mr. CADLE. 4,100 by the end of the year; 4,800 by the end of 1964.

Dr. SEAMANS. Now we do have other groups working with us in a variety of ways, and I am not quite clear that you are——

Mr. BOONE. I think you have answered what I want. I realize you can't list all of the contractors who work for you and I didn't mean that, but I was trying to get some idea now of what the average grade level for JPL personnel might be.

Listed in this section I don't find JPL funds. Where are they found?

Dr. SEAMANS. JPL will be found primarily under the lunar and planetary programs. They are responsible for the Ranger, and the Surveyor, and the various Mariner planetary flights, and the cost of those programs includes the in-house costs of JPL.

Mr. BOONE. Do you exercise close supervision managementwise, that is in administrative aspects?

Dr. SEAMANS. We most certainly do. We have our Western Operations Office, which is in Santa Monica, very near Pasadena, where JPL is located. They actually have personnel in residence at JPL for the contract administration of a program that does run to around $213 million, I believe, in fiscal 1963.

Mr. BOONE. If I got my numbers correct, there is a 700 increase in personnel there for 1964. Is that correct?

Dr. SEAMANS. Yes.

Mr. CADLE. And the details of that are in the JPL presentation, Mr. Boone, in volume I.

Mr. BOONE. Thank you.

Further down the list you show some reimbursable positions. Why did you not show the 5,000 military that work for you that you have to pay for?

Mr. CADLE. These are reimbursable project people that you are speaking of now. The 104 people on reimbursable projects that we are doing for other agencies are counted within our total because they are our employees; that is 104 people are being reimbursed by other agencies, but we are providing the people, you see.

In the other case, DOD is supplying the people and we are reimbursing them.

Mr. BOONE. The other agencies pay you for 104 salaries?

Mr. CADLE. That is correct.

Mr. BOONE. And you pay DOD for 5,000 salaries?

Mr. CADLE. Yes; 5525.

Mr. BOONE. Can you give the committee some idea of how much is involved in 1963 or 1962, some prior year, dollarwise?

Dr. SEAMANS. We have to make it clear that this is an arrangement that is actually going through a change. In the past I don't believe we have reimbursed the DOD for the full amount.

Mr. CADLE. Up until now, up until fiscal 1963, we have reimbursed the Navy and the Army people who have been working for us on quality and reliability and contract management. We have not been reimbursing the Air Force because they have not wished to be reimbursed. In other words, they were doing this work as part of their job at the factories where they were doing the inspection work on their own projects.

In fiscal 1963, negotiations have been underway in terms of NASA picking up the costs of reimbursing all of the people from the Department of Defense, and Mr. Webb has agreed that we will start reimbursing them in fiscal 1964 for all of these people, Air Force, Navy, and Army, and we have funded in our project money in 1964 to reimburse them for this effort.

It works out at roughly just between $9,500 and $10,000 per man, including all of their support costs for each one of these individuals.

Mr. BOONE. So those funds are not shown here?

Mr. WYATT. No, sir; they are part of what you might call contract moneys, but in this case the contract goes to the DOD.

Dr. SEAMANS. These are people on the DOD payroll so they don't show up in these figures.

Mr. BOONE. That means that they are about a 9.8 GS grade also.

Mr. SIEPERT. No; that was the total cost. The average cost I believe is about $7,000 on this type personnel. Those are the other costs like travel, communications, office furniture, and everything else that goes with it.

Incidentally, this reimbursement figure, Mr. Cadle, you may want to verify this, but the arrangement with the Department of Defense is we will pay this as a reimbursement. This isn't just a flat transfer. There is an estimate that the workload will be 5,500 man-years of work. If it is only 4,000 we will pay for 4,000.

Mr. CADLE. Each of the centers involved get a chit each month, showing the number of man-hours worked, and they pay the cognizant services.

Mr. BOONE. I would like to ask another question. In the past have you reprogramed into or out of these funds any additional funds?

Mr. CADLE. Into or out of what funds?

Mr. BOONE. Well, I am looking at item 11, which is personnel compensation. Have you utilized all that has been appropriated in the past?

Mr. WYATT. Yes, sir. This year, as a matter of fact, in this fiscal year we added—I will try to find that number here, we actually added some money this year to cover several thousand additional people.

Personnel costs went up $23 million in fiscal 1963 beyond the amount that we had estimated in last year's budget.

Mr. BOONE. That still comes under the 239 total?

Mr. WYATT. That is included within the total for fiscal year 1963 here.

Mr. BOONE. What was the major reason for that?

Mr. WYATT. Part of that was just pay act increases, part of the $23 million was to cover pay increases, part of it was to cover additional employees beyond those we had estimated at the budget last year.

There is not a science about this and we have to feel our way as we go through the year as to where we will have to put additional people.

Dr. SEAMANS. Our installation costs went down by some $16½ million, so the net increase of operating our institutions went up about $7 million over what we had requested in the 1963 budget.

Mr. BOONE. I have no more on reprograming, but I would like to ask some other questions.

Mr. WYDLER. Where did you get the $7 million?

Dr. SEAMANS. That was reprogramed from within the research operation and development account. You see, up until fiscal 1963 we had two separate accounts, one for salaries and expenses, and one for research and development. These were combined in fiscal 1963 so that we can reprogram money from programs and projects into the operation of our institutions.

Mr. WYDLER. Is this going to be done in 1964 as well?

Dr. SEAMANS. To a minimum amount, but if required this is an option that is open to the agency.

Mr. BOONE. How many excepted positions are you asking for this year?

Dr. SEAMANS. We are not at the moment asking for any additional from the Congress. This is a matter that is still under review by the executive branch.

The CHAIRMAN (presiding). May I follow that, within the increase of 4,000 positions, how many of them would be supergrades or under Public Law 313?

Dr. SEAMANS. I don't believe any of them would be.

Mr. BOONE. In the case of fiscal year 1963, you indicated you still have some several hundred positions unfilled. How do you estimate funds for this? Are funds appropriated to cover the whole year's salaries?

Dr. SEAMANS. This is a matter that has to be reviewed center by center, and we put together a total operating plan for the agency that sets the ceiling on each center and also sets the funds that the center has, both for personnel expenses as well as for their operations, so each center knows today how many additional people they can take on prior to the end of this fiscal year.

Mr. WYATT. Specifically to your question, Mr. Boone, I believe what you are getting at, in estimating the dollars required for the additional positions we build in what is known as a lapse rate. In our case, and I think it is a Government-wide practice, we cannot assume that we are going to hire the people at less than what they call a 25-percent lapse, or we figure that all of the people will be aboard by the first of the next calendar year.

We do not assume that they are all aboard at the first of July when we start, or within the first few months. We assume that they come on a straight line acquisition up through December 31, and that is the basis for the salary calculation. That lapse rate is built into the salary computations here.

Mr. WYDLER. Well, in connection with that, what would the lapse rate be at the proposed electronics center?

Mr. WYATT. It would be assumed here at 25-percent lapse rate or a half a year to get all of the people aboard.

Mr. WYDLER. In other words, you would have the 250 proposed employees there by the middle or by the end of this year; is that right?

Mr. WYATT. By the end of this calendar year; that is right.

Dr. SEAMANS. You will notice on page OC10–1, it shows the position lapses that are deducted from the total end-of-year figure, to take into account the 25-percent lapse that Mr. Wyatt has referred to.

The CHAIRMAN. Can you look forward in years to come to a leveling off or a decrease in the number of personnel that work for NASA?

Dr. SEAMANS. Well, we obviously must look ahead and have long-range plans. These are not approved plans, but our plans do show an increase in personnel beyond 1964, leveling off at, let us say, the end of this decade at approximately 38,000 or thereabouts, 38,000 to 40,000.

The CHAIRMAN. We seem to be doing more and more work with less and less people as automation comes in in many industries. I think, of course, there is a vast difference here but I think the Congress is concerned with the constant increases, and I would think also that the average grade level as you increase your number of personnel would at some point tend to come down a little bit, wouldn't it, as you look toward the future?

Dr. SEAMANS. Well, that is a hard question to answer obviously. We feel that we need human intelligence to make the kind of decisions that we are faced with, and you cannot completely digitize the running of projects, that the important element is the human being who must look at the facts as provided by the digital computers but that the decisionmaking, if anything, would be on a higher level rather than a lower level.

Mr. FULTON of Tennessee. Mr. Chairman.

The CHAIRMAN. Mr. Fulton.

Mr. FULTON of Tennessee. One brief question. Item 25, $91,684,000 for "Other services," I would just briefly like to know what that takes into consideration, that "Other services."

The CHAIRMAN. If the gentleman will yield, I think in order to preserve continuity let's take all of the questions on personnel compensation and personnel benefits, and then proceed to that later.

Mr. FULTON of Tennessee. All right.

Dr. SEAMANS. This does include all of the support work at a place like our Marshall Center, but we can get into that later. Perhaps tomorrow would be the time.

Mr. BOONE. I have a couple more questions, Mr. Chairman, if I may.

You mentioned turnover of personnel earlier. Has this been a serious problem with you in any particular locality or in any given region? Is there any particular reason for this?

Dr. SEAMANS. We can give you the statistics on our turnover, both total for NASA as well as our scientific and technical personnel.

I would say that it is a matter that is not serious with us but it is a matter which certainly has to be taken into account in our recruiting that we conduct each year. I believe that the overall agency figure is—

What is that?

Mr. SIEPERT. The overall agency figure is higher. It is around 8 percent on our professional staff.

Dr. SEAMANS. It is around 14 percent overall and 8 percent for the scientific and technical personnel.

(The information referred to is as follows:)

Turnover rates for NASA personnel

Fiscal year	Scientist and engineer percent turnover	Total personnel percent turnover
1962	7.7	16.2
1961	6.7	13.2
1960	6.8	11.0
1959	8.2	11.2

NOTE.—Government average separation rate, 17 percent.

Mr. BOONE. Would you know whether this is the norm in the Government?

Mr. LACKLEN. I think it runs around 20 percent governmentwide.

Mr. SIEPERT. So this is low. I believe these figures bear watching but it is more critical who you lose rather than how many you lose, so even a small percentage could be critical to us if all of a sudden we started to lose key, top staff. So far we have been fortunate in this regard.

Mr. BOONE. You have asked for 400 additional people in headquarters, I believe. Since most of the work is going to be managed from the centers, could you just tell us why you have to have 400 more people in NASA headquarters, and give us a better justification for that, sir?

Dr. SEAMANS. It is true that the particular projects are managed from the center, but there are many decisions that have to be made before a project is included in the budget, before it is approved for actual implementation, and that is the reason that we have established our program offices.

For example, in the Manned Space Flight Office we require a considerable amount of actual technical work in order to break down the overall objective for manned space flight into the specific projects that are carried out at our Manned Spacecraft Center on the Gemini.

and the Apollo, and at Marshall on the Saturns and down at the Launch Operations Center on the implementation of the facilities there, so there is no relief as far as headquarters is concerned.

We have to take very broad national objectives for space and reduce them down to the specifics of project objectives, costs, human resources, facilities, and then delegate responsibility for the actual implementation to the centers.

Mr. BOONE. I believe Mr. Webb testified earlier before this committee that the funding should level off in subsequent years. Do you anticipate that headquarters, or certainly that certain of the centers should level off as far as their demand for personnel is concerned? Are the requests here primarily for manned space flight?

Dr. SEAMANS. Are you talking about the projection for the next 5 years, the long-term growth of NASA? Some of the centers will level off in 1964 or 1965, others will continue to grow.

For example, the Electronic Research Center will just be started in 1964, and we anticipate that it will grow in 3 or 4 years' time to approximately 2,000 people.

Mr. SIEPERT. Of the 400 increased personnel in headquarters, 246 of these are in the program offices and 130 of those 246 are in the Office of Manned Space Flight, so it is by all odds the greatest element of increase at this time.

Mr. BOONE. Do you intend to rent facilities at Boston for the Electronics Center, place people there before you get the construction completed?

Dr. SEAMANS. Yes, we do. It would be our intention provided the Center is approved by the Congress, that we would rent space just as we have at Houston, to build up personnel at the same time that we plan the actual facilities and design them and construct them.

Mr. BOONE. One last question, Mr. Chairman.

These people are to be researchers in-house in Boston?

Dr. SEAMANS. This would be a Center that would be similar to our Langley, Lewis, and Ames Centers where we do work in-house, but also contract with research type organizations, universities, and certain industrial type laboratories for complementary and supplementary work, so probably something like a third of the R. & D. dollar would be for in-house work and the other two-thirds out on contract.

Mr. BOONE. Would you like to discuss at this time the quality of the people that you are being able to recruit? I think you did indicate earlier the team that you had assembled. Has there been any, say, diminution of the quality of the people as time goes on here, or do you think with the increasing numbers that you can meet the demands of the space program?

Dr. SEAMANS. We have been very pleased with the quality of the people that we have been able to attract. That is the reason that I mentioned in my testimony that three-quarters of the people came from the top half of their college classes.

I know from talking to various Center Directors that they have been very pleasantly pleased at the caliber of the people whom they have recently hired and the caliber of the people who are continuing to apply for jobs. This is true at the GS levels.

I think that I should point out that we do have a very real problem when it comes to getting the senior people that are needed to take the executive responsibility at NASA.

Mr. BOONE. Does this support the need for more fellowships, say, in the management field possibly, as well as technical fields?

Dr. SEAMANS. I am not quite sure that I understand your question.

Mr. BOONE. Well, we have been discussing, for example, in our panel on science and technology, the need for additional fellowships in science generally, and I think one of the concerns of the committee up to now has been that it seems that one of NASA's major problems is a management problem and very little has been said about management aspects of fellowships or advanced studies, and we were wondering how you were taking care of that in your education program that you mentioned in your opening statement.

Dr. SEAMANS. It is true that the fellowships that we have discussed have been primarily for scientific and technical personnel.

The CHAIRMAN. I might mention when we were down at the Manned Space Center Dr. Gilruth told us about the new program that was being initiated for summer students, which included not only scientific and technical students, but also administrative, and I think this is a step in the right direction.

Dr. SEAMANS. I was just going to say that we do have a very active in-house program for acquainting our technical personnel with the more administratively oriented responsibilities that they are assuming in project management.

We have had I don't know how many classes, maybe 10 groups or something like that, of 25 each for this purpose. We have also selected special categories such as those administrative people responsible for security to have a special in-house program so that they not only understood the particular responsibilities of security but have a little broader understanding of NASA as a whole.

The CHAIRMAN. I would like to attend one of those myself.

Mr. SIEPERT. We have put through a training course that originally was 2 weeks and now we have refined it down to 1 week, on project management, for technical people and for key executives, and over the last 3 years have put over 200 of the very top of the organization through this.

At the same time we placed over 600 technical people through a procurement course, a 1-week procurement course, and it is very important to the technical person to understand why the procurement man follows certain procedures and certain laws, and we are now well along in a similar kind of course of putting our project and systems engineers through a course on management reporting techniques such as the PERT cost system, which is very fundamental to their following the progress of their work.

These are in-house efforts, though, and I think I would have to respond to Mr. Boone's question by saying that we do not regard it and have not regarded it as our function to make a major expansion of management training, as such, generally available.

However, under the Federal Training Act we do make some of our management nontechnical people eligible for training in the university centers in management techniques.

The CHAIRMAN. Dr. Seamans, are there any materials that you would care to place in the record, such as any slides that we may not

have seen or any other materials in connection with the inquiry this morning? If so, the record will be open.

Dr. SEAMANS. If I might, Mr. Chairman, I would like to review that possibility. We do have some additional information on our recruiting. Some of that information might go in the record.

The CHAIRMAN. That would be very helpful.

(The information referred to is as follows:)

The National Aeronautics and Space Act of 1958, as amended, authorized the National Aeronautics and Space Administration to conduct research into problems of flight within and outside the earth's atmosphere with a view to their practical solution; to develop, construct, test, and operate aeronautical and space vehicles for research purposes; to conduct such activities as may be required for the exploration of space; to arrange for participation by the scientific community in planning scientific measurements and observations to be made; and to provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof.

To carry out the above purposes, the agency's prime function is research and development. It must be staffed with scientists and engineers who are capable of administering research and development programs both in-house and contractor operated. This requires an increasing proportion of the total staff who have scientific and technical training and experience in conducting and supervising basic and applied research and development programs.

The fiscal year 1964 budget estimates include a total of 32,500 permanent positions of which approximately 25,000 will be in the GS grade category. It is estimated that over 11,300 or 44 percent of the GS positions will consist of administrative professionals in support of the scientific program. Thus, approximately 56 percent of the GS staff will consist of scientific, engineering, and other professional personnel. Viewed in this perspective, NASA is unique in the type of personnel it requires when compared to a number of agencies which have other than R. & D. functions as a part of their total effort. To compare NASA's GS grade structure with other agencies would require a detailed analysis of functions for comparability purposes. Some of the major elements peculiar to NASA which must be considered are:

(1) Over 90 percent of research and development obligations are for out-of-house contracts which requires constant monitoring by NASA's scientific, engineering, and administrative professional staff. As these contracts are placed and the actual expenditures grow, a higher percentage of staff will be scientific, engineering, and administrative professionals with less trades and crafts support;

(2) The complexity of NASA programs are increasing constantly in light of new discoveries and breakthroughs. This requires increases in the proportion of highly skilled scientific and engineering talent;

(3) NASA's major in-house R. & D. effort differs from that of certain other agencies. (*a*) For example, NASA's in-house R. & D. programs are conducted wholly with civil service employees. On the other hand, AEC's R. & D. programs are primarily under contract with universities. A larger proportion of scientific, engineering, and professional administrative staff is required with NASA's type of operation; (*b*) certain differences can be noted when comparing the NASA research and development effort with that of the various military agencies. The military agencies utilize commissioned officers in their R. & D. programs and these are excluded from the statistical compilation of GS-grade numbers. Also in a number of instances the GS-grade schedules include positions which are not directly related to R. & D. functions.

(4) A number of other agencies performing research and development functions have built the grade structure over a substantial period of time and their programs are relatively stable in comparison with NASA's rapidly expanding R. & D. programs;

(5) A good portion of the so-called common services which support the R. & D. functions are contracted out by NASA such as motor pools, lawn care, and other service-type activities. In contrast, many agencies have services of this nature performed by in-house staff. This results in lower average GS-grade structure in those agencies.

The following table shows NASA average GS-grade and related positions compared with all Federal average grade areas.

National Aeronautics and Space Administration [1] average GS-grade and related positions

	GS permanent positions		GS permanent and temporary positions			Federal average grade (all areas)
	Average grade	Number of positions	Average grade	Total positions	(Tempos included)	
June 30, 1951 actual	7.1	4,351	7.1	4,351	0	0
June 30, 1952 actual	8.0	4,407	8.0	4,407	0	5.5
June 30, 1953 actual	8.3	4,568	8.3	4,568	0	5.7
June 30, 1954 actual	8.5	4,083	8.5	4,083	0	5.8
June 30, 1955 actual	8.4	4,313	8.4	4,313	0	5.8
June 30, 1956 actual	8.4	4,393	8.4	4,393	0	5.9
June 30, 1957 actual	8.6	4,446	8.6	4,446	0	6.1
June 30, 1958 actual	8.9	[2] 4,400	8.9	[2] 4,400	0	6.4
June 30, 1959 actual	9.1	5,340	9.1	5,340	0	6.6
June 30, 1960 actual	9.3	6,298	9.3	6,300	(2)	6.7
June 30, 1961 actual	9.5	10,966	9.5	11,044	(78)	6.9
June 30, 1962 actual	9.8	15,510	9.5	16,154	(644)	7.0
June 30, 1963 estimate	10.0	21,296	9.8	22,154	(858)	----------
June 30, 1964 estimate	10.0	25,008	9.9	25,925	(917)	----------

[1] NACA prior to September 1958.
[2] Estimated.

NOTE.—The average grade is computed by: (*a*) Multiplying each grade number by the number of positions in the grade; (*b*) totaling the results so obtained; and (*c*) dividing the total by the number of positions involved.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Summary of personnel by location (permanent positions—end of year) fiscal year 1959 through fiscal year 1964

Location	1959 actual	1960 actual	1961 actual	1962 actual	1963 estimate	1964 estimate
Headquarters	428	589	751	1,360	1,900	2,300
Ames Research Center	1,478	1,437	1,487	1,674	2,025	2,309
Flight Research Center	336	411	441	524	575	593
Goddard Space Flight Center	782	1,265	1,497	2,414	3,200	3,700
Langley Research Center	3,297	3,202	3,287	3,770	4,025	4,296
Launch Operations Center	[1] 4	----------	----------	333	800	1,200
Lewis Research Center	2,783	2,734	2,756	3,678	4,658	5,128
Manned Spacecraft Center	----------	----------	805	1,620	3,196	3,980
Marshall Space Flight Center	----------	382	5,688	6,194	7,062	7,492
North Eastern Office	----------	----------	----------	----------	30	40
Pacific Launch Operations Office	----------	----------	----------	6	15	22
Space Nuclear Propulsion Office	----------	----------	----------	40	106	160
Wallops Station	171	229	305	407	465	530
Western Operations Office	7	37	60	136	440	500
Electronic Research Center	----------	----------	----------	----------	50	250
Total personnel	9,286	10,286	17,077	22,156	28,547	32,500

[1] Atlantic Missile Range.

Summary of personnel costs by location, fiscal year 1959 through fiscal year 1964

[In thousands of dollars]

Location	1959 actual	1960 actual	1961 actual	1962 actual	1963 estimate	1964 estimate
Headquarters	$2,486	$4,778	$7,202	$10,885	$20,208	$25,417
Ames Research Center	10,237	11,315	12,150	13,358	17,194	20,789
Flight Research Center	2,162	2,857	3,675	4,441	5,364	5,935
Goddard Space Flight Center	2,735	9,614	11,194	17,766	27,478	34,931
Langley Research Center	22,186	24,162	26,430	28,737	34,254	37,760
Launch Operations Center	[1] 15			2,999	5,533	11,088
Lewis Research Center	19,408	21,558	23,919	27,583	39,645	48,707
Manned Spacecraft Center			6,401	11,566	26,454	38,361
Marshall Space Flight Center		359	49,835	54,052	73,599	81,739
North Eastern Office					220	453
Pacific Launch Operations Office				54	157	210
Space Nuclear Propulsion Office				203	946	1,771
Wallops Station	644	1,467	2,213	2,931	3,569	4,360
Western Operations Office	48	218	534	936	2,779	5,222
Electronic Research Center					255	2,725
Total personnel costs	59,921	76,428	143,553	175,511	257,655	319,468

[1] Atlantic Missile Range.

National Aeronautics and Space Administration fiscal year 1964 estimates—Analysis of personnel by programs

Programs	Fiscal year 1962			Fiscal year 1963			Fiscal year 1964		
	Direct	Support	Total	Direct	Support	Total	Direct	Support	Total
Manned spacecraft systems	1,056	705	1,761	2,290	1,290	3,580	3,181	1,663	4,844
Launch vehicle and propulsion systems	3,438	2,088	5,526	4,497	2,735	7,232	4,780	2,930	7,710
Aerospace medicine	73	64	137	118	81	199	149	92	241
Integration and checkout	12	15	27	64	69	133	76	78	154
Systems integration	117	104	221	240	164	404	261	179	440
Meteorological satellites	168	150	318	198	181	379	267	209	476
Communications satellites	87	67	154	161	119	280	136	98	234
Advanced applications satellites	2	2	4	4	4	8	11	10	21
Industrial applications	17	19	36	38	30	68	66	46	112
Geophysics and astronomy	729	595	1,324	937	651	1,588	1,183	785	1,968
Lunar and planetary exploration	101	92	193	216	123	339	308	166	474
Bioscience	43	22	65	213	70	283	274	119	393
Launch vehicle development	634	390	1,024	522	400	922	633	484	1,117
Facility, training, and research grants	14	18	32	21	21	42	25	25	50
Space vehicle systems	1,665	1,280	2,945	1,866	1,421	3,287	2,015	1,554	3,569
Electronic systems	770	729	1,499	1,031	746	1,777	1,199	810	2,009
Human factor systems	146	50	196	201	81	282	237	151	388
Nuclear-electric systems	426	968	1,394	474	939	1,413	513	992	1,505
Nuclear rockets	299	602	901	564	826	1,390	664	871	1,535
Chemical propulsion	263	543	806	303	524	827	332	568	900
Space power	158	304	462	222	353	575	244	374	618
Aeronautics	1,202	782	1,984	1,203	795	1,998	1,242	826	2,068
Tracking and data acquisition	538	469	1,007	854	581	1,435	951	619	1,570
Total NASA for NASA	11,958	10,058	22,016	16,237	12,204	28,441	18,747	13,649	32,396
Total NASA reimbursable			140			106			104
Grand total			22,156			28,547			32,500

National Aeronautics and Space Administration, fiscal year 1964 budget—Personal services and benefits (obligations)

	Total		
	1962	1963	1964
Number of permanent employees [1]	22,016	28,441	32,396
Personnel compensation:			
Permanent positions	$148,875,573	$220,654,000	$274,288,000
Temporary employment	2,545,435	3,170,000	3,422,000
Intermittent employment	223,830	866,000	981,000
Other compensation:			
Regular pay above 52-week base			2,522,000
Overtime and holiday pay	11,876,288	14,234,000	16,747,000
Nightwork differential	202,194	275,000	304,000
Additional pay for service abroad	38,568	47,000	58,000
Reimbursable details	136,426	161,000	165,000
Total, personnel compensation	163,898,314	239,407,000	298,487,000
Personnel benefits:			
Uniform allowances	5,547	9,000	10,000
Living and quarters allowances	3,019	3,000	3,000
Life insurance	487,480	783,000	902,000
Health program	1,152,564	1,846,000	2,110,000
Retirement contributions	9,559,202	15,322,000	17,614,000
FICA taxes	77,782	140,000	174,000
Incentive awards	88,173	143,000	166,000
Other miscellaneous compensation	1,790	2,000	2,000
Total, personnel benefits	11,375,557	18,248,000	20,981,000
Total personnel services and benefits	175,273,871	257,655,000	319,468,000

[1] Excludes reimbursable positions, fiscal year 1962—140, fiscal year 1963—106, fiscal year 1964—104.

The CHAIRMAN. Do any other members of the committee have any questions?

If not, the committee stands adjourned until 10 a.m. tomorrow morning.

(The additional information requested for record is as follows:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION,
Washington, D.C., June 7, 1963.

Mr. W. H. BOONE,
Technical Consultant, Subcommittee on Applications and Tracking and Data Acquisition, Committee on Science and Astronautics, House of Representatives, Washington, D.C.

DEAR MR. BOONE: This is in reply to your letter dated May 31, 1963, in which you request certain information for the Subcommittee on Applications and Tracking and Data Acquisition for inclusion in the record of hearings for the National Aeronautics and Space Administration fiscal year 1964 authorizations.

Answers to the three questions which were requested are shown in the form of attachments I, II, and III to this letter.

Sincerely yours,

PAUL DEMBLING,
Director, Office of Legislative Affairs.

Attachments.

ATTACHMENT I

NASA records indicate that there are 12 personnel subject to dual compensation that have waived military retirement.

	Annual salary		*Annual salary*
GS–3	$4,240	GS–14	$13,270
GS–9 (2)	6,675	GS–15	14,565
GS–11	8,575	Excepted	17,500
GS–12	9,475	Do	18,500
GS–13	11,150	Do	21,000
GS–13	11,515		

ATTACHMENT II

Analysis of printing and reproduction funds in object classes other than object class 24

[In thousands of dollars]

Object class	Title	Fiscal year 1962	Fiscal year 1963	Fiscal year 1964
23	Rents, communication, utilities	398	868	1,000
25	Other services	18	36	56
26	Supplies and materials	246	435	686
31	Equipment	226	396	791
	Total	888	1,735	2,533

Since object of expenditure 24, "Printing and reproduction," by definition includes only contractual or reimbursable services, the figures supplied here are for in-house costs under other objects of expenditure.

"Rentals" include the rental of printing and office reproduction equipment.

"Other services" include the contractual maintenance and repair of printing and reproduction equipment.

"Supplies and materials" include the paper, ink, and other supplies used in the printing and reproduction operation.

"Equipment" includes the offset printing presses, offset platemaking units, process cameras, power collators, office copying machines, and peripheral items purchased for use by the printing and reproduction units.

ATTACHMENT III

A distribution of "Other contractual services" as shown in the budget justification books (vol. 1, "Operation of Installations Tab," p. OC 25–1) for "Object class 25" and appropriate explanation of the major categories under this heading are as follows:

Object class 25 "Other services fiscal year 1964 budget estimates"

[In thousands of dollars]

	Fiscal year 1962	Fiscal year 1963	Fiscal year 1974
Aircraft services	19	841	3,530
Tuition	436	642	724
Stenographic and verbatim transcript reporting services	17	18	64
Exhibit preparation, brochures, educational services, and materials	1,527	5,438	7,464
Motion picture services	1,057	2,676	4,608
Translating services	91	135	210
Advertising	449	383	383
Other services	3,437	2,337	6,423
Subtotal, other contractual services	7,033	12,470	23,406

1. *Aircraft services.*—Funds required for this purpose are to provide maintenance costs of aircraft for astronaut proficiency training requirements and to provide for operation and maintenance of executive aircraft. Requirements for such services are primarily at three locations as follows: Flight Research Center, Manned Spacecraft Center, and Launch Operations Center.

2. *Tuition.*—These requirements are for the contractual cost of tuition for graduate study and on-the-job study of NASA personnel. These requirements include tuition, fees, books, registration fees, laboratory fees, and other like items. Although funds are required for this purpose in varying amounts at nearly all installations, the major amounts are concentrated at Marshall Space Flight Center, Lewis Research Center, Goddard Space Flight Center, and Ames Research Center.

3. *Stenographic and verbatim transcript reporting services.*—This category includes all costs of contractual stenographic and reporting services. These funds are required to provide for stenographic services on a short-term basis during periods of heavy workload.

4. *Exhibit preparation, brochures, educational services, and materials.*—This includes the cost of contractual exhibit preparation, brochures, educational services, and materials. These funds are required to provide suitable displays for public showing at fairs and expositions to inform the American public and foreign nations of the specific progress in NASA programs. It further provides documentary films, management communications, photography, and television material to inform management, the public, and interested international bodies of the goals and progress of NASA programs.

5. *Motion picture services.*—This category includes cost for contractual photographic and motion picture services. Commercial photographic requirements provide film processing and developing in direct support of the photographic services of the various installations.

6. *Translating services.*—This category covers the cost of all contractual translating services. These funds are to be utilized for translating pertinent scientific documents from various foreign languages into English for use in NASA programs.

7. *Advertising.*—Includes cost of recruiting advertising services. Although there are requirements at nine installations for this type of service, the major user is NASA Headquarters. Advertising space will be bought in newspapers, college periodicals, and trade journals.

8. *Other services.*—This includes the cost of other contractual services at most of the NASA installations. Requirements under this category are for various and sundry type contracts at the installations. Typical of the type of contract under "Other contractual services" is for the operation and maintenance of motor vehicles, contract moving, and industrial health facilities. Likewise, it also includes services performed by other Government agencies.

(Whereupon, at 12:08 p.m., the subcommittee was adjourned, to be reconvened at 10 a.m., Wednesday, March 20, 1963.)

1964 NASA AUTHORIZATION

WEDNESDAY, MARCH 20, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON APPLICATIONS AND
TRACKING AND DATA ACQUISITION,
Washington, D.C.

The subcommittee met at 10 a.m., pursuant to adjournment, in room 214–B, Longworth Building, Hon. Ken Hechler (chairman of the subcommittee) presiding.

The CHAIRMAN. The committee will come to order.

We are continuing our hearings this morning on "Personnel services, operations and installations."

Mr. DAVIS. Mr. Chairman.

The CHAIRMAN. Mr. Davis.

Mr. DAVIS. If I may be pardoned for referring very briefly to the subject of computers once more, I notice that in yesterday's record on page 4182 there are some remarks which were made by my colleague Mr. Arnold Olsen of Montana in which he quotes a report to the Congress by Comptroller General Campbell, under date of March 6, 1963, the subject of which was a "Study of Financial Advantages of Purchasing Over Leasing of Electronic Data Processing Equipment in the Federal Government."

Now I should like to include in the record of this committee's hearing for this day these remarks by Mr. Olsen, and also I would like to ask Dr. Seamans if he will on behalf of NASA during the next few days append such comments as he would care to make in response to this.

Dr. SEAMANS. I would be happy to.

Mr. DAVIS. Very well.

(The excerpt from the Congressional Record of March 19, 1963, is as follows:)

REPORT TO THE CONGRESS OF THE UNITED STATES: "STUDY OF FINANCIAL ADVANTAGES OF PURCHASING OVER LEASING OF ELECTRONIC DATA-PROCESSING EQUIPMENT IN THE FEDERAL GOVERNMENT," THE COMPTROLLER GENERAL OF THE UNITED STATES, MARCH 1963

We have reviewed the report, and found it to be an exceedingly well written and accurate document which will serve as a useful input to our developing decisionmaking process for the purchasing versus leasing of electronic data-processing equipment. The report states that from the point of view of the Government, in toto, there are decided cost reductions resulting from purchase rather than lease of such equipment. Implicit in such a policy is the consideration that a computer system, upon becoming technologically obsolete at an installation, would probably still be quite appropriate for another installation's needs. Consequently, if the computer had originally been purchased and if its total life were longer than the break-even period for the lease versus purchase alternatives, then its continued use after the break-even point is reached produces major financial

savings. Complicated administrative and technical problems are, of course, inherent in such a centralization policy, However, it is patent that possible benefits definitely warrant further investigation of the situation.

We feel that not only does the report have great interest and merit for the Government overall, but also from the point of view of NASA as an individual agency. Clearly, NASA, with 133 computers, is a large and diversified user of electronic data-processing equipment, and the recommendations of the report may well be at least partially applicable within the NASA context. That is, it might be technically and economically feasible for us to purchase some fraction of our computers, even if such purchases were not dictated by current program or project needs. Then, upon becoming obsolete at their particular installations, the computers might be transferred to other installations whose needs were not as sophisticated or demanding. An analysis of this strategy and its relation to the totality of NASA data-processing considerations is presently being performed. We hope to develop a workable set of decision rules for the lease versus purchase question which will yield a more economical electronic data-processing posture for the agency overall, without subjecting our programs to negative influences.

Until such a set of rules is formulated and tested, we will continue to follow the guidelines specified in Bureau of the Budget Circular No. A–54, "Policies on selection and acquisition of automatic data processing (ADP) equipment." This policy has resulted in approximately 82 percent of our computers being leased rather than purchased, a situation which is almost directly and solely attributable to the increasingly sophisticated nature of our computer applications. The data-processing requirements of our scientific applications have often been greater than the computation power of available computers, even though the rate of advancement of computer technology has been phenomenal. We hope to effect sizable savings by extending the BOB guidelines and incorporating general NASA data-processing considerations into the framework of decisionmaking for specific, individual computer installations. Clearly, there are three basic areas of uncertainty in such a strategy: (1) accurate specification of the level and timing of future data-processing requirements, particularly in scientific data processing (90 percent of NASA data processing); (2) difficulty in estimating computation power and flexibility of future data-processing equipments; and (3) the incorporation of adequate margins of capability such that optimization of the data-processing function does not unduly constrain agency programs.

The investigation of the lease versus purchase question is only one component of a developing ADP management program through which we will insure continued efficient use of our agency wide ADP resources. It should be stressed, however, that any decision rules will remain subordinate to the needs of NASA programs. Our commitments to certain programs imply a corresponding (though difficult to estimate) data-processing resources requirement. Successful performance of NASA programs depends largely upon the use of the most technologically advanced equipment available. Electronic data-processing equipment is actually an integral part of our program resources and tools. Consequently, economic decisions made independently of the program context could result in delays and inefficiencies in program performance whose costs would far outweigh the more easily identifiable data-processing costs. Consequently, we are incorporating in our ADP management program not only criteria for insuring efficient utilization of electronic data-processing equipment per se, but also for maximizing the contribution electronic data processing can make to effective program performance.

The CHAIRMAN. We will now proceed under the heading of "Personnel compensation." What has been the maximum hiring rate of NASA in any one quarter, and what was the rate in the last quarter of fiscal 1962?

STATEMENT OF DR. ROBERT C. SEAMANS, JR., ASSOCIATE ADMINISTRATOR, NASA, ACCOMPANIED BY ALBERT F. SIEPERT, DIRECTOR OF THE OFFICE OF ADMINISTRATION; DeMARQUIS D. WYATT, DIRECTOR OF THE OFFICE OF PROGRAMS; DON D. CADLE, DEPUTY DIRECTOR OF OFFICE OF ADMINISTRATION; JOHN D. YOUNG, TO BECOME DIRECTOR OF THE OFFICE OF ADMINISTRATION; ROBERT J. LACKLEN, DIRECTOR OF PERSONNEL DIVISION; MELVIN S. DAY, DIRECTOR OF OFFICE OF SCIENTIFIC AND TECHNICAL INFORMATION; AND GEORGE J. VECCHIETTI, JR., DEPUTY DIRECTOR OF THE PROCUREMENT AND SUPPLY DIVISION

If you prefer to put that in the record——

Dr. SEAMANS. Yes, we would.

(The information requested is as follows:)

The gross rate of hire for the fourth quarter of fiscal year 1962 was 3,587 accessions. The maximum rate of hire was in the fourth quarter of fiscal year 1962.

The CHAIRMAN. How many unfilled excepted positions does NASA now have?

Dr. SEAMANS. Mr. Lacklen can look that up. We have very few. We have approximately 30, I was going to say, excepted positions. We will check on the exact number.

We have been guarding those unfilled positions very carefully, not knowing when we might get any additional ones, hoping we would get additional ones very soon.

The CHAIRMAN. The third question, what are the total——

Dr. SEAMANS. Twenty-nine is the total unfilled as of February 28, 1963.

The CHAIRMAN. Thank you.

What are the total recruitment costs and what is the cost per person, and how does this compare with industry in other Government agencies?

Dr. SEAMANS. Mr. Siepert is prepared to answer that.

The CHAIRMAN. Mr. Siepert.

Mr. SIEPERT. The total of all of our recruiting costs, these are both advertising costs, personnel that we use, any expenses that we can charge to it, run $1,222,000.

The average cost per hire based upon the 2,909 hires of scientists and engineers that came during this same fiscal period, was $420.07.

It is difficult to get exactly comparable figures from industry, but the ones in literature and the ones that we get by direct contact run much higher than this. I believe the figure is in the neighborhood of $1,600 to $1,800 a man.

The CHAIRMAN. Now we are going to take up the question of relocation costs under "Travel and transportation of persons and things." But I wonder if any members of the committee have any other questions they would like to ask on these three items.

Mr. WYDLER. Just the three that you just referred to?

The CHAIRMAN. Or "Personnel compensation."

Mr. WYDLER. I would have to go back to something we discussed yesterday and I found out I did not understand the answer, and that is the lapse factor that you use.

Is this the same lapse factor used for all of your figures? In other words, whether it is a new project, a new location, or an old location, or what have you, you only have one type of lapse factor?

Mr. WYATT. That is correct, I believe.

Mr. CADLE. Can I take that for just a moment?

When you put the budget together, the Bureau of the Budget directs that all new positions shall be lapsed on a 25-percent lapse rate, which means that by the end of December of the next fiscal year you are calculated to have all of your new employees on board.

Now in addition to this lapse factor which is built into the estimates from the very beginning, you also have additional lapse factors which are calculated on your turnover rate for each individual location.

So you have a combination of two lapse factors, first on the new positions, and then on the people who are already aboard at the end of any fiscal year.

You have a turnover rate or a lapse rate at each location and you have a period, for example, which varies by location, which covers the time elapsed from the time that a job is resigned until it is refilled, so you have a period of time on each turnover person where you are lapsing as well, that is, you are not paying any position during that period. The personnel cost part of the budget is an extremely definitive part, that is, there is no "guestimate" in this. You take actual experience factors from each of your locations and crank these in.

Now in the fiscal year 1964 estimate you have one additional factor which is a bit more complicating, and that is on January 1, as you recall, the second step of the Pay Act will come in, and this money is also cranked in for the average GS grade, so you have in the budget estimates three major factors which contribute to the final figure but the calculations are all rather definitive.

Mr. SIEPERT. Your question, I believe, was specifically with respect to the new electronic research center; was it?

Mr. WYDLER. Yes.

Mr. SIEPERT. And that would only be a 25-percent lapse because you don't have the turnover to relate to it.

Mr. CADLE. That is right.

Mr. WYDLER. Just referring now to the center for a minute, do I understand that the personnel proposed for that center is 250 persons, is that correct?

Dr. SEAMANS. Yes. What we are saying with this lapse rate is that we start off the fiscal year with no new hires, and we build up linearly each month for 6 months, arriving at 250 people by January, and then for the remainder of the year have 250 people on board.

That is the way that the personnel costs are figured, so that during the first half year you have in effect 50 percent of the people on board, in the average, the second half of the year they are all on board. There is a 25-percent deduction, if you will, over what it would be if you had everybody on board the whole time.

Mr. WYDLER. In other words, the way you figure it, by the summer of 1964, you will have the 250 people hired, is that correct?

Dr. SEAMANS. That is correct.

Mr. CADLE. That is correct.

Mr. WYDLER. Now, when will you have facilities for them to work in there, when is that project to be completed?

Dr. SEAMANS. We don't have detailed plans for that. We are asking for $5 million in this budget for construction of facilities money, both for land acquisition and for the detailed facility planning. However, we have done very preliminary planning at this time.

Mr. WYDLER. I mean is there no chance that that center, the buildings and so forth, and the facilities and the laboratories, will be prepared by the summer of 1964, is there?

Dr. SEAMANS. We will not have permanent facilities at that time. We will use rented facilities during the first several years of operation, as we have in Houston.

Mr. WYDLER. And although you won't have those facilities as such, you still will hire the 250 people to work in that center; is that it?

Dr. SEAMANS. Yes. At Houston right now we have a little over 2,400 people who are right now occupying 10 rented buildings at the same time that we are constructing our new facility.

Mr. WYDLER. So, in other words, in the meantime you intend to rent facilities for these people?

Dr. SEAMANS. That is correct.

Mr. WYDLER. Where does that appear in the budget, the rental?

Mr. CADLE. Back under "Rents, communications, and utilities," in the Object Class Schedule, volume I, under the "Operation of installations."

Mr. WYDLER. How much is proposed for this center?

Mr. CADLE. Let me check.

We have $240,000 for rents, communications, and utilities for ERC in 1964, and on the rentals we have $190,000.

Dr. SEAMANS. This shows on page OC23–1, "Electronic Research Center, $240,000."

Mr. WYDLER. I realize this next question may probably not be in your line, but probably you can tell me who would be the person to ask to get the answer to this. I would like to find out what specific research projects this center is supposed to perform, who would be the person to give me the answer to that question?

Dr. SEAMANS. Well, we have a task force that was established under the aegis of Dr. Bisplinghoff, who is the Director of Advanced Research and Technology, and we have designated Dr. Albert Kelley as the leader of this task force, which will be composed of some 25 to 30 people who will be working during the remainder of this fiscal year to plan out in detail what projects should be carried out in the Boston area. In doing this we must consider those projects that are already underway in our other centers that relate to electronics.

Mr. WYDLER. Is the plan then to stop these projects in the other centers and bring them all to Boston?

Dr. SEAMANS. No; much of the work that is going on in the other centers such as Goddard and Langley and JPL, and Ames, and Marshall, which are electronically oriented, will continue. Some of them, of course, will over a period of time be shifted to Boston and we will also add in Boston additional projects that we do not now have underway.

Mr. WYDLER. So as I understand it, Doctor, at this time we do not know what specific projects will be performed at the Boston Center?

Dr. SEAMANS. No; we have only laid them out in general areas, such as electronic component research, research in stabilization and

control, in end instrumentation, gyros, accelerometers, data processing, communications.

Mr. WYDLER. Well, that type of work is being done now at various centers, isn't it?

Dr. SEAMANS. But not as fully and completely as is required.

Mr. WYDLER. That is all the questions I have.

The CHAIRMAN. May I ask a question on the Electronics Research Center. Page ERC-2 of the Budget backup book, volume I, the number of permanent employees which you have projected at the end of fiscal 1963 is 50, and at the end of fiscal 1964 is 250, is that correct?

Dr. SEAMANS. Yes.

The CHAIRMAN. And immediately below that, Personnel Costs, end of fiscal 1963, 255,000, fiscal 1964, 2,725,000, the personnel increases fivefold, the personnel costs tenfold. I wonder if you could explain this disproportionate rise in personnel costs?

Dr. SEAMANS. Well, that is because this task force that I mentioned is in fact in part this number 50 that you see in fiscal 1963. There is another part of it, namely, the administrative support, that our Northeast Office is providing, but this has only been underway since January and it is building up, it is not even at the 50 level now, so that the cost per man is carried over a much shorter period of time, and hence there will be a greater increase shown per man in 1964 because that is measured over the full 12-month period.

Mr. RUMSFELD. Excuse me. I must confess that I don't understand your answer.

Mr. WYATT. May I illustrate it this way——

Mr. RUMSFELD. Please do.

Mr. WYATT. We started in January with no people; by the end of this year we expect to have 50 people on this task force assigned to ERC. Now let's say that their average for the year, a full year, would be $10,000 a man, approximately. Well, it turns out that it is only going to average a cost of $5,000 per man because they are not on for a full year, they are on for less than a half year as a matter of fact, that is the full 50.

Mr. RUMSFELD. I see.

Mr. WYATT. Starting next year, however, we will start in with 50 people at the start of the year and build up another 200 people by midyear, and when you figure that out it works out to the dollars shown here for a full year for an end strength of 250 people.

Mr. RUMSFELD. So in other words, in 1965 assuming that you held the 250 level it would still be higher than the personnel cost you listed for 1964?

Mr. WYATT. That is correct.

Mr. SIEPERT. Twenty-five percent higher.

The CHAIRMAN. While we are on Electronics Research Center are there any questions on this side on the Electronics Research Center?

Mr. WYDLER. If I might, on the $800,000 figure, Mr. Chairman, could you tell me how that is made up, $200,000 approximately is the proposed rent. What is the other $600,000 for operations installations?

Mr. WYATT. We have such items as this: $125,000 for travel that we estimate. We have about $67,000 for the transportation of things related to the operation of the center.

We mentioned this $240,000 for rent, communications, and utilities.

We estimate that there will be printing and reproduction costs chargeable to the center operations of about $24,000, other services which will include the assistance to the extent that in the actual operation we use services of local machine shops, this sort of thing, $144,000, and supplies and materials to operate the center during the year $120,000, and these added together make the $800,000, which also includes $80,000 for equipment.

Mr. DAVIS. Mr. Chairman, I simply wonder if any other subcommittee has jurisdiction over this as well as us.

Is this an overlapping thing, or is this the only subcommittee that will have anything to do with the Boston Center?

Mr. BOONE. I think you might ask Dr. Seamans, if you will, but I believe project activities that will be conducted in Boston are covered in the science aspect of the budget.

Mr. WYATT. That is right, Mr. Karth's subcommittee.

Mr. BOONE. This would be a good time to ask how much is involved there.

Mr. DAVIS. Yes, I would like to know just how much of the responsibility rests on this subcommittee and how much on Mr. Karth's subcommittee.

The CHAIRMAN. Well, of course, this subcommittee is concerned with personnel and personnel costs, as well as operation of installations and you can stretch this as far as you want. I think that we have a good deal to do insofar as personnel and personnel costs are concerned without impinging on the areas of other subcommittees.

Dr. SEAMANS. The program aspects of the work in this center will come under, and do come under, the Office of Advanced Research and Technology, and that is being reviewed by Mr. Karth's subcommittee.

Mr. DAVIS. Well, may I ask what factors led to the selection of this particular site?

Dr. SEAMANS. Sure, I would be happy to discuss that. If the chairman wishes I can take a few minutes on this subject, going back to the need for an additional center.

We really came at this from two directions, somewhat independently. We are a growing agency, and as we grow we must consider how to manage our business and, as we discussed yesterday, you have to have some increase in personnel within NASA in order to properly administer the contracts that we have with universities and with industry. We have the choice then of increasing the size of existing centers or of starting a new center.

We reach a point in every one of our centers where there are problems that are generated by virtue of the size of the center. Management problems increase with size and so forth, and consequently looking at it from just a management standpoint it appeared desirable to start a new center.

A second chain of events really goes back to the days of the NACA where you find that this was a research group that had very great compentence in aeronautics and propulsion and structures and materials, and did have a little in electronics. It was a question even then as to whether the research centers shouldn't do more in the electronic area.

I happened to be a member of one of the NACA subcommittees on stability and control when we urged the NACA to get more into

electronic problems, since even then the electronics part of the airplane and the missile was becoming a very large part of the total job.

Today in our space program we find that something like 65 percent of our dollars are going into electronics, electronic equipment, and subsystems. Very soon after our reorganization in 1961, I requested Dr. Bisplinghoff's office to set up a group to actively review the electronics area to see whether we were doing a sufficient amount within NASA. We recognize that there is very real competence in industry, but we questioned whether we had enough of a group within NASA to properly supervise the activity of such importance to our overall objectives.

First they came to the conclusion that we did need to increase our electronic research competence.

Second, there was the question of whether we did this at a large number of centers, with a little piece here and a little bit different orientation in another center, or whether in facing the real problem of coordinating the effort, we should take one of our centers and in effect increase its size appreciably in order to get into electronics. We did consider this second possibility at quite a number of our centers and saw that we were really setting up two centers under one roof.

Then, of course, the third possibility is the one that we selected; namely, to establish a new center. So both from a management standpoint as well as from a disciplinary need, we came to the conclusion that this is something that should be requested of the Congress for fiscal 1964.

Then there is a question of where should it be located. We feel that our research centers particularly must be close to universities where we can have an exchange of activities. We can help—actually, our top people can assist—in the training programs at the universities by teaching courses, while faculty people in the universities can come over and act as consultants to us, where people will be doing graduate work that is related to our programs, and eventually where people will come from the university into NASA as part of these various cooperative programs that we have.

So we wanted to go to an area where there was a very strong climate for electronic research, and we looked at a number of areas, and I have some information here which might be of interest to you in this regard.

We find that in the Boston area, if we take a look at the engineering degrees conferred at the doctorate level, there were 112 last year as compared with—the next highest was 44 in the New York area.

If you look at the physics degrees——

Mr. RYAN. May I interrupt?

The CHAIRMAN. Mr. Ryan.

Mr. RYAN. Are we talking about degrees conferred by the universities or people who reside in the area who hold degrees?

Dr. SEAMANS. At this moment I am talking about degrees conferred. If we take a look at the physics degrees conferred at the doctorate level, we find that in Boston there were 43 conferred out of a total of 487, and that the next highest were New York with 36, and San Francisco with 36.

It we take a look at those residing in the area who have research competence, one measure is to look at the membership in the National Academy of Sciences. We find that the total membership is 666, and

of these 99 reside in the Boston area, and the next highest is 83 in New York.

One other way of looking at this is to review the research organizations in the area. You have to define very carefully what you mean by a research organization, and we don't differentiate here between university, nonprofit or profit.

We have a definition that was used in a census recently taken by the National Academy of Sciences where we reviewed facilities employing 25 or more people with good balance between technical and nontechnical personnel. It is a facility that must operate in proper technical areas and to say that it exists, the facility must be in the standard metropolitan statistical area of one of the locations. For example, it must be located within a reasonable radius of Boston to say that it is in the Boston area.

Each industrial research laboratory has a competence in one or more of the electronics areas including such things as computer technology, circuits and circuitry research, control systems research, and so on. A list of some 15 different areas that make up the field of electronics. And the interesting thing here is that we find that in the Boston area there are 156 such research capabilities. In the Los Angeles area there are 153, and in the New York area there are 134.

So this is another measure of competence in the area that we felt was very important because it indicates not only those people who are graduating but those people who are staying in the area who would be of value to our activity working in close coordination.

The CHAIRMAN. This subcommittee is concerned with administrative and management operation of installations.

Are there any other questions on the Electronics Research Center?

Mr. ROUSH. I have something I want to put in the record at this time, Mr. Chairman.

I don't accept the arguments you put forth. Last year I read a statement by someone in the Defense Department that there was a "vacuum of intelligence," I believe they call it, in the Midwest and the tendency was to go to the east coast and to go to the west coast.

This is just snowballing. You are attracted there because someone else is there and there is no attempt to diversify this thing throughout the country. Eventually it will all be on the east coast, it will all be on the west coast, and I think that this approach, although it sounds logical that you want to be next to these people, isn't good for the country as a whole, and I would certainly like to see NASA make some effort to divide this a little bit.

Of course, I am speaking for my State, but I am also speaking for my section of the country. I think there should be an effort made to take some of these installations and some of these research centers into parts of the country where they are not located that we might cause this intelligence to be spread throughout the country and the effort to be spread throughout the country.

My people in my section of the country would appreciate your program more if we had some of these installations in the Midwest, not necessarily in Indiana, but near Purdue University and the great universities of Michigan, Notre Dame, and Indiana University, the universities of Kentucky and Illinois, where these people are also anxious to be a part of what I consider the greatest program that America has ever undertaken.

Thank you, Mr. Chairman.

Dr. SEAMANS. I might point out if I may, Mr. Chairman, that we have I believe more of our research grants-in-aid program at the University of Michigan than any other university in the country.

I would also just like to point out that last year we were being criticized by some sections of the country for starting anew in the Houston area when there was so much competence in other parts of the country, so I think that our view of this has to be that we have a very major responsibility looking at the program nationally, and we want to utilize the competence of all parts of the country to the best of our ability, but we have to go ahead building on strength and we feel that to the best of our ability we are doing this in all parts of the country.

The CHAIRMAN. "To them that hath shall be given."

Mr. RUMSFELD. I certainly concur with Congressman Roush and I question the basic reasons which you have stated for selecting this site, as I have indicated on previous occasions.

Do you feel that there is any danger, first of all, in selecting an area because supposedly this competence is there and further building it up, to the point where you will have a possible harmful effect on that area if and when your program is cut back and some other area of interest of the Government supersedes it?

I think there is an advantage to this country by spreading this around so that we don't have one-industry economies, and I think the second thing is—perhaps you don't feel this is valuable—but from strictly a strategic standpoint it seems inadvisable to have heavy concentrations of all space activity in one or two or three areas, and I think the third thing which I have mentioned previously, is the desirability of the competitive aspects of a stagnation or a stilting of ideas in one area.

I see this thing snowballing, as Mr. Roush said, where you pick one area because you supposedly have competence. Then your recruiters go to another area, such as Illinois, with the University of Illinois, Northwestern University, University of Chicago, a tremendous complex in the Midwest, and you take this talent away from it, which makes it even less desirable for future installations, and it is something that concerns me and I am quite honestly just not satisfied with that answer that there are 43 more physics degrees conferred in Boston than in New York, with 36 or some other area, it just doesn't seem to hold water with me. Maybe it is because I am not well enough acquainted with the program.

Dr. SEAMANS. Well, I subscribe to your view that it is advisable to build up in different geographic areas, and that is the reason, one of the very important reasons for having a new center as opposed to building up centers where we are now located.

As far as the desirability of going to Boston and from the standpoint of that community we looked at this and believe that there is sufficient total competence there that our Center would not saturate the area.

As a matter of fact, the six Governors in the New England area have gone officially on record that after they have reviewed it they feel that it would be highly beneficial to New England and the Boston area if we do have this Center located there.

The CHAIRMAN. Mr. Ryan.

Mr. RYAN. I think very good questions have been raised, Dr. Seamans, by Mr. Roush, and Mr. Rumsfeld, and, of course, it occurs

to me that Congress has not approved the request for this installation, and my question is, if Congress says "We do not believe this should be located in the Boston area," are you prepared and do you have the statistics available so that you could select another site?

Dr. SEAMANS. One of the reasons that we are proceeding as we are is to give the Congress a chance to review the desirability of a new center for NASA——

Mr. RYAN. It is two separate questions.

Dr. SEAMANS. We felt it only fair to indicate to you the proposition that the Center would be best for NASA and the country if located in Boston. You obviously are free to recommend any other location you may wish.

Mr. RYAN. Well, it does seem to me that NASA has failed to really consider the overall economic consequences to the national economy of placing not only this Center but other installations, and I suggested at an earlier hearing before the full committee that there really should be some coordination between NASA and the Department of Commerce in an attempt to study the effects of the location of this Center in Boston or some other installation in some other part of the country, the effects not only in terms of a concentration of scientific personnel and know-how, but also the concentration of an industry.

Now the effect of putting this installation in Boston is to strengthen and concentrate the whole electronics industry in that area rather than seeing it spread out around the country, and it occurs to me that perhaps the statistics you cited this morning are more of a justification for placing it in Boston rather than the reasons which originally impelled you to place it there.

Dr. SEAMANS. I am afraid I am not quite clear on what you are driving at, Mr. Ryan.

Mr. RYAN. Well, did you, in fact, sit down in weighing this decision and compare the number of degrees which had been conferred by the Boston universities compared with the New York universities, compared with the California universities?

Dr. SEAMANS. This is one important factor.

Mr. RYAN. At the time you made the decision?

Dr. SEAMANS. Yes, sir.

Mr. RYAN. Do you have this in written memorandum dated prior to the decision?

Dr. SEAMANS. This is a matter that was considered by the Administrator, the Deputy Administrator and myself at the time this judgment was made, these kind of factors were considered.

Mr. RYAN. The actual number of degrees conferred?

Dr. SEAMANS. This is not the kind of matter where you can arrange a complete balance sheet of every detailed factor and go to a computing machine and come out with the answer. You have to look at all of the important requirements——

Mr. RYAN. I understand that.

Dr. SEAMANS (continuing). For a center, and this is one very important factor that was considered at the time that the decision was made to make this request of the Congress.

Mr. RYAN. And you also looked up the tables from the National Academy of Science beforehand and determined there were 99 members in the Boston area?

Dr. SEAMANS. These are facts that have been available to us well before this——

Mr. RYAN. But did you actually, in making this decision, weigh the number of members of the National Academy of Science in Boston compared to New York or California?

Dr. SEAMANS. We took into account the fact that there is this competence in the Boston area in making the decision, yes.

Mr. RYAN. Well, I won't pursue it further, but I repeat that I believe what you have offered as a rationalization and a justification for a decision that you made to place this in Boston.

The CHAIRMAN. Mr. Rumsfeld.

Mr. RUMSFELD. Do you feel that the functioning of this Research Center if it at a later date was decided to place this in, say, Indiana or Illinois or Michigan or Kentucky or some other place, would not be able to do the job you have outlined for it?

Dr. SEAMANS. I think we have got to consider in our decision where we can get the maximum benefit to the space program, and we believe that by going to Boston we will on a dollar basis get the most return. That is not to say that you couldn't have a center operating in other parts of the country.

Mr. RUMSFELD. Thank you, Doctor.

The CHAIRMAN. Are there any other questions on the Electronics Research Center?

Mr. Boone.

Mr. BOONE. Dr. Seamans, does this center truly perform functions that are not available in industry in this country, or is this an in-house buildup within NASA itself?

Dr. SEAMANS. As in all of our work, industry will have a very major responsibility for the actual conduct of the research, and what we are talking about is a sufficient NASA competence that this can all be pulled together and directed toward our overall objectives.

Mr. BOONE. Thank you.

The CHAIRMAN. I would like to turn now to the Western Operations Office. I call attention to the arrival of the chairman of the full committee. The Western Operations Office, Chairman Miller, is appropriately abbreviated as WOO–2 in the backup material.

You will note on this page that the number of permanent employees in the Western Operations Office increases from 1963 to 1964 from 440 to 500. Do you follow that figure, Dr. Seamans?

Dr. SEAMANS. I will be right with you on this in just one moment. Right.

The CHAIRMAN. The increase from 440 to 500 is compared with the increase in personnel costs from $2,779,000 to $5,022,000, which is nearly a hundred percent increase in personnel costs, and a far smaller increase in the number of permanent employees.

I wonder if you could explain this?

Dr. SEAMANS. Yes, the buildup in 1963 from 136 to 440 I might point out ties in with the increasing responsibility at the Western Operations Office for contract administration on the west coast, particularly at the Downey plant of North American Aviation.

The buildup here occurred—I don't know what the actual lapse rate was in 1963 but quite naturally the 440 people were not available throughout the whole year.

The buildup was during the year, and consequently the cost per person appears low because the average number of people was actually somewhat less than the 440 figure, whereas in 1964, the buildup is much less, from 440 to 500, and consequently the average number for 1964 would be something of the order of 485 people, whereas in 1963—of course, somebody has that figure—but it must have been of the order of 300 people.

Mr. SIEPERT. It is the difference in lapse rate because of the buildup in the latter part of this year, and then you hit a more stabilized employment level in 1964.

The CHAIRMAN. Have you had a head count lately at the Western Operations Office?

Mr. CADLE. Yes.

The CHAIRMAN. How many people are actually——

Mr. CADLE. Two hundred and seventy-one, sir.

Mr. SIEPERT. We might make one comment for the committee on the North American plant. The North American Downey Plant is one of the few plants where the NASA business represents over 90 percent of the work in the plant, and there is a policy in this area that the agency, be it the Army, the Navy, the Air Force, or NASA, that has the predominant business, shall assume the responsibility of handling the in-plant contract administration services, and this takes quite a lot of people.

This is the reason I think we mentioned yesterday that the Department of Defense has 5,500 positions in its budget to handle this sort of thing in plants where they have cognizance as contrasted with NASA.

The CHAIRMAN. Do any members of the committee have any questions on the Western Operations Office?

I would like to proceed.

Chairman MILLER. Mr. Chairman.

The CHAIRMAN. Mr. Chairman.

Chairman MILLER. I have just done a little calculating here. Going back to 1962, you had 136 people and the personnel cost for salaries was $936,000, or an average of about $6,800 apiece.

Am I right?

Mr. WYATT. You would have to go back the previous year. In 1961 the number of people in the Western Operations Office was quite small, on the order of 70 or 80.

Chairman MILLER. I am not concerned with the increase, but I am concerned with the fact that the average salary was $6,800 per person, whereas in 1964 you anticipate the average pay for a person being $10,400.

Dr. SEAMANS. The confusion here is that the number of permanent employees is the end-of-year figure, not the average number of employees throughout the year.

Chairman MILLER. Of course I wasn't concerned, Doctor, with the number of employees, I was trying to reduce it to a unit, how much is each one of these people costing.

Mr. WYATT. Yes, sir, and the point that we would like to make is that you would have to look at what is the average number of employees during the year to get an average dollar cost salary.

Chairman MILLER. I was just looking at the figure here.

Mr. SIEPERT. Would it help if we computed the average man-year cost, the average salary cost for a man employed a full year in that situation?

Chairman MILLER. I think that would be helpful.

Mr. SIEPERT. That is the only way we can get a comparable problem on these differing lapse computations on the manpower.

The CHAIRMAN. I certainly think this strikes you immediately when you see these two figures.

Mr. ROUSH. Mr. Chairman.

The CHAIRMAN. Mr. Roush.

Mr. ROUSH. Using the average figures you drew out of the air of 300 for 1963 and 460 for 1964, we still have a difference of some $2,000 per man cost.

Now I realize that you pulled those figures out of the air and I think it would be helpful if we did have that.

Dr. SEAMANS. If you like, we can give you the backup figures on which these were calculated, and then you can see for yourself that the pay scale is not dramatically changing, even though the numbers might appear so.

Chairman MILLER. Personally, Mr. Chairman, I think this would be valuable because what I have done here is just what someone may do on the floor.

The CHAIRMAN. Precisely.

Chairman MILLER. And if we don't have the answer to it, it may be very embarrassing.

The CHAIRMAN. That is right. And this ties in also with the charts which we presented yesterday of the average salary and the average grade level, a comparison with other agencies.

(The information requested is as follows:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, WESTERN OPERATIONS OFFICE

Analysis of average salaries and personnel compensation

	Fiscal year 1962 actual [a]			Fiscal year 1963 estimate [a]			Fiscal year 1964 estimate [a]		
	Number of positions	Total salary	Average salary	Number of positions	Total salary	Average salary	Number of positions	Total salary	Average salary
Special positions established by the Administrator of the NASA (Public Law 87-793)	3	$50,545	$16,848	3	$54,044	$18,015	3	$54,044	$18,015
General schedule positions	133	1,112,210	8,362	437	3,952,956	9,046	497	4,655,956	9,368
Total permanent positions at annual pay rates	136	1,162,755	8,550	440	4,007,000	9,107	500	4,710,000	9,420
Deduct lapses:									
Savings from delays in filling vacancies and vacated positions at lower pay rates, leave without pay		−5,000		−2	−20,000		−3	−30,000	
Lapse savings in recruitment for new positions	−45	−405,000		−148	−1,555,000		−15	−160,000	
Net increase or decrease for change in pay scales					−32,000			+116,000	
Terminal leave payments		+2,940			+15,000			+20,000	
Total lapses (net deductions)	−45	−407,060		−150	−1,592,000		−18	−54,000	
Net permanent (man-years and net dollars)	91	755,695		290	2,415,000		482	4,656,000	
Other personnel compensation:									
Regular pay above 52-week base								37,000	
Overtime and holiday pay		43,542			75,000			75,000	
Payments to other agencies for reimbursable details		80,246			100,000			100,000	
Total personnel compensation (salaries) [1]		879,483			2,590,000			4,868,000	
Total personnel benefits (retirement, insurance, etc.)		56,517			189,000			354,000	
Total personnel compensation and benefits [2]		936,000			2,779,000			5,222,000	

[1] [2] Average salary computation:

	Fiscal year 1962 actual [a]			Fiscal year 1963 estimate [a]			Fiscal year 1964 estimate [a]		
	Costs	Man-years	Average salary	Costs	Man-years	Average salary	Costs	Man-years	Average salary
(1) Average salary—personnel compensation	$879,483	91	$9,665	$2,590,000	290	$8,931	$4,868,000	482	$10,100
(2) Average salary—personnel compensation and benefits	936,000	91	10,286	2,779,000	290	9,583	5,222,000	482	10,834

[a] Costs divided by man-years equals average salary.

NOTE.—Average salary in fiscal year 1963 lower due to higher lapse rate in higher grades.

This might be an opportunity in case you would care to make any further comment on these charts that we inserted into the record yesterday.

I wondered if you cared to make any further clarifying comments about the average salary or the average grade level of NASA employees, which appears to be much higher than any other Government agency.

Mr. SIEPERT. Mr. Chairman, I don't think we could make any useful comment right now until we actually see that chart and find out, in other words, what was divided into the total dollar figure.

It is my impression, though, that those average charts really are based upon counting the number of people in each grade, assuming a middle point in the grade or, say, the second step of the grade, and computing the salaries from it.

I will have to actually check those in more detail though before we are sure of that.

The CHAIRMAN. They are in the record of the hearing.

Mr. SIEPERT. Yes, we will have them when the transcript comes.

The CHAIRMAN. I think the most useful thing would be if, after analyzing the charts and the transcript and the prepared record, you would present a statement indicating your reaction and comments.

The CHAIRMAN. Mr. Boone.

Mr. BOONE. Would you include the 1964 numbers in that also, because, if you add the effect of the lapse rate, this figure is going to be quite high, I would think, so you want to be sure to explain that also.

Dr. SEAMANS. Yes, I indicated that we would for 1962, 1963, and 1964.

Mr. SIEPERT. Mr. Chairman, our personnel officer has given me one statistic that may relate to the question on the Western Operations Office, that is, is there an inflation in grades?

I have here information on NASA's overall average GS grade for total personnel, as contrasted with permanent GS grade averages shown in the budget, going back to 1958, and the end of 1958 the grade was 9.1. For each successive year, in 1959 it was 9.2, in 1960 it was 9.3. In 1961 it stayed at 9.3. According to this calculation, it is 9.2 in the last fiscal year we completed—that is 1962.

The CHAIRMAN. I think the major point that we were making, however, is not the plateau of grade as much as the fact that it was higher than comparable activities in the Atomic Energy Commission, the Department of Defense, and so forth.

Mr. SIEPERT. I appreciate what the chart showed. The earlier discussion was on the increase in the average salary of the Western Operations Office. It was only in that reference that I offered this material.

The CHAIRMAN. Thank you.

Mr. Boone.

Mr. BOONE. I think there was one point that was bothering the committee though, and that is with the new increase in salary levels, within grade, this certainly should not show a marked trend upward in the future.

Mr. WYATT. Well, there will be a further increase in January of 1964.

Mr. BOONE. Of salary, but not of grade.

Mr. WYATT. That is right.

Mr. BOONE. The grades would tend to go down, I would think, as the numbers increase. We will see what the numbers are.

The CHAIRMAN. If there are no further questions on personnel compensation, I would like to move on to personnel benefits, following the summary on sum 10.

Personnel benefits according to this chart have increased from fiscal years 1962 to 1964 from $11,375,557 to $20,981,000, which is an increase of approximately 90 percent, and an increase of only 50 percent in actual personnel during this period.

First, before you respond to this immediate question, Dr. Seamans, I wonder if you would indicate what is included in personnel benefits?

Dr. SEAMANS. I would like to have Mr. Siepert answer this question.

Mr. SIEPERT. The items included in our estimate on that are these that are defined by the Budget Bureau's personnel benefits: uniform allowances, living and quarters allowance, life insurance, health benefits, retirement, which, of course, is the biggest item in this, FICA, that is social security, and incentive awards are the items included in this category.

The CHAIRMAN. Would you care to comment now on the question of why the increase between 1962 and 1964 is so much larger in amount than the average increase in the personnel?

Mr. WYATT. The bulk of that increase is in the area of retirement contributions and follows the actual payroll.

In 1962, we had $9½ million of retirement contributions. That is estimated to rise in 1964 to $17,600,000, so there is an increase of $8 million just in the employees' share of the contributions over the Government's share of the retirement contribution.

Mr. SIEPERT. These are all computations based on definite criteria per man. That is, an employee of a given salary gets a certain contribution tied to his life insurance, so I think that these figures represent, let us say, actuarily determined figures, as well as any in the budget.

The reason the figures jump so high from one year to the next is again this is a function of the rapid buildup in staff, and we are back to that same problem we talked about earlier of lapse rates, and there are almost no lapses on these retirements and fringe benefits when people are on the full year.

The CHAIRMAN. Do any members of the committee have questions on personnel benefits?

Mr. DAVIS. Mr. Chairman, I would like to ask one question.

The CHAIRMAN. Mr. Davis.

Mr. DAVIS. Is this in line with what you would find in other agencies of the Government?.

Mr. SIEPERT. There is no option on our part. This is a matter of law.

Mr. DAVIS. Then it would conform exactly?

Mr. SIEPERT. Exactly, yes.

Mr. BOONE. The estimate, of course, is based on the projected 1964 figure, it is not based on some other formula for calculating personnel benefits?

Mr. WYATT. That is right.

The CHAIRMAN. Any further questions on personnel benefits?

If not, we will move on to "Travel and transportation of things."

Dr. Seamans, I am sure you are aware of this report of the Comptroller General of the United States reviewing relocation costs, which was submitted by the Comptroller General on February 19, 1963, to the Congress.

Without objection, I think we should put into the record the letter of transmittal by the Comptroller General. I will read one or two sentences of this letter:

> Enclosed is our report and review of relocation costs incurred by contractors with the Department of Defense and the National Aeronautics and Space Administration for the recruiting of salaried personnel who terminated employment shortly after they were hired.
>
> In a review conducted at 28 plants of 21 major aerospace contractors we found during a recent 12-month period over 1,400 newly hired individuals who have been relocated largely at the expense of the Government voluntarily terminated employment or were discharged for improper conduct before they completed a year's service. Only a small portion of the $892,000 incurred in relocating these short-term employes was recovered by the contractors.
>
> The Department of Defense and the National Aeronautics and Space Administration agree with our proposal that a review of the adequacy of the existing policy guidance was in order.

In short, the report indicates a number of examples where employees had been recruited and then had moved very quickly, had been given relocation allowances to move, and in many cases had moved as many as three or four times in a year, collecting relocation allowances for each of the moves.

(The letter of transmittal of the Comptroller General is as follows:)

COMPTROLLER GENERAL OF THE UNITED STATES,
Washington, February 19, 1963.

To the President of the Senate and the Speaker of the House of Representatives:

Enclosed is our report on review of relocation costs incurred by contractors with the Department of Defense and the National Aeronautics and Space Administration for the recruiting of salaried personnel who terminated employment shortly after they were hired.

In a review conducted at 28 plants of 21 major aerospace contractors, we found that, during a recent 12-month period, over 1,400 newly hired individuals who had been relocated, largely at the expense of the Government, voluntarily terminated employment or were discharged for improper conduct before they had completed a year's service. Only a small portion of the $892,000 incurred in relocating these short-term employees was recovered by the contractors. Our review disclosed further that some of these individuals were shifting between Government contractors at their own discretion and receiving relocation allowances for each move. For example, for various personal reasons, one engineer worked for three aerospace contractors within a period of 16 months and received reimbursement of about $2,700 for the expense of relocating to each contractor's plant. Such shifts indicate a basic need to discourage short tenures of employment, since they not only result in excessive relocation expenditures but also tend to disrupt important defense and space activities.

Under the terms of the contracts negotiated by the Department of Defense and the National Aeronautics and Space Administration with these companies, practically all of these costs, together with related profits, are ultimately borne by the Government. Inasmuch as the 21 companies included in our limited review incurred $892,000 for the relocation of employees who voluntarily terminated employment shortly after they were hired, we believe that the total cost incurred for such relocation expenses by all contractors engaged in defense and space programs amounts to many millions of dollars annually. However, neither the Department of Defense nor the National Aeronautics and Space Administration has issued any instructions requiring or suggesting that the contractors place restrictions on the payment of relocation allowances.

We noted that some contractors have adopted policies that tend to curb the undesirable shifting of personnel by requiring relocated employees to complete specific terms of employment, varying from 60 days to 1 year, before they are entitled to receive or retain relocation allowances. This requirement is similar

to that established for newly hired Federal employees by the act of July 5, 1960 (Public Law 86–587), which requires that such individuals reimburse the Government for relocation expenses in the event that they discontinue employment within a year after they are hired.

The majority of the contractors included in our review did not have policies requiring them to recover, nor did they attempt to recover, relocation allowances paid to newly hired employees, even though many of their employees voluntarily terminated employment within a short time after they were hired and, as shown in the report, some terminated with less than 30 days' service. In our opinion, such treatment of expenditures ultimately borne by the Government clearly establishes a definite need for an established policy, to be followed by all Government contractors, designed to discourage the unnecessary and temporary relocations at Government expense.

We invited comments on our findings from the 21 aerospace contractors covered in our review. Most of these companies advised that they were giving serious consideration to the adoption of a policy requiring recovery of relocation allowances from employees or that they had already adopted such a policy prior to our review.

The Department of Defense and the National Aeronautics and Space Administration agreed with our proposal that a review of the adequacy of existing policy guidance was in order. The Department of Defense stated further that the Armed Services Procurement Regulation Committee, in cooperation with the National Aeronautics and Space Administration, had commenced a study to review this matter and, in particular, to consider a length-of-service requirement as a condition to the allowability of relocation costs incident to recruitment. The Department of Defense said that we would be advised of the result of this study promptly upon its completion. We are recommending that in connection with this study consideration also be given to prohibiting reimbursement to contractors for relocation costs of employees who previously were employed by other defense contractors, unless the employees met the agreed length-of-service requirement or refunded any relocation costs previously paid.

Copies of this report are being sent to the President of the United States, the Secretary of Defense, the Secretaries of the Army, Navy, and Air Force, and the Administrator of the National Aeronautics and Space Administration.

JOSEPH CAMPBELL,
Comptroller General of the United States.

The CHAIRMAN. I wonder if you would comment generally on the problem, Dr. Seamans, perhaps directing your remarks specifically to the Comptroller General's report and, thirdly, indicate the steps that are being taken or should be taken by NASA in order to correct this situation?

Dr. SEAMANS. Yes.

Well, first let me say I have not seen the report. I know that our procurement people have received it and are reviewing it. This is a matter that is of concern both to us in our relations with industry, as well as within NASA. We have had to review this very carefully in connection with, for example, the Space Task Group when it moved down to establish a new center in Houston, and in that particular case we were really not able to defray all of the expenses of our employees in such a move.

In the case of our contractors, this is a matter that receives very careful scrutiny at the time we carry out contract negotiations.

Examples of this involve contractors moving into Michaud plant in New Orleans or moving down to Cape Canaveral, and the question is what part of the cost should the Government defray, what part of the cost should involve corporate funds.

The corporations obviously have to come to terms with their own employees in making such a move and come up with an arrangement that is satisfactory and financially reasonable to those that are needed in these kinds of locations, so this is a kind of problem that I am familiar with in the kind of specific cases that I have mentioned.

I think it might be well at this point to have somebody who is familiar with this particular report comment. Are you prepared, Mr. Siepert?

Mr. SIEPERT. We have Mr. Vecchietti, who is our Deputy Director of Procurement, and he has the GAO report with him.

I might say that the question that you gave us here is, has this been a problem in NASA. It is a problem with any agency that deals heavily with indust[illegible] under circumstances which in the public interest may require the contractor to locate personnel away from their home plant.

This is a problem, particularly at Michoud, which, you recognize, is a Government-owned plant, in which the contractors who won the awards to build things there were not located in that area and they had to move substantial numbers of personnel of their own organization.

The CHAIRMAN. This is certainly a problem which we recognize.

Mr. SIEPERT. Yes.

The CHAIRMAN. What we are trying to prevent is the Government paying the tab for these bounty collectors who make a custom and profession of collecting for moving frequently.

Mr. SIEPERT. There are two problems in this area. One is the itinerant employee who sees the world at somebody else's expense, and Mr. Vecchietti I think can comment on what we would propose to do to control that.

The other is the question of how much of the total dislocation cost does the Government pay, and we have had a study going on in this area in an effort to try to write a regulation which would make clear that the Government does propose to deal with a contractor in terms of the company's policy if we can establish that the company's policy was not set up expressly in order to inflate the Government's costs.

In other words, if they have an established Government policy that they move people on corporate funds in the same way, we have a hard time saying we should make them have a different policy.

The basic criteria under which these negotiations are worked out with the contractor are the simple one which says we will allow all costs which are reasonable.

Now this is a judgment factor as to what is reasonable. I think you may want some further word from Mr. Vecchietti.

The CHAIRMAN. Mr. Roush.

Mr. ROUSH. Before we go on with Mr. Vecchietti, Mr. Siepert, in your letter dated December 13, to the General Accounting Office, you state that you must take issue with the statement that:

> The policies of the Department of Defense and the National Aeronautics and Space Administration with respect to recruiting practices neither require nor suggest that the contractors attempt to control relocation expenses.

Then the reference is made to ASPR 15–205–46(e) incorporated in NASA Management Manual, by reference requires that the contractors control these costs by specifying that such costs are allowable only if necessary and reasonable.

> A further control is inherent in reference to these costs as among those on which advance agreements may be particularly important.

You don't take the stand, do you, that you cannot control these costs with your contractors? Is this what you are saying in this statement?

Mr. SIEPERT. No; our position is that we do intend to negotiate with the company exactly what relocation costs the Government will pay, based upon a consideration of what is their established company policy, matched against a regulation which we will issue, stating the general areas in which we will consider things reasonable and certain areas where we will consider the relocation costs unreasonable. We will have a regulation that will be our test.

Mr. ROUSH. Well, if there has been an abuse of this policy, you could, by negotiation with the contractor then impose upon them more stringent regulations which would control this relocation cost, at least control it to the extent that we would avoid some of the waste pointed out by the General Accounting Office.

Mr. SIEPERT. Where it has been established in a particular contractor's case that there had been an abuse; yes.

Mr. ROUSH. Why couldn't you do it generally before the abuse occurs?

Mr. SIEPERT. Well, this is what we are attempting to do, by issuing a regulation and by getting this kind of question specifically understood between the parties at the time that we definitize a contract.

Mr. ROUSH. Well, how long will it be before you come to the place where you will do this?

Mr. SIEPERT. I think this is momentarily, and I think Mr. Vecchietti can give you that.

The CHAIRMAN. If Mr. Vecchietti would come forward, I might suggest that it would be helpful to put Mr. Siepert's letter in the record also, that is the letter of December 13, 1962.

(The letter referred to, is as follows:)

DECEMBER 13, 1962.

Mr. L. K. GERHARDT,
Associate Director, General Accounting Office,
Washington, D.C.

DEAR MR. GERHARDT: The General Accounting Office draft audit report on relocation expenses incurred by contractors with the Department of Defense and the National Aeronautics and Space Administration for recruitment of salaried employees has been reviewed at NASA headquarters and at NASA field installations.

We appreciate having been afforded the opportunity to review the draft report and agree that the area selected is a proper one for concern but must take issue with the statement that "* * * the policies of the Department of Defense and the National Aeronautics and Space Administration with respect to recruiting practices neither require nor suggest that the contractors attempt to control relocation expenses.* * *" ASPR 15-205-46(e) (incorporated in the NASA Management Manual by reference) requires that contractors control these costs by specifying that such costs are allowable only if necessary and reasonable. A further control is inherent in the reference to these costs as among those on which advance agreements may be particularly important.

Additional control may well be appropriate provided such control is not so restrictive as to impede personnel movements which are beneficial if not essential to the space effort. The NASA and the DOD are jointly exploring the possibility of developing additional policy guidance and you may be assured that such explorations will give full recognition to the observations contained in your draft report.

Sincerely yours,

ALBERT F. SIEPERT,
Director of Administration.

The CHAIRMAN. Mr. Vecchietti, I wonder if you would give the reporter and the committee your full name?

Mr. VECCHIETTI. George Vecchietti, Deputy Director, Procurement and Supply Division.

I think a very brief background on the principle involved here might be helpful, and then I will speak to the GAO report.

The matter involved here is one of what is known as contract cost principles. We operate, of course, under the Armed Services Procurement Act, as does the Department of Defense, for our procurement authority.

In this area of contract cost principles there are uniform—which is unusual—uniform Governmentwide regulations on the subject, so that at least the basic rules are similar or identical for the Government. Their application may vary.

In the cost principles there is a provision that states that the costs of relocation expenses are allowable to the extent, of course, that they are reasonable and allocable to the contract involved.

The CHAIRMAN. "Where necessary," is also in here.

Mr. VECCHIETTI. Yes, where necessary to the performance of the contract, of course.

This is the general rule, and I believe that is what Mr. Siepert's letter attempted to explain, that there was not actually a void in the area of a cost principle or guidance as to how you applied relocation expense allowability.

At the same time, the GAO made two very valid points, the second one, I believe, is the most important, and it is the one that we are going to correct very quickly.

The first point was a statement to the general effect that relocation costs were not really being controlled, that is, their substance, what went into the makeup of relocation expenses.

The second point was as to employees who got paid relocation expenses for a transfer of assignment but who later within a very short period of time either voluntarily or through discharge left the area, even though the Government had paid for their relocation expenses to the area.

The GAO suggested very strongly that some effort be made in the regulations to govern this type of practice, and, to the extent that there are regulations there should be written guidance on this subject of jumping immediately after assignment to a new position.

We have here a draft, forwarded, I believe, by a memorandum of February 19 from the Comptroller General, and we have in its final stages a proposed regulation on the subject.

In essence, what this will do is provide (1) that where it is practicable—and this will be the general rule in most situations where there are sizable relocation expenses—that there will be an advance understanding between the contractor and the Government as to what constitutes relocation expenses and how much money will be involved per employee, the types of things that make up these expenses, such as moving, sale of home, brokerage fees, many of which we do not allow as a general policy. These are things that will be established prior to entering into the contract and will become a part of the contract by reference.

We will also have a policy in this regulation as we now contemplate it (and the reason I put it that way is that we are working with the

Department of Defense in an effort to come up with a uniform application of this policy) to the effect that if an employee who has been paid relocation expenses terminates his employment within 1 year either voluntarily or by discharge for cause, in such a situation the Government would be reimbursed the relocation expenses which it had allowed under the contract.

Mr. SIEPERT. By whom, the company?

Mr. VECCHIETTI. By the company, yes.

Mr. SIEPERT. This is a corporate risk for bad selection.

The CHAIRMAN. Yes. Well, that certainly sounds like a step in the right direction.

Mr. VECCHIETTI. And timewise, we believe, and I will be conservative, we should have this out in less than a month, hopefully within a week or two. We are in our final stages on this.

The CHAIRMAN. I wonder if members of the committee have any questions on this area of relocation costs?

Mr. RYAN. Would you give us an example of how this comes into play; in other words, why cannot the potential relocation costs be taken into consideration at the time the contract is written, at the time you negotiate or are dealing with a competitive contract?

In other words, you speak of Michoud bringing in people from a long distance, isn't this a factor in the contract?

Mr. VECCHIETTI. Yes, this is an advance undertsanding, this is part of the overhead. When it is a specific move solely for our benefit, solely for our contract, it would become a direct item of cost.

We do negotiate with the contract, or on these expenses. It is on occasion quite a negotiation; and, as Dr. Seamans indicated, we sometimes have to go to top management to determine the precise makeup of what goes into these costs. They then do become a part of the contract.

The thing that is missing, or has been missing, is a control on reimbursements when the employee departs shortly after he has been paid his relocation expenses. We now will cover this so that the Government will recover any relocation expenses it has paid in such situations.

The CHAIRMAN. Any further comment?

Mr. Boone.

Mr. BOONE. Does this mean that an employee working for two different companies, making the same route, could be reimbursed different amounts? Is that what you meant by standardization, to be sure that he would be paid the same amounts, or is this subject to negotiation at the time of the contract?

Mr. VECCHIETTI. I have never seen a situation where there is one employee working for two contractors, if I understood you correctly.

Mr. BOONE. I meant two different employees.

Mr. VECCHIETTI. They will not be identical reimbursements. As Dr. Seamans pointed out, it must be an established company policy, and this will be in our regulations, and it must be in existence prior to our entering into the contract. This is to prevent a company from instituting a fine set of rules that will reimburse their employees upon the receipt of a contract from the Government.

We do look at those and they are always subject to the test of reasonableness. We do not automatically accept all elements of the costs. For example, some companies would like to reimburse their employees for membership in a golf course or country club at the new

location, or lawyer's fees in the selling of a house. We have a test of what is allowable in the way of moving expenses.

We generally try to apply, but we do not use a hard-and-fast rule, the type of guidelines that we use for our own Government employees, and as you can understand, of course, that varies, depending on the category of employee involved.

Mr. BOONE. There is some leeway within the company, depending upon company policy then?

Mr. VECCHIETTI. Yes.

Mr. BOONE. May I ask, do you pay the income tax overhead?

Mr. VECCHIETTI. No, sir.

Mr. BOONE. Thank you.

The CHAIRMAN. Mr. Davis.

Mr. DAVIS. I would like to ask this question: Suppose the contract is of a temporary nature or of short duration and it involves the movement of a person to some place such as Fairbanks, Alaska, and return. Does your compensation or negotiation include the round trip?

Mr. VECCHIETTI. As a general rule, no, and again you have to apply the specific circumstance. Let me give you the general rule, if I may, sir.

Mr. DAVIS. All right.

Mr. VECCHIETTI. Our general rule is that we allow in the contract that we are writing the relocation expenses to the site of where our contract would be performed, but we do not then pay for what is termed "re-relocation" costs back to the home plant or perhaps to a new contract. Generally what is known as the gaining contract, since there probably would be a movement to another contract, would cover the return relocation expense.

However, in the specific case that you gave us, it may well be that if we have need for a man at an isolated location, knowing that it will be for a very short time, it is the subject of negotiation between ourselves and the company to determine whether or not it is something that should be reimbursed, and then to what extent. It may be partially reimbursed sharing between the company and the Government. If part of the inducement is to get them to a very remote—and this has happened—location, it may be negotiated that he be reimbursed for his return. Knowing that he is going to Alaska or some other similar location, we would probably make an arrangement whereby we would reimburse for part of that return trip, but that is when we know it in advance.

Mr. DAVIS. I see.

Dr. SEAMANS. I might add, if I might, just one point.

When we start talking about remote sites and the operation of, for example, our tracking stations around the world, we have recently in our negotiations with the Bendix Corp., which operates some of these stations for us, included the provision that if at any time we should terminate their contract and go to a new contractor that the new contractor will have the opportunity of hiring their personnel. If that should happen these personnel will have the same benefits transferred over to them in the new corporation, so that we would not then incur the cost of bringing new people out to the site and so that we can—even more important—keep the competent people on the job in order to keep proficiency up at each one of these locations.

The CHAIRMAN. Mr. Siepert, I gather your conclusion would be

then that the Armed Services Procurement Regulation certainly doesn't have enough teeth and deserves to be "beefed up" and strengthened, and you go beyond the feeling you expressed in your letter of December 13 in terms of strengthening this regulation over relocation costs?

Mr. SIEPERT. Yes; I think GAO uncovered a problem that was not apparent to the people that over the years developed ASPR. This regulation is an effort to plug those fine gaps.

The CHAIRMAN. Would anybody care to make a prediction as to the future of this policy regulation, when it is likely to be approved and come to light?

Dr. SEAMANS. As far as NASA is concerned we will follow the same procedure that we do on all of our management procedures. This will come in short order to my office, and it is obviously a desirable and sensible regulation, and we will put it immediately into effect.

The CHAIRMAN. The committee would like to have a copy immediately as soon as it is adopted, and I hope that it is adopted before the authorization bill gets on the floor.

Circular No. 279
April 8, 1963

NASA MANAGEMENT MANUAL

MATERIAL TRANSMITTED

1. This Circular sets forth policies and guidelines relative to establishing the allowability and the reasonableness of relocation expenses incurred by contractors in connection with NASA contracts and subcontracts. The intent of this Circular is to provide specific guidelines for the control of these costs within reasonable limits while maintaining sufficient flexibility to ensure that cost restrictions do not impede essential personnel movements.

2. The provisions of this Circular are mandatory to be effective May 1, 1963, but may be implemented upon receipt.

FILING INSTRUCTIONS

1. This Circular should be filed in Chapter 18, Part 15, Subpart 2, following page 1504.

RELOCATION EXPENSES INCURRED BY CONTRACTORS IN CONNECTION WITH NASA CONTRACTS AND SUBCONTRACTS

1. Purpose

This Circular sets forth policies and guidelines relative to establishing the allowability and the reasonableness of relocation expenses incurred by contractors in connection with NASA contracts and subcontracts. The intent of this Circular is to provide specific guidelines for the control of these costs within reasonable limits while maintaining sufficient flexibility to ensure that cost restrictions do not impede essential personnel movements.

2. Applicability

This Circular is applicable to NASA Headquarters and Field Installations.

3. Background

a. The increasing magnitude of relocation expenses for which contractors in the space industry claim reimbursement under their Government contracts warrants careful consideration of the manner in which these costs are generated. Such costs may be justified as necessary to defray extraordinary expenses incurred by employees in connection with personnel movements, and to offset the genuine discomfiture and disruption attendant to relocation.

b. Lacking the competitive restraints characteristic of industries governed by a greater degree of price competition, some contractors doing business exclusively or predominantly with the Government have tended to expand the scope and the magnitude of these payments. Such payments tend to heighten competition for technical personnel to the possible detriment of the space effort. The impact is

economywide since even firms which are exclusively commercial, but have a need for special technical skills, may be compelled to match or exceed these payments with a resultant cost/price spiral.

4. Policy

a. Relocation expenses are allowable as an indirect charge, to the extent allocable and reasonable, when they derive from management operations on Government contracts. Under certain circumstances, these costs may be recognized as a direct charge, for example, when specifically related to the performance under a NASA contract and such procedure is consistent with the contractor's normal accounting treatment of such costs and with generally accepted accounting principles.

b. Generally, the application of such costs to NASA contracts should be pursuant to an established policy which specifies the particular expenses to be allowed and provides for consistent treatment of all company employees but recognizes that expenses may reasonably differ among the various levels of employees. The company should have adequate internal controls to assure compliance with its policy. Exclusions and limitations are set forth in paragraph 5.

c. NASA recognizes the propriety of such costs only to the extent that they represent reimbursement for costs directly and commonly associated with relocation. NASA does not recognize the allowability of such costs:

(1) As an additional form of compensation, or

(2) As reimbursement for purely personal expenses incurred for an employee's own pleasure, or convenience; or

(3) For improving his living standards.

Increases in basic compensation which may be collateral to relocation should be scrutinized to determine whether such increases represent an attempt to circumvent relocation cost restrictions.

d. The wide diversity of these costs and the difficulties involved in determining their reasonableness render them particularly susceptible to advance understandings. It is anticipated that such advance understandings will generally be of two types:

(1) An agreement setting forth the extent to which NASA will recognize costs under contractor's general relocation policies, or

(2) An agreement governing the allowability of costs which result from mass movements or special requirements in connection with a particular contract.

All proposed advance understandings will be submitted to the Director, Procurement and Supply Division, NASA Headquarters, for approval in order to ensure consistency of approach among the NASA installations.

e. No specific format is prescribed for the execution of an advance understanding. However, such understanding should include, but not necessarily be limited to—

(1) An enumeration of those categories of expenses which will be recognized as allowable as well as those to be disallowed;

(2) Dollar limitations for each category of expense or, in lieu thereof, limitations which have the indirect effect of establishing dollar ceilings;

(3) Reference to a procedure for approving expenses and for validation of expenses incurred;

(4) A listing of the categories of employees to whom the policy is to be applicable; and

(5) An indication as to whether the expense is to be a direct charge to a contract or an indirect charge.

f. Contractors should be expected to tap the personnel resources of the area in which the work is being performed to the fullest extent feasible consistent with the company's overall personnel policy and to the extent that contractual performance will not thereby be adversely affected.

5. Guidelines

a. Employee relocation expenses, as used herein, refer to those expenses associated with a permanent change of duty assignment (the normal industry tendency is to treat all new assignments in excess of 12-months duration as permanent changes) whether incurred in conjunction with the transfer of existing employees or the movement of new hires. Retransfer costs are unallowable (i.e., a NASA contract should not normally bear both the cost of transferring an employee to a new location and the cost of returning an employee to his "home" site or some other gaining activity) although it is recognized that special circumstances; e.g., an abrupt termination, may justify acceptance of some portion of the costs associated with retransfer.

b. The allocation of relocation costs to NASA contracts should be consistent with the contractor's normal accounting treatment of such costs. Generally, such costs should be charged to overhead since it is reasonable to assume that employees involved in the move will continue in the company's employ and since such moves are basic to the company's overall operations. Under special circumstances; e.g., mass movements at the specific request of the NASA, a direct charge to the particular NASA contract(s) may be appropriate. These circumstances should normally be the subject of an advance understanding and will necessitate the screening of the contractor's overhead pool to preclude a duplication of like charges. When items ordinarily chargeable as indirect costs are charged to Government work as direct costs, the cost of like items applicable to other work of the contractor must be eliminated from indirect costs allocated to Government work.

c. Company policies, though subject to wide variation, generally provide for payment of expenses which may be categorized as premoving, moving, postmoving and dislocation expenses which do not readily fit into any of these categories as follows:

(1) *Premoving* expenditures may include such items as:

(a) Visits by the employee and his spouse to seek new quarters prior to the moving date and associated incidental expenses (e.g., babysitters, care of house pets, phone calls);

(b) Establishment of temporary quarters prior to effecting a permanent move;

(c) Visits and calls home where an employee reports alone prior to moving other members of the household;

(d) Expenses incident to disposition of housing, such as costs of canceling an unexpired lease, brokerage and legal fees, etc., and the loss that may result from the price at which the home is sold.

Costs incident to items (a) and (b) are considered allowable. Costs incident to item (c) are normally unallowable but exceptions may be recognized in special circumstances (e.g., unreasonably long separations and the established company policy provides for them). Costs incident to item (d) are unallowable.

(2) *Moving* expenditures may include transportation of employee and members of the household (including house pets), meals and lodging en route to the new location, packing, transportation of household and other effects, storage, and insurance. Such costs are allowable to the extent they are reasonable and allocable.

(3) *Postmoving* expenditures may include:

(a) Losses incurred on theft or damage during move;

(b) Closing costs on purchase of new home;

(c) Automobile owner's expense such as registration and other expenses incurred by transfer to a new location.

Costs incident to item (a) are allowable if not covered by the carrier's insurance. Costs incident to item (b) are unallowable. Costs incident to item (c) are allowable.

(4) *Dislocation* expenses may include:

(a) Removing carpets and drapes at the previous location and reinstalling at the new location,

(b) Disconnecting and reconnecting appliances and television,

(c) Prepaid fees on unexpired medical and dental plans, food locker contracts, and other miscellaneous but normal out-of-pocket expenses.

These expenses, exclusive of cleaning carpets or drapes, are considered allowable to the extent they are reasonable and are incurred by existing employees.

d. Evaluation of the proposed application of a given company plan may result in the delineation of three questionable categories of expenses:

(1) Those which are clearly unallowable;

(2) Those which may be normally allowable but are not appropriate for reimbursement under the specific circumstances; and

(3) Those considered allowable but where the degree or extent of reimbursement claimed may be excessive.

e. Such an evaluation may indicate the desirability of establishing a ceiling to limit the amount of expenses in each category which will be reimbursed to the contractor. Those items of expense determined to be allowable will be reimbursed on the basis of actual expenses incurred up to the ceiling limitation.

f. Contractors will be required to refund payments made by the Government in reimbursement for employee relocation costs if employment is terminated

voluntarily by the employee or by virtue of discharge for cause within 12 months after appointment or transfer.

6. Effective date

The provisions of this Circular are mandatory to be effective May 1, 1963, but may be implemented upon receipt.

ROBERT C. SEAMANS, Jr.,
Associate Administrator.

Any further comments on relocation cost?

Travel and transportation of persons: Very quickly we can move on with this question.

Increases in actual personnel over last year amount to about 11 percent. However, travel funds requests increased about 30 percent.

Is there any explanation that you could give us on this, Dr. Seamans?

Dr. SEAMANS. Yes. As the breakdown on page 21–1 shows and the discussion on the following page indicates, there are a variety of reasons for travel.

Part is the necessity for management of our internal affairs, and it indicates here that we need funds of approximately $4.8 million for direction and coordination of program and business activities, and by "business" is meant administrative activities.

These are in-house matters relating both to the conduct of our projects as well as to the proper review of all kinds of policies, as, for example, the one we have just discussed here, personnel matters, security, and so on.

The next item involves a coordination with other Government agencies, and with our contractors in the scientific community, and this shows an increase to $7.2 million. This, of course, reflects the very large percentage increase in our R. & D. where our total research and development is increasing by 55 percent.

The largest percentage of this is on contract to industry, in part through other Government agencies and in part direct to various contractors, and we must have travel funds so that our personnel can review at proper intervals the activities on such programs as the Apollo, and the Saturn, and this does take a large number of people.

When the Marshall Center reviews, as they do periodically, the performance on the various big booster stages, they take a team of people who are familiar with all of the different disciplines and aspects of that development to the contractor's plant and spend 3 or 4 days there and go over the program with a fine-tooth comb.

That is the largest single item in our travel budget and it is an extremely important one if we are to properly manage this expanding program.

The next item relates to the operation of our launching sites and global tracking stations in the amount of approximately $3.7 million. Again this is increasing by virtue of not only the increased number of stations around the world, but also the stations themselves are getting more complex.

We are converting the Mercury stations to Gemini and Apollo operations. They will take increased personnel as well as equipment at each of these stations to do the job for the more complicated maneuvering missions of the Gemini and the Apollo.

The remaining items relate to NASA's responsibility on various technical committees, working panels and technical and scientific societies, at a level of $1.7 million.

Here NASA is responsible to carry out various scientific and technological programs and to make this available, and one of the ways of making it available in the country at large is to have our people participate in various seminars and discussions and professional meetings.

Finally we have travel to initial duty station. We are recruiting people, this takes $1 million approximately, or is projected to take $1 million in 1964.

We have the travel of our consultants to headquarters and to our various centers and to our contractor plants. We have a charter of aircraft at a level of $1.4 million and a miscellaneous item of $470,000 for all other travel of our employees.

The CHAIRMAN. I think perhaps you got an inkling from the earlier discussion of the committee about some of the feelings of the committee toward decentralizing operations. Perhaps we could make a little private deal with you if you will continue to decentralize we will try to get you a little more money for travel.

Are there any questions that members of the committee have on travel?

Mr. WYDLER. Yes, Mr. Chairman, if I might.

Do I understand these figures for travel are figures that relate to purchase of airplane tickets, would this cover nearly all of these figures?

Mr. WYATT. Yes, sir; this would be included in this figure, passenger travel of people.

Mr. WYDLER. I mean most of these things, as I would read them they would be airplane flights, wouldn't they, that you have just mentioned, tickets of airlines?

Dr. SEAMANS. Yes; somebody takes a trip from headquarters, they have a per diem, they have obviously transportation to and fro primarily by air, miscellaneous expenses, a taxi, and so on, are all included in this category.

Mr. WYDLER. All of those items are in this item that you just read, is that correct?

Mr. SIEPERT. $16 per day, the per diem.

Mr. WYATT. Yes; on OC 21–2 are some other charges that go against this account that are not within the travel limitation, local transportation and toll charges, that is around an area such as Washington, or around an area such as Houston where you have a dozen or so different sites and employees have to move around between those sites. You pay their transportation when it is required.

Mr. WYDLER. That includes per diem then in these figures?

Mr. WYATT. The per diem is included over on the first page, under the $20.6 million. This is both travel and per diem.

Now on page 21–2, I don't believe there would be any per diem charges here.

Mr. WYDLER. I am talking about 21–1.

Mr. WYATT. Yes; that would include per diem charges.

Mr. WYDLER. Do you use armed services planes for any of this oversea travel, MATS?

Mr. CADLE. Well, it depends. I can give you a general answer, I can't give you the actual statistics on it, but generally speaking——

Mr. WYDLER. Well, I just asked do you

Mr. CADLE. Yes; on occasion we do, but it depends on the area. In other words, if it is going to, say, a European site, for example,

they are working now on tracking facilities in southern Europe, these are on regular commercial flights.

If you are going into an area where you have definite problems but where there are no commercial flights available and there are military transports going, we go by the military transport, parts of Africa, for example.

Mr. WYDLER. Is there any charge made or credit taken for those flights?

Mr. CADLE. I am not positive of that.

Do you know, George, whether we reimburse on those flights?

Yes; we do reimburse them from the military transport.

Mr. WYDLER. Now just one last question: On Electronics Research Center you show about $125,000 projected for travel next year. That would be about a thousand dollars a person up there. Is that normal for traveling?

Mr. WYATT. Yes, sir; I can give you some examples of what do constitute normal travel.

For example, at the Goddard Space Flight Center, the people average a trip that is relatively long, 10 days on the average, this is because they have the tracking responsibility. The average cost per trip has been about $310 and it is expected to go up to about $370 in 1964 because of different distances and different lengths of time. They expect in that case to increase the number of trips in 1964 over 1963 by about a thousand total trips.

Mr. WYDLER. In other words, you have a figure as to what the average figure per person is?

Mr. WYATT. Yes; in each center, we know what the average cost—

Mr. WYDLER. What is it?

Mr. WYATT. Well, in headquarters, the average cost per trip is about $230.

Mr. WYDLER. Per trip. I mean per year.

Dr. SEAMANS. Per employee.

Mr. WYDLER. Per employee per year.

Mr. CADLE. Perhaps the best way to answer this would be to get into a little discussion in terms of the percentage of people at each location who do travel.

For example, at the headquarters in the last fiscal year we had a travel percentage of 56 percent. That is, 56 percent of the people at headquarters traveled, and this reflects the kind of operation that it is, a coordination, direction type of responsibility.

Goddard, which has heavy responsibility in the project area, in tracking and data acquisition for example, 62 percent of their people in 1962 traveled, 56 percent in 1963 are projected as traveling, and 50 percent in 1964.

These are some of the examples:

Take a research center such as Langley, which is well established, which has its line of communications out. They had 34 percent of their people traveling in 1962.

In the case of ERC, you are looking at 250 people and $125,000, roughly $500 per man, but you have to remember that this is an installation which is setting up, which is getting its lines of communication established, which is going to have to do a good deal of travel to our other centers which are involved in the electronics area in order to get their responsibilities and lines of communication worked out.

Mr. WYDLER. I thought we had located this center in an area where they would have very little of this.

Mr. CADLE. They are going to have a heavy coordination role. There is a capability, Collins, for example, out in Iowa. There are many areas in the country which have heavy electronics capability, and this center is not going to be working only with the Boston electronics firms, it is going to be working with all of the firms.

The CHAIRMAN. I might say, Mr. Wydler, I have just come on some statistics prepared by Legislative Reference Service, particularly by Mr. Wise, listing average travel expenditure per employee, and under these figures prepared by Legislative Reference, 1962 actual, $456 per employee in NASA, 1963 estimated, $618, 1964 estimated, $662.

Mr. CADLE. This is if you take the total employees and divide it into the total number of dollars.

The CHAIRMAN. Yes.

Mr. CADLE. A more accurate way would be to take the total number actually traveling in each center and divide it into the total dollars.

The CHAIRMAN. I think that makes sense.

Mr. CADLE. We have all of these statistics here if you would like them.

The CHAIRMAN. Yes, they would be helpful to put them in the record I believe.

Mr. CADLE. Fine.

Mr. WYDLER. That is all I have, Mr. Chairman.

(The information is as follows:)

For locations with travel amounts over $1 million; (1) the number of people traveling, (2) the average this represents compared with total personnel at each location, (3) the average number of trips per traveler, and (4) the average cost per trip requiring 87 percent of the travel are as follows:

	Personnel traveling			Average of total personnel traveling		
	1962 (actual)	1963 (estimate)	1964 (estimate)	1962 (actual)	1963 (estimate)	1964 (estimate)
				Percent	*Percent*	*Percent*
Headquarters	760	1,200	1,400	56	63	61
Goddard	1,485	1,800	2,200	62	56	60
Langley	1,264	1,437	1,800	34	36	42
LOC	[1] 333	503	500	[1] 100	63	42
MSC	812	1,450	1,975	50	45	50
MSFC	2,441	2,920	3,433	40	41	46
	Average number trips per traveler			Average cost per trip		
	1962 (actual)	1963 (estimate)	1964 (estimate)	1962 (actual)	1963 (estimate)	1964 (estimate)
Headquarters	9	8	8	$146	$236	$240
Goddard	4	4	4	231	311	370
Langley	6	6	6	87	116	150
LOC	5	6	6	[1] 48	183	239
MSC	6	8	8	290	286	294
MSFC	6	6	7	147	164	183

[1] This is the total number of people that actually were placed on LOC's payroll when they were established. All of these people traveled back and forth to Marshall on the shuttle plane with only per diem, which accounts for the low cost per trip of $48.

The CHAIRMAN. Last year this committee reviewed at some length the use of coach fares and other reduced fare policies of NASA, and at that time we were told that several contractors such as Boeing and North American and Chrysler had established a policy of using reduced travel fares.

I wonder to what extent this is being done, and are there any indications of savings which have resulted, and have other contractors been told to initiate such policies?

Dr. SEAMANS. We do have a strict policy within NASA to fly tourist or economy whenever it is available. There is an exception that we make, if a person is on the west coast and is flying overnight and has a heavy schedule the next day, we have a provision for coming back first class.

The CHAIRMAN. You don't want him all tired out when he gets back.

Dr. SEAMANS. That is the idea of that clause.

Now as to the actual effect of this regulation, I would like to have Mr. Siepert comment.

The CHAIRMAN. Mr. Siepert.

Mr. SIEPERT. This is the kind of thing that you have to keep plugging at recurrently. Most recently with respect to our own personnel on February 25, we sent out instructions again to all of our folks reminding them of just what the policy was, and in this situation actually at this time setting up a better reporting procedure in which we would be able to get better standards of how well our employees were in fact resorting to economy transportation.

I have, for example, our air travel report for January 1963, which shows that our agency totally made 4,282 trips by plane during that period of time.

We made 1,807 of them by economy class, 1,370 by mixed class, and by this mixed class we mean a mixed mode of transportation. To get to a point part of the way you might travel by coach and then, as you know, all of the feeder airlines are first-class accommodations and not coach, so that you might finish the trip by first class.

There were, however, a total of 1,105 which were first class, and then the question comes how many of those were necessary first class as opposed to the others.

We find that on 710 of those there was no economy class available on that schedule between the two points. Particularly you will find this in a place like Huntsville, Ala. If any of you have been there, first class is the only service out of Huntsville.

In 141 cases we found that the economy class was not available at the time that the reservation was made, in other words they were sold out.

There were 254 cases, however, where so far as we can tell the employee went first class and there was not an apparent reason why he went first class.

Now that we have defined what the problem area is and we have a reporting system to follow up on it, we believe we can go back to the centers and get this total down. I think it represents quite satisfactory progress.

Mr. CADLE. We have found, I might add, that on these cases where first-class transportation was used where other classes were available, that a large number of these were in trips where they did

exceed the time limitation, a night flight, for example, where economy class was available, but in order to have the man ready for the next day's work he traveled first class.

The CHAIRMAN. Can you give me any idea as to the trend here, how does this compare through the years? Are you getting better?

Mr. SIEPERT. This is a favorable trend as far as our agency is concerned, and it is a favorable trend as the Budget Bureau would regard it. I was trying to find their figures. I think they were expecting to find better than 50-percent utilization of economy coach, and we are well above that.

The CHAIRMAN. Now what about your contractors?

Mr. SIEPERT. Well, the contractor problem is, again—we have sent letters I believe on two occasions to the contractors. A number of the contractors in response to our request have acknowledged our request, sent us copies of their policy. However, I can't say that we have statistics of a sort that I am comfortable in reporting to you how well we are doing as contrasted with our internal personnel. We have only spot information on this.

The CHAIRMAN. Any other questions on this immediate issue? Mr. Roush.

Mr. ROUSH. Would you give us the total amount which was requested from the various segments of your organization for travel as compared to the amount that you finally included in your budget request?

Mr. SIEPERT. I didn't hear the first part of the question.

Dr. SEAMANS. The question is whether we have available the travel requests for fiscal year 1964 from the installations?

Mr. ROUSH. Yes.

Dr. SEAMANS. Do we have that information?

Mr. ROUSH. I am merely asking did you cut it down.

Dr. SEAMANS. I am sure we did, but I am not sure that we have the numbers right here.

Mr. ROUSH. Could you provide that for the record?

Mr. CADLE. I have to pull this number out of my head, but I believe the total requested was about $27 million.

Dr. SEAMANS. As compared to the 22 figure.

Mr. ROUSH. That is all, Mr. Chairman.

Mr. BOONE. I have a question.

I believe the Defense Department has a policy of coach type travel and they make an exception for first-class travel, and it seems your policy is just the reverse, is that correct, you have a policy of first-class travel and——

Dr. SEAMANS. No, we certainly don't. We have a policy of tourist or economy as the general rule, and the first class is always the exception. It is the exception when it is the only way to get there because it is the only kind of transportation available, or for the very special case where somebody has to be on tap early in the morning and has to fly all night, we feel it is the part of good sense to have that man ready to do a day's work.

Mr. BOONE. It seems that two-thirds of the total number of trips in a specific case would be that high. Weren't those the figures that you gave?

Dr. SEAMANS. No, sir, the figures are quite different from that.

Mr. WYATT. The figures that we gave were that 6 percent of the travel in the month of January was for first class when there was any alternative. Only 6 percent was first class when you had any alternative as to the kind of travel you would take.

Mr. ROUSH. Is it possible in this area that some of these people would have dug into their own pockets and paid the balance just so they could go first class and still it would be reflected on your records as first-class travel?

Dr. SEAMANS. I frankly doubt that. That is not my policy. I know that.

Mr. SIEPERT. On the other hand, I think there are cases where the airlines are traveling some of our passengers first class on coach tickets because they still haven't licked the problem of overselling their coach departments. This of course doesn't cost Uncle Sam any money.

Dr. SEAMANS. I will have to look into that. I didn't know that.

I would just like to clarify this: Of the approximately 4,300 trips there were only 1,100 first class, and of that 1,100, in 710 cases it was the only way you could get there.

The CHAIRMAN. Do you have any more detail there that you would like to put in the record? It would be useful to have it in the record.

(The information requested is as follows:)

Air travel report, January 1963—Recapitulation, by type and number

	Total trips	Economy class	Mixed class	1st class			
				Total 1st class	Economy not available on regular schedule	Economy not available at time of reservation	1st class used when other available
NASA Headquarters	570	214	154	202	168	19	15
Ames Research Center	138	107	28	3			3
Flight Research Center	37	25	12				
Goddard Space Flight Center	554	378	88	88	1	1	86
Langley Research Center	291	87	146	58	19	9	30
Launch Operations Center	197	150	27	20	10	10	
Lewis Research Center	350	106	115	129	56	73	
Manned Spacecraft Center	893	634	247	12	3	7	2
Marshall Space Flight Center	1,048	4	493	551	428	13	110
Northeast Office	5			5	5		
Pacific Launch Operations Office	1		1				
SNPO, Cleveland	35	9	19	7			7
SNPO, Nevada	4	4					
Wallops Station	39	30	1	8	4	4	
Western Operations Office	120	59	39	22	16	5	1
Total	4,282	1,807	1,370	1,105	710	141	254

Mr. BOONE. May I ask one more question, Mr. Chairman?

The CHAIRMAN. Yes, Mr. Boone.

Mr. BOONE. Do you compute travel for 1964? Is this a percentage figure of 1963, or do you go into some schedule, or what?

Mr. WYATT. We go into that on a center-by-center base, the number of trips, the expected average cost per trip, the number of travelers, and the number of trips per traveler. These necessarily are arrived at by averages, and the average cost per trip.

Mr. BOONE. And you then extend it, some estimate of what you will do the next year?

Mr. WYATT. That is right.

Mr. BOONE. Thank you.

Mr. WYATT. We have our past history and we project based on the kind of activity at the center, the kind of contracts they are monitoring, changes in the load and so on.

The CHAIRMAN. Moving to page OC 21–2, rental of passenger motor vehicles by installations.

Has NASA studied the relative cost of renting versus owning these passenger vehicles or establishing motor pools?

Dr. SEAMANS. Yes; we have. I would like to have Mr. Siepert address himself to that question.

Mr. SIEPERT. We have studied this. In all frankness, I don't think we can come up and say that we have a precise criterion as to when it is to our advantage to own and when it is to our advantage to rent.

The practical situation is that the number of cars that one may own is a matter that is included in the President's budget as a submission from the President, and the Bureau of the Budget makes an allowance of the number that we may ask for.

Criteria are included in this as to how frequently we may ask for a replacement, in other words the criterion is that the car should have 60,000 miles on it or be 6 years of age, whichever comes first.

The result is that the submission of cars that are Government-owned is only a small portion of our total passenger requirements, and I don't think that I would be answering correctly to say that the number that we have asked for is because we have decided that on that number it is cheaper to own them.

Mr. WYDLER. Mr. Chairman, if I might, how many cars do you own and how many cars do you rent?

Mr. CADLE. On the inventory report at the end of the last fiscal year, we had a total of 55 automobiles, that is, sedans——

Mr. WYDLER. That you own?

Mr. CADLE. These are items which are on NASA's inventory, we had 93 station wagons, 11 ambulances, 12 buses, 546 1-ton trucks, 129 1½- to 2½-ton trucks, 84 3-ton and over trucks, for a total of 930 automotive vehicles.

Mr. WYDLER. How many automobiles did you say you had?

Mr. CADLE. Fifty-five sedans.

Mr. WYDLER. Could you tell me what number of those are Cadillacs or Imperials or Lincolns?

Mr. CADLE. We have no limousines. The Administrator is driven in a Checker cab.

Mr. WYATT. He is driven in a sedan built by the Checker Cab Co.

Mr. CADLE. We all call it the Checker cab.

Chairman MILLER. This Checker cab is quite a sizable one so it can hold a good many people when he has to take them out, and it is quite comparable, if you are familiar with it, to the type of car that used to be used to transport you from one depot to another in Chicago, and is just about as uncomfortable to ride in.

Mr. CADLE. But we don't even have medium size. The Bureau of the Budget classifies them in three classifications. The first classification are Fords, Chevrolets, and so forth, the second are Oldsmobiles, Pontiacs, Buicks, and so on, and the third class are your limousine class. We have cars in the small class only.

Mr. WYDLER. Now, how many cars do you rent?

Mr. CADLE. Do we rent total?

Mr. WYDLER. Yes, for this figure, "Rental of passenger motor vehicles," $590,000.

Mr. CADLE. I prefer, if I could, to take this one in terms of location.

Mr. WYDLER. I just want a total figure.

Mr. CADLE. All right, let me see if I can get one here. We will have to do some addition.

Mr. WYDLER. Are they all class 3 cars, too?

Mr. CADLE. On the rented vehicles, I am practically certain they all are.

The CHAIRMAN. I think it would be useful to supply that for the record later.

Mr. CADLE. The chart I have here doesn't include all of these, and the reason it is a little hard to answer is that the rental contracts, in the case of Marshall, for example, are for almost all of their vehicles, including trucks, cars, carryalls, many classes of vehicles, and it is a little difficult to add them up in total.

(The information requested is as follows:)

For fiscal year 1964 the rental of passenger-carrying vehicles will be: 237 automobiles, 81 station wagons, and 22 buses. The types of automobiles rented are broken down as follows:

	Class 1—Fords, Chevrolets	Interagency motor pools	Commercial rentals
Headquarters	9	9	
Ames	5	5	
Goddard	2	2	
Manned Spacecraft Center	42	10	32
Marshall	80		80
Launch	99		99
Total	237	26	211

The CHAIRMAN. Any further questions on travel, or transportation of persons, or anything further you want to add on that?

Dr. SEAMANS. No.

The CHAIRMAN. I think we have covered pretty well "Transportation of things." The major thing there is relocation which we have covered

Does anybody have any further questions on that?

Mr. BOONE. One question, Mr. Chairman.

You have rental of trucks here, and I gather that is for use at specific centers, and this would be in addition to the vehicular cost?

Mr. CADLE. Yes. The reason that it is a little bit difficult to answer the total question is that you have seven categories of vehicles, and I would have to go down through each installation here and total up the total rentals in order to give you a complete picture, but I will supply that for the record.

(The information requested is as follows:)

Under object class 22 "Transportation of things" $901,000 is included for rental of trucks and other transportation equipment and is in addition to the amount shown on page 385 for passenger vehicles.

The CHAIRMAN. We now move on to "Rent, communications, and utilities," and next, Mr. Davis, we get into computers. I think that was a very useful discussion yesterday.

Mr. Boone.

Mr. BOONE. In the Goddard Space Flight Center this is primarily for computers again, is it not, this $18 million?

Dr. SEAMANS. I am sure it is a large percentage although it is not the entire figure because we are renting some office space adjacent to Goddard. We have not been able to keep our facility program moving fast enough to be able to completely house all of the people there.

Mr. BOONE. Well, those costs are included in structures down below, and rents?

Dr. SEAMANS. Yes, the 18.6 includes all rents, communications, and utilities, and that is broken out into rents, communications, and utilities by type of service, and Goddard, of course, has a large number of computer equipments.

They also have heavy communication, and they are renting space and in addition, of course, are using standard utilities.

Mr. WYATT. Mr. Boone, of the 18.6 million, 16.8 is for the rental of computers

Mr. BOONE. I see. So does that mean then that the balance is for structures?

Mr. WYATT. Let's see—no, there are utility bills and——

Mr. BOONE. Do you have a figure for the Goddard rentals?

Mr. SIEPERT. $216,000 for space rentals in 1964.

Mr. BOONE. Well, that is not very great compared to prior years.

Dr. SEAMANS. It has fallen off from $365,000 because we are getting the space out there.

Mr. BOONE. Do you anticipate that this will go down?

Dr. SEAMANS. Yes.

Mr. BOONE. What about in the Washington area proper, you did have a large figure last year, I believe.

Dr. SEAMANS. That is going from $261,000 to $736,000 for space rentals in 1964.

Mr. BOONE. So it is going up.

Dr. SEAMANS. It is going up, and, in part, this is because of the Manned Space Flight Office, which is growing to over 500 people and will be utilizing rented space, I believe, out on Connecticut Avenue.

Mr. BOONE. Don't you have a new building that you are going to occupy pretty soon here?

Dr. SEAMANS. Yes, Federal Office Building No. 10–B, which is right next to Federal Office Building No. 6.

Mr. BOONE. This will not take care of your manned space flight needs?

Dr. SEAMANS. No.

Mr. BOONE. Can we expect that figure to go up from year to year?

Dr. SEAMANS. I would think as far as manned space flight it would level off at the 1964 figure.

Mr. SIEPERT. Next year, as far as this appropriation is concerned, it will be a decrease because the rental of the manned space flight building will, in 1965, be included in GSA's submission.

This is the standard procedure, when they have a chance to put it in their regular budget it is so incorporated.

Mr. CADLE. If you can get the information to GSA in time for them to include it in their estimates, then it is carried in the GSA budget. Otherwise the agency has to pay for it until the next fiscal year when GSA can pick it up in their estimates.

The CHAIRMAN. Mr. Davis.

Mr. DAVIS. Dr. Seamans, I noticed, as respects the Langley Research Center, the 1962 figure is $3⅛ million, the 1963 figure is $4½ million, and the 1964 figure the same virtually.

Now in 1962 the whole manned space flight effort was at Langley, was it not?

Dr. SEAMANS. The space task group was located there, yes.

Mr. DAVIS. And now it has been moved to Texas. Why hasn't that figure dropped? What is going on at Langley, in other words?

Mr. SIEPERT. The installations costs for the space task group were separately budgeted when they were there.

Mr. DAVIS. Well, what is going on at Langley now that occupied the same space they did? I take it it is the same space.

Dr. SEAMANS. The space task group was actually located across the field from the Langley Center, and some of that space will be utilized by Langley, inasmuch as they are growing somewhat, in order to take on a number of projects in addition to their research activities.

Mr. DAVIS. Well, what happened to the space that they did occupy after they went to Texas?

Mr. WYATT. Actually at Langley Field we occupy 2 acres, and we are phasing out what is known as the east area. The east area is a commingling of Air Force and NASA installations, including some of our older wind tunnels.

On the west side of the field is an area which, starting back in the 1940's, was entirely NASA developed.

The space task group occupied some of the space which NASA had cognizance of on the east side of the field, and some space that we obtained from the Air Force temporarily.

However, the space task group didn't exceed some 800 or so people in size at the time it was transferred, and in phasing them out, Langley has since grown somewhat, a few hundred people. There has been some expansion there, but some of the buildings we are actually turning back to the Air Force on an arrangement with them because we are gradually putting everything over on the west side of the field.

Mr. DAVIS. Well, now, is the type of research they are engaged in mostly aerodynamics or aeronautics?

Dr. SEAMANS. They are the focal point for most of our aeronautical research, the work that we are doing.

Mr. DAVIS. On the X–15?

Dr. SEAMANS. On the supersonic transport, on VTOL type aircraft, and on the work that we did in support of the Department of Defense on the TFX. That kind of work is there.

There is also a considerable activity on higher speeds for reentry, the kind of thing that is needed in support of Mercury, Gemini, and Dyna-Soar.

Mr. DAVIS. Well, the X–15 is not there.

Dr. SEAMANS. Also a great deal of material work.

Mr. DAVIS. I noticed you did not list the X–15. Is that at another installation?

Dr. SEAMANS. Flight Research is responsible for carrying out the project work; however, there was some research both at Langley and at Ames in support of that activity, the basic supporting work.

Mr. CADLE. Mr. Davis, I would like to make one point. You asked about the $2,437,000 in Langley for rents. It should be pointed

out that only $2,000 of this is for structures. They are renting a building to conduct civil service examinations at Langley. That is the only structure rental at Langley. The balance is for rental of computers.

Mr. DAVIS. Is that true of the other items; are there computer rentals in many of them?

Mr. WYATT. Yes; that is the predominant cost.

Mr. CADLE. That is the predominant rental. You see the total rental charges for space that we have in 1964 adds up to $3,411,000 or an increase of $1,054,000, and this is out of a total rent line of $39,971,000.

Mr. DAVIS. Just to pursue this to its conclusion, has the computer figure all been lumped under this figure of $34,994,000 plus $405,000?

Mr. WYATT. Yes.

Mr. DAVIS. That is all computer rental?

Mr. CADLE. Yes.

Mr. DAVIS. Thank you.

Mr. BOONE. Mr. Chairman, I was going to suggest that he give us a breakdown of these rentals, particularly the structures. If we had that for the record, we would have a pretty firm breakdown.

The CHAIRMAN. Could you do that?

Dr. SEAMANS. Yes; we would be happy to.

(The information requested is as follows:)

Analysis of rental of structures: Object class 23—Rents, communications, and utilities

[Thousands of dollars]

	Fiscal year 1963 estimate	Fiscal year 1964 estimate	Change	
Headquarters	261	736	475	Office space, storage.
Ames Research Center	24	32	8	Combined office and laboratory building to house "Life and Science" personnel until new construction is available.
Goddard Space Flight Center	345	216	−129	Office and laboratory space until new construction is available.
Langley Research Center	2	2		Office building for civil service exams.
Launch Operations Center	222	430	208	Office and auditorium space.
Lewis Research Center	58	54	−4	Rental of office space.
Manned Spacecraft Center	536	820	284	Temporary rentals pending construction of permanent site at Clear Lake.
Manned Space Flight Center	753	661	−92	Office of engineers space in Huntsville.
North Eastern Office	25	50	25	Office space.
Western Operations Office	108	238	130	Do.
Electronic Research Center	21	170	149	Do.
Total	2,355	3,411	1,054	

The CHAIRMAN. Moving to communications, leased lines, OC23–6 and 23–7 and 23–8.

I want to get a general statement. Have you become increasingly convinced that leased lines are the most advantageous and expeditious way to carry out your communications?

Dr. SEAMANS. Well, for those lines connecting important elements of NASA, NASA and DOD facilities, or the principal contractors, there is a saving to the Government to operate leased lines.

The CHAIRMAN. Are these exclusively for NASA's administrative use?

Dr. SEAMANS. No.

Mr. CADLE. The policy on the leased line, Mr. Hechler, is that in the administration of NASA the toll charges being charged between locations are under constant surveillance. When at any time the toll cost gets to 125 percent, or 25 percent more than a leased line would cost, then negotiations are entered into in order to establish a leased line between the locations involved.

In this case, take between Langley and headquarters, they find out that they are running four leased lines, and then they find that the total toll calls in addition to the leased lines adds up to 125 percent of the cost of an additional leased line, they will put in a fifth leased line.

The CHAIRMAN. My question was directed to whether these were exclusively for NASA.

Mr. CADLE. Yes, they are. You are asking about telephone conversations?

The CHAIRMAN. Yes.

Mr. CADLE. Yes, they are, these are leased lines during business hours for the locations mentioned.

The CHAIRMAN. Why, for example, here on 23–7, just to pick out one example, why does there have to be a leased line between Huntsville and Seattle, Wash.?

Mr. WYATT. The Boeing Co.

Dr. SEAMANS. Because of the work they are doing on the first stage of the Saturn V, Boeing being the principal contractor.

I think you asked the question whether this was all administrative or whether some of the technical data transmission is included, and it is my understanding that the actual leased lines for data link is included in another place in the budget.

Mr. WYATT. Under "Tracking and data acquisition."

Mr. CADLE. The method of operation on this one, Mr. Hechler, is that we are charged only for the distance. In other words, the leased-line rate is established on a distance factor only, and the charge that the telephone company makes to us is based on this. They give us a quote between locations, and by checking on the toll calls you can tell when it becomes economical to get a leased line.

Mr. BOONE. Do you do this? Is this continuously monitored by the telephone company?

Mr. CADLE. This is monitored by the headquarters.

Mr. BOONE. It is monitored by the NASA people?

Mr. CADLE. Yes, sir.

Mr. BOONE. Mr. Chairman, I have another question.

On OC23–6 you have Cape Canaveral to Marshall Space Flight Center, Cape Canaveral to Washington, showing considerable increases.

Is this as a result of your study or is this forecasted work that you think is going to occur, or what? For example, in 1963 you only had $15,000, but now you have 10 times that amount for Cape Canaveral to Marshall Space Flight Center.

Mr. CADLE. Perhaps I can clarify this. You will find, for example, under two locations, let's take Launch Operations Center and Marshall Space Flight Center, you will find lines to and from in both cases. The reason for this is that in addition to monitoring the number of calls, they also monitor the originator, in other words what installation originated the calls. Let's take, for example, a situation in which

five lines are needed, and 60 percent of the calls are originated from Launch Operations Center. Launch Operations Center will be billed for three of these lines as a matter of course.

Now in this case Launch Operations Center you realize has just come into operation, so 1964 is when they are going to have their people on board. They are making many calls to Marshall, which was the place from which they were split originally.

In this case all of the calls on leased lines prior to 1963 and 1964 were financed by Marshall Space Flight Center, because there wasn't any Launch Operations Center.

Mr. BOONE. Is that the case on Mississippi test facility, on page 23—8? Will there be in 1964 activities between NASA people at Mississippi test facility and Santa Monica and Seattle and so forth?

Dr. SEAMANS. Yes, we will be implementing the static test program for the S-II stage, being built in California.

Mr. BOONE. You are just about breaking ground now, aren't you?

Dr. SEAMANS. That is true, but this station must become operational in fiscal 1964.

Mr. BOONE. In fiscal 1964?

Dr. SEAMANS. Yes, sir.

Mr. BOONE. Fifteen months from now?

The CHAIRMAN. Here is an interesting figure on OC23–7, Marshall Space Flight Center to NASA headquarters in Washington remains exactly the same in 1962, 1963, and 1964,—28,000.

Did you use all of your money in 1962?

Dr. SEAMANS. Sixty-two is an actual and the other two are estimated.

The CHAIRMAN. So you have things so well under control that it doesn't require any increase?

Dr. SEAMANS. That is what the number say.

Mr. WYATT. It simply means the number of lines remain constant.

Mr. SIEPERT. We are saying that the traffic is sufficiently constant that we believe we will not need another line.

The CHAIRMAN. Yes.

We now move on to printing and reproduction, unless there are other questions.

What about utilities?

Mr. Boone, do you have any questions under utilities?

Mr. BOONE. I didn't have any, Mr. Chairman. I assume this is a fairly standard rate that you negotiated to get the best from the local utility companies, and, if anything, this figure will continue to rise as your installations progress toward your Apollo mission and Gemini mission.

Unless there is something they would like to add——

Dr. SEAMANS. I don't believe there is anything we want to add on that.

The CHAIRMAN. Under printing and reproduction, page OC–24–1, I note an approximate 50 percent increase in this item. I wonder if any members of the committee have any questions on this item.

Are you utilizing other Government facilities to the fullest extent possible?

Mr. WYATT. Yes. You will notice of the $4.8 million, $2.7 million will go to other Government agencies, predominantly the Government Printing Office, for the actual printing and duplicating.

The CHAIRMAN. If there are no further questions we will move on to——

Mr. RYAN. Yes, I have a question on this, Mr. Chairman.

The CHAIRMAN. Mr. Ryan.

Mr. RYAN. I don't know whether it relates to this section, but last year I remember there was some discussion about the engagement by NASA of an advertising agency.

Does any of that cost come under this printing and reproduction section?

Mr. SIEPERT. No, sir, Mr. Ryan. That comes under "Other services."

Mr. RYAN. All right, we will reach it at that point then.

The CHAIRMAN. This is the section on "Other services."

Mr. Boone.

Mr. BOONE. The question of rentals in Houston, of course, came to much discussion in the press. Would you like to make any comment on what you are doing out there with reference to reducing rents or justifying what you have, at least giving the committee some idea of it within this item?

Dr. SEAMANS. No, just as I have indicated several times in the last 2 days, we must use rented space there until such time as we have our own facilities.

We are moving ahead as rapidly as we can in the development of NASA-owned facilities, and we will start moving in the end of this year, this calendar year. Until then we are using approximately 10 different buildings, and I believe 10 different leases there in Houston.

I have been to both of these locations myself. They are adequate to get on with the job, but certainly none of them are lavish in any sense of the word.

Mr. BOONE. In this regard have you moved into the new structure at Marshall? There was a new structure?

Dr. SEAMANS. Yes, there was a new engineering and office building.

When is the occupancy date for that?

Mr. CADLE. August, midsummer, sir.

Mr. BOONE. Thank you.

Mr. RUMSFELD. Could I ask a question here?

I notice in three or four or five of these items, starting with Ames and then Flight Research Center and then Goddard, I believe, and then Lewis, the amount in 1962 is higher than it is in 1963, and then it goes back up in 1964. You are starting from a higher point and then going down and then going up. Is there any particular reason this would happen?

Dr. SEAMANS. Which page is this?

Mr. RUMSFELD. On C21–1. I thought we were asking about the "Other services."

Dr. SEAMANS. Well, in the case of Langley, there is a very good reason for that. That is because the Space Task Group has moved to Houston.

Mr. RUMSFELD. I don't believe I mentioned Langley. I said Ames and Flight Research Center and Goddard and Lewis.

Mr. WYATT. Yes, Mr. Rumsfeld, you will recall earlier in our testimony we pointed out that one of the things that we did during the fiscal year 1963 was to make a whole change in our appropriation base from the old salaries and expenses, research and development, and construction of facilities, into a new basis.

Under the old basis Ames, Langley, and Lewis had been budgeting a share of their actual in-house support of research activities under this account, and during 1963 we endeavored to reduce this simply by bookkeeping, to allocate this properly against the program charges that are in the research programs principally of the Office of Advanced Research and Technology. As a result we were able to reduce the amount allocated here to overhead or institutional support by properly charging these items against the research projects for which they were intended, and so a lot of this reduction here in these particular Centers is simply a bookkeeping change that reflects a reduction.

Mr. RUMSFELD. So in each one of these cases you would expect as far as the dollars actually spent there has been an increase?

Mr. WYATT. Yes. The question is: Do we charge it against institutional support or the project.

We have refined it, and we are putting more of it against the project costs, and that accounts for it substantially.

Mr. DAVIS. Dr. Seamans, I notice in the first line item under NASA headquarters, there was $8½ million, and then it went to $19 million, and in 1964 it goes to almost $29 million.

Now what is the explanation of such a dramtic increase in that particular item?

Dr. SEAMANS. This in part reflects the program that I discussed with you in my testimony yesterday, related to the Office of Public Affairs, which has responsibility for our educational program as well as our scientific and technical information program. Both of these activities have been strengthened and are increasing in order to satisfy the needs that we feel for making information available to a variety of different groups in this country. In part this information is for education at schools, in part to satisfy the interests of the general public, and in part to have detailed scientific and technical information available as required by industry and universtities.

We have here with us today the heads of these two particular programs; namely, the Office of Educational Programs and Services, and the Office of Scientific and Technical Information, and we can go into this in any detail that you may wish.

The CHAIRMAN. I think NASA is to be congratulated for the work that the Office of Educational Services has done. A great number of schools and higher educational institutions, both in my State and in other States have utilized these materials to very great advantage. I think it is a marvelous program that NASA has carried out in this area.

Mr. DAVIS. May I ask an additional question?

Suppose you were to get a request from some city or community for an exhibit such as a space capsule or launch vehicle or something; would this money here be the source of your furnishing them with an exhibit?

Dr. SEAMANS. Yes, it would.

Mr. SIEPERT. There is $4.4 million of this figure for exhibits, and it compares with $3.115 million which was the level this year. It is an expanding program.

Dr. SEAMANS. To give you a further breakdown, in the educational programs and services, we show $550,000 for the educational service program; we show $2 million for the space mobile; we show $1 million for the educational publications program; $2.4 million for the audio-

visual program; and $4.4 million for the exhibits, for a total of $10.5 million, as compared with last year's figure of $8.4

The CHAIRMAN. Mr. Rumsfeld, do you have a question?

Mr. RUMSFELD. Yes.

On page 25–3 you mentioned that the 104's and the 102 are for astronaut proficiency. What are the Gulfstream at the Manned Space Center and the Aero Commander at the Launch Flight Center used for?

Dr. SEAMANS. We received authorization last year to purchase three aircraft for passenger use. So we have now three Gulfstreams, one of which is based in Houston, one based in Huntsville, one will be based actually at Langley, but used primarily by Headquarters. The F–104's are quite obviously in a different category. These will be based at Edwards in order to keep our pilots proficient out there, those who are flying the X–15's, planes of that sort. There are three F–104's. And in addition, we have rented two Aero Commanders—am I right on that?—anyway, for Huntsville. These have been in operation for some time, and we have also rented——

Mr. RUMSFELD. And what is the Aero Commander used for?

Dr. SEAMANS. For transportation of key personnel out of Huntsville. Are there two?

Mr. CADLE. There are two, and a backup.

Dr. SEAMANS. Does that answer your question?

Mr. RUMSFELD. Is the same thing true of the Jet Star?

Dr. SEAMANS. The Jet Star, I was about to say—there are two Jet Stars, actually. One is rented for passenger use and is based at Canaveral for use of the Launch Operations Center. The other one was purchased out of our R. & D. account in support of the aeronautical program and will be located when it is available out at Edwards, the Flight Research Center, for special testing related to the supersonic transport.

Mr. RUMSFELD. I see. So actually this section is incorrect, then.

Mr. WYATT. No, sir; Mr. Rumsfeld, the rental of the aircraft as transportation is under another account, under the "Transportation of persons."

Mr. RUMFELD. Thank you.

Mr. WYATT. These are the service contracts to maintain airplanes—for example, the F–104's. Now, to give you an idea of the rise, in 1963 we only have $841,000 for aircraft service contracts. In 1964 it is estimated that this will rise to about $3½ million. A good share of that is the maintenance on the F–104's. You buy them, but you have to keep them maintained to keep them in flying service.

The CHAIRMAN. Could you give us a list of the maintenance contracts, how extensive a job would that be?

Mr. CADLE. It is a long list, I would say it is probably in the neighborhood of 250 to 300 contracts.

The CHAIRMAN. Well, $28 million is quite an item. We were just interested in how this generally was broken down.

Mr. WYATT. We can supply that, Mr. Chairman.

Mr. SIEPERT. I wonder if this would help. We can get to you much more quickly the service contracts over $25,000, because these do fit in a reporting system that we have.

The CHAIRMAN. All right, if that is not too extensive.

Mr. SIEPERT. By Center?

The CHAIRMAN. We don't want to delay Cooper's orbital flight, but we think that information would be interesting.

(The information is as follows:)

Estimated personal service contracts by category of service, fiscal year 1964

[In thousands of dollars]

Engineering services contracts	$6,252
Computer operation service contracts	7,367
Computer programing service contracts	913
Electrical accounting machine operations service contract	56
Consultant services, management surveys and management center services contracts	778
Technical documentation services	9,103
Chart and related art work	2,096
Other personnel services contracts	2,301
Total service contracts	28,866

Personal service contracts $25,000 and above in process during fiscal year 1963

[In thousands of dollars]

	Nature of service	Number of contracts	Cost
NASA Headquarters	Reliability and quality assurance program studies	8	719
	Computer operation services	3	120
	Service contracts for consultant services, management surveys and management center cost.	2	100
	For technical documentation services	4	4,260
	Charts, graphic arts work for publications, photography, Vu-graphs.	2	93
Subtotal			5,292
Ames Research Center	Operation and maintenance wind tunnels facilities	1	329
	Design of secondary model support	1	35
Subtotal			364
Flight Research Center	Study and design of X-15 display panel	1	28
	Design study airborne simulator	2	64
	ADP Computer Service	1	48
Subtotal			140
Goddard Space Flight Center	Engineering, design, scientific analysis, development, fabrication and maintenance service in support of inhouse projects.	1	74
	Equipment, personnel and material to perform computer operations.	1	705
	Technical writing and related services	2	167
	Visual arts, graphics, exhibits, displays and supplemental services incidental thereto.	3	178
	Service and material to operate a library in New York, N.Y.	1	68
Subtotal			1,192
Langley Research Center	Computer programing service	1	38
	Drafting services	1	64
	Electronic wiremen service	1	72
Subtotal			174
Launch Operations Center	Computer operation services	1	345
	Technical writers, historian assistants and assistant editorial aids.	1	345
	Operation of motor pool, maintenance of vehicles, and traffic management branch.	1	392
Subtotal		1	1,082
Lewis Research Center	To provide instruments to record amounts of exposure to radiation to personnel associated with the Plum Brook nuclear reactor and the analysis thereof.	2	314
Subtotal			314

Personal service contracts $25,000 and above in process during fiscal year 1963—Con.

[In thousands of dollars]

	Nature of service	Number of contracts	Cost
Manned Spacecraft Center	Support Technical Services Division, including installation and wiring, new equipment, general wiring and circuit drawing of amplifiers.	1	57
	Instrumentation calibration service	1	41
	Architecture and engineering srevices	2	112
	Computer services	2	355
	Visual arts, graphics, slides, displays, exhibits and reproductibles.	1	75
Subtotal			640
Marshall Space Flight Center	Fabrication and mock-ups	1	25
	Engineering services for field supervision, inspection and other related services pertaining to construction projects.	1	125
	Preparation, investigation, study and development of engineering studies for repair and construction of facilities.	1	350
	Land survey and foundation exploration	1	37
	Engineering support in fields of architecture, landscaping, city planning, illustrations, etc.. to support master plannings.	2	281
	Engineering drafting and illustrations service in support of managerial data center.	1	80
	Electronic interference suppression	1	68
	Personnel support for basic and applied methodologies, applications of computer methods and development of managerial data, etc.	1	81
	Personnel support in data center development	1	200
	Provide personnel support to the Data Processing Division.	1	3,954
	Technical documentation	1	494
	Charts and related art work	2	201
	Personnel support of PERT	1	75
Subtotal			5,971
Grand total			15,169

Mr. DAVIS. I understood your testimony about the purchase of aircraft this year, but how many did you already have in inventory exclusive of the ones that you are buying or hoping to buy this year?

Dr. SEAMANS. We had a variety of aircraft for research and development purposes.

Mr. DAVIS. Excluding those, how many do you have for transporting personnel?

Mr. WYATT. We will have in 1964, we expect, 12 research airplanes, 4 for proficiency, 3 executive, 1 passenger, 1 cargo, and 2 passenger-cargo, for a total of 23 NASA-owned aircraft.

Mr. DAVIS. What are the transports?

Dr. SEAMANS. We have used in headquarters a Convair, a plane transferred from the Air Force to NASA, which we based at Langley. We are going to convert that partially for transportation of people and partially to conduct R. & D. activities. We had DC–3's at Langley and Lewis.

Mr. DAVIS. Thank you.

Mr. BOONE. Since this is a fairly extensive item, I was wondering if such things as engineering design—is this standard overhead or could this be assigned to a program, and, for example, computer programing and operations, these are not in support of specific programs?

Mr. WYATT. We explained on some of these, particularly on computer support, that one could go through a bookkeeping exercise and back charge them against the projects. However, it seems that since you negotiate a contract for a monthly rental of a machine, that the source of money should be in one pot and should not come from 25 separate projects. It would just get into an overwhelming amount of bookkeeping while the dollars going out would be exactly the same.

Some of these engineering services represented here are of the same sort, they are services that instead of expanding our in-house personnel we contract with a firm to supply some general engineering support, and it can be supporting a number of things. If it is specific to a given project it is charged against that project, but if it is just general support covering a variety of projects, then we feel that the best way to control it and to account for it is in a single lump. And we have chosen in those instances to group them under this installation operations account. Wherever possible, where we can uniquely identify a contract with a project, we charge it against the project, but in cases where the same contract covers a multiplicity of work it seems more convenient as a matter of bookkeeping to charge it to operation of installations.

The CHAIRMAN. I understand that the hearings of this committee may not be indexed, but I think there is one item that deserves to be indexed, and that is everything about computers. I hope we could tell the frustrated reader the various points at which he could find discussions of computers.

Mr. BOONE. I had another question, Mr. Chairman, about construction under this item.

Could you give us an idea of the dollar value involved?

Mr. WYATT. Yes, sir. Minor construction, which is the element carried here—just a moment, I have that here.

Minor construction was estimated at $4.7 million in 1963, and we estimate about $6 million in 1964.

Now, by the definitions that we work on, no single project can exceed $250,000 and be considered a minor construction project, but these are generally less than that, they are where we erect special buildings. It amounts to brick and mortar work, but it is not a large structure. This is by direction of the act, that if it is under $250,000 we just lump it as minor construction projects.

The CHAIRMAN. Mr. Wyatt, would you care to say anything about why the other contractual services item nearly doubled between 1963 and 1964?

Mr. WYATT. Well, I have already pointed out under "Other contractual services" there are such things as this: The aircraft services that I have mentioned, that is going up by a factor of about 3 because of the new F–104 contracts, for the most part. There will be some increase in tuitions, that is where we are—somebody would have to break this particular tuition down for me.

(The information for tuition is as follows:)

Fiscal year 1962	$439,954
Fiscal year 1963	642,000
Fiscal year 1964	724,000

Mr. SIEPERT. That is a relatively small portion. The two main elements in here of increase are (1) the much larger aircraft support program, and (2) the second thing is the increases here go through

contractual services for the production of more exhibits, brochures, motion pictures; in other words, the actual materials that are used in connection with technical education programs.

The CHAIRMAN. I want to emphasize again that I think these are very valuable things for public understanding of the space program. If we are going to spend $5 billion the American people will certainly have to have a clearer understanding about what it is being spent for.

Mr. BOONE. Mr. Chairman, may I ask another question, please? In Dr. Seaman's opening statement he made some remarks about general quality assurance and reliability programs. Are they entered under this?

Dr. SEAMANS. Yes, they are.

Mr. BOONE. Can you explain a little bit in detail what is included in the reliability programs?

Mr. WYATT. Yes. Among the accounts funded here, we are, for example, at the moment, using contractual assistance to develop what we call a standard parts program for the agency, a way in which we can document and collate specifications for standard small elements for the most part that are used repetitively throughout our program so that our designers can go to a handbook and find that if I need certain kinds of transistors for certain purposes these have been qualified and can be accepted as meeting a standard of reliability. It doesn't necessarily mean that they won't have to develop a new one, but where possible, they can go to a preferred or, if you will, qualified standard parts list and find what are the items that we have a sufficient development experience on, that we can use this whenever possible.

This is one of the sorts of things.

Mr. BOONE. This is purely for parts, though, not components?

Mr. WYATT. This would be for qualified parts, down at the very elemental level.

Mr. DAVIS. Which item are we talking about?

Mr. WYATT. This appears under the "General services," "Other contractual services."

Dr. SEAMANS. And it comes out of headquarters and it amounts in fiscal 1964 to $2.7 million, as compared to $1.8 million in 1963.

Mr. WYATT. Yes.

Mr. DAVIS. Well, just to clear up something in my mind, what would come under service contracts, how do you distinguish whether it is "Other contractual services" or a service contract; what is the line of demarcation?

Mr. CADLE. They are one and the same in that they are all contracts funded under the heading "Other services."

Mr. DAVIS. They are all contracts, aren't they?

Mr. CADLE. Yes, and this heading "Other services" is a requirement laid on us by the Bureau of the Budget. All of the items which go into it come under a definition supplied by the Bureau of the Budget.

Mr. DAVIS. In other words, you listed $28 million worth of service contracts, and then the service contracts you didn't list under that you listed under "Other contractual services"?

Mr. SIEPERT. And what we included under each we attempted to explain in the narrative immediately following this table, because the definition is a little hard to follow.

It might be helpful, even, to put that kind of definition in, if you would want it.

The CHAIRMAN. Well, as an alumnus of the Bureau of the Budget, Mr. Cadle, you should be an expert.

Mr. RUMSFELD. Mr. Chairman.

Mr. RYAN. Mr. Chairman.

The CHAIRMAN. I believe Mr. Ryan has a question.

Mr. RYAN. On page 11 of your statement, Dr. Seamans, you spoke about national recruitment advertising, $250,000. Where does that appear in the backup book?

Dr. SEAMANS. I will refer to Mr. Siepert on that.

Mr. WYATT. That appears under "Other contractual services."

Mr. RYAN. All right, now, can you please explain what the $250,000 referred to on page 11 is for? I am referring to page 11 of Dr. Seamans' statement before the Commission.

Dr. SEAMANS. National recruitment advertising which is contained under headquarters in the 1964 budget.

Mr. CADLE. And this is part of the total agency cost which Mr. Siepert has here.

Mr. SIEPERT. The $250,000 item which has been handled as a headquarters item, Mr. Ryan, lumps together all of the advertising that is done agencywide, that is, representing the recruitment drive of the agency as a whole. It covers all advertising that goes into magazines like "Scientific American," the nationally circulated magazines. It does not include the total advertising bill of the agency because the Centers are authorized to place classified ads for specific positions relative to their Center in the newspapers, so that is an additional cost beyond what we have here.

The total cost for 1963 of all recruiting advertising is $383,000, of which $250,000 was in the headquarters. We are proposing in the 1964 budget the same level.

Mr. RYAN. Now, this $250,000, is that advertising placed directly by the headquarters with publications, newspapers, with media, or is there included in this a contract with an advertising agency which in turn places the ads? Can you explain that?

Mr. SIEPERT. It includes contracts we have had in the last year with two agencies to deal with the media, and actually they are experts in preparing copy for us.

Mr. RYAN. Can you break down those two contracts for us? Tell us what they are.

Mr. SIEPERT. Yes. The two contractors were Ketchum, McLeod and Grove, who during the period I showed here had $72,500 placed through them.

Mr. RYAN. That is $72,000 charged to you?

Mr. SIEPERT. That is the total cost of the advertising, and they take their commission, or their fee comes out of a rebate that comes from the publisher, so that this is the total cost of the advertising that we place. This is not the fee that Ketchum, McLeod got.

Mr. RYAN. Is this the total cost to NASA?

Mr. SIEPERT. Yes, of the advertising that went through that agency.

Mr. RYAN. And this includes any payment by NASA to the agency?

Mr. SIEPERT. We do not pay the agency. As I understand the advertising practice they get their income out of, in effect—they get it from the publisher. The publisher has a special rate.

Mr. RYAN. The agency bills you for the advertising and you were billed $72,000 by this firm—in what, fiscal 1963 or calendar 1962?

Mr. SIEPERT. This is the period of performance from January 12, 1962, to December 31, 1962.

Mr. RYAN. That is one agency. All right, what is the next?

Mr. SIEPERT. The other agency is the S. G. Stackig agency, which for the period of time December 6, 1961, through December 31, 1961, got $62,999 totally. Now, since that time we have analyzed the practice of continuing to deal with two contractors and splitting the contracts between them and reached the conclusion at the end of the year that it would be more economical for us if we concentrated on only one contractor.

As a matter of fact, we got a little bit of criticism from the advertising profession in their trade journals when they wondered why we split it in the first place. Apparently it is advertising practice in the business that a customer essentially places his ads with one agency. Since that time we have placed with the Stackig Co. from December through February 16, $28,845 of additional orders.

Mr. RYAN. Well, do you have a contract for the whole year with that agency, the whole calendar year 1963?

Mr. SIEPERT. Yes.

Mr. RYAN. Now couldn't NASA save money by placing this directly without going through an agency?

Mr. SIEPERT. If we did we would have to develop in-house advertising layout competence, which we do not have.

Mr. RYAN. You mean you would have to hire personnel?

Mr. SIEPERT. Yes.

Mr. RYAN. Well, that would be less than this cost, wouldn't it?

Mr. SIEPERT. That assumes that we could get really first-class talent of this sort, and our survey of it would indicate that the advertising people haven't normally regarded civil service as a profitable career for them.

Mr. RYAN. Don't you have in-house talent now which designs your brochures and does layouts for you? Who does that?

Mr. THOMPSON. This is being done on a contract basis to the extent that we do it. Some of it is done by the Government Printing Office.

The CHAIRMAN. Would you indicate your name and title?

Mr. THOMPSON. Shelby Thompson, Director of Educational Programs and Services.

Mr. SIEPERT. There is one other thing relevant here. If a Government agency designs its own layouts and places it with a national publication, they will charge us their published rate and there will be no rebate to us. In other words, it would cost the Government just as much, not less, to place the ad directly with the "Scientific American" as to go through an advertiser, because the commission comes from the publisher back to the profession, not the client.

Mr. DAVIS. That same thing is true for candidates for political office with newspapers.

The CHAIRMAN. Yes, they have got us both ways.

Mr. Rumsfeld.

Mr. RUMSFELD. If we could go back to this item on exhibits; as I recall, the figure was in the neighborhood of $10 million.

Dr. SEAMANS. No, the figure for the exhibits program is $4.4 million, which is included as part of the educational programs and services which is part of the $10.5 million.

Mr. RUMSFELD. Let's take the 10.47, the educational services; do you anticipate that this is going to level off, or do you anticipate that, say in fiscal 1964, you are going to continue this progression in the general category of "Other contractual services" from 12 to 23 up to, say 48, since this is a good portion of the "Other contractual services?"

Dr. SEAMANS. The demand for this kind of service is more than we can satisfy. Mr. Thompson here might comment on that.

Mr. THOMPSON. I would anticipate it might begin to level. It is a little difficult for us to guess this because, so far, we have had a rising curve on it, and the public requests coming to us are such that we have been hard put to satisfy them. But I would anticipate that we would reach a leveling area in fiscal 1964. This is my own thinking.

Mr. RUMSFELD. It would seem to me that this would be logical, in that you are working with a fixed population in this country, roughly.

Mr. THOMPSON. We hope this is the case, it would make the problem much easier for us to handle.

The CHAIRMAN. A fixed population?

Mr. RUMSFELD. Relatively, compared to the numbers in the budget.

Thank you.

The CHAIRMAN. Any other questions by members of the committee on this point?

Mr. Boone.

Mr. BOONE. Mr. Chairman; Dr. Seamans, you mentioned in your opening statement a contract for documentation services, and I assume that this includes the information on the retrieval aspect of NASA's work. Maybe you could tell us some of the details on this and how you coordinate with the other agencies of the Department of Defense as well as industry.

Dr. SEAMANS. I would like to call on Mr. Day, who is in charge of the Office of Scientific and Technical Information, to discuss that contract.

Mr. BOONE. That is included under these contractual services?

Dr. SEAMANS. Yes. the documentation program shows in 1964 at a level of $6.5 million. The technical publications program is $2.3 million and the technical services program, $0.4 million—for a total of $9.3 million.

Mr. BOONE. Those are service contracts?

Dr. SEAMANS. Yes.

Mr. Day.

Mr. DAY. My name is Melvin Day. I am Director of the Office of Scientific and Technical Information.

As Dr. Seamans pointed out, a major portion of our budget is used for our basic documentation work, which is done primarily under contract. We have set up under contract a scientific and technical information facility. This facility is responsible for collecting the material coming out of our own scientific and technical programs, for organizing this information and making it available to people within our own programs for their use, for making the same information available for other users both within and outside Government. This includes the educational community, the industrial community, and so forth.

We also have the responsibility of seeing to it that all other information that is produced in areas related to our own that can be used within the NASA technical programs is organized and put into the

hands of our technical people for their use so that they can use this information and not unnecessarily duplicate work that has been done elsewhere.

Our facility is a computerized facility. A major emphasis of our service is on local access, and that is to provide, wherever possible, information products and services and tools to the ultimate consumer, which in many cases is the scientist or the engineer, to give him the capability of knowing what is available both within and outside of our own program, to give him the searching tools and, if at all possible, to give him automatically the information materials themselves.

We work very, very closely with the Department of Defense and other Government agencies, such as the Atomic Energy Commission, National Science Foundation, and so forth, so that our programs, insofar as possible, can be integrated.

We have working agreements and working arrangements with the two other major agencies having aerospace programs, namely, the Atomic Energy Commission and the Department of Defense, whereby material which is processed into their system, and vice versa, can be fed automatically into the major documentation centers of the other agencies in order to eliminate unnecessarily the duplication of processing.

We utilize their processing, they utilize our processing, so that the intellectual work input can be reduced to a minimum, being performed at only one location. Our services are generally available in support of our own programs to our centers, our contractors and subcontractors, other Government agencies, and their contractors.

Mr. BOONE. Could you give the committee some example of how this system works, and by that I mean how long does it take you to get a document or how long does it take to get a sketch?

Mr. DAY. With your indulgence, Mr. Chairman, I will give you an example of what I mean. Under our present program great emphasis is placed on speed, the speed of getting the information not only into the system but essentially out of the system and into the hands of people who can use this material. Under this program material is received at our documentation facility and on a semimonthly basis our agency issues this abstract journal star which serves two purposes:

It is an announcement tool, in that it announces not only the aerospace reports coming out of our agency, but also those other agencies. The second portion is set up so that it is a current finding tool; there are four indexes. We cumulate the indexes on a quarterly semiannual, third quarterly, and annual basis, so it is also a retrospective literature searching tool. This index section is a computer print-out.

The material received by us, must be reviewed, evaluated, abstracted, indexed, and announced in this journal, and this journal distributed in the hands of our users within 4 to 6 weeks following receipt of our material in our processing center.

This compares very favorably with many abstracting journals, whose coverage of the published literature currently requires somewhere in the area of 4 to 6 months.

Mr. WYDLER. How many of those do you distribute?

Mr. DAY. About 8,500 copies, semimonthly.

Mr. WYDLER. And how many requests do you receive for further information per month?

Mr. DAY. We are receiving requests now at the rate of 250,000 a year.

Mr. DAVIS. That is, individual inquiries?

Mr. DAY. Yes; as a result of this journal. We know that they are a result of this journal because each request carries a specific number, and that number can only be found in the journal.

Mr. DAVIS. Is the expense of printing borne by you, and is it done by you or is it done by GPO?

Mr. DAY. This is done by GPO but we pay for it.

Dr. SEAMANS. We pay for it out of this account.

Mr. DAVIS. But they physically do it.

Dr. SEAMANS. Yes.

Mr. BOONE. You didn't mention cross-referencing, which seems to be the biggest problem in this whole field. I assume you have to do that also, and you have some manner to expedite at least retrieval of the document?

Mr. DAY. Yes; there are four indexes in each issue. This is where referencing will come in. The same indexing information is in our computers, and working with the other agencies we attempt to cross-reference to their materials, and they, of course, try to cross-reference to our materials.

Mr. BOONE. Thank you.

Mr. DAVIS. Well, what would be a typical item that you would find in that report?

Mr. DAY. A report coming out of Goddard or a report coming out of any of our centers or out of other laboratories.

Dr. SEAMANS. Pick a specific one.

Mr. DAVIS. What would be the content of the report, is what I mean.

Mr. DAY. For example, here is one out of Martin Co., in Baltimore. It is entitled "A Fundamental Inequality for Finite Differential Equations."

Mr. WYDLER. Is that typical?

Mr. DAY. Yes. Here is another. "An Analog Computer Method for Analyzing a Two-Dimensional Trajectory of a Single-Stage Rocket Vehicle."

Now, the second phase of the program involves our publication portion of the program, and this is primarily a repackaging program whereby much of the material that comes out in the initial form of a research and development report is essentially boiled down, condensed, repackaged and put into language which makes it much more understandable to these other communities which we service; namely, the educational community, the industrial community.

The CHAIRMAN. Thank you very much.

We will now move on to supplies and materials. We are getting near the end of the wire.

Do any of the members of the committee have any questions under either of these two headings, "Supplies and materials" and "Equipment"?

Mr. BOONE. I have a question, Mr. Chairman.

The CHAIRMAN. Yes.

Mr. BOONE. Well, maybe I can make an observation. It appears that these are fairly expensive individual items in this budget. I wonder what sort of management controls do you exercise over this particular item? How do you effectively manage their use?

Mr. SIEPERT. Well, the control of this item actually is a field operational responsibility; that is, when the money is appropriated and allotted. These are part of the resources that are signed off or allocated to the field center, based upon operational plans which are developed by the centers and submitted to Washington.

The Washington headquarters does not follow each of these items down as to how they are being expended. We have found from experience that we will get the most effective utilization of this money if we hold the field center responsible for making choices. The center director is presented with a problem here of less resources, substantially less resources, than he asked for in the first place to meet the requirements of his individual installation. He is responsible for keeping it in first-class shape and first-class supply.

Dr. SEAMANS. So the overall control is a budgetary control exercised by headquarters, but within the budget the center director has the responsibility to authorize expenditures against these two accounts.

Mr. WYATT. This is a very large item, I might say, Mr. Chairman. For example, in the agency as a whole we show a total item count of about 278,000 items that are carried. For example, Marshall with the space flight development program has about 98,000 items in their inventory that they have to handle.

The CHAIRMAN. We are not going to ask you to supply those for the committee.

Mr. SIEPERT. Mr. Wyatt raises one point that I did overlook with respect to the supply item and the way supplies are handled. There is an element here in which the headquarters has taken quite an interest, and that is to try to develop an overall NASA concept of handling supplies in such a way that large amounts of obsolescent items are not accumulated in the centers. We have made substantial progress in developing new supply techniques where the supplies are on a first-in, first-out basis, where you order an economic quantity rather than constantly replenishing small items at a high-unit-cost basis. This is one overall program in the agency on which we have made substantial progress in the last year. The question of whether you buy pipes or whether you buy photographic equipment to meet a particular need has been placed in the field center responsibility.

Mr. BOONE. My question was primarily based on the fact that usually if you are buying, for example, electrical supplies, this is taken care of under a contract with a contractor, so these must be individual use items.

Mr. SIEPERT. These are the items of expenditure for the running of our own centers; that is, where the items desired are not directly tied in with a particular project for which we have project money.

The CHAIRMAN. I have a question which it may only be possible to answer by a Bureau of the Budget expert. When is an item an item of photographic supply and when does it come under the next heading of equipment? I see you have photographic under "Supplies and materials," $1,645,000, and then also photographic under "Equipment."

Dr. SEAMANS. I think in the first place, you are talking about such things as film, and in the second case you are talking about large items.

Mr. CADLE. In this one, Mr. Chairman, you have the definitions for each one of the subbreaks under each of these classifications. You go down your inventory list and you pick out each item which fits the definition.

Dr. SEAMANS. But in general the "Supplies and materials" are expendable items, whereas the "Equipment" is not; it is a permanent piece of test equipment.

Dr. CADLE. Here is the definition that we are going on——

The CHAIRMAN. Well, what I am searching for is not so much a definition as to avoid things cropping up in two different places.

Mr. CADLE. Here is the definition, Mr. Chairman: They are—

ordinarily consumed or expended within 1 year after they are put into use, or converted in the process of construction or manufacture, or used to form a minor part of equipment or fixed property, or of like monetary value.

This is the definition that we follow. Then for each subbreak under supplies and materials we have more definitions and each of these items is classified according to the Government-wide definition.

The CHAIRMAN. All I want to be assured is that if photographic items appear in two different places it doesn't mean the same thing.

Mr. CADLE. It doesn't.

The CHAIRMAN. Mr. Boone, do you have further questions?

Mr. BOONE. I have no further questions.

The CHAIRMAN. Are there any further questions under supplies and materials?

Any further questions under "Equipment"? Under "Equipment" there is an item for $11,012,000 for instrumentation and electronic equipment.

Dr. SEAMANS. This will cover things like oscilloscopes, meters.

The CHAIRMAN. Can you break it down by installations?

Mr. WYATT. I can only break the total equipment down.

Dr. SEAMANS. You can break down this item if they want.

Mr. WYATT. Yes; I do have a breakdown. The largest single center there is the Launch Operations Center at $3,170,000. This is again because the Launch Operations Center is just being set up and getting underway. The test that we are using generally as to whether a piece of equipment shall be charged against an operation of installation account or against a using project is what is the reason for buying the equipment. If it is bought in order to execute a particular project, it will be charged against the project. If it is bought in order to build a capability as at the Launch Operations Center, a capability to do the things that have to be done at a launch operations center, regardless of the project, then we charge it into this account.

As I say, that is the largest single item. The next largest item is at the Manned Space Flight Center. Again, this is a center which is growing and which we are still equipping as a basic research and development center. That $2,700,000.

The next largest center is Goddard Space Flight Center at a million and a half.

The CHAIRMAN. I think this gives the general idea. Did you want to say anything further about what comes under that heading?

Are there any further illustrations you want to give aside from the geographical breakdown, as to what this entails?

Mr. WYATT. Just the general thing, that if it is bought in order to give a capability for doing a class of work associated with a center, and not for a specific project, then it is charged and bought under this account.

Mr. BOONE. One question, Mr. Chairman.

The CHAIRMAN. Mr. Boone.

Mr. BOONE. Are you buying supplies, for example, for the Michoud operation?

Mr. SIEFERT. The raw materials that Chrysler uses?

Mr. BOONE. Handtools, test equipment, this sort of thing, you have an item here, portable handtools, machine and fabricating equipment——

Mr. WYATT. This would come under the Marshall account. The total Marshall account in this category is only $576,000. That would cover Marshall, Michoud, and Mississippi test facilities.

Mr. BOONE. So most of that type of equipment is being supplied with project funds?

Mr. WYATT. Yes; most of it.

The CHAIRMAN. I think the heading "Insurance claims and indemnities" is self-explanatory.

There is one general question. I wonder, Dr. Seamans, if you could give us some information, after reflection, for the record, and that is on incentive-type contracts. I wonder if in general you could work up a statement on NASA's experience with incentive-type contracts and how they work. Is there any history of savings to the Government in this type of contract?

STATEMENT ON INCENTIVE-TYPE CONTRACTS SUBMITTED BY DR. ROBERT C. SEAMANS, JR., ASSOCIATE ADMINISTRATOR, NASA

NASA is attempting to place incentive provisions in its contracts which will reward contractors for superior performance and cost savings, and penalize them for inferior performance and excessive costs. The conventional way this is done is to set up cost and performance targets under fixed price incentive (FPI) or cost-plus-incentive-fee (CPIF) types of contracts. If a contractor can successfully better these targets he receives an extra profit, but if he fails to come up to the target he loses profit, all in accordance with a formula set forth in the contract. In order to fix fair targets it is necessary to have past cost and performance data.

Since NASA's projects are for the most part new and involve hardware never before produced, this past information is not usually available. However, NASA has been able to apply selected incentives in a number of appropriate procurement situations. Presently, 10 NASA contracts include incentive provisions; others are being negotiated. The Administrator in early 1961 announced the NASA policy of applying incentive provisions in all appropriate procurements. Now, each procurement plan is required to discuss incentive possibilities and provide for incorporation of such provisions, wherever possible, in any resulting contract. Basically, NASA is seeking to minimize the use of cost-plus-fixed-fee contracts.

NASA Circular 242, dated September 1, 1962, covering the use of incentive contracts, has been promulgated throughout the agency. This establishes the ground rules and approval procedures in addition to the policy and responsibilities for both business and technical personnel within NASA. A copy is attached.

In order to utilize any past experience and prevent duplication of effort, liaison is maintained with all organizations having definite contributions to make to NASA's overall knowledge of the incentive contracting field. In addition, copies of the "NASA Incentive Contracting Guide" have been distributed throughout the agency. To further build up NASA in-house capability, a series of twenty 5-day sessions of formal instruction in the use and application of incentive provisions has been scheduled. The first was held at Lewis Research Center during the week April 1 through 5, 1963.

At the moment, the type of contract which appears to offer much promise for the application of incentive provisions in NASA's particular type of procurements is what has been called the cost-plus-award-fee (CPAF) contract. This is the type of contract that has been negotiated with Aerojet-General on the NERVA project, a joint NASA–AEC program, and also with Bendix for the operation and

maintenance of the Mercury tracking stations. The method and principles involved in this type of contract are summarized in the following paragraph.

Under the cost-plus-award-fee concept, provision is made for a basic fee which may be adjusted upward to a maximum amount on the basis of improved performance, as unilaterally determined by NASA. Evaluation is made in accordance with general criteria set forth in the contract. The determination as to fee adjustment is made by a senior NASA official or board specifically designated in the contract. Normally, these contracts designate heads of NASA installations or their deputies as the officials to make award fee determinations. Internal methods and procedures used in evaluating the contractor's performance are not normally spelled out in the contract, but are reduced to writing and transmitted to the contractor. NASA is maintaining a close watch over these contracts to determine their effectiveness, as well as their potential for further NASA application.

Another contract, now being reviewed for final approval, involves the more conventional fixed-price incentive approach. This one was negotiated by our Langley Research Center with Ling-Temco-Vought on the Scout vehicle program.

NASA has not as yet made extensive use of incentive contracts. However, in addition to new contractual tasks, NASA is also actively seeking new opportunities for converting existing contracts to our incentive basis. This policy will be included in all major CPAF contracts to permit this policy to be implemented in the future. As our usage increases we hope to be able to show benefits to the Government by the use of incentive features in our contracts.

NASA CIRCULAR NO. 242 (ES-1)

(Effective date September 1, 1962)

USE OF INCENTIVE CONTRACTS

1. Purpose

This Circular sets forth policies and procedures to be followed in the use of incentive contracts.

2. Applicability

This Circular is applicable to NASA Headquarters and field installations.

3. Background

a. On March 15, 1962, in Revision 8 to ASPR, the Department of Defense revised its policies regarding the criteria for using the various types of contracts authorized (ASPR, Section III, Part 4). One significant effect of this revision was to emphasize greater use of incentive provisions. The judicious application of this policy to NASA R. & D. procurements requires a case-by-case examination of the characteristics of each procurement in accordance with the provisions of this Circular.

b. NASA Headquarters plans to enter into a contract for the conduct of a course of instruction in incentive contracting for NASA-wide use to build up greater in-house capability in the use of this type of contract. It is also expected that suitable instructional material regarding incentive contracting will be distributed for general use throughout NASA.

4. Policy

a. It is important that NASA effectively utilize incentive provisions of both a cost and performance type in placing its contracts. However, the difficulties of employing this form of contract and the serious consequences that can result from its misapplication or from its negotiation by personnel who are not adequately trained in its use call for the exercise of particular care and good judgment.

b. Accordingly, it has been found necessary to adopt procedures that will result in—

(1) Effectively seeking out procurements that lend themselves to the use of contract incentives provisions;

(2) Avoiding the use of incentive provisions in situations where they are unsuited and where their use could have adverse results; and

(3) Insuring, in connection with contracts in which incentive provisions are to be included, that the skills necessary to draft and negotiate the appropriate incentive provisions are available to NASA procurement offices.

5. Responsibilities of Director, Procurement and Supply Division

a. In order to implement the foregoing policy objectives, the Director, Procurement and Supply Division, NASA Headquarters, will perform the following functions:

(1) Review, with headquarters program offices and with NASA field installations, as necessary, forthcoming procurements in order to select, well in advance, those procurements which appear to lend themselves to the inclusion of incentive features;

(2) Provide or arrange for guidance and technical assistance to procurement offices in connection with the drafting and negotiation of incentive provisions in those contracts approved in advance by the Director, Procurement and Supply Division, for application of incentive provisions;

(3) Review and make recommendations to field installations with regard to proposals made by them as to the use of incentive provisions in forthcoming contracts;

(4) Appraise the capability within NASA to select, negotiate, and administer incentive contracting and assist in making required training arrangements;

(5) Study, in conjunction with the Director of Financial Management, Office of Administration, and the Director of Management Reports, Office of Programs, NASA Headquarters, the linking of incentive provisions to PERT-COST;

(6) Maintain close contact with the Department of Defense in the incentives field and keep informed of other studies, literature, or developments within the Government and industry bearing on incentive contracting;

(7) Attempt as NASA capability and experience increase, to develop more precise policy guidelines governing use within NASA of incentive provisions, if such guidelines appear desirable; and

(8) Report quarterly to the Associate Administrator regarding the progress being made within NASA to utilize incentive provisions.

b. In carrying out the functions in subparagraph a, the Director, Procurement and Supply Division, will utilize the assistance of the Headquarters Program Offices, the General Counsel, and the Audit Division.

6. Approvals required before selection of contracts for inclusion of incentive provisions

a. No procurement will be selected for the inclusion of an incentive provision until such inclusion has been recommended or approved in advance by the Director, Procurement and Supply Division, NASA Headquarters. However, such advance recommendation or approval shall not be construed as requiring the preparation of a contract with incentive features if it appears, in the course of negotiations, that the exercise of good business judgment requires a different contractual arrangement. Every procurement plan will contain a discussion of the feasibility of applying incentive provisions as well as a recommendation regarding the use of such provisions in the particular procurement.

b. The Director, Procurement and Supply Division, will, in the case of each procurement for which incentives have been recommended or approved, provide such assistance as may be necessary to ensure that the procurement office in question has the requisite capability to draft, negotiate, and administer the incentive provisions. The degree to which Headquarters personnel participate in any phase of the preparation or negotiation of such a provision will be determined by the Director, Procurement and Supply Division.

c. Due to the difficulties inherent in incentive contracting and the limited capabilities presently within NASA, any contract containing an incentive provision will require the approval of the Director, Procurement and Supply Division, before it becomes a contract binding on the parties regardless of whether the contract requires approval at NASA Headquarters under other provisions of the NASA Procurement Regulations or whether advance authorization under subparagraph a above was obtained. This requirement will be reviewed from time to time to determine whether it can be partially or completely removed.

7. Technical assistance

The selection, drafting, negotiation, and administration of contract incentives require a team effort in which substantial technical assistance must be provided to procurement and legal personnel. The contracting officer will obtain such assistance from technical personnel in his organization and shall be satisfied that the project director or comparable official is in agreement with the incentive approach being followed in any given case. Any differences of opinion will be brought

to the attention of the Director, Procurement and Supply Division, NASA Headquarters.

ALBERT J. SIEPERT,
Director of Administration.

Dr. SEAMANS. I would be happy to work up something for the record and make a short statement now, that we are endeavoring to use incentive contracts to the maximum of our capability. Wherever we can we are introducing incentive arrangements in our contracting, feeling that in this way we will get maximum participation from the contractor, in the top management structure at the contractor's plant, knowing from experience that this has a tremendous effect upon the employees working on the particular project, feeling that they are actually affecting the profits of their corporation. So this we feel is something that must be done on more of our contracting as we go along, but we are still experimenting, if you will, as to the best ways to set up the incentive fee. It must relate, obviously, to schedules, to the performance of the equipment, to the ability of the contractor to hold costs and items of that sort.

Mr. WYDLER. Mr. Chairman.

The CHAIRMAN. Mr. Wydler.

Mr. WYDLER. Before we close this part of the hearings, Mr. Chairman, I want to say something about what our colleague, Mr. Ryan, said earlier, regarding the Electronic Research Center.

I happen to share his feelings as he stated them, regarding this Center, but to try to be fair about it, I would just like to get a few facts regarding that Center clear in my mind.

Could you tell me when it was that the decision was made to have an Electronic Research Center? When was that decision made?

Dr. SEAMANS. As I indicated in my comments, I requested in writing the Advanced Research and Technology Office to consider the problems associated with electronic research, including the possibility of a center, I believe in January of last year, that is 14 months ago.

Mr. WYDLER. And when was the decision to have such a center made?

Dr. SEAMANS. The decision was finally made at the time that we wrapped up the budget requests for this year.

Mr. WYDLER. Which would have been when?

Dr. SEAMANS. Let's see, we finally firmed up our budget request with the Bureau of the Budget and the President, I beleieve, in early December.

Mr. WYDLER. Of this year?

Dr. SEAMANS. Well, the most recent December, yes; 4 months ago.

Mr WYDLER. And when was the decision made to locate that center in Boston?

Dr SEAMANS The decision was made at that time

Mr. WYDLER. You mean this was simultaneous?

Dr. SEAMANS. Yes, at the time that the plans were firmed up with the President and the Bureau of the Budget for a center, it was also agreed that it would be preferable to have the center in the Boston area, and this is a matter that should be reviewed by the Congress and shows openly and specifically in the budget request.

Mr. WYDLER. The thing that I am driving at here is, is it that NASA wants an Electronic Research Center, or is it that NASA wants an Electronic Research Center in Boston, which is it?

Dr. SEAMANS. The first thing we want is an Electronics Research Center, and, second, we feel the best place to locate it is in Boston.

Mr. WYDLER. But those are two different propositions.

Dr. SEAMANS. Certainly.

Mr. WYDLER. Now, there are some papers which you showed me today which I understand we are going to incorporate in the record. I would just like to clarify in my own mind, there is some sort of report here signed by Mr. Laurence Gilchrist, Chief of the Guidance and Navigation Center. The first page of this report is cut off so that you can see no date on this.

Can you tell me what date this report was made?

Dr. SEAMANS. Yes; I can get you the date. I don't happen to know what the date is.

Mr. WYDLER. Well, could you tell me why this page was cut off on the top?

Dr. SEAMANS. No; it was just only that those were papers that I had available in my own possession and I can give you that information. I judge it was taken out of a larger report and that was the only pertinent information.

Mr. WYDLER. Now the pages on these reports entitled "Engineering Degrees Conferred," "Physics Degrees Conferred," "Membership of National Academy of Sciences," who made these reports?

Dr. SEAMANS. I believe there is another piece of paper that you have that indicates the source of that information. Is there not a third sheet, another dittoed sheet that actually has the source?

Mr. WYDLER. This [indicating]?

Dr. SEAMANS. No; just two items on a piece of paper.

The CHAIRMAN. I would suggest that all of these items should go into the record if it is agreeable, Mr. Wydler.

Mr. WYDLER. All right.

You will supply the person that made these reports and the date on which they were made?

Dr. SEAMANS. Yes, I would be happy to.

(The following information is provided for the record:)

FACTORS LEADING TO THE REQUEST FOR AN ELECTRONICS RESEARCH CENTER AND THE SELECTION OF THE GREATER BOSTON AREA AS ITS LOCATION

Mr. Webb addressed the following letter to the Honorable George P. Miller, Chairman of the House Committee on Science and Astronautics, concerning NASA's need for an Electronics Research Center, the planning that led up to the fiscal year 1964 budget request for the Center, and the reasons why the greater Boston area was selected as its location.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION,
Washington, D.C., March 21, 1963.

Hon. GEORGE P. MILLER,
Chairman, Committee on Science and Astronautics,
House of Representatives, Washington, D.C.

DEAR MR. CHAIRMAN: In response to your telephoned request, this letter sets forth a brief summary of the reasons why NASA has proposed establishment of an Electronics Research Center, and an explanation of the selection of the Greater Boston area for its location.

The requirement for increasing NASA's capability in electronics research is an outgrowth of the manner in which NASA was originally established. NASA is composed of a number of research and development Centers inherited from other agencies, and new NASA Centers authorized by Congress since 1958. These Centers have provided NASA with a competence in the many disciplines supporting space exploration. None of these Centers, however, has a large concentration of

personnel, and effort devoted toward electronics research and advanced development.

When formed in October 1958, NASA's core of strength came from the National Advisory Committee for Aeronautics. From NACA, NASA acquired four proven laboratories: Ames Research Center at Moffett Field, the Lewis Research Center at Cleveland, the Langley Research Center at Hampton, Va., and the Flight Research Center at Edwards, Calif. In addition, this heritage included a modest rocket-launching station at Wallops Island. These laboratories, with their 8,000 personnel and advanced facilities, comprised this Nation's principal governmental research capability in aeronautics and brought to NASA great strength in aerodynamics, propulsion, structures, and materials research.

This base of research competence was further strengthened at the time by the transfer to NASA from the U.S. Army of the California Institute of Technology's Jet Propulsion Laboratory. JPL scientists and engineers brought to NASA additional strength in propulsion, spacecraft technology, lunar and planetary sciences, and deep space tracking and data acquisition.

A third resource transferred to NASA during this early period was a group of about 300 scientific and technical personnel of the Naval Research Laboratory who had been doing extensive research on the upper atmosphere. This group brought to NASA very significant strength in atmospheric sciences and geophysics and formed an essential cadre for NASA in these important fields of science. Almost simultaneously with this transfer, NASA was given responsibility for Project Vanguard. An excellent team of Navy scientists and engineers, under the leadership of Dr. John Hagen, joined NASA to continue directing this work and brought to NASA additional talent in both launch vehicle and spacecraft development. These two groups of former Navy scientists and engineers established a nucleus for what later became the Goddard Space Flight Center in Greenbelt, Md. This Laboratory exercises technical direction over several key scientific satellite development programs and also manages our efforts in communication satellite systems and meteorological satellite systems.

In 1960, the President also transferred to NASA Dr. von Braun and his Development Operations Division from the U.S. Army Ballistic Missile Agency. This transfer brought to NASA an essential engineering strength in launch vehicle design, development, assembly, test, and launch operations and completed the early structure of the organization.

Following the President's decision in May 1961 to accelerate the Nation's civilian space program, Congress authorized the establishment of a network of development installations geared to the challenges of manned space flight, including manned lunar landing within this decade. The Manned Spacecraft Center was established at Houston, Tex., to direct the development of manned spacecraft, supervise the training of astronauts, and exercise operational control over such missions as Gemini and Apollo. The large Government-owned Michoud plant near New Orleans was reactivated for use as the major fabrication and assembly facility for large launch vehicles. A new test area was established in southern Mississippi, approximately 35 miles from the Michoud assembly facility, to provide the extensive and advanced integration, test, and checkout facilities required for the large launch vehicles. Finally, the Launch Operations Center was established on Merritt Island at Cape Canaveral, Fla., in order to direct the complex launch operations demanded by the development and fabrication of the Saturn I, Saturn IB, and Saturn V.

During these first 4 years of NASA's life, Congress has authorized the creation of a sufficient national base of Government-owned and operated laboratories to permit the effective management and utilization of a very large industrial base in private industry, both resources being essential parts of a team to discharge the large responsibilities in space exploration assigned to NASA. As a part of NASA's installation complex, Congress has continuously recognized the need for a strong inhouse research competence to provide the technical foundation so necessary to success for all elements of the space program, industrial, military, and scientific. As a result, additional personnel, resources, and facilities have been provided where necessary to already established laboratories such as Lewis and Langley, leading to the increased capability required for advanced programs of space exploration.

During the first few years of NASA's existence, the Agency relied heavily on existing electronics technology and electronics research being conducted in industry and in universities for the aeronautics and missile fields. Electronics research and development within the Agency has been conducted on a decentralized basis primarily as an adjunct to the major booster, spacecraft, or ground support system

developments. As a consequence, most of the NASA centers developed a limited electronics research competence closely related to those specific technical areas and development missions comprising their primary missions.

By 1961, a number of top NASA space scientists and engineers began to recognize the need for additional electronics research and advanced development. The accumulated flight experience was beginning to show the significant differences between the atmospheric and the space environments for electronics components and systems. The magnitude and importance of the problem is reflected in the fact that electronics components account for over 40 percent of the cost of our boosters, over 70 percent of the cost of our spacecraft, and over 90 percent of the cost of the resources going to tracking and data acquisition. It was becoming clear that the existing technical base was not adequate to the growing electronics requirements.

Following discussions with members of the NASA staff and others about this problem, I took a number of steps to correct this deficiency. A separate office of electronics and control was created within the Office of Advanced Research and Technology during the NASA Headquarters reorganization of November 1961. This office, under the leadership of Dr. Albert J. Kelley, was asked to study in detail NASA's present resources and capabilities in electronics research, the long-range needs of the overall space program in this field, and to recommend a plan to meet these needs.

Dr. Kelley's group found that although NASA was involved deeply in developmental projects covering almost all segments of the electronics field, NASA's inhouse research efforts were diffused and comprised a relatively small cumulative effort. Our program for contractual research in electronics was handicapped by NASA's lack of a group of able scientific and engineering personnel concentrating on electronics and associated physics research and relating such contracted research effectively to the overall space program. Early in the fall of 1962, Dr. Kelley reported that NASA's long-range requirements for inhouse competence required a substantial increase in electronic research efforts and strongly recommended the establishment of a new research center. This matter was carefully reviewed by Dr. Bisplinghoff, the Director of the Office of Advanced Research and Technology, Dr. Seamans, Dr. Dryden, and myself. We were unanimous in our judgment that the best interest of NASA and of the Nation would be served by the establishment of a new electronics laboratory to fulfill the requirements of the Nation's aeronautics and space program.

Before reaching this judgment, consideration was given to several ways o creating an inhouse electronics research capability. One was to increase the present electronics research capability at several NASA research centers. A second was to create a major electronics subcenter at an existing NASA center. The third was to create a new electronics research laboratory. Although the estimated costs in personnel and facilities for these three approaches is similar in magnitude, our judgment was based on other factors. The first course of action was not adopted primarily because the total program would remain diffused and electronics research would not receive the primary attention that it warranted. Moreover, it would not permit the creation of an essential "critical mass" or concentration of electronics capability which is needed to perform the many advanced efforts in electronics research and technology facing NASA and the Nation. We rejected the concept of a satellite or appendix to an existing NASA laboratory because we were concerned that the addition of a satellite facility would adversely affect both the quality of performance in the ongoing effort of any center charged with this additional responsibility as well as of the electronics research we urgently need.

The basic purpose of the laboratory is to provide this agency with the inhouse competence it requires to properly plan, conduct, direct, and supervise a major segment of electronics research and advanced development in our aeronautical and space program. As much as possible of this will be under contract or grant to universities or industries capable of performing the work required. Existing NASA centers will continue to carry out some electronics research and will conduct those developments necessary for their primary missions. These centers will draw heavily on the proposed center for electronics technology, components, subsystems, and prototype systems required for their projects. In carrying out its responsibilities, the new laboratory would perform these essential tasks:

1. Conduct an inhouse program of basic research and advanced technology in electronics and the related physics disciplines aimed at the needs of the Nation's space program.

2. Provide other NASA centers with advanced technological concepts, components, and selected prototype developments necessary for the success of their missions.

3. Develop performance parameters and standards for electronics components and systems for use by all elements of NASA.

4. Provide technical assistance to NASA centers and industry on space electronics problems.

5. Provide technical direction for a system based on utilizing the advanced research and development capabilities which exist in industry; provide a focus for the establishment of NASA-wide policies and actions to encourage industry to increase its research and development capabilities; and provide technical direction for selected contractor research design and development efforts requiring a high degree of advanced technology.

6. Provide the liaison between the university research community and NASA's research and development efforts required in this highly advanced field of science and technology.

With regard to the selection of a site for the proposed new research center, there were several basic criteria that had to be satisfied. A community having adequate utilities, services, communications, and transportation facilities was, of course, basic. In addition, it would be very desirable to be assured of adequate housing and the related family welfare, education, and recreation facilities, as well as adequate land in a reasonably convenient location not in conflict with local metropolitan planning. However, in addition to these considerations, there were two overriding criteria which carried the greatest weight in the selection. The first of these was to have the research center located in close proximity to institutions of graduate and postgraduate scientific and engineering education which are already deeply immersed in the forefront of the electronics basic research and technology over a broad range. The second was to be located in an area where the industrial community has allied technical interests and are research oriented.

Although there were several locations in the East, the Midwest, and the Far West which could be favorably considered to a greater or lesser extent, the Greater Boston area was superior to any other in offering major advantages relating to these essential requirements.

I hope the above information will be adequate for your purposes.

I will be happy to provide any additional information you may require.

Sincerely yours,

JAMES E. WEBB, *Administrator.*

The following information is also submitted. In reviewing alternative locations for a new NASA Electronics Research Center, consideration was given to the industrial and university research climate in areas of the United States having a concentration of electronics capability. The conclusion was that Boston had the best research environment for the establishment of an electronics research center. Examples of some of the specific comparisons that can be made are shown below:

INSTITUTIONS OF HIGHER SCIENTIFIC AND ENGINEERING EDUCATION

A comparison of institutions of higher scientific and engineering education indicates that certain cities stand out both in absolute and relative size. New York, Los Angeles–Long Beach, San Francisco–Oakland, San Jose, Boston, Philadelphia, and Chicago lead in the number of higher engineering and physics degrees granted by highly noted educational institutions. As a further index of scientific excellence, most of these cities lead in terms of resident members of the National Academy of Sciences. Boston ranks highest, both absolutely and proportionally in terms of higher degrees annually granted in engineering and physics, and in membership in the NAS, and in the NAS sections for physics and engineering.

Engineering degrees conferred, 1959–60, by area

Area	Bachelor's	2d level degree	Doctorate	U.S. rank by size of population
National total, all colleges	37,808	7,159	786	
1. New York, N.Y.	1,680	634	44	1
2. Newark, N.J.	392	111		13
3. Jersey City, N.J.	207	153		42
4. Paterson-Clifton-Passaic, N.J.				18
5. Los Angeles-Long Beach, Calif.	587	519	31	2
6. Chicago, Ill.	498	145	38	3
7. Philadelphia, Pennsylvania-New Jersey	655	190	11	4
8. San Francisco-Oakland, Calif.	505	177	27	6
9. Boston, Mass.	1,063	729	112	7
10. St. Louis, Missouri-Illinois	381	59	9	9
11. Minneapolis-St. Paul, Minn.	530	81	24	14
12. Milwaukee, Wis.	344			17
13. Dallas, Tex.	156	93		20
14. San Diego, Calif.				23
15. San Jose, Calif.	428	303	41	39
16. Madison, Wis.	524	129	20	112

NOTE.—For the various SMSA's, only those degrees conferred by institutions having undergraduate engineering curriculums accredited by the engineers' council for professional development are counted.

Physics degrees conferred, 1959–60, by area

Area	2d level degree	Doctorate	U.S. rank by size of population
National total, all colleges	1,073	487	
1. New York, N.Y.	66	36	1
2. Newark, N.J.			13
3. Jersey City, N.J.	18		42
4. Paterson-Clifton-Passaic, N.J.			18
5. Los Angeles-Long Beach, Calif.	53	30	2
6. Chicago, Ill.	41	25	3
7. Philadelphia, Pennsylvania-New Jersey	52	11	4
8. San Francisco-Oakland, Calif.	25	36	6
9. Boston, Mass.	78	43	7
10. St. Louis, Missouri-Illinois	6	11	9
11. Minneapolis-St. Paul, Minn.	15	6	14
12. Milwaukee, Wis.	3		17
13. Dallas, Tex.			20
14. San Diego, Calif.	12		23
15. San Jose, Calif.	9	7	39
16. Madison, Wis.	30	10	112
Total	408	215	

Membership of National Academy of Sciences by area—Membership as of July 1, 1962

Area	Total	Physics	Engineering	U.S. rank by size of population
All members and members emeriti	666	94	50	
1. New York, N.Y.	83	11	4	1
2. Newark, N.J.	11		5	13
3. Jersey City, N.J.				42
4. Paterson-Clifton-Passaic, N.J.	3			18
5. Los Angeles-Long Beach, Calif.	50	8	3	2
6. Chicago, Ill.	25	9		3
7. Philadelphia, Pennsylvania-New Jersey	11		1	4
8. San Francisco-Oakland, Calif.	47	10		6
9. Boston, Mass.	99	17	14	7
10. St. Louis, Missouri-Illinois	9		1	9
11. Minneapolis-St. Paul, Minn.	10	2		14
12. Milwaukee, Wis.				17
13. Dallas, Tex.	1			20
14. San Diego, Calif.	15	2		23
15. San Jose, Calif.	23	5	3	39
16. Madison, Wis.	24			112
Total	411	64	31	

Allied Industry and Industrial Research

A number of cities, New York, Los Angeles-Long Beach, Chicago, Newark, and Boston, are leaders in the number of electronics manufacturing plants that they contain. An indication of the research orientation of this industry is provided by a comparison of industrial research laboratories involved in electronics or related physics in each of the standard metropolitan statistical area. A ranking of the top standard metropolitan statistical area's shows the following comparison staring from the top down: Boston, Los Angeles-Long Beach, New York, and San Francisco, dropping off sharply after New York.

Industrial Research Laboratory Capabilities by Technical and Geographical Area

The following comparison is based on a survey of industrial research laboratories having capabilities in 1 or more of 15 technical areas associated with electronics and related physics research. Each firm having a facility or facilities in a city is scored once for a capability in each of the 15 technical areas (i.e., a firm with 2 laboratories in a city with capabilities in 8 areas would receive 8 points). Only concerns employing more than 25 people and having a good balance between technical and nontechnical personnel are shown. Survey is based on: National Academy of Sciences-National Research Council Publication 844, "Industrial Research Laboratories of the United States," 11th edition, 1960.

PERTINENT TECHNICAL AREAS

a. Computer technology, including analog and digital computer, data processing, and logic circuit research.
b. Circuits and circuitry research.
c. Communications theory an communications systems research.
d. Control systems research, including flight control.
e. Detection systems research, including doppler, infrared, optical, photoelectric, radar, and television research.
f. Electromechanical system research, including servomechanisms and tracking.
g. Electronics research (general).
h. Environmental research, including quality control and test equipment.
i. Simulator research, including simulation (general) and nondestructive testing.
j. Guidance research, including gyroscope, inertial and navigation research.
k. Instrumentation research, including telemetry and transducers.
l. Operations research, including mathematics and systems engineering.
m. Microwave and ferrite research.
n. Space physics research, including cryogenics, crystallography, and time measurement research.
o. Semiconductor research, including solid state physics and transistor research.

Technical area

Standard metropolitan statistical area	Total	*a.*	*b.*	*c.*	*d.*	*e.*	*f.*	*g.*	*h.*	*i.*	*j.*	*k.*	*l.*	*m.*	*n.*	*o.*
1. New York, N.Y.	134	19	5	7	2	19	7	14	3	1	14	9	5	8	8	13
2. Newark, N.J.	18	0	1	0	0	1	1	3	2	0	0	2	0	1	1	6
3. Jersey City, N.J.	5	0	0	1	0	1	0	0	0	1	2	0	0	0	0	0
4. Paterson-Clifton-Passaic, N.J.	7	0	0	0	1	1	0	0	0	0	2	0	1	0	1	1
5. Los Angeles-Long Beach, Calif.	153	26	2	2	9	20	10	10	2	4	17	16	7	3	14	11
6. Chicago, Ill.	46	4	3	3	4	4	1	11	1	0	3	7	2	0	2	1
7. Philadelphia, Pennsylvania-New Jersey	26	4	1	1	3	2	1	3	0	0	1	4	1	0	1	4
8. San Francisco-Oakland, Calif.	52	8	1	0	4	6	2	4	1	1	3	5	4	3	3	7
9. Boston, Mass.	156	27	5	7	8	20	4	16	3	1	8	10	8	10	15	14
10. St. Louis, Missouri-Illinois	9	1	0	0	1	0	1	1	0	0	1	1	1	0	1	1
11. Minneapolis-St. Paul, Minn.	26	6	0	0	3	2	2	4	0	0	1	3	0	0	1	4
12. Milwaukee, Wis.	8	0	0	0	3	0	0	1	0	0	1	0	0	0	1	2
13. Dallas, Tex.	15	2	0	0	1	3	2	2	0	0	1	2	0	0	1	1
14. San Diego, Calif.	11	1	0	0	0	3	1	0	0	0	1	1	1	0	2	1
15. San Jose, Calif.	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
16. Madison, Wis.	4	0	0	0	1	0	0	1	0	0	0	0	0	1	0	1

Mr. WYDLER. All right.

Dr. SEAMANS. I am surprised they are not right here with that group of people. I don't have them right here.

Mr. RYAN. Could I see those, Mr. Wydler?

Mr. WYDLER. Yes.

Mr. RYAN. May I raise a question on this very point, Mr. Chairman?

The CHAIRMAN. Yes, Mr. Ryan.

Mr. RYAN. I believe that when we had the hearing in the full committee I asked one of the witnesses, I don't remember which one, if he could supply whatever memorandum there was within the agency recommending the selection of Boston as the site. I believe—and I cannot tell you who was the witness at the time—testified that there had been a recommendation and it did discuss the pro and con of Boston versus other sites, and he said that he would check into it and see if that could be supplied for the record.

Would you be willing to check into that and see what happened to that request?

Dr. SEAMANS. I would be happy to check on that, yes.

The CHAIRMAN. I think we are getting kind of close to the end of our time here. I would like very much to see if we could draw this to a conclusion, so we don't violate the constitutional amendment against cruel and unusual punishment.

Mr. BOONE. Could I ask one last question, and ask Dr. Seamans to limit it to 3 minutes or something like this?

I realize it is a rather controversial one, but the committee is continually asked about the letting of contracts, single source, sole sources of procurements, and the manner in which NASA goes about doing this.

Would you like to add some words here for clarification?

The CHAIRMAN. I think this might be one that you could submit some information for the record. I think it would be better to have a statement that the committee could analyze.

STATEMENT SUBMITTED BY DR. ROBERT C. SEAMANS, JR., ASSOCIATE ADMINISTRATOR, NASA

NASA is under the same statutory procurement authority as is the Department of Defense; that is, what is commonly referred to as the Armed Services Procurement Act. While, as an independent agency, we are not subject to the Armed Services Procurement Regulation, our own procurement regulations are in most respects similar to that regulation. There is good reason for this: In addition to having the same statutory requirements, we do most of our contracting with essentially the same segments of American industry as does the Department of Defense.

The statute, and our regulations, prescribe as the preferred method of contracting the sealed bid, or formal advertising method. Formal advertising is most effective and is used in those situations where there are adequate numbers of qualified suppliers, when the product to be bought can be precisely described by definitive specifications, where competitive fixed prices can be obtained, and where time permits the formalities incident to this type of procurement. Under this procedure, sealed bids are publicly opened at a prescribed date and time, and award is made to the lowest bidder who is "responsive" (bid meets the exact terms and conditions of the invitation for bids), and who is "responsible" (determined to be capable of performing the contract).

Negotiation may be resorted to under certain stipulated exceptions, 17 in number, of which 6 require a determination and finding that formal advertising is impracticable, by the Administrator himself. One of these six is where the procurement is for research, development, or test. It is in this category that the

bulk of our dollars are spent—for such things as the design and development of large rocket engines, nuclear rocket engines, manned space vehicles, and scientific satellites, most of which have never before been built and for which it is impracticable to draft precise definitive specifications or to establish costs in advance with that degree of certainty required for fixed-price formal advertising. As a result, we must resort to negotiation. This does not mean that we do not obtain competition. We can and do. This competition is based far more on technical considerations and management competence than on price. It has been our experience in this respect that the company ranked highest in these factors is the one that can perform the contract most efficiently, in a timely manner, and at the lowest overall cost to the Government. The competition obtained in negotiated procurements is real and intensely keen. Top management in NASA is fully aware of the need for, and benefits of, competitive procurement. It has instituted an active and continuing program stressing competition and requiring all echelons involved in the procurement process to seek out a maximum of ways and means to achieve it.

Nevertheless, it must be recognized that there are, and will continue to be, certain situations where seeking competitive proposals is not feasible or even necesarily in the best overall interests of the Government. The following are illustrative of such situations:

1. *Follow-on contracts.*—This is the situation in which contracts for additional or closely related work are placed with the same contractor originally selected to perform the initial research and development in a given project, and where to select another source would require an extensive period of preparation for manufacture and additional cost to the Government by reason of duplication of investment or preparation. Some examples are: additional development and production phases of the E–1, J–2, and LE–115A–3 engines, and Centaur vehicles, all placed by new contracts with the contractors originally selected (in this case by the Army and Air Force, respectively) for the research and development. Another example is the placement of a contract for the S–IVB stage with the same contractor who developed and built the S–IV stage, on which S–IVB development is based. Likewise, the Gemini contract was placed with the Mercury contractor, for the reasons stated above, and more particularly, since the Gemini capsule, though larger and more complex, is essentially based on the Mercury capsule configuration. In both of these latter cases, the contractors for the original work were selected as a result of competitive negotiated procurement.

2. *Facilities contract.*—Facilities must be acquired and installed at the plants where the research and development contract is being performed. While the Government, where necessary, furnishes some facilities to its research and development contractors, it would be impracticable to select another contractor to acquire and install other needed facilities in the research and development contractor's own plant. As a result, such facilities contracts are placed with the research and development contractor. However, pursuant to our established policy, we require the contractor, in acquiring the facilities, to use competitive procurement to the maximum practicable extent.

3. *Unsolicited proposals.*—This is an area which differs from the normal procurement process whereby NASA formulates its own requirements, competitively solicits offers, and awards to the source offering the best value to the Government. Unsolicited proposals are generally for new ideas, concepts, or methods. They are the product of original thinking by the organization or individual presenting them. NASA derives many benefits from the ideas presented in such proposals. An unsolicited proposal is carefully evaluated by cognizant NASA technical personnel, and if determined to be novel, well planned, or developed, and of value to NASA's programs, a contract is awarded to the proposer. If such proposals were generally to be made the basis for competitive solicitation, it would discourage their submission, and valuable information and ideas would be lost by the Government. While the dollar value of individual contracts resulting from unsolicited proposals is not large, the number of such contracts are substantial.

4. *Unique capabilities.*—There are certain situations where the nature and scope of the work is such that very special technical, management, and organizational capabilities are required. In such situations, while it cannot be said that there is only one company capable of performing the work, a particular company nevertheless stands out among all others as possessing a superior combination of the requisite, and sometimes unique, skills. Even in such situations, it is only after careful and comprehensive analysis within NASA, involving all appropriate levels of management—business and technical—that the decision is made to award

a contract without formal, solicited competition. Examples of this rarely used method of procurement are the Bellcomm contract for systems engineering and the General Electric contract for checkout, reliability assessment, and integration, both for the Apollo program, and both described in Dr. Seamans' and Mr. Holmes' recent statements and testimony before the subcommittees of the House Committee on Science and Astronautics.

In summary, NASA's policy is that its procurements will be placed by competitive processes to the maximum practicable extent, whether it be by formal advertising or by negotiation. It is only in situations where the particular circumstances fully justify it, that resort is made to a single source for a given procurement.

There is another subject that Mr. Ryan wanted to bring up which I think, despite the fact that we had hoped to finish today, perhaps Mr. Ryan, you want to raise, and then when we come to the conclusion of our hearings in about 2 weeks, I think Dr. Seamans, if you would be willing to come back to discuss this one question, we would appreciate it.

Mr. Ryan.

Mr. RYAN. Mr. Chairman, this relates to personnel.

Dr. Seamans, I have been concerned with the management type contracts which NASA has with General Electric, Bellcomm, and I don't know which others.

Last year I asked whether or not NASA had presented to the Bureau of the Budget a request for the necessary supergrades or personnel which could carry on in-house this work, and I believe that one of the reasons NASA gave—in fact, I am sure that one of the reasons NASA gave for entering into these two contracts was that the Congress would not approve salaries commensurate with the work required, and I would like to explore that whole question and know now exactly what personnel are employed under these contracts and any other similar contracts, and what the cost to the Government of those contracts is, and what the estimated cost to the Government would be is this work was performed in-house.

That is very general——

Dr. SEAMANS. I understand the question very well. I judge you would like to discuss it at some other time, Mr. Chairman.

Mr. RYAN. I don't want to go into it today, the hour is late and you have had a long drawn-out morning, all of you.

The CHAIRMAN. I think that this is one that instead of answering for the record, perhaps, Mr. Ryan, you would prefer, and the committee might prefer after we have finished our hearings on weather and communications satellites, that you might find an appropriate and convenient time to come back and talk about this, and more or less cap off the hearings.

Dr. SEAMANS. This is certainly a most important area and we would be happy to review it in whatever detail you wish.

Mr. RYAN. Fine, thank you.

The CHAIRMAN. Certainly the members of the committee appreciate the superior testimony which you have given us this morning, Dr. Seamans, and your associates, Mr. Siepert, Mr. Wyatt, Mr. Cadle, and your other associates.

I think it is indicative of the thoroughness with which NASA is prepared to justify its budget, and I want to congratulate each of you personally on the cooperation which you have given the committee and the extensive information and clear understanding you have given the committee.

Are there any further observations?

The committee stands adjourned.

(The additional information requested for the record is as follows:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION,
OFFICE OF THE ADMINISTRATOR,
Washington, D.C., June 14, 1963.

Mr. W. H. BOONE,
Staff Consultant, Committee on Science and Astronautics,
House of Representatives, Washington, D.C.

DEAR MR. BOONE: In reference to the question you recently referred to us concerning the average GS grade level of Negro employees in the National Aeronautics and Space Administration Headquarters, we have been informed that this average is currently GS–6. Not included in this average is an excepted position, Director of Management Reports, Office of Programs, which also is occupied by a Negro employee. In addition there are 16 wage board positions in the headquarters filled by Negroes.

We hope this information will be helpful to the committee.

Sincerely yours,

PAUL G. DEMBLING,
Director, Office of Legislative Affairs.

(Whereupon, at 1:03 p.m., the subcommittee was adjourned.)

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1964 NASA AUTHORIZATION

TUESDAY, MARCH 26, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON APPLICATIONS AND
TRACKING AND DATA ACQUISITION,
Washington, D.C.

The subcommittee met at 10 a.m., pursuant to adjournment, in room 214–B, Longworth Building, Hon. John W. Davis presiding.

Mr. DAVIS. This morning the committee is concerned with the activities of the National Weather Satellite Center and the relationship of the Weather Bureau with NASA in the development of the Nimbus satellite program. The entire weather program which this country has embarked upon has been one of the most productive of all the space effort today. In fact, it may be the only currently operative satellite system to which dollar savings can be directly attributed at this time. I think we are all aware of the tremendous work which the TIROS program is performing in giving hurricane and typhoon warnings at home as well as abroad.

We have as our witness this morning Dr. S. Fred Singer, Director of the National Weather Satellite Center. We are happy to welcome you, Dr. Singer. You may proceed with your prepared statement.

STATEMENT OF DR. S. FRED SINGER, DIRECTOR, NATIONAL WEATHER SATELLITE CENTER, DEPARTMENT OF COMMERCE, WEATHER BUREAU

Mr. Chairman and committee members, it gives me great pleasure to appear again before this committee. I am keenly aware of your continuing interest in the progress of the National Operational Meteorological Satellite System (NOMSS) and I appreciate this opportunity to report to you on developments and achievements which have taken place since my appearance before you in September 1962.

Our organization has matured in its stewardship of NOMSS; we have reacted swiftly and instituted an interim operational system based on TIROS only a few weeks after discussing the plans before your committee last September. We are completing a thorough operational analysis of users' requirements and of costs, to insure that the eventual operational satellite system will be an optimum one from the point of view of cost-benefit ratio.

Now, the Weather Bureau, as you know, is actively supporting the national space effort in at least six ways: (1) By operationally using the data obtained through TIROS for weather analysis and forecast-

ing; (2) by undertaking, in response to Congress, to establish and operate the National Operational Meteorological Satellite System; (3) by conducting applicable research in its Meteorological Satellite Laboratory; (4) by investigating potential nonmeteorological by-products of weather satellites; (5) by planning the institution of an operational meteorological rocket-sounding network, and (6) by providing specialized meteorological assistance and services to the NASA Mercury and Gemini spaceflight programs.

These program areas have been described in the annual report to the Congress from the President, entitled "U.S. Aeronautics and Space Activities, 1962." With your permission, therefore, I shall supply the pertinent material for the record, and limit my prepared remarks to our most urgent, most important, and most challenging responsibility—the establishment and operation of the National Operational Meteorological Satellite System (NOMSS).

I would like, further, to set forth my remarks on NOMSS in the form of four statements: The first to present background, and in general terms, the arrangements under which we are operating, including our funding of NASA activities; the second, to discuss what we have done to organize ourselves to fulfill both our current and future NOMSS responsibilities, and to discuss the implications of these responsibilities upon our interface with the NASA; the third to describe what we at the National Weather Satellite Center now visualize to be the probable operational meteorological satellite systems of the immediate and long-range future; and the fourth to describe in some detail our most significant NOMSS achievements of the past 6 months.

NOMSS, the committee will recall, is the result of recommendations made by an interagency working group known as POMS.

These recommendations led to the incorporation in the Supplmental Appropriations Act, 1962 (Public Law 87–332) of funds earmarked for the Weather Bureau to provide for the "continuous observation of worldwide meteorological conditions from space satellites." This resulted in the definition of NOMSS requiring, for implementation, the joint efforts of the Weather Bureau and NASA.

Quoting from the POMS report:

> **Overall management of the system would be assigned to the U.S. Weather Bureau, which would be directly responsible for data acquisition, communications, processing, analysis, and dissemination. Development and procurement of spacecraft and launch vehicles, including the actual conduct of launch operations, would be delegated to NASA. It is contemplated that NASA would also participate in spacecraft control and programing and in data acquisition. Participation of the military services and other user agencies, as required, is expected.**

As a necessary first step, the Department of Commerce, representing the Weather Bureau, entered into an interagency agreement with NASA on January 18, 1962, to delineate the functional responsibilities under which each organization would conduct its respective part of the cooperative program during the initial phase of the program. The agreed-upon division of Weather Bureau and NASA roles was intended to be consistent with the former's traditional role as the National Meteorological Service and the latter's statutory responsibility as the Nation's civilian space agency. This interagency agree-

ment differs in some important details from the POMS report, but this reflects the fact that the initial phase would require a larger degree of emphasis on R. & D., particularly on spacecraft R. & D.

In February 1962, the Weather Bureau established the Meteorological Satellite Activities at Suitland, Md., as a new organizational segment. In August 1962, it was designated the National Weather Satellite Center. NWSC provides the organizational framework within which the Weather Bureau performs its technical, managerial, and operational functions with respect to NOMSS. I will discuss later the management operations of NWSC and our present interface with NASA.

Weather Bureau appropriations available or requested to support the TIROS and Nimbus programs through fiscal year 1964 are set forth in the following table:

Weather Bureau financial plan, meteorological satellite operation appropriation

[Millions of dollars]

	1962	1963	1964
Appropriation or estimate:			
For Nimbus program	$48.0	$27.9	$23.0
For Tiros program		12.1	
Total	48.0	40.0	23.0
Obligations:			
A. To NASA:[1]			
1. Nimbus program:			
a. Spacecraft	(2.5) 20.0		(2) 16.0
b. Launch vehicles & launching:			
Thor-Agena	(2) 13.0		
Atlas-Agena			(2) 16.6
c. Command and data acquisition:			
Construction of stations	11.2		
Nimbus peculiar equipment	.9	2.5	3.0
Station operation			1.5
Communication links			.5
d. Technical control and programing		.2	.5
e. Technical management	.6	.4	.8
Total, Nimbus	45.7	3.1	38.9
2. Tiros program:			
a. Spacecraft		(3) 3.6	.3
b. Launch vehicles and launching: Thor-Delta		(2) 5.0	
c. Command and data acquisition:			
Station operations		.3	.9
Communications			.2
d. Programing and analysis		.2	1.2
e. Technical management		.1	.3
Total, Tiros		9.2	2.9
3. Automatic picture transmission (APT) system			.6
Total, reimbursement to NASA	45.7	12.3	42.4
B. Weather Bureau:			
1. Operational staff at CDA stations			.2
2. Data processing, analysis, and archiving	1.3	2.9	3.8
3. Technical management	.8	.8	.8
Total, Weather Bureau	2.1	3.7	4.8
Total obligations	47.8	16.0	47.2

[1] These are estimates only. Reimbursements to NASA will be made on the basis of actual costs incurred for the activities finally approved.

This table also indicates the amounts to be made available to NASA under reimbursable arrangements. I shall simply summarize this funding by reporting to you that: (*a*) The Weather Bureau portion of the TIROS program is fully financed through a reprograming of a portion of our meteorological satellite operations appropriation; (*b*) for Nimbus, appropriations already available are sufficient to establish and equip the facilities required for weather-data acquisition, processing, analysis, and archiving; and to procure four Nimbus spacecraft; and (*c*) the 1964 budget estimate submitted to the Congress requests operating funds to place the NOMSS program into operational status during fiscal year 1964.

Having described some of the background, I would like to go on to discuss the matters which were of major concern to this committee. Last September, delays encountered in developing the Nimbus spacecraft were discussed by NASA, the Weather Bureau, and the Department of Defense, before this committee. Subsequently, in its report, "Space and the Weather," the committee endorsed the concept of orbiting additional TIROS satellites until such time as the Nimbus system proves itself operationally satisfactory. The NWSC took the initiative in proposing a technical plan known as TOSS (Tiros Operational Satellite System). Agreement was reached between the Weather Bureau and NASA covering the funding of additional TIROS launches, and the necessary procurement action has been initiated. Under this agreement, three R. & D. flights will be funded by NASA and two operational flights by the Weather Bureau.

All operational costs, such as those required by the command and data-acquisition stations, communication links, and by programing and technical management functions, will be shared on a pro rata basis according to the number of R. & D. versus operational launches; that is, 60 percent NASA, 40 percent Weather Bureau.

The committee report of December 3 last year, further expressed concern over decisionmaking and management authority in the Nimbus program, recommended consideration of the creation of a court of appeal for obtaining binding decisions, and asked to be informed of the measures taken by the Weather Bureau and NASA to create such an entity. For our part, we in the Weather Bureau do not believe that the state of things warrants such action. We do believe that where there is uncertainty about Weather Bureau or NASA responsibility and authority, this uncertainty can be resolved by discussions at the working level, or at the management level. As a final resort, we can appeal to the Secretary of Commerce and Administrator of NASA; such an appeal has never been necessary, and we do not contemplate this necessity.

I would like, now, to discuss the organizational steps which we have taken to fulfill our NOMSS responsibilities and to accommodate future trends in operational weather satellite technology. I would like to deal, also, with the implications of these trends upon our working relationships with other Government agencies, and with NASA in particular.

The National Weather Satellite Center believes that its structure and operation must be kept dynamic and responsive to the technical changes and new management demands of the space age. For this reason, we have within recent weeks organized the Center along the

functional lines indicated by the attached organization chart. These lines reflect the lessons learned and experience gained in the NOMSS program to date.

Our activities, as you can see, are now divided into four major Divisions: Operations, Research, Systems, and Spaceflight Support.

(1) The Operations Division carries on the analysis of the satellite data on an operational, that is to say, on a real time basis. It is a 24-hour-a-day operation where data are received at the acquisition stations, analyzed, transmitted to the users, and archived. In addition, the Operations Division also receives the user inputs on the programming of the satellite and transmits the appropriate instructions to the NASA TIROS Control Center. In the NOMSS program, of course, this Division will be responsible for the Data-Processing Center, which is now being constructed at Suitland.

(2) The Research Division is our Meteorological Satellite Laboratory which has been in existence for many years as the preeminent scientific group doing research on satellite meteorology. This Division has essentially two major functions:

(*a*) Research with the help of satellite data to obtain a better understanding of how the atmosphere works; (*b*) the design and testing of advanced meteorological sensors for future satellites. The research scientists of the Meteorological Satellite Laboratory are also available as inhouse consultants for a variety of problems which occur in the other divisions. They also monitor a large and ever-increasing number of university grants and contracts for research with weather satellite data.

(3) Our new organization chart (fig. 4a) shows that we have added a Systems Division. This activity is expected to spearhead Weather Bureau developmental activities concerning (*a*) future improvement and modifications to the Nimbus operational program, (*b*) meteorological data handling and dissemination, and (*c*) advanced systems intended to extend the usefulness of NOMSS.

(4) Of particular interest to this committee may be our new Spaceflight Support Division. The operations of this group are funded for by NASA, and currently consist of providing meteorological forecast and advisory services to the NASA manned spaceflight program. These services have been rendered throughout Project Mercury and are being extended into Gemini and Apollo. It is expected that our spaceflight support will, in time, be enlarged still further to include the analysis and forecasting of the terrestrial environment at much higher altitudes, in addition to that of conventional weather.

We do not consider organization a static thing. We intend to keep ours dynamic to meet current and anticipated problems and responsibilities. But instead of increasing our size, we hope to limit ourselves to our present authorized complement of about 300 personnel of all types. We want to keep ourselves small and flexible to insure continued effective technical and management communication, upward, downward, and laterally. We rely heavily on contracts now, and make sure that each one is monitored by experts in our center. Basic research we contract to universities and other nonprofit institutions; applied research and developmental work is contracted to industry; and, of course the design and construction of spacecraft is handled by NASA, again under a reimbursable-type contract. The

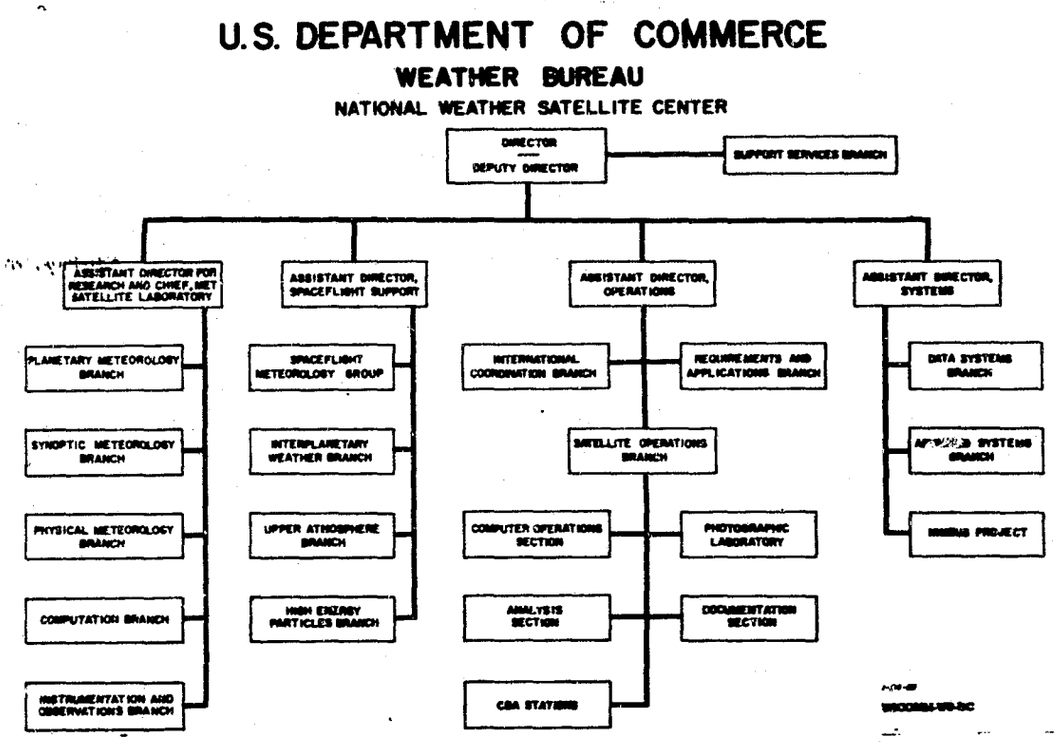


FIGURE 4a

management group for NOMSS itself is made up of less than a dozen of us who monitor the fiscal and technical performance, set specifications on weather satellite systems, and direct several operational analysis, both in-house and with outside contractors, to evaluate and improve the cost-benefit ratio of weather satellites.

Just as we must keep our organization flexible and responsive to change, so we must keep adaptable the ground rules under which we operate. Essentially these rules are the terms of the existing interagency agreement between NASA and the Department of Commerce for the implementation of phase I of the Nimbus Operational System. These terms, derived relatively early in the Nimbus program, represented an initial effort to define the relative responsibilities of the two agencies.

As each future phase of NOMSS approaches the implementation state, we and NASA must reexamine our ground rules to insure that they are compatible with the particular weather satellite system in question, and that they reflect the accumulated technical and management experience both in the meteorological and space technology fields.

Mr. Chairman, I think I would like to stop at this point——

Mr. DAVIS. All right.

Dr. SINGER (continuing). And continue with the rest of the statement at a later time.

Mr. DAVIS. That will be all right.

Initially, I'd like to address an inquiry or two with reference to the Nimbus program, Dr. Singer.

In hearings last August before this committee, it was revealed that there had been a slippage in the Nimbus program. I believe the testi-

mony was to the effect it was about 18 months behind what had been hoped for.

It also came to light that the Department of Defense was extremely interested in the program and felt that it had a vital stake in the successful launch of a Nimbus satellite.

Now, at the present time, I understand that it is hoped that an experimental Nimbus can be launched in calendar year 1963. Do you agree that the outlook is still bright for that event to take place?

Dr. SINGER. Yes, sir; this is my understanding.

We keep in constant touch, both technically and fiscally, with the Nimbus project and I believe this is a correct estimate; yes, sir.

Mr. DAVIS. Now, has this slippage in the Nimbus program resulted in the necessity of firing more TIROS satellites than was originally scheduled, or would you say that there is no connection between the TIROS launchings and the Nimbus slippage?

Dr. SINGER. The slippage of Nimbus, as you will recall, led to the institution of an operational TIROS system. This was brought about after the hearings last year before this committee.

We stated then that if Nimbus were to slip further, we would want to insure a continued operational coverage so that the users who are depending on the data from weather satellites would be covered in the event Nimbus did slip.

Following these hearings, we made arrangements with NASA for a program whereby the Weather Bureau would fund additional TIROS satellites through a reprograming of funds originally intended for Nimbus.

This has now gone into effect.

We expect to have the additional TIROS satellites available for firing as required.

Mr. DAVIS. Now, in your opinion, was the slippage on the Nimbus program due simply to technical problems caused by the sensor. Was there any other cause for the slippage?

Dr. SINGER. I believe I can say quite unequivocally the slippage in Nimbus is due to technical difficulties; that these technical difficulties arose after the program was started; that these technical difficulties were not foreseen and probably could not have been foreseen in their entirety.

The undertaking of a project such as that of Nimbus is a very complex one and it is virtually impossible for anyone to be able to foresee what he will run up against.

Mr. DAVIS. In your judgment has the fact that our Department of Defense fired a nuclear bomb in outer space and thereby created a field of radioactivity complicated the Nimbus program?

Dr. SINGER. The creation of the artificial radiation belt has lead to a decrease in the lifetime of solar cells on orbiting satellites and, therefore, wisely I think, the Nimbus project decided to change their solar cell setup. This not only guarantees a better solar power supply for the present Nimbus, but will, in my opinion, lead to an improved power supply for future Nimbus satellites.

In other words, I think it is a good technical change, irrespective of whether the bomb was fired in space or not. It has, however, led to a procurement delay, not a technical delay.

Mr. DAVIS. Well, you still don't qualify your statement to the effect that the artificial radiation belt also will shorten the life of a satellite—or of a solar cell.

Dr. SINGER. Well, sir, it's not possible to make such a blanket statement.

As an example, I will quote the fact that TIROS V, which was launched in June of 1962 shortly before the atomic explosion, has suffered no ill effects and is still operating perfectly.

In fact, I checked this morning. The quality of the picture is better than ever.

Mr. DAVIS. On a recent trip out to Goddard, this committee was shown, what I suppose was a "mockup" of a Nimbus satellite, and the panels of the solar cells, as I recall, were 3-feet wide each and 8-feet long, and each one had about 10,000 of these blue solar cells on it.

Now, has that configuration been changed or is that the latest one?

Dr. SINGER. No, sir; the configuration, the mechanical configuration, has not been changed.

What has been changed is the character of the cell itself. Instead of the use of so-called P/N cells, they are using N/P cells. What this means is that they are using cells which are more radiation resistant.

It also allows you to attach the cells to the panels in a better way mechanically so they won't fall off under vibration, and this again, I think, is a technical improvement, and leads to a greater reliability of the satellite.

So, the change from one type of cell to another has two technical improvements.

I have personally gone into this matter, since it constituted a delay, to assure myself that the change was necessary.

I am satisfied the matter has been handled in the best possible way.

Mr. DAVIS. Now you mentioned a few minutes ago, the fact that the Nimbus was not launched as soon as it had been hoped, caused an operational TIROS to be launched.

Now you further, earlier in your testimony this morning, said there would be two R. & D. launches of TIROS and three operational launches—was it the other way around—three R. & D. launches and two operational launches?

Well, what is the big thing that distinguishes between a R. & D. TIROS and an operational TIROS?

As a matter of fact, the first one you launched turned out to be virtually operational, didn't it?

Dr. SINGER. It's a matter of definition. Let me explain my definition.

Mr. DAVIS. All right.

Dr. SINGER. In the first place, a small correction—an operational TIROS has not yet been launched. We can define the TIROS satellites here as to whether they are, indeed, operational, by the type funding they are getting.

If they are funded by the NASA they are R. & D. and if they are funded by the Weather Bureau they are operational.

If they are funded by the Weather Bureau they are under the control of the Weather Bureau. We can specify the kind of sensors they have. We insist they have these sensors and we can specify the launch time.

With the R. & D. satellites we can request and urge NASA to include certain sensors, and we can urge and request them to launch the satellite at a particular time—let's say, for example, just before the hurricane season—so that we will have coverage; but I don't think we can legally insist on it because it is, after all, a R. & D. satellite intended for R. & D. purposes primarily, and funded by NASA on a R. & D. program.

But as a matter of fact, NASA had been most responsive to our requests, particularly our scheduling requests.

As an example, we asked them to slip a firing which was scheduled for the very near future.

We asked them to slip this firing because both TIROS V and VI are working perfectly.

We saw no point in having a third satellite up there from an operational point of view. From a research point of view, they might have liked to have the satellite up there to try out a new sensor or a new scheme, but they deferred to our request to save this particular satellite for a later date when we would need it.

Mr. DAVIS. To move to a slightly different subject for a moment.

Mr. HECHLER. Mr. Chairman, before we leave that, may I ask Dr. Singer what is the current schedule for future TIROS launching?

Dr. SINGER. We always fix on a tentative date by quarters of calendar years.

These dates, at the request of NASA, are classified and later declassified and released shortly before the launch.

However, we want to reconsider the launch schedule at a later time in the light of whether either TIROS V and VI is still operating.

Roughly speaking, we want to be sure we have satellite coverage during the time of year which is of greatest meteorological concern to the United States.

That is to say, during the August-September-October hurricane season we want to be sure a satellite is in an orbit which will cover the northern hemisphere.

Therefore, we will carefully watch TIROS V and VI performance. If they show any kind of deterioration, we will schedule a satellite for a launch suitable to cover the hurricane season.

Mr. RUMSFELD. I was just curious about this possibility. If the two TIROS satellites are operating properly as we approach August and September, is it possible you will suggest they again slip the additional TIROS shot?

Dr. SINGER. It is possible, but I think we would be very chary to do this because we might be pushing our luck too far. Failure of a satellite can occur at any time, and it would be unexpected and unforeseen. We may not want to take this chance in the fall, but we are willing to take this chance in the spring.

Mr. RUMSFELD. I see.

Dr. SINGER. We are now approaching, by the way, the very happy situation that was discussed last September, I recall, by Mr. Fulton of Pennsylvania, where we actually have satellites on the shelf. Something that we have never had before and where we can, in fact, schedule our launchings in an intelligent way to lower the general cost of the whole satellite system.

Mr. RUMSFELD. Doctor Singer, do you assume that when you request a slippage of a firing for operational reasons, that research con-

siderations being made by NASA are of insufficient meaning that they would willingly go along when they do go along, as they did in this last case?

Dr. SINGER. It's a matter of sitting down and working these things out. We are as interested as NASA is in seeing the research go forward, for from the research will come better satellites and better sensors. So we do have basically the same interests and we have had no real problem in the scheduling of the TIROS satellites.

But in the operational satellites we will have, I think, the necessary legal and managerial control to specify exactly what goes into them.

Mr. RUMSFELD. I see. Is there—this is possibly not a question that should properly be asked of you; but do you know of instances where tests have been made on, say, solar cells—for the TIROS and Nimbus projects or on other satellites—not connected with the program that you are concerned with?

Dr. SINGER. Testing solar cells, for example, to check their radiation resistance?

Mr. RUMSFELD. Yes.

Dr. SINGER. Those kinds of tests generally are done in the laboratories under controlled conditions. What one does is measure the radiations in space to see what is up there affecting the cells. One then produces these various conditions in the laboratory and exposes the solar cells to them.

Mr. RUMSFELD. You said there were tests required that had to be made in space.

For example, this next TIROS. There's some reason for launching this next TIROS instead of waiting for the Nimbus?

Dr. SINGER. These are not tests of solar cells. These are tests of new orbits.

Mr. RUMSFELD. Can these be tested in the laboratory?

Dr. SINGER. No; they cannot.

Mr. RUMSFELD. They cannot?

Mr. DAVIS. Mr. Chairman?

Chairman MILLER. Doctor, we speak of making a successive number of R. & D. orbitings, TIROS satellites. These successive orbits—do not necessarily follow the pattern of the one before. Each one has a specific reason, hasn't it, for being sent up? In other words, to develop new data to improve over the prior experiment. Isn't that the reason you have to go through with the R. & D. firing?

Dr. SINGER. Yes, sir.

Chairman MILLER. It's not just a question of sending up a vehicle that is to be considered standard. They are each different and each has a very different probe for scientific reasons.

Dr. SINGER. It has turned out there have been modifications on successive TIROS spacecraft and also modifications in the orbit.

For example, the first four TIROS satellites were launched in 48° orbit and then it was decided to try a 58° orbit to see what improvement one would obtain in coverage.

The improvement is considerable.

Mr. DAVIS. When you say 58°, it might be well to explain what you mean. Is that the angle of the orbit as with respect to the equator?

Dr. SINGER. That is correct.

Chairman MILLER. Doesn't that throw you pretty far north?

Dr. SINGER. This is the reason we want it at 58°. As it turns out, if you go much farther north you don't gain a great deal.

Chairman MILLER. Where is it farthest north—over the Pacific someplace?

Dr. SINGER. It will go as far north as 58° latitude and will hit successively at different longitudes; so during the lifetime of a satellite it will just about cover the whole Earth.

Chairman MILLER. It will just about cover the whole Earth?

Dr. SINGER. In fact, since it's operating at considerable altitude, it can look farther north than 58°.

It can see, for example, the subarctic ice conditions. It can check on polar meteorology and, in fact, we have been able to obtain with TIROS V, a wonderful set of pictures giving the meteorological conditions around Antarctica for the first time.

These have never been observed from any conventional meteorological network. There just isn't one down there.

Mr. DAVIS. Doctor, so this record will show a little bit of the difference between TIROS and Nimbus, it is true. TIROS sees only about a tenth of the Earth each day. Is that not correct?

Dr. SINGER. Roughly 15 percent, sir.

Mr. DAVIS. And also it's true TIROS is not capable of being controlled to make it always look at the Earth.

It's oriented—it's spin oriented, is it not? And consequently is looking away from the Earth quite a bit of the time, although it has a consistent attitude with respect to the Sun. It's not always pointed at the Earth?

Dr. SINGER. Yes, sir; but TIROS can be modified and this brings me back to the earlier question about the TIROS operational satellites.

We can, for example, and we may wish to, specify to NASA to launch our operational TIROS satellites in a certain way to give complete coverage of the Earth or to provide a camera system which can be oriented to the Earth by means of a special arrangement which I actually hope to discuss in the second part of my testimony.

Mr. DAVIS. Now, of course, Nimbus will be fully able to keep the earth in view all the time?

Dr. SINGER. Nimbus is a much superior satellite compared to TIROS. Nevertheless, much more can be done with TIROS than has been done. We have made studies, and so has NASA, to see how the TIROS satellite can be adapted to obtain a better operational coverage.

Mr. DAVIS. Now, pointing up another difference between TIROS and Nimbus; as I recall it, the camera system aboard TIROS is able to resolve distances only down to points about 2 miles apart. Is that not correct?

Dr. SINGER. This is so; it often works out to be about 4 or 5 miles. Of course, when the camera looks at large angles from the vertical the distances are really very much greater.

Mr. DAVIS. What will Nimbus resolving power be?

Dr. SINGER. Nimbus should be able to resolve half a mile at the center of the picture.

Mr. DAVIS. Is that a sufficient resolving power to help you see such phenomena as tornadoes?

Dr. SINGER. We cannot see the actual funnel tornado cloud from above because it is suspended and therefore hidden under a larger cloud system. We can now recognize certain features of the larger clouds as hail and tornado producing clouds; but to do this we will need the higher resolution camera systems.

Chairman MILLER. Doctor, we talk of tornadoes and hurricanes.

Is there a difference between them?

Dr. SINGER. Yes, sir, a considerable difference. Hurricanes, typhoons, "Willy-Willies"—they are all the same thing.

They are called different names in different parts of the world. They are all what we call tropical cyclones with winds over 65 knots. They occur over most tropical oceans, both north and south of the Equator. Not really at the Equator.

Chairman MILLER. These you can see?

Dr. SINGER. Oh, yes, their cloud systems have very large dimensions—on the order of 500 miles across, although the area of hurricane force winds will be smaller than the size of the cloud shield.

They have very long lifetimes. They will last many days as they travel over the oceans; many eventually hit the land and die.

Tornadoes, on the other hand, are imbeddled in smaller cloud masses about 100 miles across. The area of violent tornado winds is much smaller, sometimes only a hundred yards or less across. They have very short lifetimes and spring up in areas quite far removed from the tropics.

It is unfortunately true that the United States is one of the countries that seems to be hardest hit by tornadoes. We lose a tremendous amount of property and many lives. For example, in recent years, in Gainesville, Ga., over 200 people died in 1 tornado. The same tornado, I recall, caused property damage of about $13 million.

During the last 2 years there has been damage on the order of $10 million in Chicago, in St. Louis, in Cleveland, and other cities.

Chairman MILLER. The tornadoes just spring up; they go up pretty rapidly.

You think that we could ever be able to determine from the air where they are, in time to warn people?

Dr. SINGER. Yes, sir.

I would like to show you, in the final part of my presentation, some interesting pictures.

I will point out certain types of clouds we know now to be tornado clouds. We think we have a good chance of determining what kinds of clouds have tornadoes in them.

Chairman MILLER. Have you defined these clouds since the orbiting of the first TIROS?

Dr. SINGER. Yes, sir, and we have published scientific reports on these studies.

Chairman MILLER. So that you are making very rapid progress in this field?

Dr. SINGER. We are making progress in our research laboratory in the identification of clouds from pictures.

We do this by coupling together the satellite data and surface data obtained from ground observations, ground radar, and other meteorological aids. I will be glad to elaborate on this when I show the slides.

Mr. HECHLER. Dr. Singer, did you attend the International Astronautical Congress last fall?

Dr. SINGER. Yes, sir. I did.

Mr. HECHLER. There was some talk that came out of that Congress, that the Soviet Union was making strides in the development of meteorological satellites.

There were some rumors that perhaps this spring the Soviet Union might have reached a point where it might be ready to launch a satellite with about the same capability as TIROS I.

I wonder if you could tell us what you know of Soviet progress in this field and if you have any reason to believe that they are as far advanced as we are in the development of meteorological satellites.

Dr. SINGER. Sir, I have no special knowledge in the sense that I do not have access to any classified information. Whatever remarks I make here are based on my own judgment and experience and, of course, conversations with Soviet scientists.

One of the most significant parts of our space program, of course, has been the development of weather satellites as Mr. Davis has mentioned.

It has made a tremendous impact internationally, and it has made a tremendous impact on the Soviets, especially on Soviet scientists.

For example, many of the research publications of Soviet scientists regularly quote U.S. sources such as our scientists at the NWSC. Furthermore, they use TIROS satellite data for their own research and publish papers on the results.

This indicates their great interest in having weather satellite data.

A further development, which I think is of some interest is the fact that the direction of the Soviet space effort, scientifically speaking, has now been taken over by Y. K. Federov. Dr. Federov is a well-known, quite outstanding Soviet meteorologist and geophysicist. In 1957, he published a review article on weather satellites in which he reviewed mainly U.S. plans and developments and also expressed his own personal convictions and interests in weather satellites.

You might say he is now the Scientific Director of the Soviet Space Agency, if there were such a position.

Chairman MILLER. He is the Jim Webb of the Soviet Space Agency?

Dr. SINGER. It is difficult to say. He could possibly be the Dryden of the Soviet Space Agency.

What is interesting is that he came to the United States to visit the Weather Bureau. He visited us at Suitland and told us he had been just appointed and made the Chief of the Soviet Union "Weather Bureau" which would make him also an equivalent to Dr. Reichelderfer.

One can put two and two together and conclude that construction and early launch of weather satellites is probably one of the immediate Soviet aims.

Chairman MILLER. Can they tap our satellite? They can, can't they, if it's turned on? They can get our pictures?

Dr. SINGER. No, sir; they cannot.

Chairman MILLER. They can't?

Dr. SINGER. The way TIROS is now arranged, only our own read-out stations in the United States can get the pictures. This is not done for security reasons, but only to keep unauthorized people from interfering with the satellite performance.

You know, the pictures are stored on the tape recorders. If someone else had the ability to turn on the satellite and get the information, we wouldn't be able to get it in the United States.

In fact, there have been some difficulties in the command circuits, due to spurious radio signals from aircraft. This has been fixed now.

Mr. HECHLER. From the standpoint of national interest, what advantages would you say would derive from a strictly technical standpoint or scientific standpoint, in sharing our weather satellite information with the Soviet Union?

Is there any advantage, for example, in having additional readout stations on Soviet territory?

Dr. SINGER. May I make a slight prefacing remark here, since you mention the words "scientific" and "operational."

I make a distinction, which may not be generally shared, between the scientific and operational aspects. I think the information from weather satellites has both scientific significance and operational significance. I feel it's very important that you gentlemen understand this distinction.

The scientific aspects of the data, of course, are very clear cut. They aid us in our understanding of how the atmosphere works. They are very important.

The operational aspects, however, have a different type of importance. They have direct economic and, in some cases, military importance. They are worth money.

You might ask "How does one distinguish between the scientific aspects of the data and the operational aspects of the data?"

It's very hard, but one distinguishing feature is the way in which the data are transmitted. If data are transmitted in real-time over microwave links—expensive wide-band microwave links—they obviously are being used operationally and should be treated as having operational significance. If they are being transmitted by airmail, then they have only scientific significance.

We have been exchanging data with the Soviets for some time now and have been giving them satellite data of scientific significance. In other words, they get our reprints and some of our pictures by airmail.

We are now speaking, however, about an exchange on an operational basis. That is to say, exchanging weather data more or less as they are received—more or less in real-time.

Such operational data from the Soviets would be of value to us in the following way. They would enable us to get a more frequent coverage of the Earth every day provided that the Soviets have a satellite system in operation which is compatible with ours and which is in orbits that complement ours.

I have given a very full answer to this question because I did want to stress the important difference between the scientific and operational aspects of the weather satellite data.

Mr. HECHLER. I am glad you brought that out.

I had a question from a student the other day; in view of the fact we are so far ahead of the Soviet Union in the development of weather satellites, what do we gain by exchanging information with them?

I think your emphasis on the scientific aspects clarified that.

Mr. DAVIS. Dr. Singer, moving back to a little more discussion of our intramural weather program; our subcommittee, or a large part of it, went to the Wallops Station last Friday.

There, we met a number of NASA employees—we were given a demonstration, in fact, of a readout from TIROS and we noticed that you had some Weather Bureau people there, working right with the NASA employees.

Now, I would like to know if you've had any problems dealing with—from a management standpoint, or in working with—the weather satellite as respects the Weather Bureau and NASA.

Would you take a few moments to describe your relationship, whether or not you have met with problems and what you think of it?

Dr. SINGER. In the TIROS program, we have no real problems.

The Weather Bureau people are at the readout stations under an agreement that we have with NASA to make whatever operational use that can be made of the R. & D. TIROS data. As you know, they have done a splendid job of making operational use of such data.

Although quite unexpected, as soon as the first TIROS went up it was realized that operational use could be made of the data. I'm very pleased to report it has been made continuously and has probably contributed greatly to the economy of our country.

Chairman MILLER. Would you say this is a bonus, an unexpected bonus, we got?

Dr. SINGER. Yes, sir. For the Nimbus program—which got started before TIROS actually, but hasn't yet flown—the Nimbus program there has set up a formal intragency agreement between NASA and the Department of Commerce to delineate the respective responsibilities of the two agencies. This covers the first phase of the Nimbus program.

Mr. DAVIS. I notice in this year's budget, so far as NASA is concerned, there is $46.8 million requested for weather satellite money. Now, that is in addition, of course, to the money which the Weather Bureau is requesting for similar work.

I believe your total—I haven't had time to examine this in detail—comes to $38.9 million.

Is that correct—that is, of the money which you expect during the coming fiscal year, to reimburse NASA with for their weather work?

Dr. SINGER. Could I go back one step, sir?

Dr. DAVIS. Yes, sir.

Dr. SINGER. NASA appropriates funds for R. & D. purposes and is paying, completely, for the development of the Nimbus satellite. We are transferring money to NASA to purchase additional developed satellites for operational use.

Now, in fact, the funds are somewhat commingled. If the development had been completed and if the satellites were on the shelf, we would transfer the money to NASA to buy those satellites.

As the satellites are not really completed, the R. & D. and operational funds are comingled; however, we keep a very accurate check on the operational funds.

Mr. Frey, Mr. Carl Frey here, is financial liaison representative at NASA. He is responsible for seeing to it that we know about every penny that NASA is spending of our funds.

These figures that you see here represent formal purchase orders that we have either given to NASA or contemplate giving to NASA. They are not yet reimbursements.

Reimbursements to NASA are made only after they actually expend funds and after we have made sure they expended the funds in the manner authorized by the purchase order. After we have checked to be sure we are paying only for the operational aspects of the program, then we reimburse NASA.

Mr. RUMSFELD. Just to clear up the record; I believe the $38.9 million figure you used is just for Nimbus and the total would be $42.4 million, and that's an estimate.

Mr. DAVIS. That is confined to Nimbus.

Dr. SINGER. This figure of $38.9 million is what we expect to obligate to NASA in fiscal 1964.

Mr. RUMSFELD. For the Nimbus program only?

Dr. SINGER. For Nimbus. We have already obligated, in 1962, $45.7 million, and we've obligated, in 1963, $3.1 million—all for the Nimbus program.

Mr. BOONE. Now, Dr. Singer, your total budget request for 1964, though, is only $23 million.

That's what you are requesting. Is that correct? The $38.9 million included 1963, as well as your hope for 1964 program?

Dr. SINGER. Yes. May I explain the appropriation under which we are operating? It is called the Meteorological Satellite Operations appropriation (MSO).

It is, in fact, our authorizing appropriation because in the supplemental of 1962, our authorization to establish and operate the National Operational Meteorological Satellite System (NOMSS) was tied to this particular appropriation.

This is the only specific language we have right now for all the operational satellite work we are doing. We are anxious, therefore, to keep this appropriation.

If it should disappear, we may lose our specific operational authority, so far as Congress is concerned.

Now, this appropriation provides funds which remain available until spent. This is similar to the funding authority you provide to NASA, differing only in that we do not have authority for what I believe is called incremental funding.

In our case, funds are appropriated for the full cost of the operational programs, and remain available until expended. You will note that in 1963 we received $40 million, but we obligated only $6.8 million for the Nimbus program. This was mainly due to the fact that the Nimbus program had been delayed.

Therefore, we deferred obligating any of the 1963 funds to NASA for spacecraft and launching functions. Neither of us saw a need for any additional obligational authority. This was a good thing because we, therefore, had funds available to reprogram for the TIROS operational program. We were able to purchase three additional TIROS satellites to carry us through the entire interim period until the Nimbus program becomes operational.

Mr. DAVIS. Moving to the TIROS part of this page, for a minute, I notice for 1964, a $2.9 million scheduled for TIROS money.

Dr. SINGER. That is correct.

Mr. DAVIS. As I understand it—as I understand your testimony, TIROS has become virtually an on-the-shelf item, has it not?

Dr. SINGER. In some respects, yes.

Mr. DAVIS. You buy them from RCA Corp.?

Dr. SINGER. Not directly. We use, and will continue to use, NASA as the executive agent.

Mr. DAVIS. They are bought from the RCA Corp., are they?

Dr. SINGER. Yes.

Mr. DAVIS. And they cost about $1.3 million apiece. Is that not correct?

Dr. SINGER. That is right.

Mr. DAVIS. And the cost of launching one is about $2½ million.

Dr. SINGER. Yes, sir.

Mr. DAVIS. In view of that, I am unable to understand why you would have had $5 million scheduled in 1963 for launching, and none in 1962, and no money in 1964.

Dr. SINGER. I can explain this.

Mr. DAVIS. All right.

Dr. SINGER. Up until last fall, the TIROS program was entirely funded by NASA. It was the R. & D. TIROS program and, therefore, we show no funds transferred to NASA in 1962.

After the hearings last September, it became evident that it was necessary to institute a program of operational TIROS launches to carry us through the interim period until Nimbus became operational. Therefore, we reprogramed some of the MSO appropriation—Meteorological Satellite Operations appropriation. We call it MSO for short.

We reprogramed $12.1 million of 1963 funds to cover our share of the cooperative TIROS operational program.

However, we obligated to NASA only those amounts they needed immediately for long leadtime procurements.

That is to say, in 1963 we obligated funds for the procurement of the spacecraft, the launch vehicles, and a few other items of an operational nature.

Next year we will provide to NASA the remainder of our share of the actual operational costs.

Mr. DAVIS. Then the fact that those figures appear under 1963 simply means they came out of your 1963 money.

It doesn't mean they were launched that year at all?

Dr. SINGER. That is correct. Our share of the entire program is funded from our 1963 appropriation. The financial table does not show the year in which the launches will occur.

Mr. DAVIS. I understand.

Mr. RUMSFELD. Along this same subject, I'd just like to have you put this whole thing in perspective for me.

What is the total budget of the Weather Bureau?

Dr. SINGER. The whole Weather Bureau?

Mr. RUMSFELD. Yes, the whole Weather Bureau?

Dr. SINGER. I can make a guess. I believe on the order of $110 million.

Mr. DAVIS. Would you like to supply it for the record later—if you don't have it with you?

(The information is as follows:)

Summary of Weather Bureau appropriations

Appropriation	1963 actual	1964 estimate
Salaries and expenses	$59,500,000	$67,200,000
Research and development	11,000,000	13,500,000
Research and development (special foreign currency program)		1,000,000
Establishment of meteorological facilities	4,325,000	4,800,000
Meteorological satellite operations	40,000,000	23,000,000
Total, all appropriations	114,825,000	109,500,000

Summary of Weather Bureau funding for meteorological satellites and rockets

[Thousands of dollars]

Appropriation and purpose	Actual, 1962	Estimate, 1963	Estimate, 1964
Salaries and expenses:			
(a) Experimental operational program using data from NASA's series of R. & D. TIROS satellites. Supports Weather Bureau staff at the Point Mugu and Wallops Island readout stations, at the analysis and documentation sections of the National Weather Satellite Center (NWSC), at the National Meteorological Center, and at the National Weather Records Center (archiving functions)	1,000	1,000	1,000
(b) Administrative support of NWSC			210
Research and development:			
(a) Development of instrumentation for meteorological satellites and conduct of basic and applied research using satellite data. This activity is performed by the Meteorological Satellite Laboratory of the NWSC	2,200	2,202	2,263
(b) Development of a National Meteorological Rocketsonde Network			500
Meteorological satellite operations: Establishment and operation of NOMSS using the Nimbus spacecraft as the basic spacecraft, and extension of the TIROS program	48,000	40,000	22,000
Total	51,200	43,202	26,973

Mr. RUMSFELD. For the entire Weather Bureau of the Department of Commerce?

Dr. SINGER. For the entire Weather Bureau; all of the Weather Bureau operations which covers much more than weather satellites.

Mr. RUMSFELD. I appreciate that.

Now, what is the total National Operational Meteorological Satellite System budget, which you are the Director of, this segment of the Weather Bureau?

Dr. SINGER. This is shown in the table included in my opening statement. The figures show the total of the MSO appropriation to be $48 million in 1962; $40 million in 1963; and we are requesting $23 million for 1964.

Mr. RUMSFELD. How can you pay NASA $42.4 million out of a $23 million budget?

Dr. SINGER. We do this——

Mr. RUMSFELD. This is what bothers me.

Dr. SINGER. We are allowed to carry over any funds that we have not obligated.

In other words, we did not obligate very much of our funds, in 1963.

Mr. RUMSFELD. Your total budget is $23 million for 1964 and you are going to carry over and actually spend a great deal more than this.

Dr. SINGER. Yes.

Mr. RUMSFELD. This is the request.

Dr. SINGER. We don't obligate funds until the very last minute and we do this in order to be able to——

Mr. RUMSFELD. I try to do the same thing.

Dr. SINGER. In order to gain flexibility.

Mr. RUMSFELD. What do you anticipate the proportions to be, say, in fiscal 1965?

You said the total Weather Bureau budget for 1964 is $110 million and your budget is $23 million for your program within the Weather Bureau and your payment to NASA is $42 million.

Do you anticipate this payment to NASA to go up in 1965 or down, and do you anticipate your budget to go up or down?

Dr. SINGER. In 1965—in 1965 and 1966 we will probably be funding at the rate of two Nimbus satellites a year, so that the NASA reimbursable portion will remain relatively constant at two spacecraft and two launch vehicles. We expect that our operational cost will rise, but very slowly.

However, our operational cost, as you can see, is only a small fraction of the cost of the entire program at the present time.

Mr. RUMSFELD. Thank you, sir.

Mr. DAVIS. Dr. Singer, as you no doubt know, there are quite a few people in NASA, particularly out at Goddard, who are engaged in weather satellite work.

My recollection is that there are, maybe 100 at Goddard and there is also a group of approximately 100 in the Colemont Building, Maryland, in quarters which are separated, only through necessity, from their colleagues out at Goddard, and there is in this year's budget request from NASA one item of about $4 million for the construction of a laboratory, meteorogical laboratory at Goddard.

Now, I notice that you, in your testimony, refer to the fact that you have a research laboratory for meteorological satellites.

You mentioned this laboratory had been in existence a good while.

Dr. SINGER. Yes, sir.

Mr. DAVIS. Firstly, are you familiar with the meteorological satellite work going on at Goddard and at Colemont, Md.?

Dr. SINGER. If you are referring to the Nimbus project; yes, I am.

Mr. DAVIS. I believe it is almost exclusively Nimbus.

Dr. SINGER. Yes, sir; it's my job to be familiar with it.

Mr. DAVIS. Would you comment to the best of your knowledge, as to whether there is any duplication of effort and whether both laboratories are necessary?

Dr. SINGER. Sir, I'm afraid I cannot really comment very intelligently or appropriately on this point since I don't know what activities will be carried on in this building and since I have not discussed the matter with NASA nor has the matter been brought before me.

However, what I can do, and will be every pleased to do, is tell you exactly what we plan on doing and define it in any detail that you wish to have.

Mr. DAVIS. All right.

Mr. WYDLER. Mr. Chairman, if I might, on that very point—you mean to say you never had any discussion with NASA about this construction of this laboratory which is supposedly closely related and allied to the very project you are working on?

Dr. SINGER. I personally have had no discussion on this matter.

Mr. WYDLER. Would anyone else in the Weather Bureau have had any such discussion?

Dr. SINGER. Let me turn to my financial specialist and ask him.

Mr. FREY. Not to my knowledge.

Mr. DAVIS. All right, Doctor Singer, suppose you then state for the record what you plan to do.

Dr. SINGER. In the immediate phase of Nimbus, we plan to carry out the functions which are designated as Weather Bureau responsibilities in the NASA/WB interagency agreement.

I have mentioned them in my presentation here. They include particularly the functions of meteorological data processing, analysis, and dissemination.

I should point out that in the eventual operational satellite system we would probably want to implement the basic understandings listed in the letter that the Secretary of Commerce wrote to the Administrator of NASA when the interagency agreement was transmitted.

This transmittal letter states:

The Weather Bureau will transfer funds to NASA for additional communications required specifically for the operational program but *with the understanding that eventually these meteorological communications will be a Weather Bureau function.* [Italic supplied.]

Mr. DAVIS. The point that we'd like to get at is, as I stated earlier, there is a budget request for a $4 million meteorological laboratory at Goddard.

You state that you have a meteorological research and development laboratory in the Weather Bureau.

Now, you had set out a few minutes ago to state what you intend to do at your laboratory in the Weather Bureau and, frankly, I wish you would pursue that so that we may then look into this weather research effort at Goddard and see whether or not there is a duplication.

Dr. SINGER. All right.

I think I can best do this by going fairly quickly over the second part of my written statement which describes the data-processing facilities that we are establishing at Suitland and describes to some extent the activities in our Meteorological Research Laboratory.

You will then be able to judge to what extent any of these activities are being duplicated.

Mr. DAVIS. All right. May I more or less off the record ask you about how long you think it will take to complete the second part of your testimony?

Dr. SINGER. The second part of the testimony will take approximately 10 minutes and the slides might take another 5 minutes.

Mr. DAVIS. Well, with the permission of my colleagues, we will permit you to go ahead and complete the second part of your testimony and the slides before we begin any further questioning.

Dr. SINGER. I will try to be brief. I may eliminate certain parts of the prepared statement if I feel that they don't contribute appreciably.

In starting my presentation of the technical, as opposed to the management, aspect of the weather satellite programs, I can do no better than to quote from the conclusions of the POMS report.

Weather exerts a tremendous influence on all mankind. From its careful observation and study can come untold benefits, including improved weather

analyses and forecasts over the entire Earth. The potential savings in life, property, produce, natural resources, and even in personal convenience are difficult to assess. That a meteorological satellite system can make a major contribution is beyond doubt.

It is both possible, and clearly in the national interest, to satisfy the requirements of all the U.S. weather services for meteorological satellite observations with a single, national system. This same system could provide major services to the international community of nations.

Essentially, the POMS report here explains why weather is important and why it makes sense to have a single national weather satellite system.

These conclusions we have learned are indeed correct and hold up under the most searching examination. The Chief of the U.S. Weather Bureau, Dr. F. W. Reichelderfer, has already reported to you last September on the tremendous impact which the success of the U.S. satellite program has made on other nations. The State Department witnesses testified further to its great political impact. And, of course, the immediate initiative taken by the United States, in exploiting space technology for economic purposes, in particular for weather forecasting, has made a deep impression on the technical and scientific community throughout the world. I am sure that it is responsible in no small measure for the readiness of the Soviet Union to conduct bilateral negotiations, and for their acceptance of the invitation by President Kennedy to use space for peaceful purposes.

I will concern myself here with the more technical aspects. One of the most exciting developments has been the development by NASA of an automatic picture transmission system for a weather satellite. Its successful ground test was announced last December and it will soon be tested in a satellite. This system transmits to a ground observer a satellite TV picture of his immediate area. Any ground station within broadcast range of the satellite can receive the picture if it has a very simple and inexpensive antenna, receiver, and facsimile record—a kind of "instant weather." This development represents a major breakthrough in an operational sense, in terms of introducing real-time weather satellite information, with high resolution, to the user in the field.

This does not obviate the need for global weather data, which are always required in order to make more accurate long-range forecasts. But it does give the individual user a means of directly viewing his own immediate area, and it also is useful for very short-range weather forecasting. It is, in principle, possible to transmit all the pictures from Nimbus to users in the field, but the cost of transmission becomes extremely high.

This development of a direct read-out system is of sufficient operational importance to warrant a careful reassessment of the national weather satellite program. Discussions among representatives of interested agencies, and in particular the Defense Department, indicate a tremendous interest in making the APT system available as soon as possible on an operational basis. The Defense Department and the Weather Bureau have already procured some 40 ground stations and plan to procure an additional number in order to meet operational requirements. Thus, it makes sense to think of a direct read-out satellite independent of Nimbus. It appears feasible, for example, to incorporate the direct readout feature into our operational version

of the TIROS satellite, making only minor changes and incurring no new spacecraft developments.

This is what I had reference to earlier when I stated we can control the TIROS satellites we fund. If we feel the user requirements are best served by incorporating the direct read-out feature, we will ask NASA to incorporate this direct read-out feature if it can be done within our funding limitations.

We are, above all, concerned with lowering the cost-to-benefit ratio of the NOMSS. An operational analysis which assigns realistic costs to every part of the system, including the transmission of data, is now nearly complete. It appears to us that a direct read-out system represents an economic solution to the problem of getting quickly to the user a high resolution picture which portrays the local meteorological situation; Nimbus provides the lower resolution global cloud analysis which allows him to make longer range forecasts.

To summarize, it appears the direct read-out feature is economical in that we can reduce the cost of communicating the high resolution pictures to the users. Also important is the fact that we can serve many users who canot be reached by normal communication channels. For example, ships at sea; large transoceanic aircraft and military units operating on a mobile basis.

These are all very good reasons for instituting this direct read-out capability.

We would be remiss if we did not mention the important international aspects of a direct read-out satellite system. At this time, when only the United States and the Soviet Union have plans for implementing a full-scale operational satellite system involving elaborate spacecraft, expensive central read-out stations, and data-processing facilities, it is heartening to realize the other countries of the world, especially the newer nations, can participate by investing in a low-cost ground station.

The capability to observe local weather should be particularly important for the tropical countries. These countries suffer from the absence of a well-developed meteorological service, as well as a lack of weather stations and a good communication system. Moreover, they are heavily dependent on agriculture, which depends critically on the weather. The tropical countries also have such problems as locusts, whose migration, in turn, depends on the local weather.

Altogether, we should expect tremendous goodwill to result from the implementation of direct read-out satellites, as a contribution to the improvement of the weather services of all of the nations of the world.

I think this is a great contribution the United States can make to the general welfare of the world.

Mr. DAVIS. Would we not want to build into such a device the ability to turn it off when we wanted to or render it unreadable, unintelligible?

Dr. SINGER. All of the meteorological satellite systems have such a capability.

Mr. RUMSFELD. You started earlier, as a result of some questions, to mention the advantages of exchanging this information or this process with the Russians.

You mentioned cost and you mentioned the fact we would get greater worldwide coverage.

Is there anything else that comes to mind? I mean, so far as the coverage goes, the coverage we are going to get of the world by having additional stations is going to be in the areas, for the most part, the vast majority of Americans are not using; and the areas the Russians would be getting would be exactly those they are using.

So far as an exchange, this isn't much of an exchange.

Is there other—are there additional factors that come to your mind?

Dr. SINGER. There are additional factors; yes.

The additional factors are these:

The U.S. Weather Services involve global responsibilities. We have bases overseas. We have friendly countries who rely on us to a large extent to fulfill their meteorological requirements.

Furthermore, weather by its very nature is a global phenomenon and in order to predict the weather on a really long-range basis, we must have access to information from all over the world.

This is basically the problem the Russians have also.

Chairman MILLER. Isn't that the whole problem and the reason you have a worldwide weather organization, on the part of the United Nations, where they have been able to get together with the Soviets; because weather that may affect us may be spawning over Siberia right now.

Dr. SINGER. The interchange of weather information benefits everyone concerned and this practice has now become quite well established.

Mr. DAVIS. Dr. Singer, in order that we may properly understand the testimony; do your answers have to do simply with the direct read-out device that you mentioned, or are you now talking about all weather satellites? Do we then have the capacity to turn off TIROS?

Dr. SINGER. Yes; we do. Actually TIROS is turned on by command as I explained before.

The same will be true with Nimbus.

We do not contemplate unauthorized personnel will be able to interrogate Nimbus.

Mr. DAVIS. And it is true of TIROS?

Dr. SINGER. It is true.

Mr. DAVIS. It would be impossible for unauthorized personnel to interrogate TIROS?

Dr. SINGER. That is correct.

Mr. DAVIS. When you talk about direct read-out, that is a completely different proposition?

Dr. SINGER. That is a completely different proposition.

Mr. DAVIS. And you are talking about something that might possibly come into existence in the future, that would be available to all countries that would enable them to read the weather only in their immediate vicinity?

Dr. SINGER. Yes, sir.

Mr. DAVIS. Of course, that is a far cry from TIROS or Nimbus?

Dr. SINGER. Well, it is a technical development which has been completed and can be incorporated—in fact, will be incorporated—in TIROS and Nimbus. It can be turned off at any time.

Mr. DAVIS. All right. Mr. Rumsfeld?

Mr. RUMSFELD. Do you anticipate this responsibility will be given to the Russians so they will be within your definition of "authorized persons?"

Dr. SINGER. No, I do not.

Mr. RUMSFELD. This would not be the case.

Do you know that this is not the plan or are you just——

Dr. SINGER. This is not the plan at the present time.

Now, plans can be changed; but I think there would have to be a good reason for changing them.

Mr. RUMSFELD. We have so many problems of accumulating information and disseminating information. As each department of the Government comes upon new things, it strikes me they have a very real responsibility to raise these new possible problems for resolution with other related problems within Government.

I assume you are doing that.

Dr. SINGER. Yes, we are.

I would like to support this, if I may by reading from my prepared statement.

There are important unforseen aspects of weather satellites; namely, the possibility of extracting information which is not strictly meteorological, from a system designed primarily for weather forecasting.

This is an example of what you have just mentioned.

I discussed last September the many existing applications such as forest fire detection, snow reconnaissance, ice reconnaissance, and the possible detection of locust clouds.

We feel that it is appropriate for us to take the initiative in pointing out such applications wherever we see them, and in establishing their feasibility; and then, of course, in turning over the application to the appropriate Government agency to pursue.

Mr. RUMSFELD. I am glad to hear that.

Dr. SINGER. For the future development of an operational satellite system, our major concern must be a low operating cost. We have completed the systems analysis, which has convinced us that a long operating life, perhaps several years, is one of the most important goals for an operational satellite. We feel that the design of a spacecraft capable of operating for many years should be initiated immediately. By the very nature of its mission, the research aspects will have to be subordinated, and it may indeed turn out that research satellites and operational satellites are not compatible in the sense that they cannot be based on the same spacecraft design.

As I indicated in my opening remarks, I want to describe, in this fourth and final part of my prepared statement, our most significant NOMSS achievements since my last appearance before this committee.

These achievements have been many, most of them individually small, but collectively of major importance to the national space effort. They are, in essence, the data processing achievements which will insure Weather Bureau readiness to receive, handle, and disseminate, in real-time, the more than 5 billion bits of weather data transmitted to Earth by Nimbus every day.

To do these things we are establishing an advanced processing capability for weather satellite data at our Suitland, Md., location. Here we will process satellite meteorological data in two ways:

In the first, the signals received from the satelliteborne TV camera will be converted on the ground into the cloud pictures as they originally appeared to the camera. Several preliminary editing steps must be carired out, however.

The pictures must be located geographically, using precomputed orbital tracks, the exact time of each picture frame to the nearest second, and the attitude of the satellite. Latitude and longitude grids will then be computed for each picture and converted into electrical signals. These, in turn, will be combined with the incoming picture signals to produce photographic copies of the cloud pictures with the grids superimposed upon them. In making these computations we shall take into account distortions produced by the satellite camera systems and correct for them in preparing the gridding signals. Provision will also be made for precise determination of picture locations through rapid preanalysis of the data to locate landmarks and other visible clues to exact position.

In the second processing method, all data from the satellite, including pictorial cloud images and infrared scan signals, will be converted into numerical values for precise evaluation and correlation by computer. This conversion takes place at upward of 1 million values per second. All the data from a given orbit will be stored on magnetic tapes and disk files and will be withdrawn to the central computer unit in batches for evaluation.

This second processing technique, like the first, will locate each data element geographically and remove system distortion. The elements will then be grouped in accordance with a fine-meshed global network based on standard map projections. By comparision with a file of surface brightness, maintained in the computer, clouds will be separated from background and will be characterized in each grid square as to coverage, height, distribution, and brightness.

These values will be then combined in the computer to produce global mosaics of cloud conditions in a form for direct weathher analysis and forecast applications. These mosaics will be available pictorially and in numerical form to the world meteorological community. Infrared measurements will be processed in similar fashion to provide heat balance data for numerical forecasting and for providing information needed to know cloud heights, surface temperatures, and other parameters in the global atmosphere.

To do these things we are establishing an advanced processing capability for weather satellite data at our Suitland (Md.) location. We have already constructed the necessary addition to the building and are prepared to move the equipment in within the next month and be in operation by this summer.

In the first processing techinque, the signals are received from the satellite-borne camera and converted on the ground. Now I have discussed here in a quite detailed fashion this technique to indicate the complexity of the data processing job. It is not a simple job. It requires a great deal of forethought.

We have taken care to make sure it is just as flexible as we can make it to be able to take care of any new developments in weather satellites.

We have three different ways of processing the data for three different types of users.

We can, by processing the data, extract and provide such information as clouds and in turn, the distribution of clouds, their brightness, and even their heights; and these cloud maps will go out to the users because they are an immense aid in forecasting.

The activity of this data processing center is described in detail in

these last few pages, but I would like to turn now, finally, to the importance of the work of our Meteorological Satellite Laboratory.

I have mentioned that this is the largest and preeminent scientific laboratory in the field of satellite meteorology. Such research, carried out on the basis of cloud pictures and infrated measurements, is very exciting to research scientists. Without the knowledge derived from such research, the Nation's weather satellite program, our data processing complex, and the communications channels by which meteorological information can be globally distributed would fall far short of achieving its potential for usefulness.

Through research, we increase our knowledge of the nature of the weather data provided by satellites, and constantly learn new things about such data and how to apply them to the maximum benefit of mankind.

Now, I've brought with me some slides I think will illustrate much better than these words, just what the Laboratory does.

With your permission, Mr. Chairman, I'd like to run through just seven of these slides to indicate how the Laboratory operates.

This is a picture of the Caribbean (fig. 5). You will recognize the island of Cuba, as well as some of the Bahama islands.

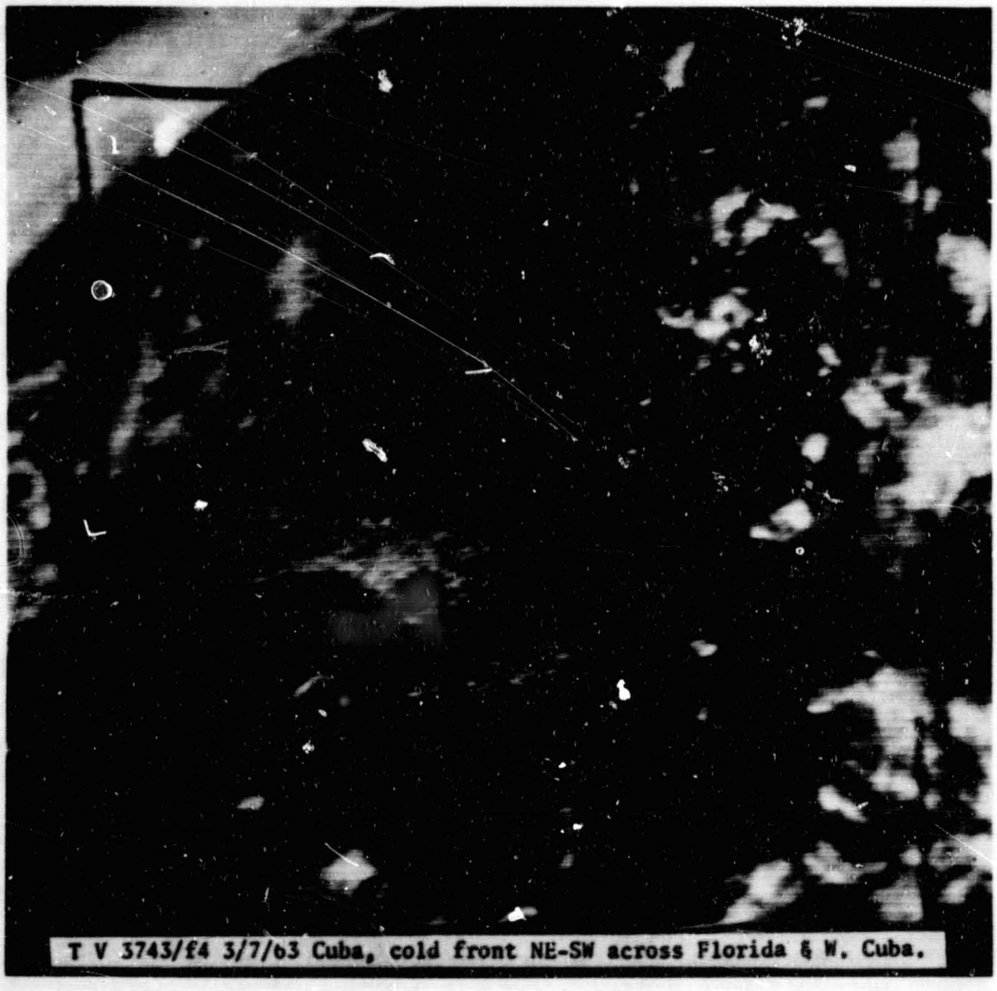


FIGURE 5

What this picture illustrates, I think better than I could portray it in words, is (in the upper left-hand corner) a cloudband—a cold front which is sweeping through the Caribbean. You can tell the position of this cloudband with an accuracy of about 3 to 4 miles which means you can tell the time that the weather is going to get bad to a time accuracy of a few minutes. This type of information, in my opinion, has tremendous operational importance for many different purposes.

This (fig. 6) shows, on the left-hand side, the Florida Peninsula. Stretching out over the Gulf of Mexico, you see a bright band of clouds

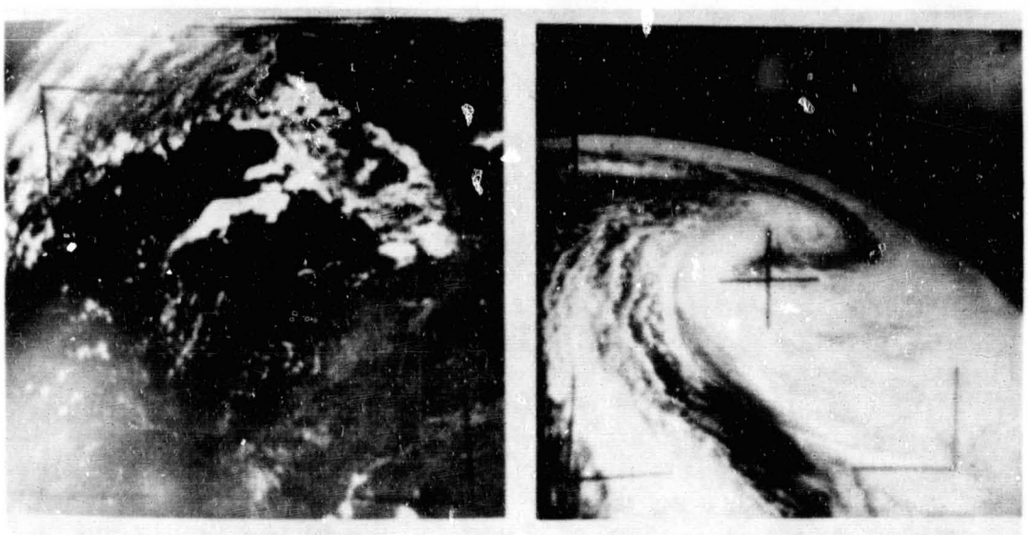


FIGURE 6

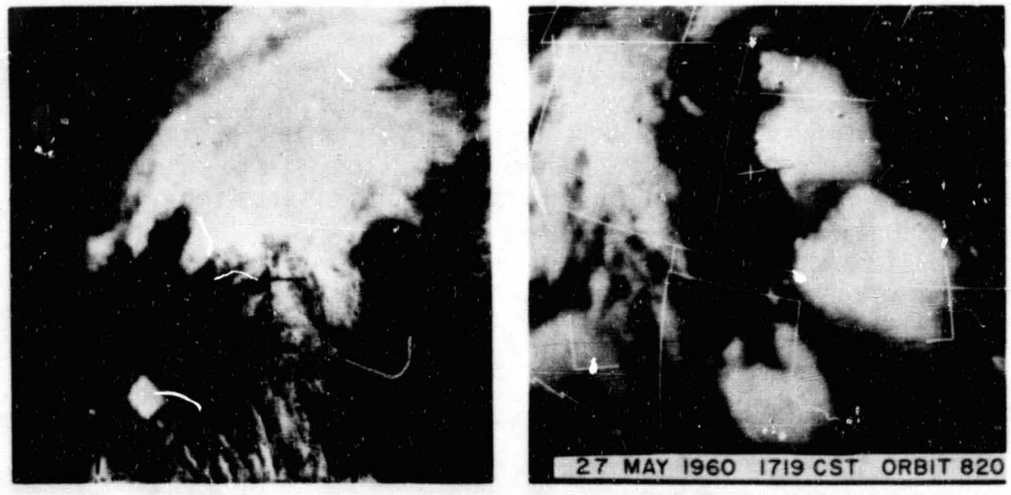
in a nearly straight line. That is a squall line. It produces severe weather especially in the air but also on the ground, on the ocean. It gives rise to extreme air turbulence and, to severe thunderstorms below. This sort of information is of extreme importance to aviation and to smaller ships. On the right-hand side you see an example of an extra-tropical cyclone in the Atlantic. This type of picture has, for the first time, confirmed the textbook ideas of how such a cloud system should look. Now we see that some of the cloud pictures really turn out to look like the textbooks have pictured them. Others do not.

Now, of course, our laboratories are trying to discover the reasons such differences exist.

On the right side is a picture (fig. 7) taken of the Central United States. You can see Texas in the lower right-hand corner. Oklahoma just above, the Panhandle sticking out.

What I want to call to your attention are the three large cloud masses on the right-hand side of the picture. The scientific examination of this picture showed these cloud masses were extremely bright compared to the clouds in the left side of the picture. Also, they showed these cloud masses had very sharp borders on the western edge and "fuzzy" borders on the eastern edge.

The ground observations with which we compared the satellite observation showed each one of these three clouds contained the most



Left side. Right side.

FIGURE 7

violent types of weather that you can imagine. One of them had a tornado and all of them had hail. In one case the hail was as large as a baseball. It was a very violent weather situation.

Chairman MILLER. How high was that taken?

Dr. SINGER. This was taken from 450 miles.

Chairman MILLER. How high are the tops of those clouds?

Dr. SINGER. This is a very important question which we can answer now only by inference because of the brightness of the clouds and because we know something about the nature of the cloud.

We say that the tops are about 50,000 feet high.

With Nimbus and infrared data, we will be able to measure the temperature of the cloud tops. Once we know this temperature, we will also know the altitude of the clouds.

This is one of the purposes of our Research Laboratory—to establish techniques by which we can obtain, from satellite pictures, further information about clouds.

Chairman MILLER. This is off the record.

(Off the record.)

Mr. ROUSH. Doctor are you able to detect seasonal changes or are you doing any research so as to more definitely pinpoint seasonal changes in various sections of the country?

Dr. SINGER. Yes, sir. Another group in our Research Laboratory has made a study of the seasonal change in the heat budget of the earth—studying the radiation which is emitted back into space and comparing it with the radiation which is received from the sun.

The heat budget determines essentially the way in which the sun drives the atmosphere. We find the heat budget is not as it is described in the text books and we are trying to see whether this has any direct influence on climatic conditions.

Mr. ROUSH. Do you anticipate this will be of any practical value, say, to an Indiana farmer?

Dr. SINGER. I really do. I feel that our only hope for really long range forecasts, that is to say, forecasts extending over seasons, must come from global data; and the only method we have for obtaining global data economically is through weather satellites.

Mr. ROUSH. Thank you.

Dr. SINGER. If I may, I'd like to discuss the picture on the left of the slide. Notice the little square cloud at the bottom. This is a violent tornado cloud, similar to the clouds in the picture on the right. It is also a very bright cloud, much brighter than, for example, the cloud mass just above it.

These are isolated examples. From such pictures, we hope to be able to find the explanation of why some clouds produce tornadoes and others do not.

Next slide, please (fig. 8).

This is an extremely interesting picture of a cloud formation showing definite whirls and eddies. These can yield further information about what is going on in the atmosphere. Our job is to interpret such formations in order to discover what is going on. We find these whirls or eddies were produced when moist sea air swept by islands located just off the coast of Africa; in the wake of these islands are produced these eddies extending to distances of up to 300 miles.

I'd like to show these peculiar cloud formations because each one of them has a reason. The reason was not known in advance. It had to be figured out by research (fig. 9).

On the right-hand side, you see a mass of clouds which seem to have a peculiar grainy pattern which look to be almost like little cells. We find that such clouds are produced in a lower layer of unstable air topped by a so-called inversion layer of quite stable air.

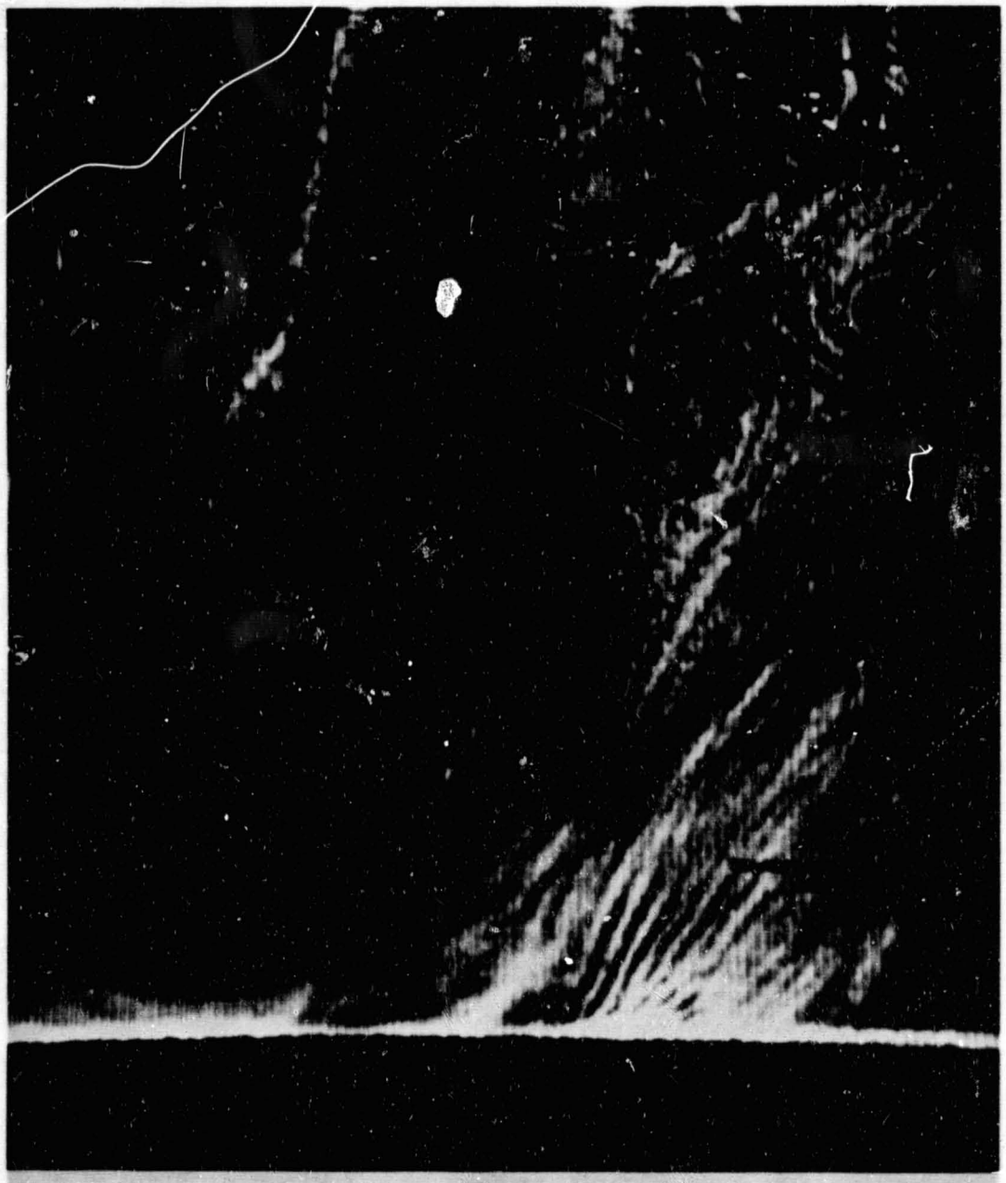
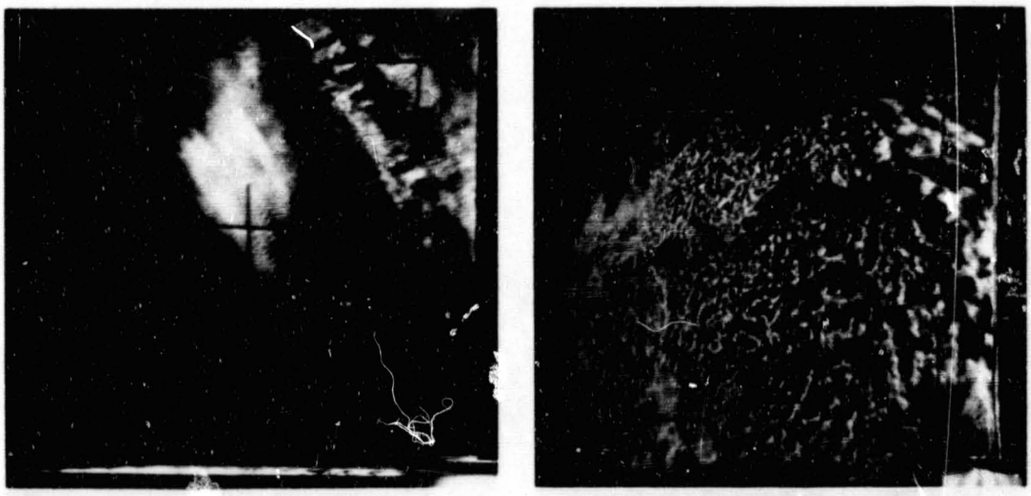


FIGURE 8



Left side. Right side.

FIGURE 9

This inversion layer acts like a lid on the lower atmosphere. Below the lid some turbulence is generated where these cloud cells are formed. Above the clouds, at levels often below 10,000 feet, the air is quite smooth. This also is of importance to pilots flying long, over-sea routes.

Once we have identified the cause correctly, we can transmit this information to our operational people and they, in turn, will know how to interpret such cloud pictures in the future.

On the left-hand side, you see a phenomenon which was discovered in satellites and is caused by waves—gravity waves. These waves are produced when air passes over a mountain chain and you notice the very pretty and very regular waviness in the cloud pattern which occurs as the air passes over the mountain chain. Every time the air goes up it produces a cloud and every time it goes down there are no clouds; so, you can see that the clouds represent the tops of the waves. Such waves are often associated with clear air turbulence which is experienced by jet aircraft flying at about 35,000 feet near the Rocky Mountains.

Next slide (fig. 10).

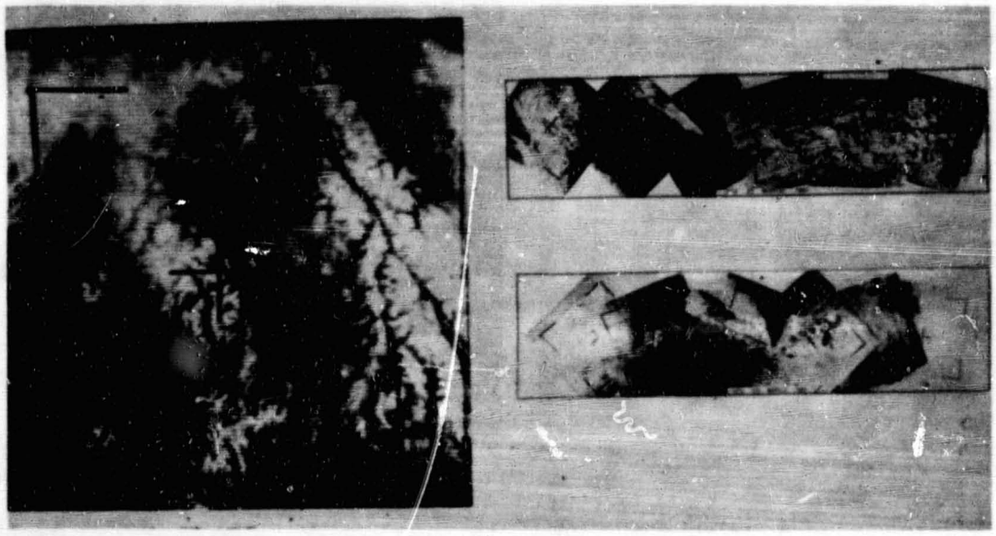


FIGURE 10

FIGURE 10(a)

These pictures indicate some of the nonmeteorological applications of satellites—applications not strictly meterological. This picture shows snow and ice, which have great meteorological significance. On the left-hand side you see snow patterns in the Cascade Range and in the Rocky Mountains in the Western United States and Southern Canada. You can even trace the Columbia River.

Notice the peculiar dendritic pattern of the snow. We now have enough experience so we can sometimes distinguish snow right away from clouds simply by the brightness pattern. Of course, one can always tell snow from clouds by coming back several days later and comparing pictures. The snow will still be there while the clouds will have moved away on some days.

On the right-hand side are some pictures of ice conditions in the Gulf of St. Lawrence.

We are now able to survey such ice conditions routinely with satellites and, furthermore, we may be in the position of predicting the breakup of ice in advance. This, of course, would be a valuable service to shipping.

These pictures show the situation several days apart. You can see that part of the ice has broken up. Examination of the pictures leads us to believe we could have predicted the breakup if we had known what to look for in the pictures. Well, now we know what to look for.

Next slide (fig. 11).

This final slide shows the country of Italy. All that white stuff on top is snow in the Alps. It shows up extremely well. You can see that the snow area extends down almost to the Mediterranean. In the lower part of the picture you can see clouds covering the southern portion of Italy.

I believe that's all.

Mr. HECHLER. Mr. Singer, how many photographs has Tiros V and VI actually transmitted?

Dr. SINGER. I think it is now on the order of 50,000 pictures. Tiros V has been in operation now for 286 days, an alltime record. Tiros VI has been in operation 195 days, longer than any of the preceding satellites, longer than Tiros I to IV.

Chairman MILLER. What was the anticipated life of them when we put them up?

Dr. SINGER. The designed life for Tiros initially was 3 months. Tiros V has now exceeded 9 months, and Tiros VI is just about double the initial limit now.

Mr. DAVIS. Have you ever tried to arrive at a cost per picture, say Tiros V, for example?

Dr. SINGER. Yes, sir; one can do this by dividing the cost of a single Tiros satellite and launch vehicle (amounting to $3.7 million), plus the operating costs by the number of pictures received.

Mr. DAVIS. You have not done that?

Dr. SINGER. I can do this now.

If you figured roughly $5 million cost divided by 50,000 pictures, you get a cost of $100 per picture.

Mr. DAVIS. Pursuing the laboratory question—I asked earlier, what size is your laboratory physically?

Dr. SINGER. Our laboratory—our whole center is housed in one wing of Federal Office Building No. 4 in Suitland. We started with one

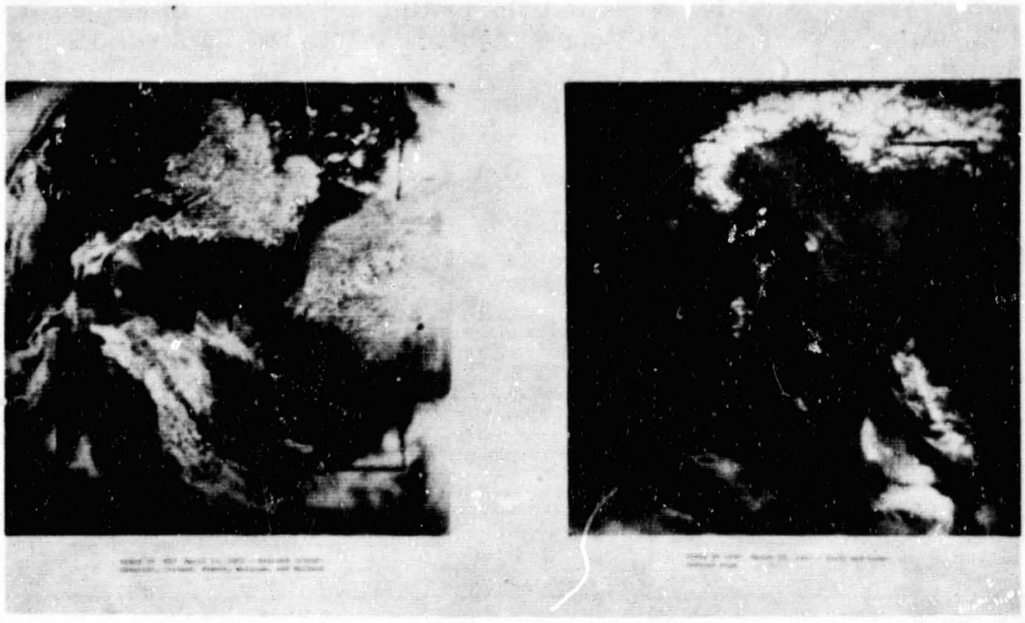


FIGURE 11

floor. We have added a second floor, and are now completing the addition of a partial third floor which will house the data processing complex.

Mr. DAVIS. Can you, for the record, supply us at your convenience with the amount of floorspace you have devoted to your laboratory?

Dr. SINGER. Yes, sir. I will do that.

(The requested information is as follows:)

Total square footage of usable floor space occupied by the National Weather Satellite Center, Weather Bureau (Federal Office Building No. 4, Suitland, Md.)

Function	Wing	Floor	Space (square feet)
Meteorological Satellite Laboratory	0	1	17,904
Executive, technical, and administrative	0	2	18,295
Data acquisition	0	2	1,000
Data archiving	0	2	960
Computer complex	0	3	5,646
Training, storage, etc	3	2	1,750
Total NWSC floor space			45,555

Mr. DAVIS. And how many employees do you have—or rather, what is your personnel?

Dr. SINGER. Our authorized staffing is now 246 positions for both the TIROS and Nimbus operational programs and for the Meteorological Satellite Laboratory. Our actual number of employees is well below this, on the order of 172 as of March 1.

Mr. DAVIS. This Laboratory we are discussing, is it purely the Satellite Laboratory?

Dr. SINGER. Sir?

Mr. DAVIS. Is it purely a Satellite Laboratory?

Dr. SINGER. We use the word "laboratory" only to denote the division performing meteorological satellite research.

If you like, of course, you could call the whole building a laboratory; but strictly speaking, we use the word "laboratory" in connection with research so we call it the "Research Laboratory."

The Research Laboratory occupies the first floor; our Operations Division and Management Division occupy the second floor; and the third floor will be occupied by the Data Processing Center.

Mr. DAVIS. Now, what sort of physical equipment do you have in your Laboratory?

Dr. SINGER. We have, of course, a long list of physical equipment. Let me classify it.

Our greatest investment, I think, is in data processing equipment, including some very expensive and very high speed electronic computing machines.

These we must have in order to handle, in real time, the large amount of data we anticipate getting from Nimbus.

We have as sizable investment in laboratory instrumentation for the design and testing of new sensors for weather satellites. This includes equipment to calibrate sensors before they are flown in satellites.

At the present time, we have an active role in the calibration of the cameras before they are put into TIROS and we regard this as part

of our responsibility in the Nimbus program or in any other operational weather satellite program.

Mr. DAVIS. Now what limits would you set upon your group—that is, where would you separate your function from that of NASA with respect to your weather satellites?

Certainly, for example, you wouldn't spin test them or something like that.

Dr. SINGER. No, sir.

Mr. DAVIS. Just how would you arrive at where you would stop and expect NASA to take over with respect to a weather satellite?

Dr. SINGER. I'd like to discuss this in two parts.

The first part is the initial phase in which the R. & D. of the spacecraft still plays a very important role, and the second part is the eventual system which we regard as a purely operational one.

We are directly responsible—this is our understanding—for all of the processing of all the meteorological data.

You might ask "What are meteorological data?" The meteorological data are the data received from the meteorological sensors. These data from the television cameras, infrared equipment and other meteorological sensors should come to us directly for processing.

As I've described in my prepared statement, the processing consists of calibration, of adding geographic grids to make sure that we know where each piece of data comes from, and of making various corrections to the data to remove, for example, the distortion of the camera lens and things of that type.

Mr. RUMSFELD. Could I just ask a question on this?

Where is this being done now?

Dr. SINGER. The camera calibration for TIROS is being done by us working with RCA.

Mr. RUMSFELD. Where?

Dr. SINGER. At the RCA plant.

Mr. RUMSFELD. Isn't NASA participating in some of this, and if not; aren't Weather Bureau people doing it on NASA facilities or in NASA facilities?

Dr. SINGER. We calibrate the data that we are going to use operationally from TIROS.

That is to say, we calibrate the television camera.

Now, when the data come back—in the processing stations, at Wallops Island and at the Pacific Missile Range at Point Mugu—the grids are added at those points.

Mr. RUMSFELD. Who does this physically? Your people at NASA?

Dr. SINGER. No, this is done by contract personnel now.

Mr. RUMSFELD. It is reimbursed?

Dr. SINGER. Well you see——

Dr. DAVIS. We are actually moving from one subject to another.

We started out talking about what part of the weather research and development you would do at your laboratory.

Now, we have gotten into data processing.

I don't object to changing the subject, but I did hope we could exhaust this phase about your laboratory versus a laboratory out at Goddard.

Dr. SINGER. I'd like to do this and I think the best thing would be to describe our functions as we plan to carry them out in the Nimbus program.

I would rather not go into the TIROS program too much, because that is really a NASA program which was started as a NASA R. & D. program and we are really in this program only because it turns out TIROS has operational significance.

For the Nimbus program, we have an interagency agreement which covers the initial phase and I'd like to describe to you how we carry out our functions under this agreement.

We process the meteorological data. NASA processes spacecraft data.

For example, NASA is responsible for the processing of all data from the tracking stations to establish the orbit of the spacecraft.

NASA is responsible for processing the data from their telemetering sets in the satellite to establish, for example, the temperatures at various points in the spacecraft.

These are all proper spacecraft functions.

Mr. DAVIS. Dr. Singer, I don't believe that will help us decide whether there is a duplication between laboratories, a discussion of which agency processes the data you require.

Now, as regards the laboratories, I understand you to say you considered it your function to calibrate the sensors put on the weather satellite—and I don't quarrel with that position you take.

I should think also you'd decide what sensors go on the weather satellite or, at least, what they should be able to do when they are on them.

Dr. SINGER. Insofar as the satellite program is designed to be an operational program, we have the authority in the interagency agreement to specify the sensors and I think it makes sense also that we should calibrate them since we have to use the output of the sensors and have to know what it means.

Mr. DAVIS. Anything else you do to the weather satellite, except calibrate the sensors and specify them?

Dr. SINGER. We specify the configuration of an operational satellite. Then we delegate to NASA the construction of the spacecraft. the procurement of the rockets, the launching of the spacecraft, the tracking of the spacecraft in orbit, and the processing of the spacecraft data.

Oh yes, and the operation of the Command and Data Acquisition Station.

Mr. DAVIS. So far as laboratories are concerned, there is no reason to be concerned with data acquisition, is there?

Dr. SINGER. No; data acquisition is handled at the CDA stations.

Mr. DAVIS. Can you give us any reason why NASA should have a meteorological laboratory?

Dr. SINGER. I am afraid I can't properly comment on this matter, because NASA has not discussed it with us and I am not aware what function this laboratory is going to fulfill.

Mr. HECHLER. Dr. Singer, you think your activities would be seriously handicapped if there were no laboratory constructed at Goddard?

Dr. SINGER. Sir, I feel that NASA may—I don't know what they have in mind.

As I say, we have not discussed the matter. They may decide that it is more economical to construct facilities at Goddard rather than to rent space at Silver Spring for the Nimbus project.

I understand that the Nimbus project would move into this building.

Mr. HECHLER. The weather project would not fold up if construction was not made at Goddard?

Dr. SINGER. No; the Weather Bureau would not.

Mr. BOONE. May I ask a question?

I think Dr. Singer started on processing with regard to that to show there was a function in the control circuitry of the satellite that must be performed by NASA.

Now, there is the signal channel that gives them the picture. That's the thing he will operate on?

I think we must assume someone must operate on the control circuitry of the satellite.

I believe if you would continue by describing a signal channel and by describing the data processing channel which must be operated on by NASA and then the processing that must be performed by you; it might further clarify.

Mr. WYDLER. If I may, Mr. Chairman, before you do that; may I just ask one question I think you can comment on?

Don't you feel NASA, in planning a meteorological laboratory, should discuss it with you?

Dr. SINGER. Yes, sir; I do.

Mr. WYDLER. Good.

Mr. DAVIS. Mr. Rumsfeld?

Mr. RUMSFELD. For the record, and for my personal benefit, would you tell me what CDA is?

Dr. SINGER. Command and Data Acquisition.

Mr. RUMSFELD. Thank you.

Dr. SINGER. I was referring here to the satellite receiving stations.

Mr. RUMSFELD. Right.

Mr. DAVIS. In that connection, you would not, in your laboratory or any other place, concern yourself with the command of a weather satellite, would you?

That is controlling its attitude?

Dr. SINGER. No, the Nimbus satellite should be self-controlled.

We would concern ourselves with making any corrections or initiating any command that affects the meteorological performance of the satellite.

We think that's our proper concern.

Mr. DAVIS. When you say the meteorological performance, you mean merely the function of its sensors?

Dr. SINGER. Yes, sir. For example, right now we make the decision on TIROS of which areas of the world are to be photographed.

As you mentioned, TIROS can cover only 15 percent of the globe.

We have to decide in advance which 15 percent we are going to look at today.

Mr. DAVIS. Suppose you needed a slight correction; would you regard that as a NASA function?

Dr. SINGER. I would like to look at it in the following way; in the sense that the Weather Bureau has the overall responsibility for the operational satellite system, I think it should be our decision. But I think the execution should be done by NASA since they are the ones working with the spacecraft and, therefore, intimately familiar with how to carry out the job.

Chairman MILLER. Isn't it true under the law this is their function and their responsibility, so you don't come into it? This is why it's in the law—so you and a dozen agencies can't be giving orders to things in space.

That's one of the reasons the law specifies NASA shall have authority over outer space; so you can tell them to correct that satellite but they correct it.

Dr. SINGER. They correct it, yes; but it would make sense, for example, for them to work directly—in fact, they do work directly—with our people who give them these directions.

Chairman MILLER. Sure, they are not going to do these things unless you ask them to. There is no friction between you two.

Dr. SINGER. No.

Mr. WYDLER. For example, the meteorological facilities will be turned over to your department?

Dr. SINGER. As far as I know, NASA has no meteorological facilities.

Mr. WYDLER. What is this, what facilities are they talking about?

Mr. DAVIS. I don't recall the word "facilities," Mr. Wydler.

Mr. WYDLER. It was a letter—a letter you read.

Dr. SINGER. The letter is from Secretary Hodges to Mr. Webb and expresses his understanding of what will follow after the initial phase of Nimbus.

Mr. WYDLER. Right.

Dr. SINGER. In the initial phase of Nimbus——

Mr. WYDLER. You can paraphrase it. What would happen?

Dr. SINGER. The Weather Bureau, according to the original POMS report, would be responsible for the wide-band communication link from the CDA stations back to Washington.

In the initial phase of the Nimbus program covered by the agreement, this responsibility is delegated to the NASA.

This was done because of the fact that in initiating this, many R. & D. aspects entered into the picture.

We feel that, however, after the program develops into a fully operational program, the function of data transmission should revert back to the Weather Bureau.

Mr. WYDLER. When is that supposed to happen?

Mr. DAVIS. May I just point out this?

Mr. WYDLER. Very well.

Mr. DAVIS. We have a more or less parallel situation as respects communications satellites and this committee versus the Committee on Interstate and Foreign Commerce which has jurisdiction of such things as the television industry and what not.

I think Dr. Singer's testimony earlier went not to the actual physical turning over of the facilities, but simply the recognition, the function of management of a weather satellite or using its data should be a Weather Bureau function as distinguished from a NASA function.

Dr. SINGER. That is exactly what I'm trying to get at. I'm trying to get at what those words "turning over the facilities" mean.

Mr. DAVIS. I understand.

Dr. SINGER. It means we would fund for them and operate them.

Mr. WYDLER. When would that take place?

Dr. SINGER. As early as possible. In any case, after the initial phase of Nimbus is over, which will be after four launchings.

Mr. WYDLER. Could you give us a year for that?

Dr. SINGER. It was contemplated to be 1965.

Chairman MILLER. In other words, as soon as you get fully operational, then NASA steps out of the picture?

Dr. SINGER. Out of the operational picture.

Chairman MILLER. Out of the operational picture; except for the responsibility it will continue to launch your spacecraft because that's its function.

Dr. SINGER. To procure the spacecraft, to launch them, and talk to them in orbit.

Chairman MILLER. The rest of it, as to the date when this will take place, we had hoped it would be a little sooner, but we find there were some slippages.

You find yourself, then, in the position of using what was an experimental vehicle where you can—to the practical operation where we are talking, maybe the authorities are a little fuzzy, as you get things perfected; NASA is not a branch of Government that wants to operate anything.

Dr. SINGER. I believe the important thing you gentlemen on this committee would want to consider is "flexibility."

Once you build facilities, it becomes difficult to change arrangements.

For example, we are building a facility for meteorological data processing now.

If, in the future, it should be decided that this function belongs to NASA, I think it would be extremely difficult to accomplish this transfer simply because we have already constructed a fixed facility with machinery at Suitland.

Therefore, one should, I think, in any construction program, consider not only the immediate assignments, but also the eventual operational assignments.

Mr. DAVIS. Now let me understand one little thing or two about the function of the Weather Bureau Laboratory.

Would you, for example, in trying to decide what cameras or what infrared equipment would be put aboard a satellite, would you go far enough to try to figure out or find out for yourselves whether it could survive in an environment of outer space or would you look to NASA t do that?

Dr. SINGER. We would look to NASA to give us that advice, but we would check it. That is our responsibility.

Mr. DAVIS. Functionally, your laboratory is primarily concerned with deciding what instruments will send the information or pick up the information you want?

Dr. SINGER. Yes, sir, and which instruments will do it in the best possible manner.

Mr. DAVIS. You would decide whether it would work in outer space or not?

Dr. SINGER. We depend on NASA to supply us with the expert information on that.

Mr. DAVIS. Whether it is satisfactory for a launching?

Dr. SINGER. NASA would do that.

Mr. DAVIS. These are some of the things, perhaps, a Meteorological Laboratory at Goddard might concern itself with.

Dr. SINGER. Any research aspect of this type is NASA's proper function.

Mr. DAVIS. Knowing what weight could be tolerated, would be a NASA function, what payload could be put in such and such orbit?

Dr. SINGER. Yes, sir.

Mr. DAVIS. Are there any further questions?

Mr. Boone?

Mr. BOONE. I have about three question, Mr. Chairman.

Doctor Singer, is it anticipated or is it necessary that NASA operate on any of the sensory data before transmission to you?

Dr. SINGER. No, sir, the data can be should be, and will be transmitted directly to us, NASA will also look at the data, not for operational use but for disagnostic use to see if the equipment is working properly. If it is not, they will, in consultation with us, take such action as seems best to improve the performance of the equipment.

Mr. BOONE. In what form do you get this data?

Dr. SINGER. The data will reach us in the form of electrical impulses over a microwave link.

Mr. BOONE. You record it on tape or put it into the machine right away?

Dr. SINGER. We record it on the tape and put it on the machine simultaneously.

Mr. BOONE. Do you think Nimbus will be launched this year?

Dr. SINGER. We have been advised to look forward to a first Nimbus launch during this calendar year.

Mr. BOONE. What measures do you take to see the schedule is a realistic one? How do you manage your aspect of their development?

Do you have men working side by side with them? Do you go to the contractor plant?

Dr. SINGER. We have a Weather Bureau man in the Nimbus project whose job it is to take care of data utilization which is a Weather Bureau function in the Nimbus project and who is also supposed to keep me informed of all technical aspects of the Nimbus project.

We also have Mr. Frey, whom you met earlier, who does a similar job on the financial aspects.

Mr. BOONE. One last question, Mr. Chairman.

Last year we had testimony before the subcommittee in which they were so surprised when a witness said there was no urgency, apparently, no urgency assigned to the development of the Nimbus program.

After you have been associated with this for somewhat over a year, are you happy with the organizational setup? Are you pleased with the management that is now in existence and are you confident that you are getting the requirement that you need from all of the users?

Dr. SINGER. I have been associated with the Weather Bureau and with this project since last June—about 9 months now. The management situation has been improved considerably, I would say, especially after the hearings last September. We have been able to resolve a good many problems and are now in the process of resolving a few gray areas remaining in the interface. We are getting the user requirements transmitted to the Weather Bureau, I think, in an excellent way.

We have to go out and talk to many users who never thought they could use satellite data and convince them we have something that will do the job for them.

Mr. BOONE. The development is proceeding with some urgency then. Is this correct?

Dr. SINGER. It is indeed, sir. It certainly is, so far as we are concerned.

Mr. HECHLER. Pursuing that just one step further, can you suggest any improvements in the administrative arrangements that would make it work more smoothly or more expeditiously?

Dr. SINGER. With regard to the Nimbus project?

Dr. SINGER. No, sir; I cannot. I think we have a fairly effective method of managing the programs.

As I mentioned in my testimony, a court of appeal was advocated by this committee. We have never had occasion to use one and I don't expect we will, because we find we can resolve problems at either the working level or at my level, the management level.

Mr. HECHLER. Turning to another question very briefly, you mentioned the contract which the National Weather Satellite Center has. About how much of your annual budget would be in contracts?

Dr. SINGER. Approximately 90 to 95 percent is in the form of contracts.

Mr. HECHLER. Primarily research?

Dr. SINGER. Primarily to NASA in the reimbursable contract to construct the spacecraft, procure rockets, and construct and operate CDA stations. We also have a sizable contracting effort in research. We are trying constantly to involve more universities in working with satellite data.

We realize that there is a great amount of important information stored in these pictures. After they have fulfilled their operational usefulness we would like to see scientists in various places try to figure out what these pictures mean.

We are making slow but steady progress in persuading them to do it. There is always some reluctance toward going into a new field. People have their own problems.

We are trying to convince them this is a very worthwhile field in which to work.

Mr. HECHLER. One final question.

I think I have a pretty clear picture about what the Weather Bureau funds for NASA, but I'm not exactly clear how much NASA funds for the Weather Bureau.

You mentioned, for example, the space flight support and other things like that.

Dr. SINGER. Yes, sir. We have a division, Spaceflight Support, which is funded under reimbursable arrangements by NASA.

We have 38 positions in this Division of which 16 are filled. The reimbursable amount comes to about $350,000.

Mr. HECHLER. This is——

Dr. SINGER. Annually.

Mr. HECHLER. What else does NASA fund for the Weather Bureau?

Dr. SINGER. I believe that's all.

The Weather Bureau is performing a job, a service job, for NASA. NASA has the prime responsibility; they decide what this group will do for them. This group is under my administrative control, but under the technical control of NASA's Manned Space Flight Center in Houston.

Mr. DAVIS. Mr. Wydler?

Mr. WYDLER. Is there a regular meeting of NASA representatives, representatives from your department, and the military, regarding this entire program?

Dr. SINGER. Yes, sir. There are two coordinating groups or committees—one primarily for the research and spacecraft aspects which is advisory to NASA, (JMSAC); and the other for user requirements. This is advisory to the Weather Bureau.

This is how we, in part, carry out our function of collecting and coordinating user requirements.

Mr. WYDLER. I mean, because it would appear to me what you are doing, in effect, is taking pictures of Earth which would seem to me to have a very strong useful purpose from a military point of view and I just wondered—I wanted to make sure as I understood it that the military was a part of this team that was developing this satellite and the techniques of photography and so forth that are being developed here.

Dr. SINGER. I should explain that the satellite does not have any direct military importance in the sense that the pictures from the satellite do not have a high enough resolution to be useful for direct military purposes.

Mr. WYDLER. I understand that's the situation today.

Dr. SINGER. We do not contemplate increasing the resolution of the satellite for one very simple reason—it costs too much money.

If you increase the resolution you have to handle much more data and the cost of data handling is extremely high. Since we are interested in meteorology, we would like, if possible, to strike a better balance between resolution and cost. In effect, this would make our resolution worse.

In fact, we would like to put our resolution at just the right point—reduce it just enough to enable us to extract all the useful meteorological information without having to pay for any excess baggage.

This is one of our real tough jobs.

Mr. WYDLER. I mean, what excess baggage are you paying for now?

Dr. SINGER. We may be, at this time, getting a resolution that is higher than what we really need to do an adequate job of global weather analysis.

Mr. WYDLER. What is that costing you?

Dr. SINGER. It will cost us, approximately, over $1 million a year just to ship the data from Alaska to Washington.

Mr. WYDLER. Costing you, or costing who—a million dollars a year?

Dr. SINGER. The taxpayer, eventually; but it will come out of my budget.

Mr. WYDLER. Out of your budget? You pay that to who?

Dr. SINGER. To NASA. They, in turn, contract with communication groups for the necessary facilities.

Mr. WYDLER. You think you can do away with that?

Dr. SINGER. Not completely, but we'd like to see whether we can save money by reducing the communication costs.

We might be able to do this by transmitting the data in degraded form.

We even talked about the future possibility of doing some of the data analyzing inside the satellite itself. We must find a more eco-

nomical means to transmit pictures to the ultimate users of weather data.

This is why the Direct Read-Out Satellite is such an economical solution.

Mr. WYDLER. Actually, NASA itself is acquiring a lot of this data, isn't it, and bringing it down and giving it to you to be processed.

Doesn't NASA perform that part of the job?

Dr. SINGER. We reimburse them for this.

Mr. WYDLER. Are they collecting some of this data you don't need, as well as A.T. & T., that you are talking about?

Dr. SINGER. The resolution of the camera determines the amount of data that you get every day. It amounts now to 5 billion bits. We think we will need that much data. One of my major jobs right now is to figure out ways of decreasing the volume of data flow. One way is to see if we cannot extract adequate meteorological information from less data.

Let's assume that the cost of shipping data is roughly proportional to the amount of data. If we could cut the amount to 1 billion bits from 5 billion, we would only have to pay one-fifth as much for shipping, a proportionally less amount for analyzing it, and a still lesser amount for distributing it.

Mr. DAVIS. Let me point this out, Dr. Singer, it's not a question of whether NASA or the Weather Bureau gets the data as respects the cost of transmitting the data or communicating it, is it?

Dr. SINGER. No, sir.

Mr. DAVIS. It's just a matter of the fact the only good way we have of transmitting data from Alaska to the United States is over the A.T. & T. system.

Dr. SINGER. It's not commercial all the way. I believe in Alaska we use military facilities.

Chairman MILLER. The Department of Defense handles all of the communication up there and out of there it comes directly in here? Of course, this is one of the things you are working for.

In future satellites you will develop a camera most likely that will give you the stuff you want and won't have this high resolution?

Dr. SINGER. We may need this resolution. We will learn from experience.

Chairman MILLER. That is something no one can tell about. We are still working in a vacuum. Beginning to see what we need, but we haven't the tools for working it yet.

Dr. SINGER. I thought you would be interested in knowing we are doing this type of thinking. We are not satisfied with the state of things as they are, but are examining it carefully—even now before we have the first Nimbus—to know whether we can actually optimize the cost-to-benefit ratio.

Mr. HECHLER. Dr. Singer, you get around a good deal.

I wondered if you heard any rumors, maybe the Department of Defense might be interested in developing a meteorological satellite?

Dr. SINGER. No, sir. It seems to me the Department of Defense requirements have been adequately stated to us.

They are going to be stated to us again formally through the Joint Meteorological Group which has the Army, Navy, Air Force, and Weather Bureau on it, I think the national system, the one we are working on, will satisfy all the defense requirements.

Mr. DAVIS. Thank you.

Chairman MILLER. I thought we were closing.

Mr. WYDLER. I just have one little question, if you know the answer.

Can you tell me what the average GS rating of the people that work in your department is?

Dr. SINGER. No, sir, I cannot.

Mr. WYDLER. Can you supply that for me?

Dr. SINGER. Yes, I certainly can.

(The information requested is as follows:)

Average grade of GS positions at the National Weather Satellite Center

Fiscal year	Number of GS positions	Average grade
1963	246	GS-10.1.
1964 estimate	298	GS-10.5.

NOTE.—Includes only permanent positions supported by appropriated funds. An additional 38 positions with an average grade of GS-10 are financed by NASA under reimbursable arrangements for meteorologica support of the Mercury and Gemini programs.

Mr. WYDLER. Thank you.

Mr. DAVIS. Mr. Chairman?

Chairman MILLER. Mr. Chairman, if you are closing--

Dr. SINGER. I wish the grades were higher.

Mr. WYDLER. I realize that.

Chairman MILLER. I want to express my appreciation for the work Dr. Singer is doing. Want to congratulate him on it, and we are very happy—the country should be very happy, Doctor, that you are with the Weather Bureau.

Dr. SINGER. Thank you.

Chairman MILLER. And that you are working, you and your staff, are working on this program.

It is a refreshing one and to my way of thinking, if nothing comes out of the space effort except the fact that we may be able to—that we will be able to resolve the weather within a limited period of years, it would pay for the cost of this whole effort.

Dr. SINGER. Thank you, sir. We certainly feel that way.

Mr. HECHLER. Mr. Chairman, I'd like to add my compliments, too. I think you and your staff and your associates have done a really outstanding job in the National Weather Satellite Center.

Dr. SINGER. Thank you.

Mr. DAVIS. I'd like to say all the members of the subcommittee subscribe to, fully, what Chairman Miller and the chairman of the subcommittee has expressed.

On behalf of the subcommittee, I want to thank you for coming before us and giving such interesting and valuable testimony today.

At this time the committee will adjourn.

(Whereupon at 12:22 p.m. the committee was adjourned.)

1964 NASA AUTHORIZATION

WEDNESDAY, APRIL 3, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON APPLICATIONS AND
TRACKING AND DATA ACQUISITION,
Washington, D.C.

The subcommittee met at 10 a.m., pursuant to call, in room 214–B, Longworth Building, Hon. John W. Davis (member of the subcommittee) presiding.

Mr. DAVIS. Gentlemen, I am going to adhere to our policy of starting virtually on time, even though I am the only member of the subcommittee at this point. So I will call the committee to order.

I am glad to have you back, Dr. Seamans, and also am glad to welcome Dr. Tepper as a witness today. I suppose you are expecting to make the first statement today, Dr. Seamans?

Dr. SEAMANS. No, Dr. Tepper is prepared to make a statement on the meteorological program, and we will proceed if you wish.

Mr. DAVIS. Very well.

(The biographical sketch of Dr. Morris Tepper is as follows:)

Dr. Morris Tepper, Director of Meteorological Systems in the Office of Applications, joined the headquarters staff of the National Aeronautics and Space Administration on April 20, 1959. Previously he was Chief of the Severe Local Storms Research Unit, U.S. Weather Bureau.

Born in Palestine in 1916, Dr. Tepper came to the United States in 1922 and became a citizen in 1926. He earned a bachelor of arts degree in 1936 and a master of arts degree in 1938 from Brooklyn College, and a Ph. D. from Johns Hopkins University in 1952.

Dr. Tepper joined the Air Force in 1943 and served as weather officer in the Pacific theater of operations until 1946 when in August he joined the staff of the U.S. Weather Bureau, Washington, D.C., as research meteorologist. In 1951, he became Chief of the Severe Local Storms Research Unit.

From 1952 to 1959, he taught fluid mechanics and dynamic meteorology at the Graduate School, U.S. Department of Agriculture.

Dr. Tepper has written many papers in technical journals on theoretical and experimental aspects of severe local storms and on meteorological satellites. In 1950, he was the joint recipient of the Meissinger Award of the American Meteorological Society for his work on the application of hydraulic analogy to meteorological problems. In 1961 he received the Distinguished Alumni Award from Brooklyn College.

His professional memberships include the American Meteorological Society, the American Institute of Aeronautics and Astronautics and the Washington Academy of Sciences. He sits on several National and Government committees which plan and coordinate activities in the atmospheric sciences.

Dr. and Mrs. Tepper (the former Sandra Levin) and their sons, Andrew and Bradford, live in Silver Spring, Md.

STATEMENT OF DR. ROBERT C. SEAMANS, JR., ASSOCIATE ADMINISTRATOR, NASA; ACCOMPANIED BY DR. MORRIS TEPPER, DIRECTOR, METEOROLOGICAL SYSTEMS, OFFICE OF APPLICATIONS

Dr. TEPPER. Mr. Chairman and members of the subcommittee, I am happy to have this opportunity to appear before you again to discuss the programs of the Office of Meteorogical Systems.

In this discuss, I shall begin with a few remarks on the objectives of our program and then proceed with a detailed description of the flight and supporting research activities that we are developing in order to fulfill our responsibilities inherent in the statement of objectives. I shall try to emphasize our plans for the coming fiscal year, in order that you may note how these plans fit into the overall program pattern (fig. 35).

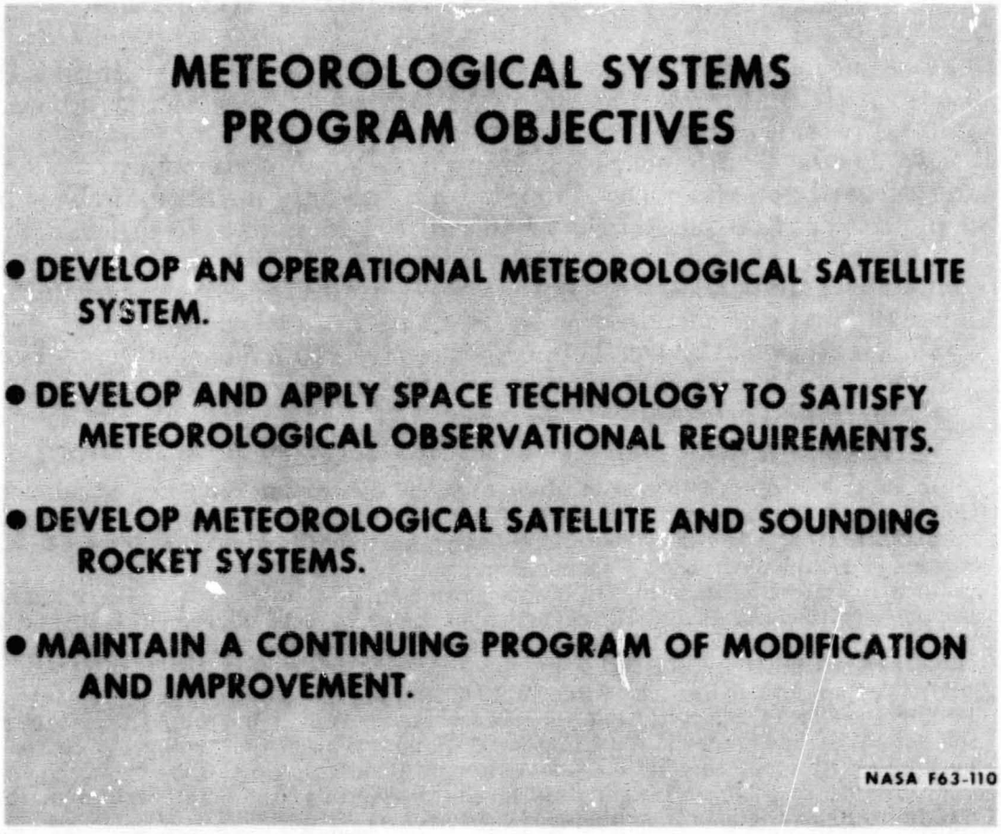


FIGURE 35

PROGRAM OBJECTIVES

We are currently actively engaged, together with the U.S. Weather Bureau, in the development of an operational meteorological satellite system. This system is to be used by the Weather Bureau in the fulfillment of its responsibilities for the analysis and forecasting of the weather.

I shall refer later to the extent to which TIROS data have assisted in this regard.

The development of an operational system involves the development of a reliable system that will provide data continuously and on a current basis so as to be useful to the forecaster in a timely manner.

More generally, our objective is to develop various aspects of space technology and integrate this technology into appropriate systems which will provide the meteorological observations required by the meteorologist.

This objective is quite broad and reflects our intent also to be responsive to the requirements of the research meteorologist for additional data to help him better understand the weather processes and thus lay a firmer foundation for more accurate forecasting and eventual experiments in weather modification and control.

In more specific terms, we can state that our objective is the development of meteorological satellite and sounding rocket systems.

Finally, it is our objective to maintain a continuing program for modifying and improving the developed systems in the light of developments in space technology and of new or sharpened user requirements.

FLIGHT PROGRAM

The hardware elements of our flight program are illustrated on this chart (fig. 36). In the lower left corner is a schematic representation of the small and large sounding rockets which are used in acquiring atmospheric data samples. Then we see TIROS, the spin-stabilized

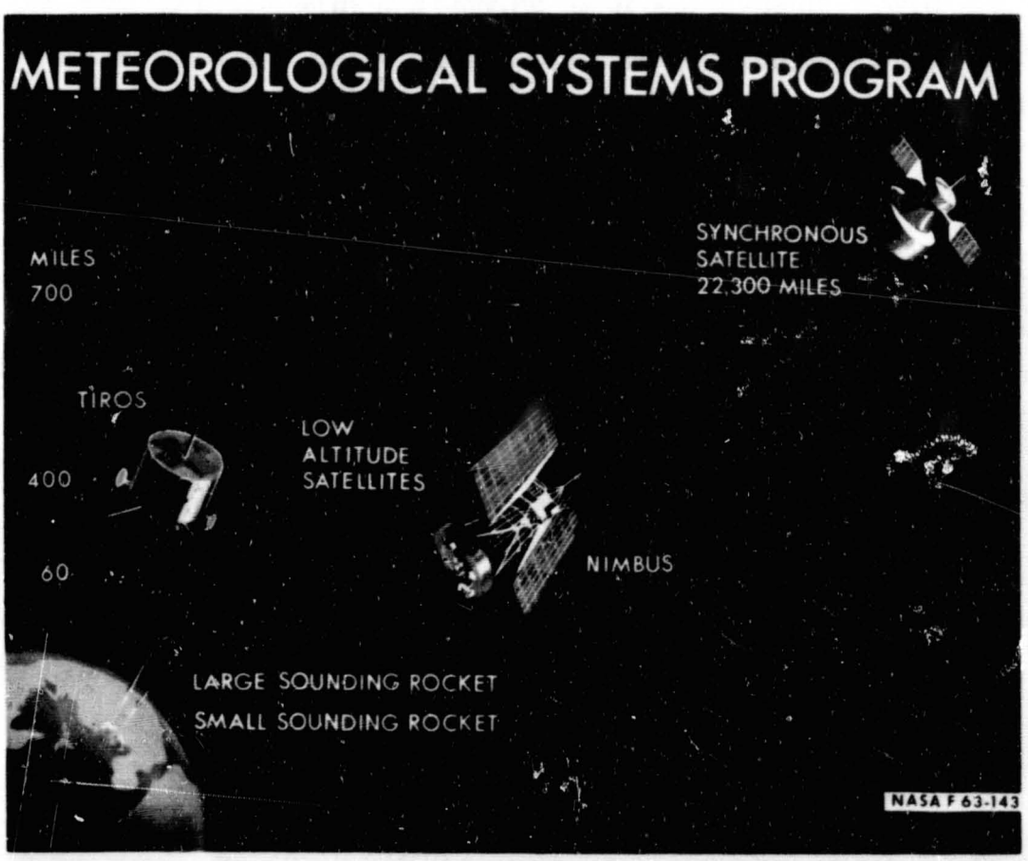


FIGURE 36

satellite which has done so much to establish the feasibility and to demonstrate the capabilities of satellite technology in meteorological flight systems.

Nimbus, the large satellite now under construction incorporates as many as possible of the techniques now available to us to improve the quality of the satellite systems.

In the upper right of the chart is a schematic representation of a synchronous satellite orbiting at an altitude of 22,300 miles. Such a spacecraft should make it possible to continuously observe the weather conditions over a selected segment of the Earth's surface. This satellite is still in the conceptual stage and hardware development for it has not yet been initiated.

I would like now to discuss these flight programs in a little more detail. In view of its spectacular achievement, I think it would be appropriate to begin with the TIROS program.

TIROS

The TIROS satellite is the old standby and foundation of our current flight activity. The chart (fig. 37) shows some of the characteristics of the six TIROS satellites that we have already launched successfully.

TIROS II functioned for 10 months.

TIROS V is still operating on one camera. It has been up since the middle of last June and so it is more than 9 months old already.

TIROS VI went up in the middle of September. It is still operating with one camera and so it has finished 6 months.

TIROS SATELLITES

	LAUNCH DATE	USEFUL LIFE	INCLINATION
TIROS I	APRIL 1, 1960	2½ MO.	48 DEGREES
TIROS II	NOV. 23, 1960	10 MO.	48 DEGREES
TIROS III	JULY 12, 1961	4½ MO.	48 DEGREES
TIROS IV	FEB 8, 1962	4½ MO.	48 DEGREES
TIROS V	JUNE 19, 1962	STILL OPERATING	58 DEGREES
TIROS VI	SEP. 18, 1962	STILL OPERATING	58 DEGREES

NASA F 63-145

FIGURE 37

You can see from these data that the lifetime of the TIROS satellite has ranged from 2½ to 10 months. TIROS has severe limitations from the point of view of data coverage. These have been pointed out in the past. Briefly, they are that since TIROS is spin stabilized it does not see the Earth continuously, and it is also limited in coverage by the angle of its orbital inclination.

On this next chart (fig. 38) we have a compilation of some of the operational support that TIROS has given to the Weather Bureau. Over 215,000 total and 168,000 usable pictures of cloud cover have been obtained from the TIROS satellites to the end of February.

From these pictures over 5,000 cloud cover analyses were prepared, over 700 special storm advisories have been issued and there have been

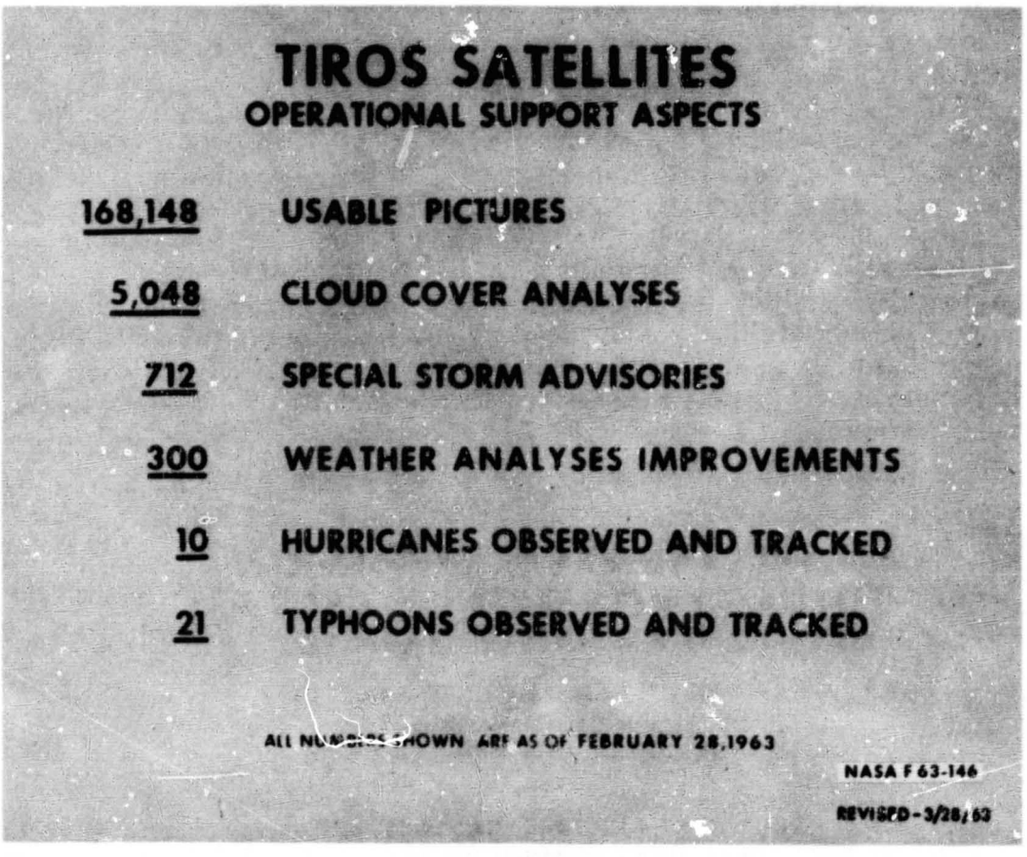


FIGURE 38

300 specific instances where the weather analysis has been improved. There were 10 hurricanes and 21 typhoons observed in the sequences of photographs taken by TIROS and these were often tracked over a period of several successive days.

This type of support has, of course, proved extremely valuable to the Weather Bureau and the DOD in their day-to-day operation.

TIROS has also provided a wealth of very useful data to research meterologists both within the Government and at various universities and research institutes who are interested in the many different types of atmospheric circulations and now have these data to assist them in pursuing theoretical and empirical studies of atmospheric phenomena.

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As I indicated to this committee a few weeks ago, the TIROS project is on schedule in all of its phases. We now have relative freedom to schedule the next few launches not on the basis of spacecraft availability but on the most favorable time with regard to meteorological coverage.

At the present time, there are two TIROS satellites still operating in orbit. These continue to provide good picture data. In view of the excellent performance of the TIROS V and VI, our original launch date of the next TIROS has now been intentionally delayed twice. Its current launch date has been set to give maximum coverage during the hurricane season. While TIROS V and VI are providing data in one part of the globe, the next satellite will provide data in another.

This additional coverage will increase the frequency of observation over the South Atlantic during the hurricane season and thus assist in maintaining a continuous vigil over the area where these severe storms are born.

TIROS launches will also continue to be used as research satellites.

On the next chart (fig. 39) we have indicated some of the experiments to be conducted by the next five TIROS research and development spacecraft which are now part of NASA-approved activity.

These spacecraft will be flown at intervals of several months starting later this spring. You will note that the first of them is intended to assist in the developmnt of the horizon scanner for the Nimbus meterological satellite. Another will give us an opportunity to flight test the automatic picture transmission system which I shall discuss in a moment. We may attempt a polar launch to acquire data in the polar region.

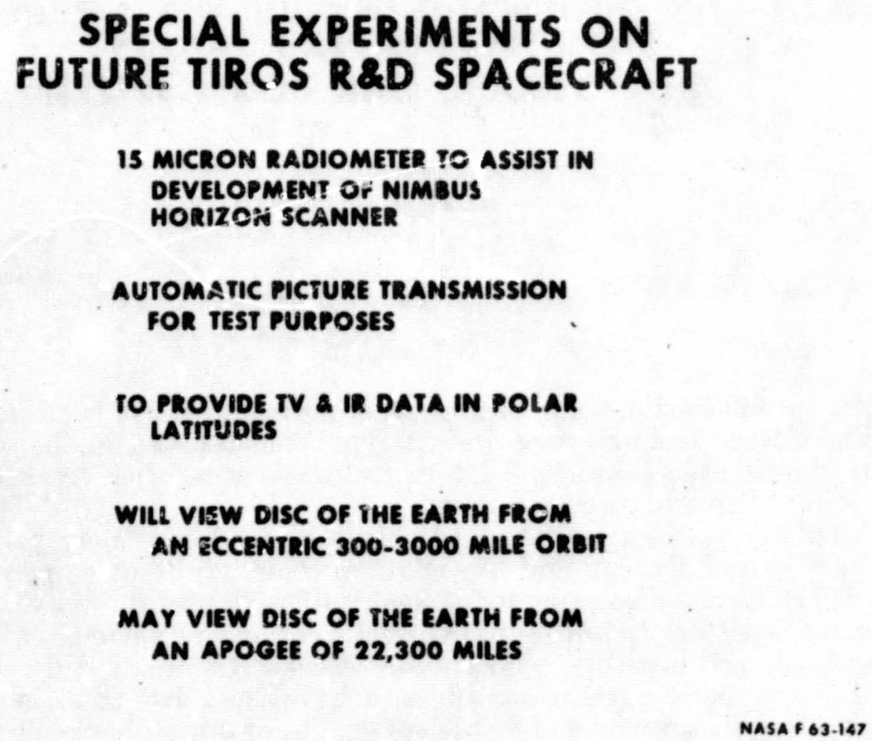

FIGURE 39

The TIROS satellites will also carry experiments intended to aid in determining design factors for satellites for the future. In particular, they will investigate the coverage from other altitudes than the altitude of about 400 miles which is presently the customary one for the TIROS system. Although these TIROS will be flown as research and development vehicles, the cloud cover data which they proved will continue to be made available for operational purposes as has been done in the previous TIROS launches. It is planned to continue to provide these data until Nimbus/NOS data are available on a regular basis.

As stated a moment ago, one of these TIROS is expected to be used to give us an opportunity to flight test the automatic picture transmission system. This device, referred to as the APT system, is designed to continuously transmit pictures of local cloud conditions to weather stations near the track of the satellite (fig. 40).

In the normal mode of operation, weather satellite cloud pictures are transmitted to elaborate command and data acquisition stations at a relatively rapid rate. This requires the use of wide radio bandwidths and large 60-foot antennas or their equivalent.

In the APT system, we make a trade-off. We use slow transmission rates and thus permit the use of small bandwidths, and a relatively small (about 15 feet long) spiral antenna.

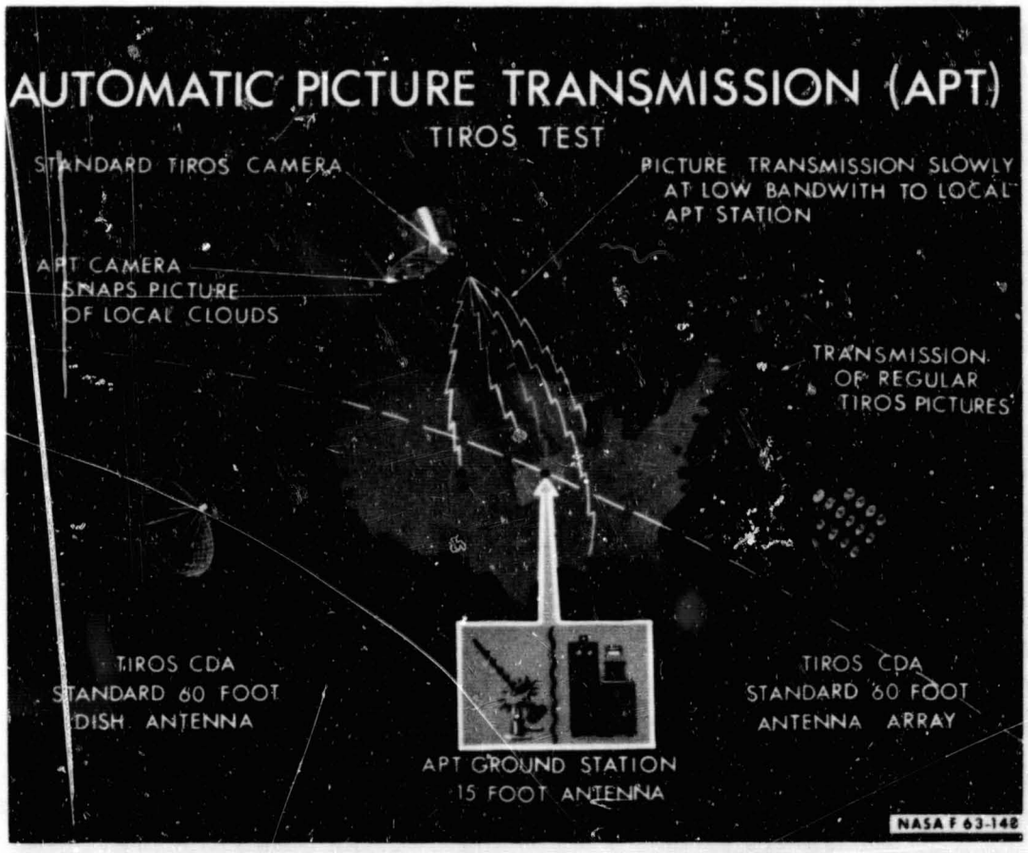

FIGURE 40

The camera in the satellite snaps a picture of the clouds below about once every 3 minutes. The picture is snapped in a fraction of a second, and stored on a special surface in the vidicon camera. The rest of the 3-minute period is used to slowly scan the picture electronically and transmit it to the ground station. Then the cycle is automatically repeated.

At the ground station, the console is used to point the antenna, by manual control, toward the satellite; to receive the picture, and to display it on a facsimile recorder (which is similar to the equipment used for wirephotos). Each picture will cover an area a bit larger than the TIROS pictures—actually about 1,000 by 1,000 miles—and the quality is expected to be about the same as the TIROS pictures.

The ground equipment costs less than $50,000 per set and so is sufficiently inexpensive to ultimately permit many major U.S. and foreign weather stations to be equipped with one.

Mr. DAVIS. Is this the system, Dr. Tepper, that Dr. Singer referred to last week as "instant weather"?

Dr. TEPPER. I believe this is the thing that he referred to by that name, yes, sir. The automatic picture transmission system was designed for the Nimbus satellite but successful development of hardware has made it possible to perform some engineering and systems tests using a TIROS spacecraft.

A flight test on TIROS will permit checkout of the system using a number of ground stations at various locations around the world. When used later in conjunction with Nimbus, APT will enable meteorologists at any place equipped with the ground station to obtain direct cloud cover pictures of their local area. When flown on a Nimbus satellite, the pictures, about four to seven, may be received from one to three orbits daily, near noon at any part of the world.

NIMBUS

I have already mentioned the Nimbus satellite in my discussion today and it has been discussed in some detail before this committee in the past. With your permission, I would like to restate the primary objectives that we are attempting to fulfill with Nimbus.

I would like to address myself, then, to the question—Why proceed with Nimbus if TIROS has proven to be such a successful satellite? First of all the Nimbus sensors represent an improvement over those that exist in TIROS. The cameras are improved, and the radiation sensors are improved.

Other systems have similarly been improved. But we are doing much more with Nimbus than improving the sensors. In essence, Nimbus represents a major step forward over TIROS in these five areas (fig. 41).

1. ORIENTATION

The TIROS system provides pictures most of which were taken when the satellite is looking at the Earth from other than a vertical angle. Only during a very small portion of this orbit does TIROS look straight down. The oblique angle of the major pictures causes difficulty in rectifying the pictures and in interpreting the cloud patterns due to the changing scale.

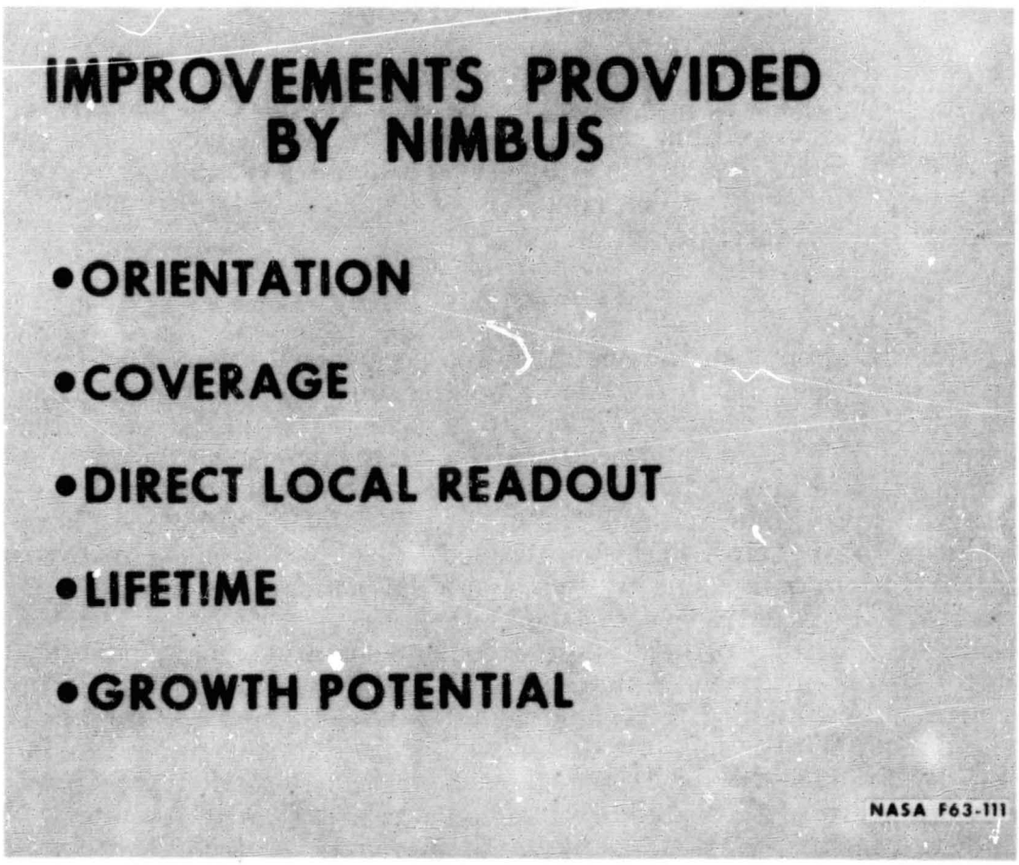

FIGURE 41

Nimbus is being developed as an Earth-oriented satellite which will view the Earth vertically during its entire lifetime, and thus eliminate much of the rectification difficulty.

2. COVERAGE

As you know, TIROS is in an inclined orbit of about 58° and is spin stabilized. This means that pictures can be taken of the Earth cloud cover only when TIROS cameras are looking at the sunlit portion of the Earth. This, combined with the fact that we have only two readout stations in the United States, on the east coast and the west coast, limits the amount of data of the Earth's cloud cover that TIROS can provide. The polar regions are completely inaccessible.

It has been estimated that TIROS provides somewhere between 10 and 25 percent of the global cloud cover per day. Meteorological requirements are for total global observations. Nimbus is to be launched in a near polar orbit and is to view every portion of the Earth every day.

The TIROS cameras, when looking vertically down, view an area of 700 miles on a side. The Nimbus camera system will provide a corresponding picture of about 1,500 by 600 miles. The forward motion of the satellite will thus provide a strip 1,500 miles wide, approximately from pole to pole during each orbit.

3. DIRECT LOCAL READOUT

I have already described the automatic picture transmission subsystem that was developed for Nimbus. This system is to provide to the local forecaster in his field station a picture of the cloud cover in his area. We feel that, when fully developed, this system may represent one of the greatest contributions of the meteorological satellite program to local forecasting.

4. LIFETIME

To be useful on a continuous basis, an operational system must have a reasonably long life. As I have pointed out, the TIROS lifetime has varied from 2 months to about 10 months. The limitation on the lifetime of TIROS is determined by the electronic system design and component lifetimes. It is difficult to estimate what this might be.

As you know, our earlier estimates were that this might be about 3 months. In general, we have exceeded this expectation. However, we feel that an operational system should have a lifetime of at least 6 months and eventually 1 year or more.

In addition to carefully engineered systems and reliable quality control in manufacturing, design redundancy plays a major role in achieving useful long life. The original Nimbus design has included redundancy. Unfortunately, due to weight limitations imposed on it, the first Nimbus will be launched without this redundancy. However, the future developed operational spacecraft will include redundant systems.

5. GROWTH POTENTIAL

One of the more important elements of the current design of Nimbus is its potential for growth. In reviewing meteorological requirements for ultimate operational systems, we find that the cloud pictures and the infrared radiation measurements satisfy these requirements only in part.

Other requirements for operational systems include the need for instrumentation to provide many more observations such as those of winds, extent and intensity of precipitation, vertical structure of temperature, moisture and density, index of refraction, height of tropopause and ionospheric layers, measurements of surface pressure, and identification of ground cover.

In addition, requirements for environmental data needed for research on launch vehicle design and operation or, more generally, for the understanding of the atmosphere, include solar and terrestrial radiation measurements, measurements of atmospheric composition, aurora and ion density, measurements of magnetic and electrical fields, meteor activity, and atmospheric optical properties.

The number of times observations of these measurements are required varies from a few times a day to once daily. Thus, you see it is important that a meteorological satellite have the flexibility for growth so that when suitable instrumentation is developed which can provide observations to assist either in operations or research, then the satellite can accept these instruments without too much difficulty. Nimbus is designed to do just that (fig. 42). It is designed so that its three major subsystems of power, control, and sensory ring are more

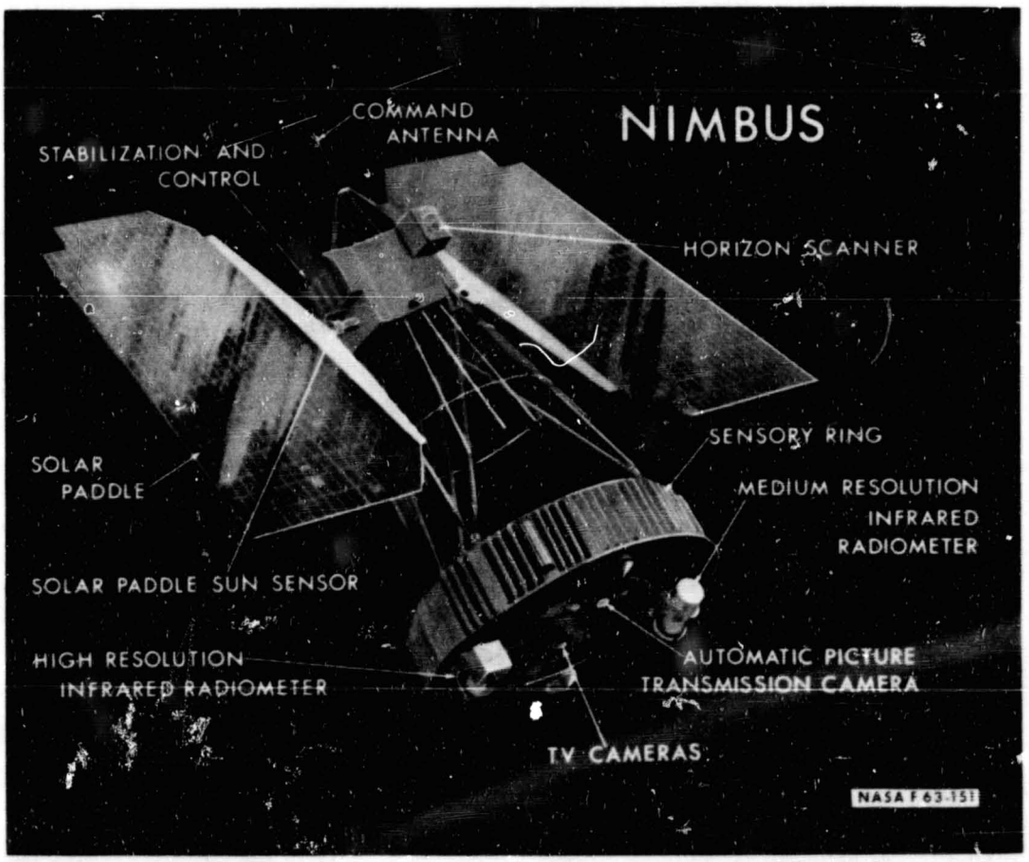

FIGURE 42

or less independent one from the other. It is designed on a modular concept so that new and improved instrumentation can be installed and old ones removed without requiring major redesign of the satellite.

Each one of these five elements—orientation, coverage, direct local readout, lifetime, and growth potential—represents a major advance over TIROS. Nimbus, including all these, represents an extremely large step forward beyond the TIROS capability.

The Nimbus technical difficulties of the past were associated with the development of these five elements. We now believe that our major difficulties are behind us. The prototypes of the various subsystems have been tested successfully. It remains to combine the various subsystems and to check them out together as operating prototype and flight system. This then is the current status of Nimbus.

The prototype sensory ring components are being assembled, and the assembled ring will be tested in a vacuum thermal chamber during the next 2 months. The full prototype spacecraft will be tested during the summer. The flight spacecraft will be tested through the early fall. When the spacecraft passes the testing procedures, we will be ready to launch Nimbus and we estimate this to be before the end of this year. We feel that the tests will be met successfully. Our confidence in this estimate of the launch time is based upon the following factors:

1. The sensory ring subsystems have been qualified independently in performance and environmental tests.

Mr. DAVIS. Dr. Tepper, this is just to satisfy some curiosity I have about the terminology. Now why do you use the word "ring," when you say "the sensory ring"?

Dr. TEPPER. Well the bottom of Nimbus is torus shape and we refer to this as the sensory ring because the sensors fit into and are attached to this ring.

Mr. DAVIS. All of these sensors?

Dr. TEPPER. Yes, sir; the control sits on top and the solar paddles are on the side.

Mr. DAVIS. I see.

Dr. TEPPER. But all the sensory and component equipment other than the controls and the solar paddles are contained in this ring on the bottom.

Mr. DAVIS. Thank you, sir.

Dr. TEPPER. Repeating, then, the sensory ring subsystems, those that go in the bottom, have been qualified independently in performance and environmental tests (fig. 43). Each subsystem has been statically

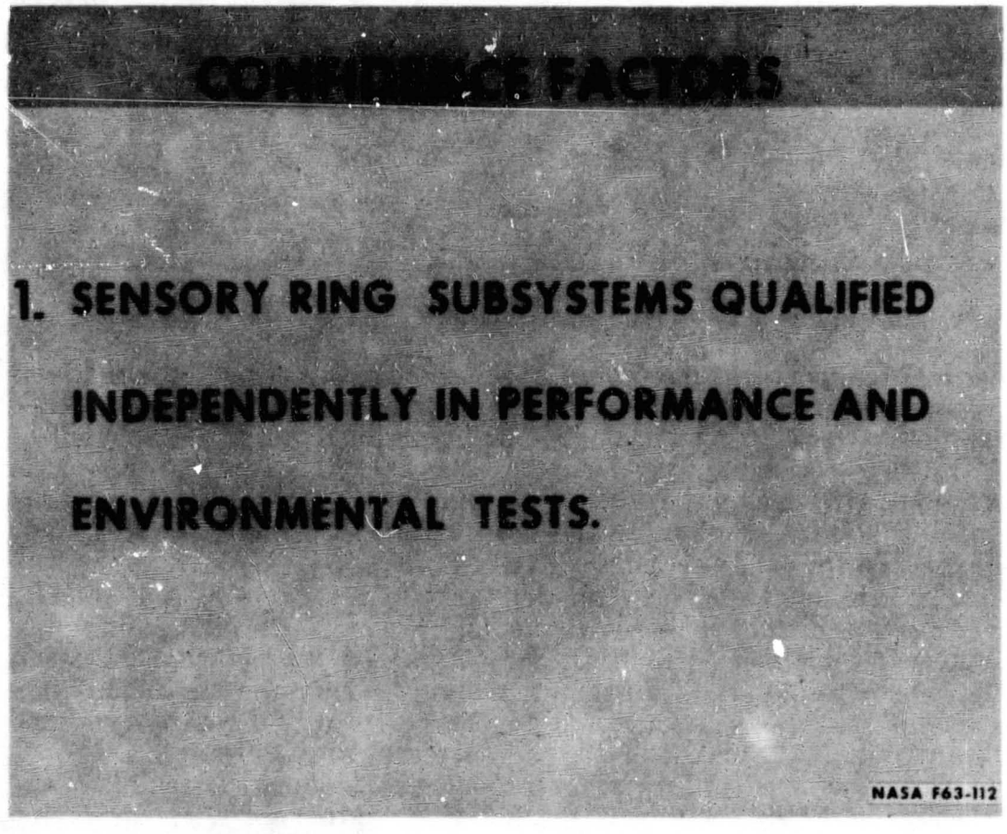

FIGURE 43

tested under environmental conditions, and they have met very rigid specifications.

The next slide (fig. 44) shows the advanced vidicon camera system cameras in a bench test to demonstrate the satisfactory performance of the subsytem. This 3-camera array will view a portion of the Earth, 1,500 miles wide.

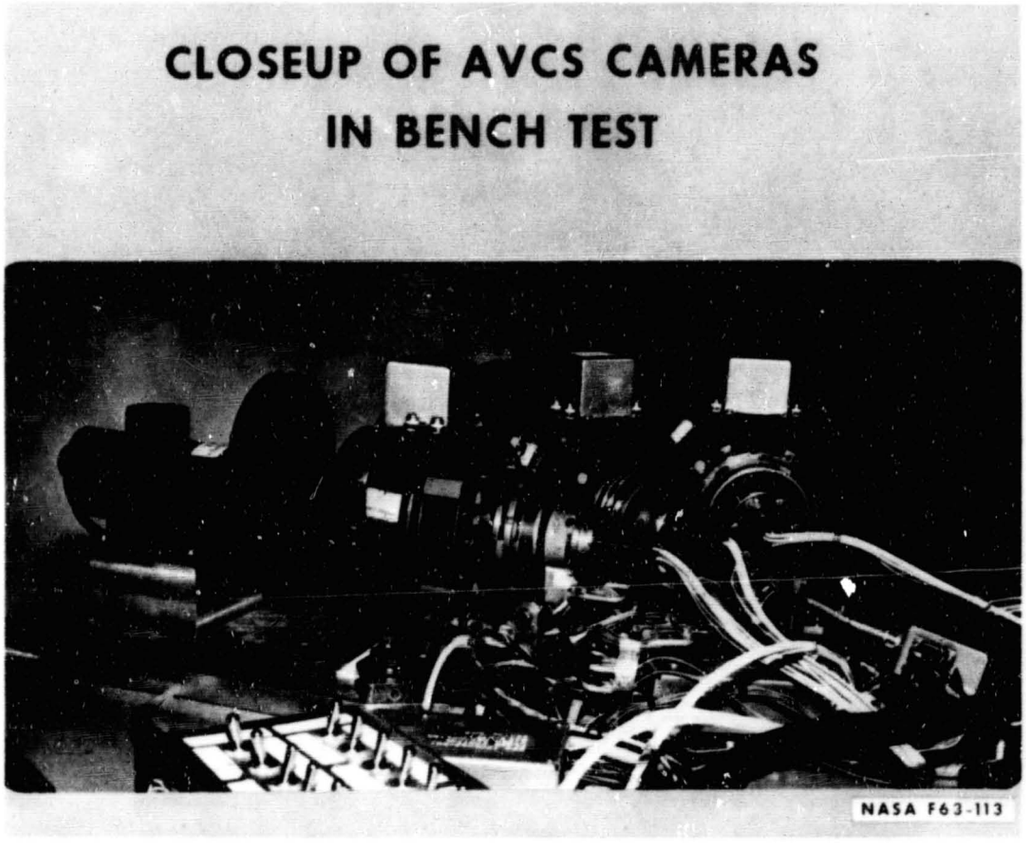

FIGURE 44

2. The structural design has been proven by extensive tests on a full scale vibration model (fig. 45). A full-scale structural model of the Nimbus satellite was placed on the mechanical shaker as shown on the next slide (fig. 46). Rigorous testing simulated conditions much greater than expected at launch. The vehicle has successfully passed these demanding tests.

Mr. DAVIS. Was that done at Goddard?

Dr. TEPPER. No, sir; this was done at General Electric, at the contractor's plant.

Mr. DAVIS. Yes, sir.

Dr. TEPPER. 3. The thermal problems have been analyzed, solved, and the solutions verified using a thermal model (fig. 47). This model is shown with the vacuum chamber in which the testing was accomplished in the following slide (fig. 48). Thus, Nimbus has the demonstrated capability to keep its components within their working range of temperature.

4. The preprototype stabilization and control system has been "flown" for many hours on an air bearing using a variety of model Earth conditions (fig. 49). This system has demonstrated its capability to stabilize and control the Nimbus spacecraft along all three axes as shown on the following slide (fig. 50). The vertical post indicated in this slide is a support column going to the air bearing on which the preprototype spacecraft is resting. It is supported by just a layer of air.

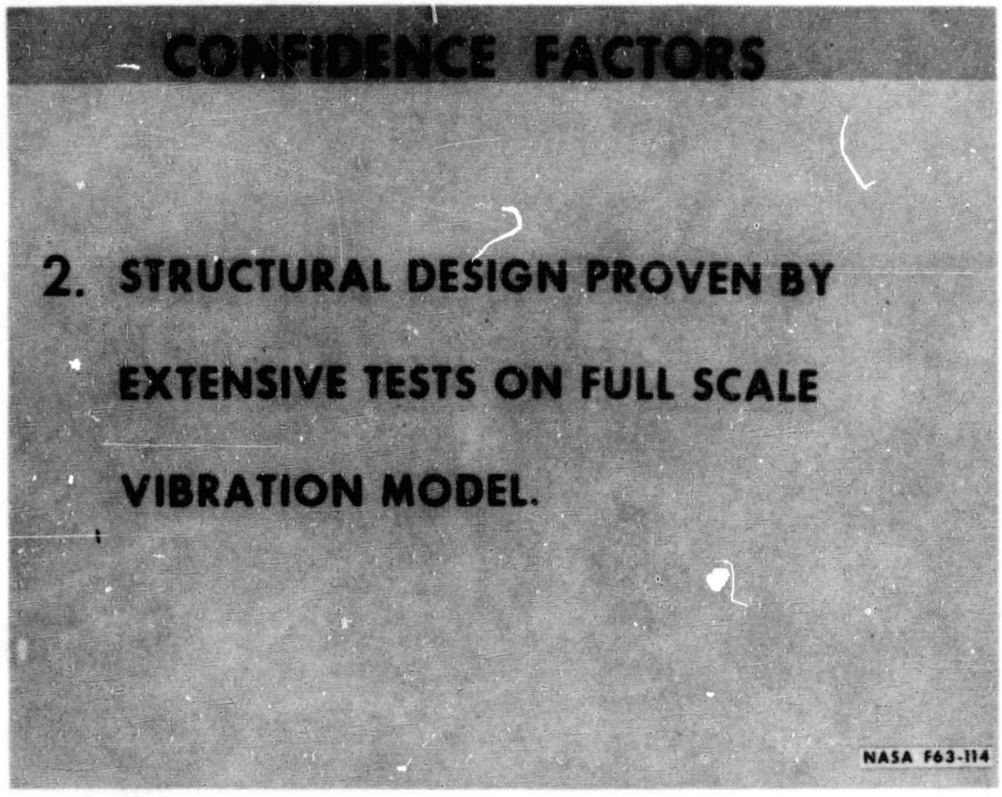

FIGURE 45

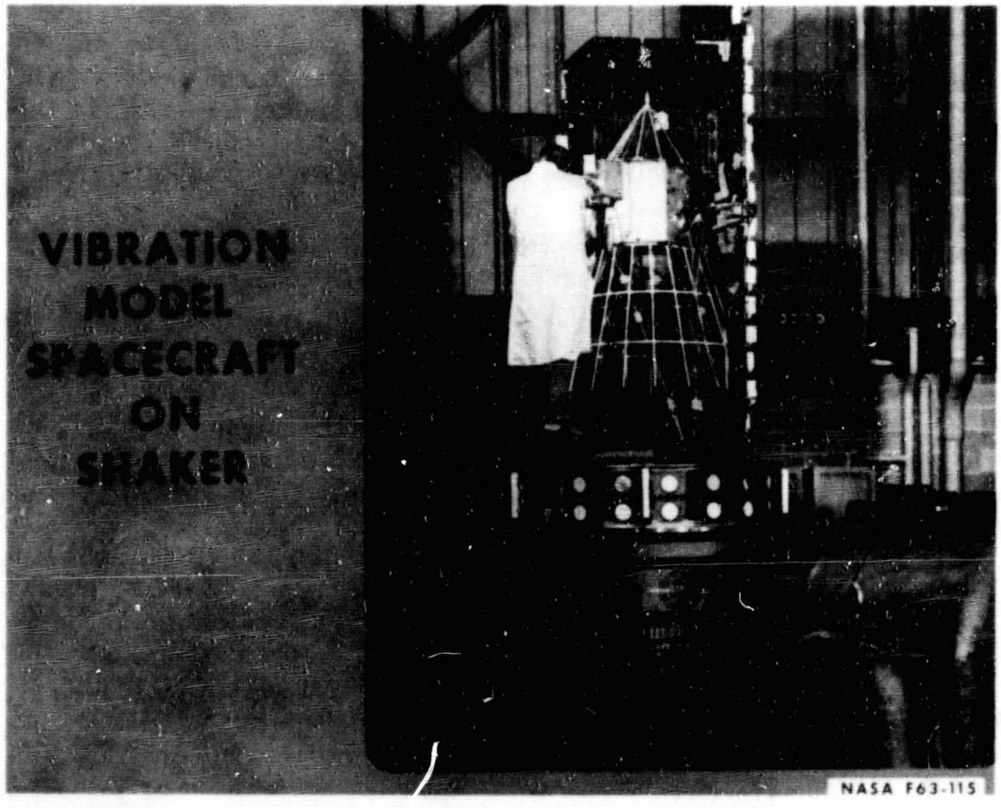

FIGURE 46

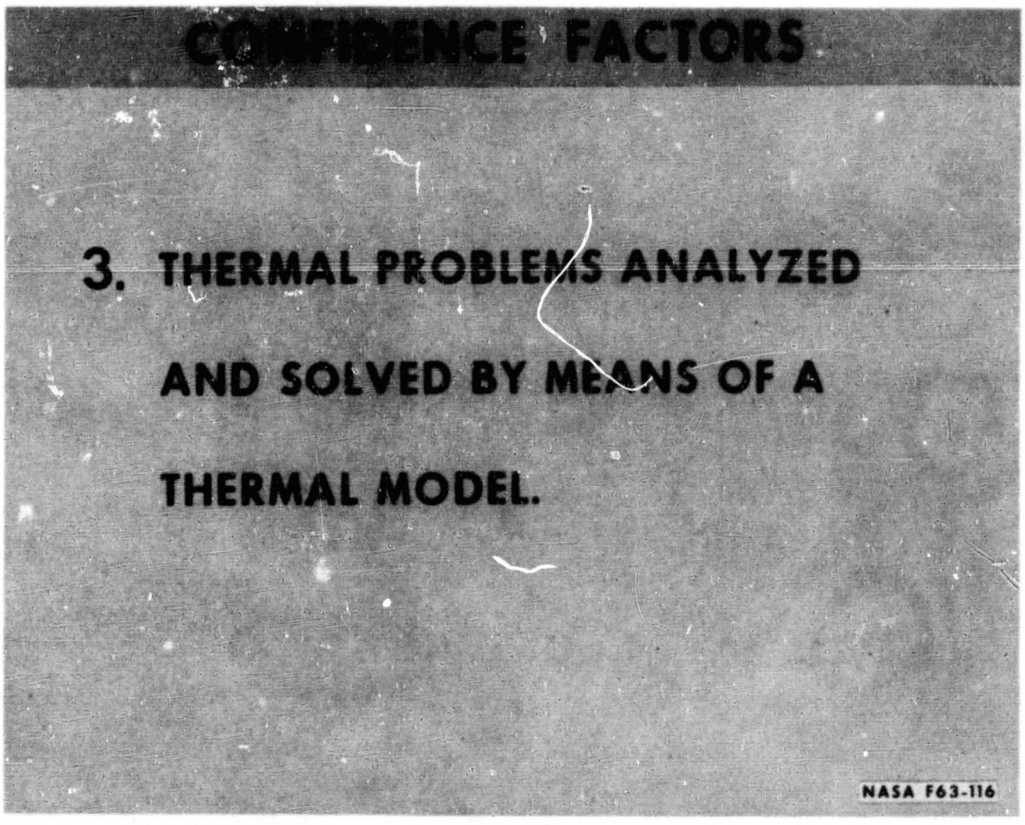

FIGURE 47

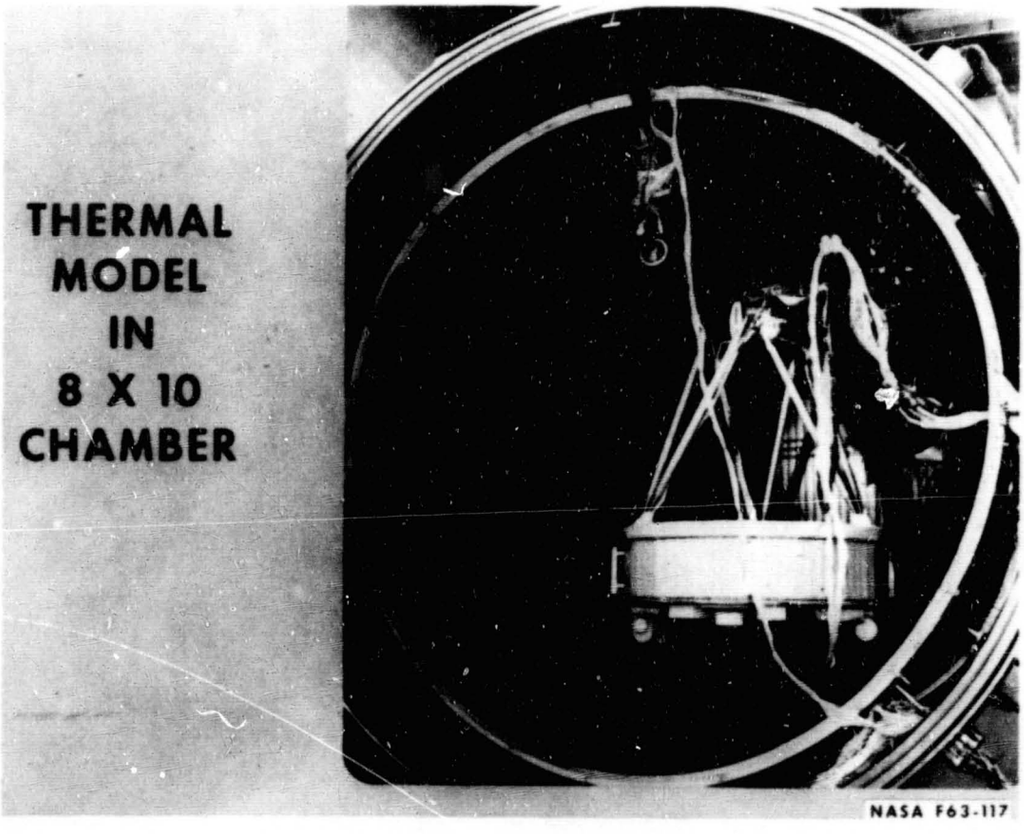

FIGURE 48

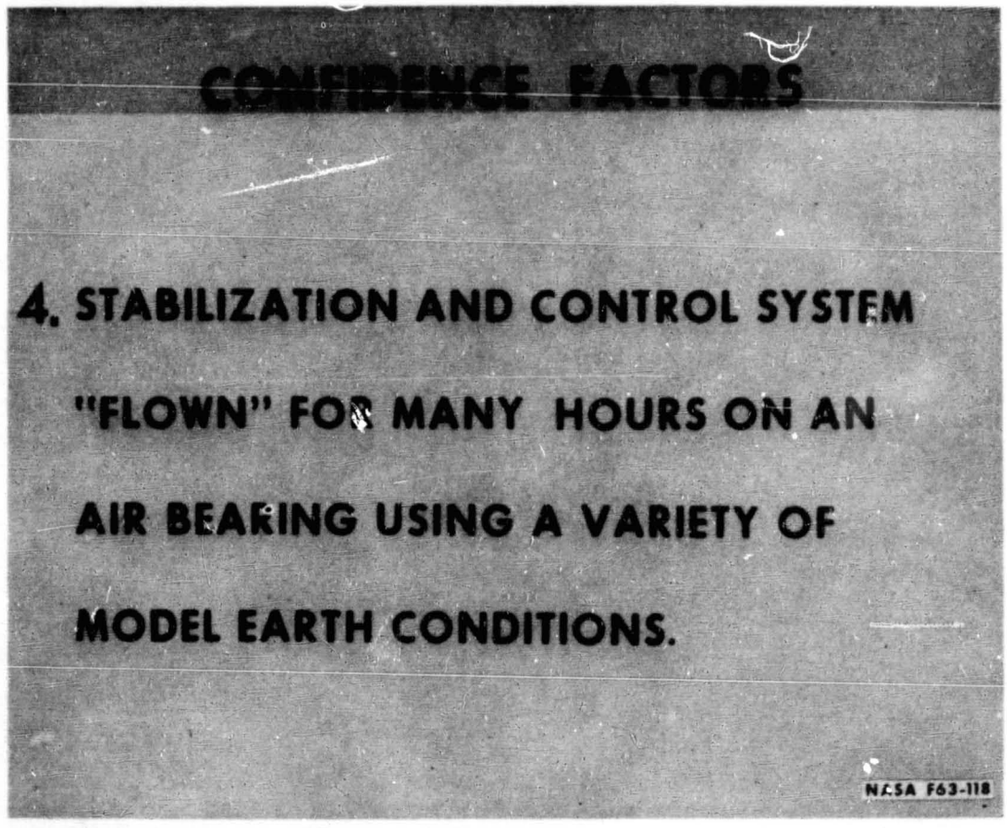

FIGURE 49

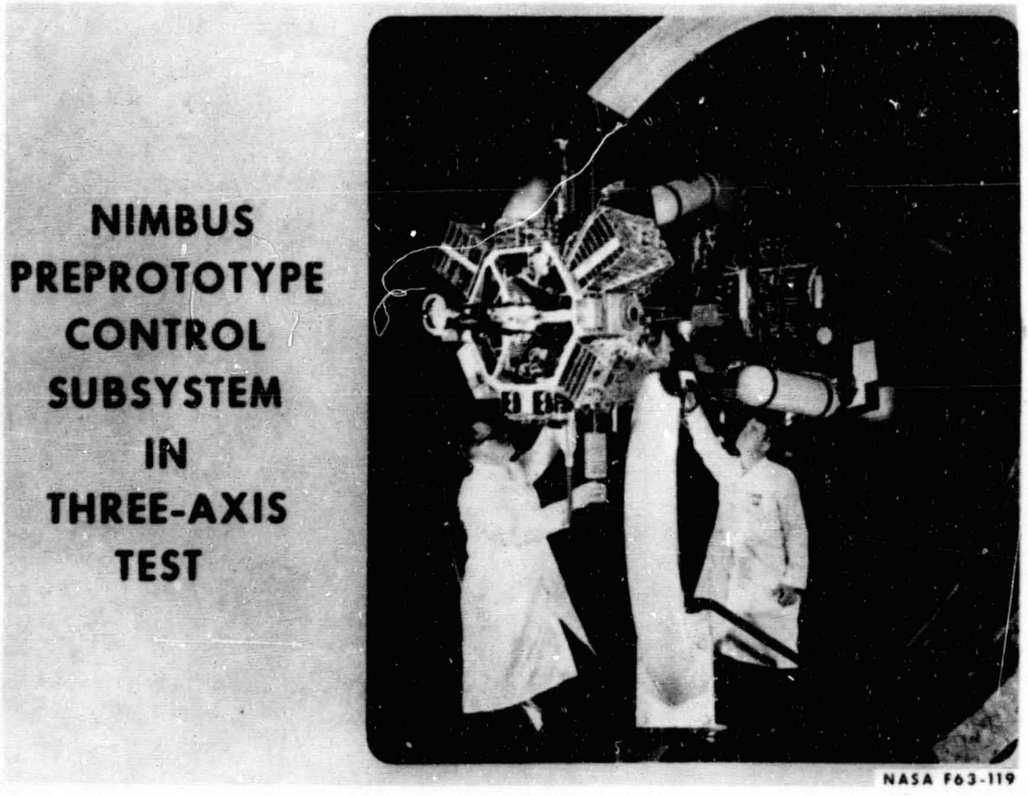

FIGURE 50

On the left of the spacecraft you see the components of the control system. It is a preprototype system and it is not included inside its normal configuration, it is outside in order to be readily accessible for improvements and corrections. But is has been flown on this air bearing many times, and successfully.

These tests were made using an air bearing at the center of gravity and under a wide variety of simulated earth and solar conditions, covering the full range required for operation.

5. Complete systems tests have been conducted using preprototype engineering models (fig. 51); that is, in addition to the individual component tests, the various elements of the preprototype systems were connected together and have operated as a complete system.

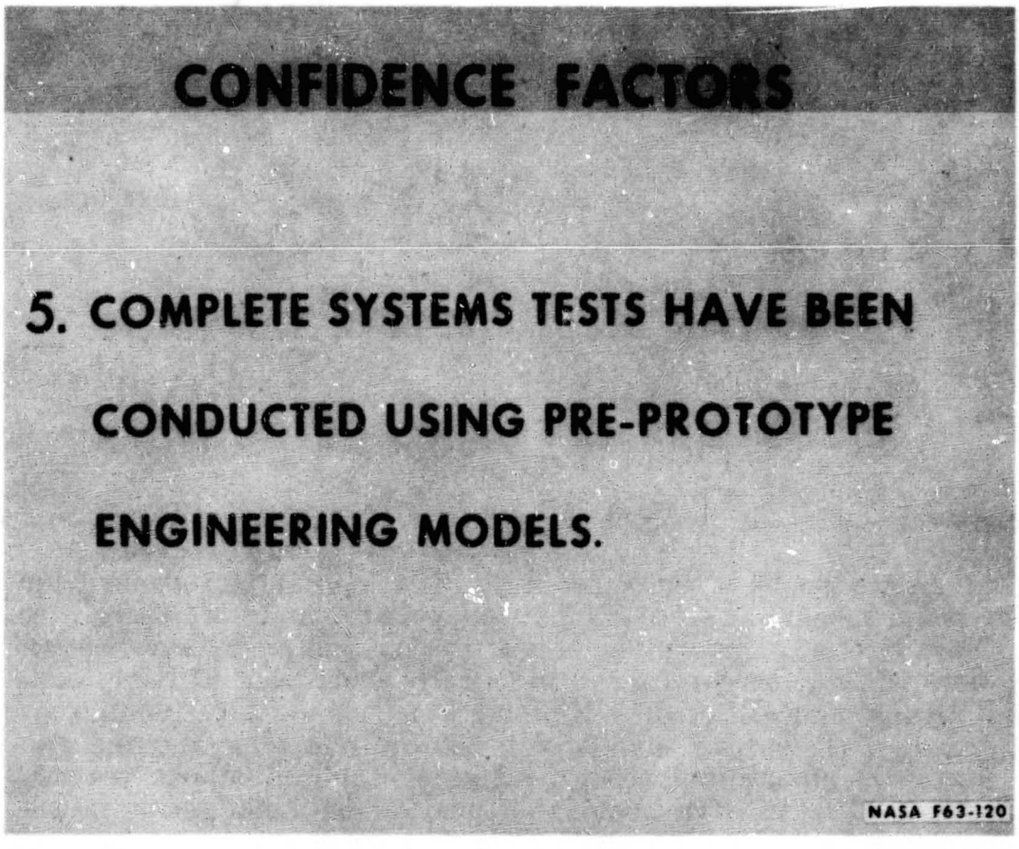

FIGURE 51

Thus, we know that the components not only work separately, but in assembled systems as well.

The data acquisition hardware development has also been moving forward. We have on this chart (fig. 52) a photograph of the Command and Data Acquisition Station in Fairbanks, Alaska. This is one of the large antennas which is being erected to collect data from the Nimbus satellite. Similar antennas to this will be erected for the operational meteorological satellite system.

This first antenna is intended to support NASA's research and development program both in meteorological and other scientific satellites. When the operational antennas are functioning they will

FIGURE 52

take over the job of the routine data acquisition for the operational program.

An agreement has been signed with the Canadian Government for the establishment of a similar antenna installation in the northern part of Nova Scotia. The combination of the Alaskan and Nova Scotian stations will give us coverage of practically every orbit of Nimbus, so that all the data collected by Nimbus, which should give 100-percent coverage of the earth's surface, will be acquired. One antenna also backs up the other antenna not in a 100-percent fashion, but to a sufficient extent to maintain reasonable service should one station fail.

SOUNDING ROCKETS

In meteorological systems we are also concerned with the development of sounding rockets for the exploration and measurement of the atmosphere in the region above 20 miles and below about 150 miles, accessible to neither satellites nor balloon-borne instruments. From the indications of recent research, this region serves as an important link between the variations in the solar radiation and their effect on the lower regions in terms of air motion and the surface weather.

Sounding rockets as applied to the region of 20–40 miles, although they are for the most part still experimental, have revealed the potential value of this atmospheric region to systematic study by means of a network of sounding stations.

We are consequently engaged in developing a meteorological rocket sounding system for this region. It is referred to as the small rocket sounding system because it is based on a smaller rocket. This system will involve developmental research in all components (motor, sensors, data acquisition, and data reduction).

The development requirements for the system are rather stringent. The motor must be reliable. It must be launched at a specified time under a variety of adverse weather conditions and its flight path must be reliably predicted; that is, have a small impact area.

There is also a flight safety aspect which may be achieved by some form of frangibility or self-destruction which will permit safe operation over inhabited or at least sparsely inhabited areas.

The wind sensor should accurately respond to the vertical variations of the wind rather than integrated response over a large vertical interval. The sensors of temperature, density and/or pressure should provide accurate and as direct as possible measurements of ambient atmospheric conditions with minimum reaction to outside influences.

To permit use in a network, the data acquisition component should be a self-sufficient unit independent of the present range support that is now required. The data reduction components of the system should permit rapid conversion of the telemetry records into the necessary meteorological units to allow quick dissemination of the data for analysis and utilization.

Some of the small rocket sounding techniques which are presently used at various range are shown on the chart (fig. 53). In this first

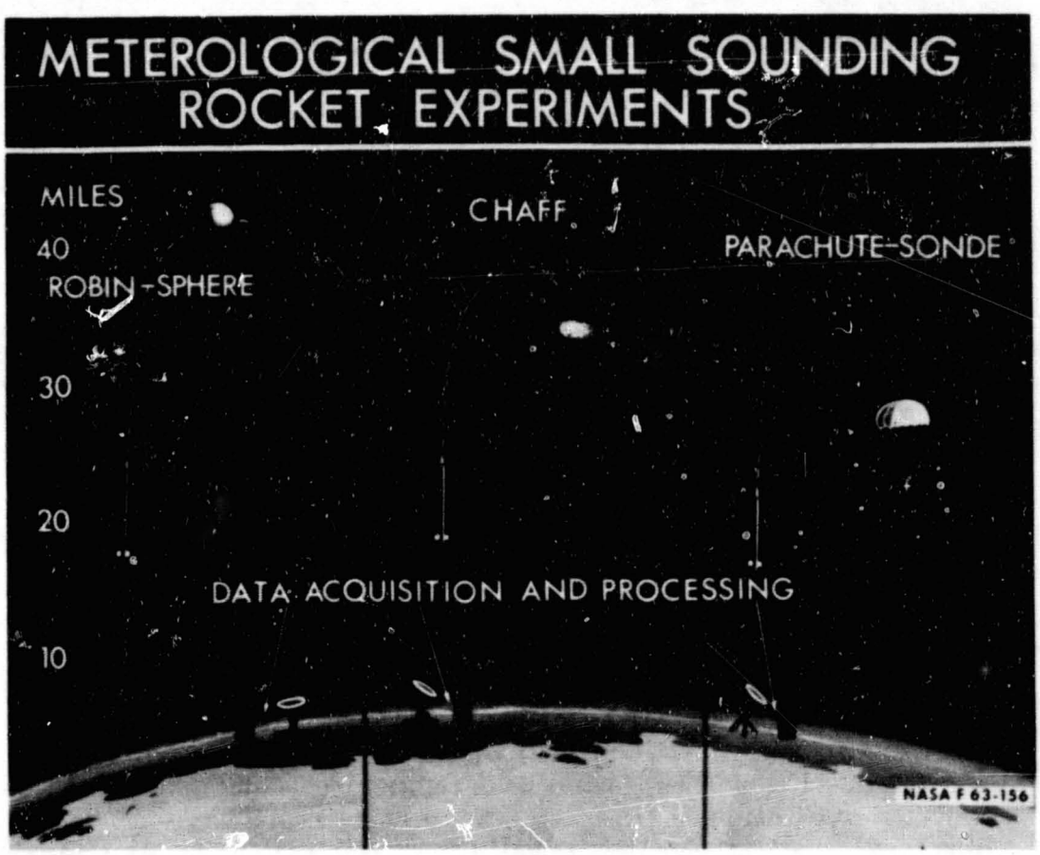

FIGURE 53

method the sphere's downward trajectory is tracked by radar and, from this track, the meteorologist can determine wind and density.

Another technique uses a chaff payload consisting of a million or more extremely thin rod shaped pieces of radar reflecting material. These, after ejection from the rocket at apogee, form a cloud of small reflecting particles which is tracked by radar as it descends providing a measurement of the wind.

The third technique employs a parachute and a temperature sensing instrument. As it descends, a temperature measurement is transmitted continuously to the ground and the radar track of the parachute provides the wind measurement.

Large sounding rocket systems are shown on the next chart (fig. 54). These techniques extend our knowledge of the atmosphere to altitudes

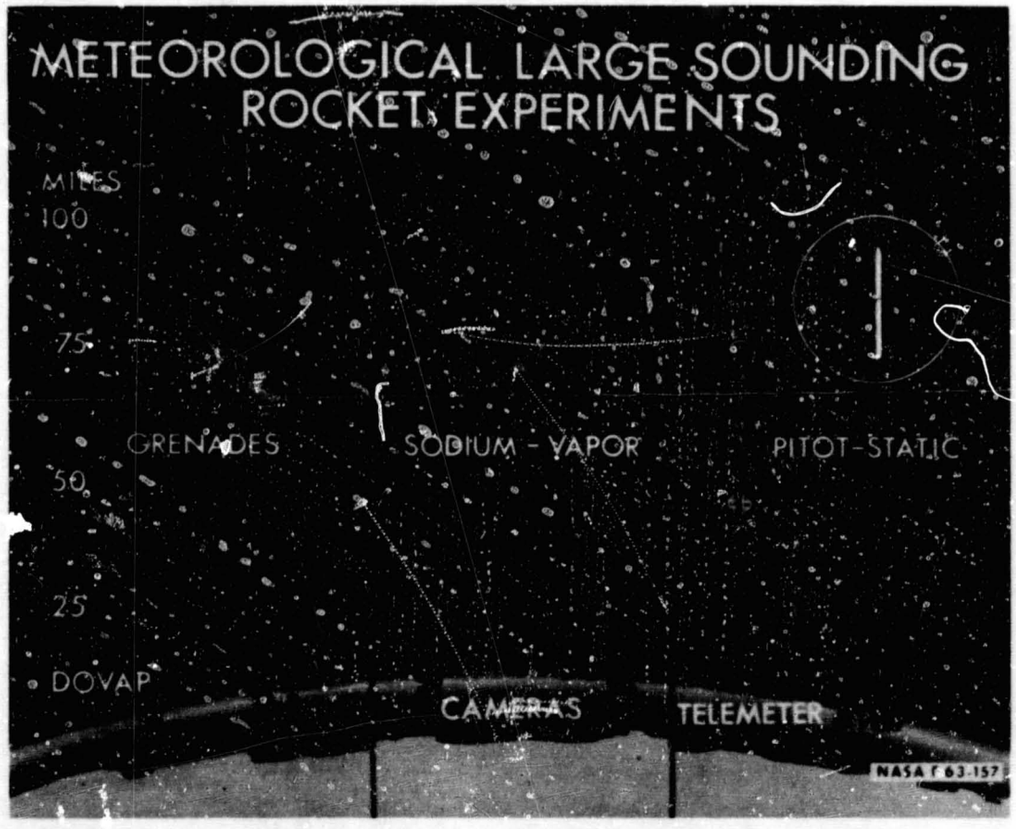

FIGURE 54

up to about 100 miles. The experiments are distributed throughout the seasons of the year and at several locations to sample the geographical and seasonal variations of the atmospheric structure.

In the first technique shown, a series of grenades are ejected and exploded at intervals along the trajectory of the rocket. The location of the grenade at time of explosion is determined by radar and/or optically, and the time of arrival of the sound wave is measured at the ground. From these, wind and temperature are determined as a function of altitude.

The next method releases a sodium vapor trail along the upper portion of the rocket's trajectory. Time lapse photographs of the

trail's deformation provide data for the computation of wind velocity.

The pitot static tube technique provides on-board measurements of pressure which are used to compute atmospheric density and wind. In this large sounding rocket area, Meteorological Systems works closely with the Office of Space Sciences since many of the experiments provide atmospheric measurements required by research and applications groups in both meteorology and aeronomy.

FLIGHT SCHEDULE

On this chart (fig. 55), we have the launch schedule for meteorological satellites. TIROS research and development flights are indicated on the first line.

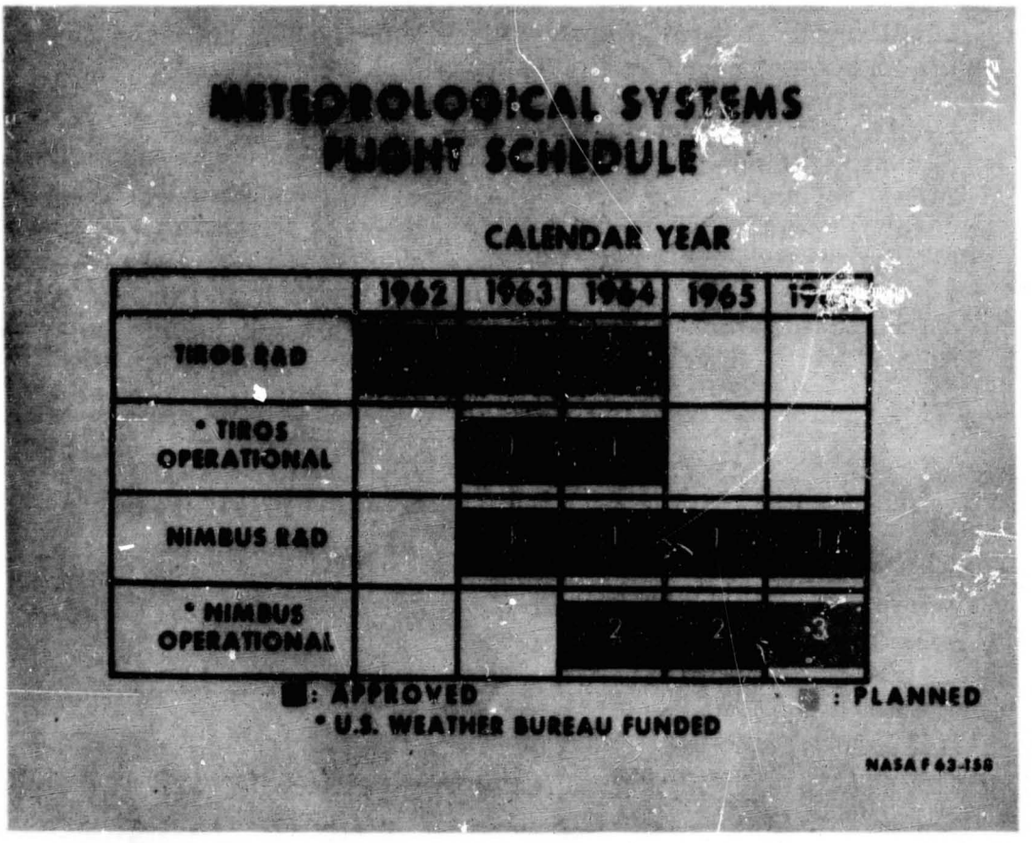

FIGURE 55

I have already spoken about these in detail. Briefly, they show that you have approximately three in 1963 and two next year.

The TIROS operational shows two satellites which are being funded by the Weather Bureau in order to more fully support operational requirements until the time Nimbus becomes available. Nimbus research and development flight operations should begin at the end of this year and continue into 1966 and beyond.

Nimbus operational satellites funded by the Weather Bureau and which are to back up the Nimbus research and development to make sure the Weather Bureau gets adequate coverage in the early phases of the Nimbus program, will be initiated in 1964; they will, of course,

also be continued after the initial research and development phase of Nimbus is completed.

You will notice in the lower right-hand corner, the coloring of the box is different because this is not approved as yet. The others are in the program.

In the large meteorological sounding rocket program, it is planned to fire approximately 45 per year. These will be distributed at various latitudes to measure the atmospheric structure in the various climmatic regions from the Arctic to the Tropics.

The small meteorological sounding rocket program is aimed at providing a standardized flight article which will meet the requirements at an overall minimum cost. Approximately 100 rockets will be launched per year in this program.

Mr. DAVIS. Can you give me an estimate of the cost per launch for large and small rockets, sounding rockets?

Dr. TEPPER. Approximately $10,000 for the large, and within the neighborhood of $1,500 to $2,000 per launch for the small.

Mr. DAVIS. Thank you, sir.

Dr. TEPPER. Supporting research and technology.

Accomplishments in supporting research and technology provide improvements for current projects and the technical foundation for future progress. In fulfilling the objectives of the S. R. & T. effort, many areas of activity are undertaken.

I have chosen three areas of supporting research and technology as illustrative of what is being done in support of our ongoing meteorological work (fig. 56). The first is our continuing effort toward a

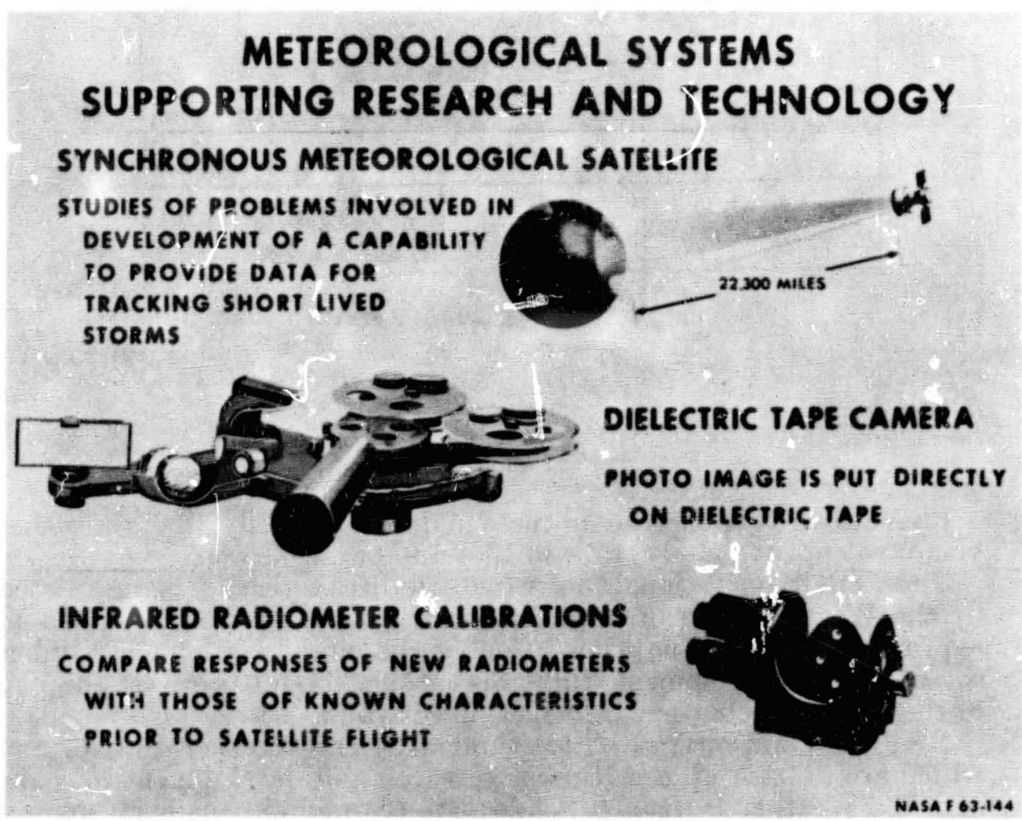

FIGURE 56

system capability for continuous monitoring of atmospheric events particularly for the tracking of short-lived storms.

During the current fiscal year, contract and in-house activities are being conducted to uncover and evaluate the problems associated with the subsystem developments required to provide this kind of a capability. In the next fiscal year, the results of these studies will be applied in the initiation of the development of pre-prototype hardware requiring long leadtimes.

I have noted here, as a second item, the dielectric (or electrostatic) tape system development. This is a devedopment which has been going on for some time on a laboratory basis and is now approaching what we call prototype status, that is the status where it is almost in shape to be flown but must first be subjected to rigid performance and environmental testing.

The dielectric tape camera is a technique whereby the image which is normally formed in the TV camera of our meteorological satellites is formed not on a fixed screen within a vacuum tube but on a piece of plastic tape which has been appropriately coated to be photoresponsive. As the lens forms the image on this tape which is pulled past the lens system much as a magnetic tape is pulled past the recording head in a conventional tape recorder the variations in light intensity are stored on the tape in the form of electrostatic charges. It is from this storage process that the device draws its alternate name—the electrostatic tape recorder.

With these charges on the tape we have in one operation recorded an optical image on a medium which adapts itself directly to an electrical playback. This is in contrast to conventional photographic——

Mr. DAVIS. Excuse me, Doctor. Is that the same thing that they ordinarily call video tape in the television industry?

Dr. TEPPER. No, it is not.

Mr. DAVIS. It is not the same.

Well, what is video tape? It is not a film, is it?

Dr. TEPPER. No, I don't think so. I believe the pictures are put, as signals, onto the tape, and then as the signals are played back they are converted back into a picture.

Mr. DAVIS. Oh.

Dr. TEPPER. These are electrostatic charges that are placed on the tape.

Mr. DAVIS. It is not a signal?

Dr. TEPPER. It is not a signal of that kind. This is in contrast to conventional photographic film which would have to be processed and then scanned with a photoelectric device, or to the TV camera unit where we would normally scan the TV image and store the electrical signals on a magnetic tape recorder which would then be read back.

In either of these, we would have used two cooperating systems to achieve the same objective that the dielectric tape can handle in one step. With the development of this system, we hope to be able to improve the performance of future meteorological satellites by reducing their complexity and weight, and by increasing the detail on cloud patterns that can be seen.

The third supporting research item indicated here is the work we carry on in calibrating and improving our infrared sensors. A good deal of information in the meteorological satellite program is col-

lected by infrared detector systems which record data such as the temperatures of the clouds and the ground cover as they come into view beneath the satellite.

A program of flying sensors on balloons, to get experimental data under field circumstances, is carried on.

There is also a laboratory program under which standards of infrared radiation are developed so that the sensors to be used in satellites may be carefully calibrated to verify the stability of their performance and their range of spectral sensitivity.

In this way each instrument that goes into a meteorological satellite has been checked to see that it will give the best in performance that the state of the art will permit.

For new sensor development, searches are being made in the electromagnetic spectrum for regions in that spectrum that are related to the physics of the atmosphere. For each of the significant radiation regions, suitable flight hardware has to be developed.

Finally, I would like to discuss the proposed Meteorolical Systems Development Laboratory or building.

We are proposing a building that will bring together personnel and activities related to the meteorological systems effort that I have just described. These people are now located in widely scattered locations in three buildings in the Washington area. Travel between the several buildings now being used creates difficulties in coordinating the research effort, and result in much lost time in traveling between the facilities. The work that will be accomplished in this building will include project management, research on planetary atmospheres, experiments in physics of atmospheric gases, and data evaluation based on known properties of the atmosphere.

In this building we will continue the execution of the responsibilities assigned to NASA. This work includes research and development, and administering the research and development of meteorological systems and systems components. Specifically, this will include work on the TIROS and Nimbus projects as well as work on other approved meteorological systems and our supporting research and technology program.

In-house research and development that will be done in this building will emphasize spacecraft and rocket applications. We plan to develop tools and techniques for the measurement of atmospheric elements with rockets and satellites.

Further developments of such tools as radiometers, spectrometers, and radiation dectors will also be accomplished. We will develop telemetry components peculiar to meteorological spacecraft, including analog-to-digital converters. Another series of developments will be devoted to special spacecraft mechanical instrumentation.

Advanced data storage systems, such as digital tape recorders, will feature improved reliability and life. Specifically this includes improvement in precision capstans, roller assemblies, tape guides, et cetera. Such work will also be applied to our video recorders for flight use.

Further, there will be development of mechanical and electrical components through the preprototype stage, for future systems. In-house studies will be made to determine what satellite data can be eliminated or compressed, or converted into different forms without

loss of significant information. Day-night television development will be included, since present systems are incapable of providing pictures both day and night.

Thus, the work to be accomplished in this building comprises much of our on-going efforts and in-house capabilities required to fulfill the NASA responsibility in meteorological systems.

Thank you, Mr. Chairman.

Mr. DAVIS. Thank you, sir. Dr. Tepper, if I may I would like to start at the end of your statement. And go backward a little bit.

We have from time to time during the hearings conducted by the subcommittee encountered the item of this laboratory. We have also learned that the Weather Bureau has a laboratory.

I would first like for you to state for the record such information as you may possess which would establish that there is no duplication between any Weather Bureau laboratory and the one which you describe in the final part of your statement.

Dr. TEPPER. I have described what we do in the program and our intent to bring together these activities into this one building.

The Weather Bureau laboratory is for the Weather Bureau purposes, to accomplish their responsibilities under the program.

And I find that the two laboratories, meaning buildings where research is conducted, are essentially required for the execution of the respective responsibilities. And so we have to get to a statement of what are the responsibilities of the two agencies.

The Weather Bureau responsibilities as have been indicated to this committee before are to provide for the operational program—requirements for the operational program and the types of meteorological observations that the program must produce.

There is research that must be conducted in connection with the development and execution of these responsibilities. This is done in the Weather Bureau laboratory.

The Weather Bureau also has responsibility of receiving this data from the operational system and using it for their operational purposes, that is for weather analysis and for forecasting. And there is research and development that is associated with this. For instance, how do you use this information?

Mr. DAVIS. You mean Weather Bureau research?

Dr. TEPPER. I am talking about the Weather Bureau first. So in these two areas of providing the requirements and providing a statement of what observations the satellite should produce for their use in weather analysis and forecasting, the Weather Bureau must do research and development. This is one area of research and development they do, and justifiably so. The other area concerns how they shall use this data for their execution of their analysis and forecasting functions. There is research and development that is involved here, too.

These are the types of activities, as I understand them, that the Weather Bureau conducts in its building in Suitland.

NASA, on the other hand, has the general responsibility as I indicated in my first slide, of developing systems—flight systems or spacecraft systems. And the entire operation of developing these types of flight hardware both for operational purposes and for research purposes, of receiving the requirements of the Weather Bureau and other

users and interpreting them in terms of flight hardware, and conducting the entire flight program and in getting the type of industrial support that is required and monitoring the support. All this is done by NASA and would be housed in the NASA Building.

So I see no duplication between the two activities. The two buildings are to house the people that will perform the functions of the two agencies in this program.

Mr. HECHLER. Mr. Chairman.

Mr. DAVIS. Yes, Mr. Hechler.

Mr. HECHLER. Dr. Tepper, have you discussed the Goddard Laboratory with the Weather Bureau?

Dr. TEPPER. Not in terms of a building. Our problem is that we now need another building because our people are located in three different places and we are going to ask Congress to give us a single place to house them.

Mr. HECHLER. No. I simply was interested in your mechanism of keeping the Weather Bureau informed, or interchanging information in areas of mutual interest.

Dr. TEPPER. Yes. We definitely make it a point to exchange information and to provide the Weather Bureau with information of mutual interest. There is no question about that.

Mr. HECHLER. I mean on this specific point.

Dr. TEPPER. The operations that we are involved in these buildings are the subject of discussion all the time.

The fact that we are asking Congress for one building to be located in Greenbelt as opposed to a location in three different places we did not think would be the type of discussions that are necessary to be carried out between two agencies.

Mr. WYDLER. Mr. Chairman.

Mr. DAVIS. Yes, Mr. Wydler.

Mr. WYDLER. In other words, if I understand, the new building is merely a building. It doesn't change your operations whatsoever, is that correct?

Dr. TEPPER. It does not change our program responsibilities at all, no, sir.

Mr. WYDLER. And you are not going to do anything in the new building that you weren't doing in the old buildings?

Dr. TEPPER. We will not do anything in the new building that the program doesn't call for. Our program is developing and there are new things in connection with the Nimbus flight, for example.

Nimbus hasn't flown as yet and when Nimbus does fly we would normally be doing other things in this building that we are not doing now simply because Nimbus hasn't flown.

Mr. WYDLER. You don't plan to do——

Dr. TEPPER. Oh, yes.

Mr. WYDLER. Anything in the new building that you weren't doing in the old buildings, is that right?

Dr. TEPPER. We do not plan to do anything in the new building that we would not be doing in the other places.

Mr. DAVIS. Put it this way, Dr. Tepper. If you don't get a new building you will still do the same thing but have to do it somewhere else?

Dr. TEPPER. That is right. We will have to do it in three different places and the people will have to travel 10 miles rather than across

the hall in order to get their coordination done and we think it is good management to get all the people in one place and eliminate this continual communications difficulty and impediment that is in their way right now. And with the flight of Nimbus, this coordination and communication difficulty will be even more of an impediment.

Mr. DAVIS. Then the construction of this building doesn't indicate at all that there is any new activity being initiated by NASA in the field of meteorological research?

Dr. TEPPER. Absolutely, that is right, sir.

Mr. HECHLER. By our questions we don't want to indicate that we want to stop progress today with the construction of the building.

Mr. ROUSH. Mr. Chairman.

Mr. DAVIS. Mr. Roush.

Mr. ROUSH. Mr. Chairman, the chairman can speak for himself on that matter.

How far apart are the three buildings now?

Dr. TEPPER. I think they are approximately 10 miles apart.

Mr. ROUSH. You mean in a triangle?

Dr. TEPPER. Something like that, yes. One is in Hyattsville, one is in Silver Spring, and the other one is in Greenbelt.

Mr. ROUSH. Well, I cant quite understand why there has to be so much traffic between the three buildings.

Dr. TEPPER. Well, this is a single organization. It's the Aeronomy and Meteorology Division of Goddard. The people in the organization are administratively responsible one to another. And the people can't be in all three places at the same time.

The people that are working in one place have to refer to activities of people working in another place. And it is for that very reason, of getting them closer together, that we are asking for this building, so that they can have more direct and personal communication, which is very much required.

For example, the Nimbus project is located in the Colemont Building in Silver Spring. They are essentially program managers and contract monitors of the effort that is going on. From time to time they need to have guidance and technical support from the support elements that are located in another part of the same organization, which is in Greenbelt, and this requires either a telephone call with all the difficulties associated with explaining things over the telephone——

Mr. ROUSH. How many people are involved in this operation?

Dr. SEAMANS. Can I take that?

Dr. TEPPER. Yes.

Dr. SEAMANS. I wonder if I could just speak to this point, Mr. Chairman.

First I would like to explain that the Goddard Space Flight Center has grown appreciably. For fiscal years 1962 and 1963, our budget projections were 2,400 and 3,200, respectively. Our request for 1964 will take us up to 3,700. That is the total Goddard complement.

It is our objective to provide facilities, including housing, for these people in one location out at Greenbelt. We feel this is far and away the most efficient operation. We are renting space as we build up in size, just because of the very normal factor that housing tends to lag behind the actual manpower buildup.

As far as the meteorological program is concerned, we had 430 people at the end of 1962, 243 projected for the end of 1963, and 319 people projected for the end of 1964.

Mr. ROUSH. Pardon me. Are you referring now to the people who are presently located in the three separate locations?

Dr. SEAMANS. This is the total number of people at Goddard engaged in the meteorological program, including overhead people.

Mr. DAVIS. That includes the other two sites, too, Colemont and Greenbelt?

Dr. SEAMANS. That includes all three sites. In addition there are some administrative people who are included also at Greenbelt.

So in the course of building up the Goddard capability, we are attempting to bring together in logical segments individuals who are concerned with the same type activity.

If you review the total Goddard plans, you will see that there is also a group for meteorology, one for space science, and another one for tracking and data acquisition, and so forth.

This is all part of an overall plan to be able to better coordinate the activities at Goddard.

Mr. ROUSH. I don't mean to be overly critical, Mr. Seamans.

I feel that it is best that we be critical here rather than on the floor of the House. When we come to the floor of the House with a bill, I would like to be in a position to go all out in defense of that bill.

I assume that you have examined possibly the possibility of present buildings, other Government buildings, that might house all three of these present segments of the present operations? Have you done that?

Dr. SEAMANS. Well, as you probably remember, we did use space at the Naval Research Laboratory for a period of time when the Goddard activity was starting.

This is not a way to manage a program of this type effectively. In the long run it is essential that the individuals in each center be colocated, except for those people who have field responsibilities and must be located elsewhere.

Mr. WYDLER. Mr. Chairman.

Mr. DAVIS. Mr. Wydler.

Mr. WYDLER. How close is Goddard to the location of the meteorological laboratory?

Dr. TEPPER. Well, one is at Greenbelt and the other is in Suitland, Md. I would say 15 miles. I think it is separated by about 15 miles.

Mr. WYDLER. Are they going to be brought any closer together by this new laboratory at Goddard?

Mr. DAVIS. Now, you used the word "meteorological" there. I think Goddard calls their meteorological laboratory the same as the Weather Bureau laboratory.

Mr. WYDLER. I am talking about the Weather Bureau laboratory. You understand which one I am speaking of?

Dr. TEPPER. Yes. Is your question, would they be closer together physically?

Mr. WYDLER. Yes.

Dr. TEPPER. I think Silver Spring is about that distance from Suitland and so is Hyattsville. I would say that the difference isn't appreciable.

Mr. WYDLER. Let me ask you this. I would like to ask this of Dr. Seamans. In this case, Doctor, you want to bring, as I understand it, the various components of this meteorological laboratories together at one place at Goddard; is that right?

Dr. SEAMANS. That is correct.

Mr. WYDLER. How is that consistent with the idea, for instance, in electronic research to put the laboratory up in Boston and not at Goddard as well?

Dr. SEAMANS. Well, this is another whole area, of course, of activity.

The responsibility of Goddard involves not only the meteorological program but the communication program and much of our space science program.

On the other hand, the activities projected for the electronic research center are concerned with a particular technology and are not directly concerned with the kind of project activity that are now going on or planned for Goddard.

Mr. WYDLER. Well, it seems to me that in one case you are saying that it serves your purposes better to bring everything together and centralize it at Goddard, and in the other case you are saying that you want to take the research development on electronics, though, and place that up in some other particular area that serves the purposes better. And I am trying to understand what the distinction is between those two things.

Dr. SEAMANS. The responsibilities at Goddard do include development of electronic components, that is right. While under development, it is planned to manage this activity out of the Goddard Space Flight Center.

The work projected for Boston will be research oriented. It will involve basic work, for example, on components, and work that is not going on at Goddard. However, the research work projected for Boston would have an output that would be utilized not only by Goddard but also by our other space flight centers—centers at Huntsville and Houston, JPL, and so forth. But it is a very major segment of activity which we believe should be brought together in one place, an activity that could grow to something like 2,000 people.

Mr. WYDLER. Why isn't that place Goddard?

Dr. SEAMANS. Well, that is a possibility that was considered, namely the possibility of significantly adding to one of our existing centers. We could have added 2,000 people to Goddard or Langley or one of our others centers.

In so doing, however, we are actually establishing side by side two centers. We increase the management problems at one center.

Mr. WYDLER. But in this case you are going to take the three laboratories and combine them?

Dr. SEAMANS. That is right. These are activities that are now located within 10 or 15 miles one of the other. This is part of a plan which we have always had, namely to bring together at Greenbelt all of the people who are important to Dr. Goett, who is the director.

Mr. WYDLER. Mr. Chairman, I have a different question.

Mr. DAVIS. Yes.

Mr. WYDLER. I listened to your discussion of your saying what the distinction between what the Weather Bureau function is and what yours is, if I understood it, then, and under the definition you gave,

who should do the research and development of radiation sensors and techniques?

Dr. TEPPER. The radiation sensors and techniques that are involved or to be included in a spacecraft and how they fit into the spacecraft and what their interface is with the spacecraft itself and what the telemetry measurements are when they come back from space, that is how you interpret them in terms of physical variables—this is NASA's responsibility. The scientific study of the physics of the atmosphere in terms of its radiation properties and laboratory experiments that might suggest suitable sensors and work with sensors that might produce information on the behavior of the atmosphere could be done by the Weather Bureau.

Mr. WYDLER. Could be or should be?

Dr. TEPPER. Oh, it should be done by any research meteorologist who is interested in this problem.

Dr. SEAMANS. It is the responsibility of the Weather Bureau.

Mr. WYDLER. Well, now, let me ask you, Doctor, frankly, is it practical for you to separate research out in development of sensors, on the method you just described to me?

Dr. TEPPER. Yes.

Mr. WYDLER. Can you do one of those without doing the other?

Dr. TEPPER. Oh, definitely. It is absolutely essential that it be separated because the two problems are entirely different. May I give a specific illustration as to what is actually happening?

Mr. WYDLER. Yes.

Dr. TEPPER. The problem of measuring the vertical distribution of temperature in the atmosphere, is a very important one and it is a definite requirement. It has been suggested by Dr. Kaplan that a certain technique might do this, by using a spectrometer that measures radiation in the 15 micron band.

This was suggested by theory. Now, the Weather Bureau for the past 2 years or more, and I might say initially funded by NASA to do this 3 years ago, has been studying the problems that are associated with this theory. They have developed a spectrometer in their laboratory. It sits on the desk and it has electronics associated with it. They have been viewing the atmosphere with this spectrometer. They have been working with it and trying to develop the principles of how this type of spectrometer can provide useful information.

They have now reached a point at which we feel we should now proceed to flight hardware. Now, this becomes a new area entirely in R. & D. The configuration of this spectrometer will probably have to change.

Its structure might have to change. The material that it is made out of might have to change.

The entire electronic system associated with the telemetry system may have to change, simply because you are now putting it into a different environment than the laboratory. These are the two areas. One is the laboratory experiment in terms of what it can produce and the other one is adapting this type of instrument into a spacecraft environment. These must be separated. There are two different types of people that are involved here.

Mr. WYDLER. In other words, if I understand you, then, the research that the Weather Bureau does is strictly on the theory of trying to get

some sort of return, regardless of the practicality of getting this up into the air, is that right?

Dr. TEPPER. That is right.

Mr. DAVIS. Well, may I see if this is not true.

Your answer converted to still simpler terms is that the Weather Bureau might, for example, put together a perfectly satisfactory camera that would produce a picture which was all they needed in the way of a picture, but you, in examining that camera to see whether or not you could use it on a satellite, might find that it could not withstand the vibration of a launch and it might tear all to pieces and if it withstood that it couldn't withstand the very low temperatures of outer space, where the lens might fall apart, and all of those tests might require the camera to be completely redesigned and made out of different material and it might not look at all like the original camera you got from the Weather Bureau, is that right?

Dr. TEPPER. That is absolutely right.

Mr. WYDLER. Then, I am really a little bit confused because I can't understand how the Weather Bureau can spend a lot of time and money and effort to develop items which are going to be impractical when you try to put them in a spacecraft. That is what they are developing them for in the first place. And that is the reason I asked the question: Don't you have to do this research as a unit? How can you separate it into distinct parts like that and make any sense out of the program?

Dr. TEPPER. Well, it isn't the way that you have just described it, Mr. Wydler.

Mr. WYDLER. All right, then, how is it?

Dr. TEPPER. There is a logical separation between the theory of measurement as to what types of things will measure what in the atmosphere. And this is one R. & D. effort. And the other is—how do you convert this into flight hardware?

Mr. WYDLER. I understand that. I mean they may have an idea that if they could have a 5-ton object it might be the best thing that they could use to measure the weather on the earth.

Dr. TEPPER. That is right.

Mr. WYDLER. This may be so. But they have to take into account the fact they can't get that up into the air, at least under present conditions.

(Dr. Tepper nods.)

Mr. WYDLER. I don't see how they can operate at all unless they are working with the idea from the first place that they are going to use this in space.

Dr. TEPPER. Well, I can assure you that the closeness of the working level people precludes their working on something that is totally impractical. Whatever they are doing, they are working not only with our knowledge but—in this spectrometer instance, for example, we are delighted with the work that they are doing to develop the principles of the spectrometer in this spectual range. And although the instrument that they have in the laboratory of the Weather Bureau right now is not suitable for flight, we feel relatively confident that we will be able to convert it to a flight article.

Mr. HECHLER. Doesn't this boil down to a question of coordination and exchange of information? It doesn't necessarily have to be the same unit. But this committee has been disturbed a little in the past

that there seems to be not a very active exchange of information and coordination between NASA and the Weather Bureau.

Dr. TEPPER. I wish I knew how to allay your fears in this regard, because I feel that this is a very, very closely coordinated group, or groups of activity.

Mr. DAVIS. Would it not be pertinent to mention that you, yourself, were with the Weather Bureau for a number of years? And probably that entered into the fact that you were considered for your present position with NASA, the fact that you did have such a knowledge of the workings of the Weather Bureau.

Dr. TEPPER. Well, I would hope it was broader than that.

Mr. DAVIS. How long were you with the Weather Bureau, Dr. Tepper?

Dr. TEPPER. About 13 years.

Mr. DAVIS. And what was your position with the Weather Bureau?

Dr. TEPPER. I was in charge of a research unit in the central office involved with study of severe local storms.

Mr. DAVIS. And then how long have you now been with NASA?

Dr. TEPPER. Approximately 4 years, a little over 4 years.

Mr. BOONE. Mr. Chairman, if I may——

Mr. DAVIS. All right, Mr. Boone.

Mr. BOONE. Dr. Tepper, maybe you could tell the committee just what organization that you have to be sure that the meteorological research that you are doing contributes to the Weather Bureau's responsibility of giving out data that is useable to all of its users?

Dr. TEPPER. I would be delighted to, yes.

Mr. BOONE. What methods do you have for coordination, which I think is most important?

Dr. TEPPER. We have tried to establish areas of contact and coordination at all possible levels between the two organizations, starting from the very working level on project areas.

As we have mentioned before, the Nimbus project is divided into four areas: Spacecraft, launch vehicle, data acquisition, and data utilization.

The day that the Nimbus project was instituted we requested the Weather Bureau to name a man to the data utilization job as a subsystem manager and he has been the data subsystem manager since that time.

Mr. BOONE. If I may interrupt. I think you have gone through that with the project activity. How about the meteorological research, which seems to be the gray area?

The meteorological research as I understand it is a function of the Weather Bureau.

Now—for example, sounding rockets. Are you coordinating your sounding rocket investigations with the Weather Bureau?

Dr. TEPPER. Yes, sir.

Mr. BOONE. And does this meet a need of the Weather Bureau to determine certain data?

Dr. TEPPER. Well, I will speak to the case that you spoke of, of the sounding rockets.

It was a little over a year ago that the coordinating committee of NASA and the DOD, the AACB (Aeronautics and Astronautics Coordinating Board) looked into this problem of the sounding rockets

for this country, and asked a study group to come up with a recommendation as to what should be done in this area.

I was on this subgroup. And our recommendation was that the Weather Bureau should be requested to undertake the responsibility of establishing a network of rocket stations in order to provide information of the atmosphere above radiosonde level. And to do this we suggested the organization of a joint working committee chaired by the Weather Bureau, with membership of NASA and DOD and DOD departments. This is the Joint Meteorological Rocket Network Steering Committee. The function of this steering committee is to proceed with national requirements for a network of stations that would provide the meteorologist with information above 100,000 feet which is the current upper ceiling of the radiosonde.

Our activity in the rocket program of developing a workable operational system is parallel to our operation in the satellite program. We are trying to develop a system which can be used in this operational network by the Weather Bureau in getting data that it wants. And the Weather Bureau is fully aware of our activity in this regard.

Mr. BOONE. So through similar organizations you know that your research work is responsive to their needs, is that correct?

Dr. TEPPER. Yes, sir.

Mr. BOONE. That is all, Mr. Chairman.

Mr. DAVIS. Dr. Tepper, just before we leave for the morning the subject of the Laboratory, I would like just by way of discussion to look into a few comparative costs.

As I recall it, the first TIROS cost about $15 million to launch, did it not?

Dr. TEPPER. I believe that we had spent about that much money by the time the first TIROS was launched, that is about right, yes, sir.

Mr. DAVIS. And then by the time of the second one, there was about $9 million that could be charged to it?

Dr. TEPPER. I don't recall the specific numbers.

Mr. DAVIS. At any rate, the present TIROS cost is about $3.7 million, isn't it?

Dr. TEPPER. Completely launched—well, let's see, $1.2, $2.5, plus—oh, just the launch, without the operations, and without acquiring data, that is approximately right, sir.

Mr. DAVIS. Almost $4 million?

Dr. TEPPER. That is right.

Mr. DAVIS. And the price of this building in which you would like to consolidate all your laboratory effort then is only slightly more than one TIROS launch.

Dr. TEPPER. The numbers would indicate that, yes, sir.

Mr. DAVIS. I am reminded of an instance in last year's budget in which the committee spent more time talking about the price of a parking lot at one of the Goddard buildings than they did the satellite program. And I think probably one of the reasons for that is that every Member of Congress can quite easily visualize a parking lot, but we have a little trouble visualizing some of the other things that cost so much money.

Mr. Boone, I wonder if you could ask Dr. Tepper a few questions about this summary here.

Mr. BOONE. All right, sir.

Dr. Tepper, do you have a listing of reprograming actions within your meteorological satellite apportionment of last year?

Dr. TEPPER. Well, I can talk to that, if you desire.

Mr. BOONE. Please do.

Dr. TEPPER. Well, within the reprograming area for last year, I think the main activity that we undertook during fiscal year 1963 was the addition of more TIROS; three additional ones and a backup and the associated launch vehicles.

The rest of the flight program was practically identical with the way we had planned for it. And our people in Goddard point with pride to the fact that the Nimbus program almost came out to the nickel.

So I think that—this TIROS reprograming represents the main thing.

Also we deferred any activity on the synchronous meteorological satellite in the hardware sense during the past fiscal year.

So these are the two major program areas that were involved in reprograming.

Mr. HECHLER. Excuse me. How much more did the additional TIROS launches cost? How much more reprograming?

Dr. TEPPER. I think it was about $13 million.

Mr. BOONE. There were how many more additional? Two additional TIROS?

Dr. TEPPER. There were three additional and the backup, plus launch vehicles.

Mr. BOONE. Three.

Mr. WYDLER. Do I understand that to be $13 million in addition to the $21,200,000 shown in the volume, the volume of supplemental data for fiscal 1964?

Mr. HECHLER. Page 19.

Mr. BOONE. I think the number in 1963 was something like $3 million, and you upped it $18 million to take care of these three additional shots?

Dr. SEAMANS. I believe that is correct.

Dr. TEPPER. I think that is correct.

Mr. WYDLER. It includes the reprograming?

Dr. TEPPER. It includes the reprograming.

Mr. RYAN. May I ask a question, Mr. Chairman?

Mr. DAVIS. Mr. Ryan.

Mr. RYAN. From what source did the $18 million come, what part? Where did you make your shift?

Dr. SEAMANS. This is a matter that came up yesterday and I referred back to the discussion we had several weeks ago with the full committee, where I discussed the total reprograming action within NASA.

It is not possible to identify where the dollars come from for a particular project. You have to look at the total NASA program and see how each program has changed from the original 1963 submission to the actual allocation of the funds within NASA. In this case we have gone from approximately $3 million to about $21 million.

In other words, we have increased TIROS by about $18 million. We can't say that this came from any particular project, because that is not the way we keep track of our funds.

Mr. RYAN. No. But in order to allocate $18 million to TIROS, something else had to suffer that was in your estimate last year.

Dr. SEAMANS. That is right. We discussed——

Mr. RYAN. You can't point to any particular program that suffered as a result, in which you made a change in order to move $18 million to TIROS?

Dr. SEAMANS. Well, this is the discussion that we had several weeks ago.

Mr. RYAN. That is right.

Dr. SEAMANS. Of course, one of the major areas was the Nova program, where we had of the order of several hundred million dollars in our budget request, and these funds were not subsequently allocated for development of the Nova vehicle.

Mr. BOONE. Dr. Seamans, there appears to be a $12 million internal reprograming in the meteorological area, and I think you only required $6 million from outside the meteorological area, if my adding of the numbers is correct here.

Dr. SEAMANS. I believe that is correct.

You can compare the 1963 request and then the actual figures that are contained in this present budget estimate.

Mr. BOONE. Right. I think the basis of the question is: Is there that much reprograming leeway in the 1964 request?

Dr. SEAMANS. We don't think——

Mr. BOONE. If you had to go through $12 million in the 1964 program, where would it come from?

Dr. SEAMANS. Well, I don't know of any area where the money could come from. There are bound to be changes in the total program as we proceed. My expectation is that the changes will be considerably less in fiscal 1964 than they were in 1963, because the largest single area involves manned space flight and we have in the course of the last 12 months defined the mission mode for the lunar project. This was the one area that gave us far and away the largest amount of reprograming activity.

Mr. RYAN. Mr. Chairman, on this point.

Mr. DAVIS. Yes.

Mr. RYAN. If it is a fact that $12 of the $18 million was reprogramed within your program, Dr. Tepper, can you identify that $12 million?

I understand from Dr. Seamans that the six could not be identified because it may have come from Nova or some other part of the whole NASA program. But can you say what shifts were made in your program within the meteorological section?

Dr. TEPPER. The information that I have here indicates that the primary drops were in the Supporting Research and Technology field, where we did not proceed with hardware development for the synchronous meteorological satellite, and this is about, almost $5 million in that area.

Mr. HECHLER. Did you take anything from Nimbus?

Dr. TEPPER. No, sir; nothing significant. It is less than a million dollars.

Mr. BOONE. Is that what you called advanced meteorological system component development in this year's budget? On page 18.

Last year's submission and this year's submission were considerably different. It is a little bit difficult to relate the two when you start adding numbers.

Mr. RYAN. Double or more.

Dr. TEPPER. The synchronous meteorological satellite is broken out specifically, as synchronous meteorological satellite under supporting research and technology this year.

Mr. RYAN. You are only spending $850,000 on that, is that right?

Dr. TEPPER. We are asking for $950,000 in 1964.

Mr. RYAN. Then this other work would be done regardless of whether you went ahead with AEROS or not—advanced meteorological sensor development, advanced meteorological systems components development?

Dr. TEPPER. Yes.

Mr. RYAN. I see.

In addition to your funds now, how much Weather Bureau money did you have transferred to you last year?

Dr. TEPPER. I will have to get this.

Mr. RYAN. If you have the record, can you give it for both Nimbus and TIROS?

Dr. TEPPER. Yes.

Regarding the fiscal year 1963 figures for TIROS—we don't have this money yet. These are the funds that we are discussing with the Weather Bureau with regard to a reimbursable order.

Mr. RYAN. Must you have this money before you obligate it?

Dr. TEPPER. Yes.

Mr. RYAN. OK. So there are 1963 moneys that you have not obligated that you anticipate.

Dr. TEPPER. Yes.

Mr. RYAN. For both TIROS and Nimbus?

Dr. TEPPER. That is right, sir.

Mr. RYAN. And how much of these?

Dr. TEPPER. Under TIROS, they are $9.2 million, and under Nimbus they are $3,080,000 in fiscal year 1963.

We are still carrying over from fiscal year 1962, a portion of the $45,670,000, which has been given to us on a reimbursable work order.

Mr. RYAN. And you can submit for the record a breakdown of those obligations?

Dr. TEPPER. Yes, sir.

Mr. RYAN. Now how about for 1964?

Dr. TEPPER. For 1964, the requirements that we have discussed with the Weather Bureau for a reimbursable work order would be $41,800,000.

Mr. RYAN. And you can submit for the record a breakdown of that?

Dr. TEPPER. Yes, sir.

Mr. RYAN. Before we leave this subject—if I might, Mr. Chairman.

Mr. DAVIS. Yes, Mr. Ryan.

Mr. RYAN. If I might develop something on this area.

Could we have an explanation as to what formula you used to determine the reimbursement from the Weather Bureau to NASA?

Dr. TEPPER. Yes, I will be——

Mr. RYAN. What are you asking the Weather Bureau to reimburse you for? Let's take—was it only in TIROS and Nimbus that you had reimbursement or expenses?

Dr. TEPPER. The reimbursements to date have been defined by an agreement between the two organizations——

Mr. RYAN. Is this a written agreement?

Dr. TEPPER. Yes, sir.

Mr. RYAN. Do you have a copy of it that is available?

Dr. TEPPER. We can submit it for the record.

(The information is as follows:)

JANUARY 1962.

AGREEMENT BETWEEN NATIONAL AERONAUTICS AND SPACE ADMINISTRATION AND DEPARTMENT OF COMMERCE-U.S. WEATHER BUREAU CONCERNING IMPLEMENTATION OF NIMBUS OPERATIONAL SYSTEM (NOS)

The supplemental appropriations act, 1962, provides the first increment of funds to the Department of Commerce-U.S. Weather Bureau for the joint NASA–USWB implementation of the first phase of a national operational meteorological satellite system.

This phase is to be designated as the Nimbus operational system (NOS), and will correspond to the time period coincident with the NASA Nimbus R. & D. program, and thus is expected to extend approximately through 1965.

It is the purpose of this joint agreement to set forth the functional responsibilities and operating procedures under which NASA and USWB will conduct their respective parts of the NOS program.

A. RESPONSIBILITIES

The functional responsibilities of the USWB and the NASA under NOS will be as follows:

1. U.S. Weather Bureau:
   (*a*) Determination of the overall meteorological requirements;
   (*b*) Specification of quantities to be measured by the satellite meteorological instruments;
   (*c*) Processing of data for operational meteorological purposes;
   (*d*) Integration of data into weather analyses;
   (*e*) Use of data and analyses for forecasts;
   (*f*) Dissemination of data, analyses, and forecasts;
   (*g*) Archives (processing, storage, retrieval);
   (*h*) Research and climatological use of data.
2. National Aeronautics and Space Administration:
   (*a*) Design, fabrication, and test of the spacecraft;
   (*b*) Procurement of the lanuch vehicle;
   (*c*) Maintenance of launch sites;
   (*d*) Construction of command and data acquisition stations;
   (*e*) Prelaunch preparation of spacecraft and vehicle;
   (*f*) Launch operations, including scheduling;
   (*g*) Tracking and orbit determination;
   (*h*) Programing and command to satellite;
   (*i*) Data recovery at command and data designation stations;
   (*j*) Communication of data to meteorological satellite activities organization.

B. EXECUTION OF THE NOS PROJECT

NASA has assigned the responsibility for the execution of its part of the NOS program to the Goddard Space Flight Center, Greenbelt, Md., which will conduct the effort in conjunction with its research and development project for Nimbus. The Goddard Space Flight Center will manage, direct, and coordinate its efforts through and by the Nimbus Project Office of the Aeronomy and Meteorology Division. The USWB shall assign one of its staff to the Nimbus Project Office as data utilization systems manager.

The USWB has assigned the responsibility for the execution of its part of the NOS program to the meteorological satellite activities organization.

C. FUNDING

Funds required for the implementation of NASA responsibilities under this program will be made available by the USWB to NASA on a reimbursable order in accordance with the financial operating plan attached hereto and any amendments subsequently approved by NASA and the USWB. NASA will apply these funds in accordance with the provisions stated in said plan and more specifically in the Nimbus operational system project development plan. Accountability and reporting will be in accordance with the provisions of the NOS project funding agreement attached hereto.

D. BUDGET PREPARATION

Budget preparation, submission, and justification shall be conducted in a coordinated manner. Based on the meteorological requirements and any financial constraints stated by the USWB, NASA, and the USWB will each year jointly agree on a single set of program assumptions. NASA then, on the basis of these agreed assumptions, will prepare and provide to the USWB an estimate of funds required for the execution of its responsibilities under this agreement. Such information shall be provided in the degree of detail, including necessary narrative and explanatory material, in which the USWB is required to submit its budget requests to the Bureau of the Budget and the Congress. Incompatibilities between requirements and financial constraints will be resolved by discussion and mutual agreement. While the primary responsibility for the further submission and defense of the NOS budget will be that of the USWB, NASA will, if requested, assist the USWB in defending, before the Bureau of the Budget and the Congress, those budget items pertinent to its areas of responsibility as defined in this agreement.

E. AMENDMENTS

This agreement shall be subject to amendment at any time by the mutual agreement of both parties. Addenda may be added to cover areas not adequately covered in this basic agreement.

F. RELEASE OF PUBLIC INFORMATION

Release of public information shall be in accordance with the policy guidance agreement executed by the USWB and NASA on October 20, 1961, including any amendments thereto.

G. RESOLUTION OF QUESTIONS

USWB and NASA will exercise regular coordination and review of the project by means of a Nimbus Steering Committee composed of the following two members:

Chief, Aeronomy and Meteorology Division, GSFC.
Deputy Director of Meteorological Satellite Activities, USWB.

Policy differences which cannot be resolved within the project framework or the Steering Committee will be referred to the Director of MSA, USWB, and the Director of Meteorological Systems Office of Applications, NASA.

JAMES C. WEBB,
Administrator, National Aeronautics and Space Administration.
LUTHER H. HODGES,
Secretary of Commerce.

[Addendum to NASA/WB agreement]

FUNDING AGREEMENT NASA–USWB

In accordance with the provisions of the NASA-Department of Commerce-U.S. Weather Bureau agreement for the implementation of the NOS project, dated _____, the following funding arrangements are established.

A. METHOD OF FUNDING

1. The Weather Bureau will issue a reimbursable Government order to NASA in accordance with the NASA operating plan estimate approved by NASA and the Weather Bureau.

B. METHOD OF COSTING

1. Where possible, the requirements for flight hardware and ground equipment in support of operational spacecraft will be included in existing NASA contracts for "flight hardware." In order to provide for equitable distribution of cost between R. & D. and operational spacecraft and ground equipment, the total cost of these items will be apportioned between NASA and U.S. Weather Bureau on a pro rata basis, based on the number of R. & D. versus operational flight models in each contract as reflected in the financial operating plan. Costs of the prototype spacecraft development will be borne by the R. & D. project.

2. Personnel services cost included in "direct management" will be based on timecard records of personnel assigned to management of the projects and prorated where applicable between R. & D. and operational effort. Other direct management cost will be charged on an actual cost incurred basis.

3. A companion job order system will be established within the GSFC accounting system to accumulate all pro rata and specifically identifiable costs of the NOS program.

Dr. TEPPER. The agreement states that the Weather Bureau will pay on a pro rata basis for the number of flight articles that are associated with this part of the program.

Mr. RYAN. What is a flight article?

Dr. TEPPER. Well, this is to differentiate it from a prototype which doesn't fly but is just tested at the plant.

We do not charge the Weather Bureau for the prototype development. This is the R. & D. area that we feel is our responsibility.

But for the spacecraft that go into orbit, the Weather Bureau is charged on a pro rata basis for those spacecraft, which you saw identified on the flight schedule as the Weather Bureau flight articles.

Mr. RYAN. Is there anything else besides the spacecraft included?

Dr. TEPPER. Yes. There is the read-out station. The command and data acquisition stations—the one in Fairbanks, Alaska, and the one that is being developed in Nova Scotia, are being paid for entirely by the Weather Bureau by a reimbursable work order to us. We are constructing the facility for the Weather Bureau. The launch vehicles are also included.

There are also costs that we call technical management, which involves our people. And program and computing activities associated with each of these flights.

So these are the general areas that are involved in the reimbursable.

The spacecraft, the command and data-acquisition stations, the launch vehicle, the technical management and the programing and computing areas.

Mr. RYAN. And that is for each program, Nimbus and TIROS?

Dr. TEPPER. Yes.

Mr. RYAN. Do you think you could supply, Mr. Chairman, for the record, the breakdown for fiscal 1963 on those two items for each program?

Dr. TEPPER. Yes, sir. This, I understood, is what was requested.

Mr. RYAN. Right. This was the agreement?

Dr. TEPPER. Yes.

(The information requested is as follows:)

Reimbursable funds summary (TOSS-NOS)

[In thousands of dollars]

Fiscal year	Actual	Anticipated			
	1962	1963		1964	
Total appropriation	48,000	40,000		[1] 23,000 carryover—24,222	
Weather Bureau usage	2,330	3,500		5,422	
Reimbursement to NASA	NOS	NOS	TOSS	NOSS	TOSS
Spacecraft	20,000	0	3,620	16,000	300
CDA	12,100	2,500	500	5,000	2,100
C. of F	(11,140)				
Project peculiar equipment	(960)	(2,500)		(3,000)	
Operations			(500)	(1,500)	(2,100)
Communications				(500)	
Launch vehicles	13,000	0	5,000	16,600	0
Technical management	570	430	80	800	500
Programing and computing	0	150	0	500	0
Total project	45,670	3,080	9,200	38,900	2,900
Total reimbursement	45,670	12,280		41,800	

[1] 633 additional in WB budget for APT.

NASA usage of fiscal year 1962 N.O.S. reimbursable funds from Weather Bureau N.O.S. financial status as of Jan. 31, 1963

	Reimbursable authority	Cumulative expenditures	Unliquidated obligation	Total obligated	Out standing commitments	Total commitments and obligations
Spacecraft:						
Integration and test		$3,754,000		$3,754,000	$2,200,000	$5,954,000
Controls		999,999	$1	1,000,000	700,000	1,700,000
Power supply		653,969	1,191,591	1,845,560	400,000	2,245,560
PCM telemetry		860,000	698,000	1,558,000	860,000	2,418,000
Command clock		33,275	140,914	174,189	381,100	555,289
Camera system		1,038,572	268,765	1,307,337	931,085	2,238,422
Radiometers		259,811	24,794	284,605	160,395	445,000
Tape recorders					148,000	148,000
Transmitter					12,000	12,000
Total spacecraft	[1]$20,960,000	7,599,626	2,324,065	9,923,691	5,792,580	15,716,271
CDA:						
Ground support equipment		71,000	339,000	410,000	1,261,500	1,671,500
Construction of Alaska station		286,747	3,001,553	3,288,300	1,172,413	4,460,713
Construction of Canada station		60,949	2,129,051	2,190,000	942,329	3,132,329
Total CDA stations	11,140,000	418,691	5,469,604	5,888,300	3,376,242	9,264,542
Programing and computing	0	64,148	219,672	283,820	247,450	531,270
Technical management	570,000	546,166		546,166		546,166
Total N.O.S. (less vehicles)	32,670,000	8,628,636	8,013,341	16,641,977	9,416,272	26,058,249
Launch vehicles	13,000,000	0	1,700,000	1,700,000	0	1,700,000
Grand total	45,670,000	8,628,636	9,713,341	18,341,977	9,416,272	27,758,249

[1] Includes $960,000 project peculiar equipment at ground stations identified as CDA on WB order.

Mr. DAVIS. All right.

Mr. BOONE. On page 19 of volume 5, Dr. Tepper, you have $4 million for data acquisition. Is this something that the Tracking and Data Acquisition Office of NASA cannot supply to you?

Dr. TEPPER. This is on the Nimbus?

Mr. BOONE. This is specifically for Nimbus.

Dr. TEPPER. Yes.

Mr. BOONE. And this is for operational control stations or ground stations?

Dr. TEPPER. This is correct. This is in order to operate not the antenna system which is the tracking data acquisition responsibility, but those parts of the data acquisition system which are peculiar to Nimbus. This is equipment—we call it Nimbus-peculiar equipment—that is at the command and data acquisition stations which is different and separate from the antenna itself. For example, there is ground equipment associated with the cameras that has to be operated.

There are the high resolution infrared radiometer receivers, and other ground equipment at the command and data acquisition stations.

There is the housekeeping telemetry—the PCM telemetry—that has to be received and recorded. In general terms this data acquisition item covers the operation of these types of equipments which are Nimbus-peculiar—that are operated specifically for the Nimbus satellite.

Mr. DAVIS. How many such stations will need to be built?

Dr. TEPPER. There has to be one set of Nimbus-peculiar equipment associated with each readout station.

Mr. DAVIS. How many readout stations?

Dr. TEPPER. There will be one at Fairbanks, one at an east coast station, and there will be one at Goddard. There will be three in all.

Mr. DAVIS. Yes. It will be built on the existing property, I suppose. suppose.

Dr. TEPPER. Yes. The equipment is being built on the existing property. This is in order to integrate it and to make it a working system with the antenna system.

Mr. DAVIS. I see.

Mr. HECHLER. Mr. Chairman.

Mr. DAVIS. Yes, Mr. Hechler.

Mr. HECHLER. In the future, when you get a synchronous weather satellite, will all this equipment, readout equipment, Nimbus-peculiar equipment, be written off and useless and junked?

Dr. TEPPER. No, sir; and neither will Nimbus be junked.

Requirements for a synchronous meteorological satellite are independently very definite and specific. It will satisfy requirements and give data which are required and which can't be provided by Nimbus, and conversely Nimbus will be able to do things that the synchronous meteorological satellite will not be able to do.

The dream of the meteorologist is to combine both into one system, but how that is done and which is the best way of proceeding with the synchronous meteorological satellite we are still not sure.

Mr. HECHLER. You don't think the synchronous satellite could completely replace Nimbus?

Dr. TEPPER. I think it is too early to tell. We don't know enough about the problems. But conceptually they do different things, and I don't think I would want to try to complicate it, to have one satellite do what these two can do.

Mr. HECHLER. I hope you understand the purpose of my question is to try to avoid overinvestment in equipment.

Dr. TEPPER. Yes, sir.

Dr. SEAMANS. Let me just reemphasize though which Dr. Tepper has said. The possibility of a synchronous satellite is under investigation. We do not have an approved project for the development of such a satellite. In order to carry out the investigation, it is first necessary to carry out system-type studies as well as to investigate certain of the very important elements that will be needed in such a system—for example, the Zoomar type lens.

Mr. HECHLER. I see your system studies request has gone down from $300,000 to $50,000 in fiscal 1964. What does this indicate?

Dr. SEAMANS. Can you comment on that?

Dr. TEPPER. This is with regard to synchronous meteorological satellite?

Mr. HECHLER. Yes.

Dr. TEPPER. Well, we aren't programing any more system studies until we get the results of the system study that we now have under contract.

We are programing some funds to begin some work on long leadtime hardware items, as they develop out of the system study. We are not going into any type of a spacecraft configuration necessarily but just looking at the types of elements of this system that require long leadtime attention.

Mr. HECHLER. It is so wonderful when you get a 500-percent decrease in a budget item, that I wanted to call it to your attention.

Mr. WYDLER. Mr. Chairman.

Mr. DAVIS. Yes, Mr. Wydler.

Mr. WYDLER. Dr. Tepper, I notice here now for the year 1964, calendar year 1964, you have three TIROS shots scheduled and three Nimbus shots scheduled. Will they be flying at the same time?

Dr. TEPPER. They might—yes; there will be overlap.

Mr. WYDLER. Now, what is the difference between a TIROS R. & D. shot and a TIROS operational shot?

Dr. TEPPER. One of the slides that I had listed the type of experiments that we would hope to attempt on the Nimbus research and development. Each——

Mr. WYDLER. No, I am asking you about TIROS.

Dr. TEPPER. I am sorry, I meant TIROS.

Mr. WYDLER. Yes.

Dr. TEPPER. For example, the next shot, its research and development objective is to try a 15-micron sensor, which is part of the control system of the Nimbus, to get some information on the 15-micron sensor.

Mr. WYDLER. But the TIROS R. & D. shots are going to take pictures, too; aren't they?

Dr. TEPPER. Definitely.

Mr. WYDLER. They are going to perform the normal functions?

Dr. TEPPER. They will continue to provide the types of data that we have been providing up to now in an operational sense. So that we are doing a double duty in this regard.

Mr. WYDLER. Now why do you need both TIROS satellites in 1964 and Nimbus? In other words, what I am suggesting to you is what are

we going to learn from these TIROS shots in 1964 that makes it worth while to put them up?

Dr. TEPPER. There are two objectives for putting up the TIROS satellites in 1964 and planning for them. The first is that Nimbus is still an unknown factor. We are absolutely sure they will be a very satisfactory satellite but we have to be sure that there is something available to operational people in case we run into problems. So we have to plan for a continuation of the TIROS program until we are more certain of the availability of Nimbus in an operational sense. This is one reason.

The other reason is that TIROS in an R. & D. sense is going to be experimenting with new things and new systems that can't be done and is not going to be done and is not being planned for Nimbus.

Mr. WYDLER. But you are not going to have any more TIROS shots after this calendar year 1964; are you?

Dr. TEPPER. The schedule does not indicate any.

Mr. WYDLER. I am trying to determine: What is the use of doing things on TIROS which you can't do on Nimbus if you are not going to have any more TIROS shots?

Dr. TEPPER. The experiment is what I am referring to, and not the vehicle that is doing it. Let me explain the experiment.

The experiment on TIROS in 1964, for example, would be in a highly eccentric orbit. We want to do this once. TIROS is planned to orbit in this experiment from 300 miles to 3,000 miles and higher. This will permit a look at the Earth from that altitude in order to get information that we have never had before as to how the cloud cover looks in different scales.

Now this is an experiment that needs to be run only once. We don't have to repeat this experiment necessarily. But the information would be very valuable when it comes to putting up a synchronous meteorological satellite which will look at the Earth from a considerable distance.

Mr. WYDLER. Why couldn't that be done by Nimbus?

Dr. TEPPER. Because Nimbus' altitude is only at 600 miles and we want to go out to 3,000 or perhaps 22,000 miles.

Mr. WYDLER. You are incorporating changes into TIROS now. I mean you are adapting TIROS to do it, that is all?

Dr. TEPPER. Yes.

Mr. WYDLER. It doesn't mean it couldn't be done by Nimbus, does it?

Dr. TEPPER. I think the problems associated with putting Nimbus in a 22,000-mile orbit would be very considerable. Its weight is much greater than TIROS. And if we could do it, we would have solved the AEROS problem, because this is essentially what we want to do, is to place a satellite such as Nimbus into an equatorial orbit.

Mr. WYDLER. You feel these three TIROS shots for 1964, assuming that the Nimbus shots are successful this year, Dr. Tepper, are still necessary?

Dr. TEPPER. Yes, these are very good experiments and should be done.

Mr. WYDLER. All right.

Mr. DAVIS. Dr. Tepper, by the time Nimbus is launched, you will have invested about how much in the Nimbus program?

Dr. TEPPER. The first Nimbus: I would say roughly $60 million or so.

Dr. SEAMANS. More than that.

Mr. DAVIS. Well, if that is approximately right, that is all I was interested in.

Dr. TEPPER. All right.

Mr. DAVIS. By the time Nimbus becomes an on-the-shelf item, if TIROS can now be said to be, what will be its price? Can you get at that?

Dr. TEPPER. It would be no more than a guess, and we have to make such guesses where we are in our planning. And the guesses that we are making is for a spacecraft it would be approximately $10 million per spacecraft, not counting launch vehicle or operations money.

Mr. DAVIS. And on the basis of your present knowledge, you do not hope for a useful life of more than 1 year per Nimbus?

Dr. TEPPER. It is difficult to estimate this. I don't know whether we would be considered good estimators or bad estimators with TIROS. We estimated 3 months and we have a TIROS that is working almost 10 months now. If we have similar good fortune with Nimbus, then our estimates of 6 months to a year could be multiplied by a factor. But we need more experience with the operation of this spacecraft before we can be more specific.

One thing we know we have to do. We have to look at our power requirements on Nimbus. It is sort of marginal. We will have to improve that. Our control system has to be improved. The amount of gas we carry, for example, to operate the control elements, gas jets, limits the lifetime of the satellite now to this area. So there are many things that we have to have experience with before we can estimate.

Our estimate now is that life of our early Nimbuses will probably be between 6 months to a year. Our estimate could be off badly in either direction.

Mr. DAVIS. Well, it would be a pretty safe observation to make to say that the national investment in the weather satellite program will continue to grow so far as we can see in the future, especially with such things as SYNCOM still in the future, Nimbus still not operational. Would you not say it would continue to grow?

Dr. TEPPER. Well, up to a certain point. Maybe the next 2 years, it will continue to grow for the next 2 years. But I think there is a leveling-off point, where the operational system becomes standardized, and when the R. & D. settles down to a one major launch per year to satisfy our requiremetns to continually improve the spacecraft and to develop new sensors. We think that R. & D. will require about one launch a year.

Of course, we will still be involved in launching the Weather Bureau operational satellites. But from the cost point of view, I think the operational system will settle down and R. & D. activities will settle down. And that might be—well, within 5 years, I would say.

Mr. DAVIS. Well, when it does settle down, do you expect then, as I heard your answer, that there will still be about one R. & D. launch per year?

Dr. TEPPER. I think this would be highly desirable and necessary to maintain the proper updating of the existing operational system and including new sensors and new information that may be required essentially for research and not for operations.

There are requirements that would suggest and—well, more than suggest, that would make it highly desirable that we do this, that we have at least one research and development satellite per year or at the rate of one per year.

Mr. DAVIS. Now, you were recently at the conference which was held in Rome, were you not, in Rome, Italy?

Dr. TEPPER. Yes, sir.

Mr. DAVIS. Was any discussion had there with respect to the sharing of weather satellite expenses between this country and Russia?

Dr. TEPPER. Not the satellites themselves. The costs on——

Mr. DAVIS. The data?

Dr. TEPPER. Yes. The cost-sharing clause that was considered and agreed on was the link, the hard link, the communications link, to transfer the data between Washington and Moscow.

This link, it was agreed to, would be shared equally by the United States and the Soviet Union with regard to cost.

But the spacecraft itself and the spacecraft development was not involved in this agreement.

Mr. DAVIS. Then there was nothing in your discussions at Rome that would enter into your prognostication about our future weather satellite costs?

Dr. SEAMANS. No.

The effect of that agreement on the cost of these spacecraft and the boosters and the supporting research would not be affected by those discussions in Rome.

Mr. HECHLER. Mr. Chairman.

Mr. DAVIS. Yes, Mr. Hechler.

Mr. HECHLER. Dr. Tepper, or Dr. Seamans, have you gotten any indication of the progress of the Soviet Union on meteorological satellites?

Dr. TEPPER. Yes.

Mr. HECHLER. There are rumors from time to time that the Soviet Union has felt very self-conscious that it hasn't made as much progress as the United States of America in the weather satellite field.

There have been rumors the increased interest has perhaps resulted ina lot more emphasis on development. And I wondered if you had any appraisal of this?

Dr. TEPPER. Well, when we were in Rome, the Russians indicated that they had been flying meteorological sensors aboard their Cosmos series. So this part we know.

In our discussions with the Soviets, we had to discuss a date as to when the mutual exchange of information would start and continue to go. And we were very clear in our discussions that this exchange would be done on an equal basis. We would be interested in participating in this line if we could get the same type of information that we transmitted across this line. This includes cloud pictures and satellite data. And they were aware of it.

And the fact that they agreed to start on an experimental basis in early 1964 and lead to a regular basis in mid-1964 I think would lead one to draw the conclusion that their program would be geared to being able to produce experimental data in the early part of 1964 on a nonregular basis and providing data on a regular basis toward the middle or the end of 1964.

Mr. DAVIS. Is that all?

Mr. HECHLER. May I ask, Mr. Chairman, just one question?

We asked this question of the Weather Bureau and I would just like to get your reaction, too, on the advantages from the standpoint of national interest to the United States in the sharing of meteorological satellite information with the Soviet Union.

Dr. TEPPER. I think the advantages are at least of two kinds.

One is simple economics or quantity. If they can provide a certain amount of data, then a certain amount of data is made available to us that we wouldn't have had before. So from that point of view they would increase the amount of data provided by our program.

The other advantage as I see it is the involvement of other scientists, and in this case of the Soviet scientists, in this type of an analysis and investigation program. And I might say that in our discussions the Soviets were very anxious to exchange methods and techniques of analysis and interpretation, and to have mutual discussions in regard to how we view and use these data, so we would learn from them and they would learn from us in the utilization of this data for meteorological purposes.

Mr. HECHLER. Well, the average man on the street you see might well ask the question: In view of the fact that the United States is so far ahead of the Soviet Union in meteorological satellites, why should we share our data with them when they are not sharing completely their data in those phases of booster development where they are way ahead of us.

Dr. TEPPER. Well, I repeat that the agreement was based on a tacit agreement between both parties that we share in kind, and we are not going to give them anything that we are not going to get in return, of a product which is comparable in return. So if we are going to give them pictures, we are going to get pictures.

Mr. HECHLER. I understand.

Dr. SEAMANS. Let me say, this is a self-policing system. Though we will not count out each picture one by one and insist on one coming back for exactly one going over. But they have got to respond in kind and on the same time scale or we are not going to transmit the data to Moscow.

So if they have the capability, then we will benefit from the fact that they are taking the pictures at the same time we are. If they haven't got the capability, then they are not going to benefit from our program.

Mr. HECHLER. You would support the conclusion that we are way ahead of them in this development?

Dr. SEAMANS. Well, I would refer to Dr. Tepper. He was at the meeting and I was not. I do understand that they have with their Cosmos series taken some cloud pictures. My own understanding is, however, that we have taken many more cloud pictures over a protracted period of time.

Mr. HECHLER. Thank you.

Mr. DAVIS. In the time that remains, I would like for Mr. Boone to go over some of the dollar items, please.

Mr. BOONE. Dr. Tepper, if we could go back to page 19 of volume 5 and start with TIROS.

Do you expect that there will be a sizable expenditure in TIROS in 1965?

Dr. TEPPER. No, sir. The program doesn't call for a sizable expenditure for TIROS in 1965. As the program is indicated right now, if we will be doing anything in 1965, it will be sort of cleaning up.

Mr. BOONE. All right, sir.

Now these dollar amounts that you are requesting here in 1964, are they for the procurement of already developed items?

Dr. TEPPER. The major procurement, as I have indicated, for the additional TIROS has been done this year. The additional requirements are for modification that might be required to the configurations as they are now. This is for the spacecraft and subsystem items.

Mr. BOONE. For example, $1.6 million for data acquisition. Is this for equipment?

Dr. TEPPER. Sir?

Mr. BOONE. Is this for equipment?

Dr. TEPPER. No; this is for the operation, operation of the station and the receipt of the data.

Mr. BOONE. I see.

How about the engineering utilization of the data at $1.3 million?

Dr. TEPPER. Yes, sir.

Mr. BOONE. Is that an in-house type thing? Are you contracting out for some company to reduce data?

Dr. TEPPER. Yes, sir.

Mr. BOONE. What type of data is that?

Dr. TEPPER. This is in order to get attitude determination, the gridding processes, and the extraction of IR data from magnetic tapes. These are all out on contract.

Mr. BOONE. This is a continuing contract?

Dr. TEPPER. Yes.

Mr. BOONE. Is this one contract or several contracts?

Dr. TEPPER. I have mentioned several in my statement just now. The IR reduction is Airtronics. The gridding I think is with Allied Research.

Mr. BOONE. Mr. Chairman, could we request a breakdown of the contractors that you have in 1963 for these data reduction items?

Dr. TEPPER. All right.

(The information requested is as follows:)

TIROS engineering utilization of data—Contractors in fiscal year 1963

[Budgeted amount $1,400,000]

Contractor	Dollars committed	Description
Allied Research Corp	500,000	Gridding of pictures at CDA stations.
IBM	200,000	Computer services for attitude determination.
IBM and Airtronics	300,000	Computer rental and services p imarily related to IR data reduction
Budd Electronics	100,000	Work relative.
Miscellaneous small contracts and procurements in support of in-house effort.	300,000	Pattern recognition techniques.

Mr. BOONE. Going down to the Nimbus——

Mr. RYAN. Before we leave TIROS, may I ask a question, Mr. Boone?

Mr. BOONE. Yes, sir.

Mr. DAVIS. Mr. Ryan.

Mr. RYAN. Out of the $21.2 million for 1963, were you reimbursed any of that amount by the Weather Bureau?

Dr. TEPPER. No, sir.

Mr. RYAN. Do you expect to be?

Dr. TEPPER. No, sir. This is the NASA research and development program.

Mr. RYAN. But this is $5 million for a spacecraft.

Dr. TEPPER. This is for three spacecraft and the backup. The three additional spacecraft and the backup came out of those funds, or were part of those funds.

Mr. RYAN. You are not asking for any reimbursement?

Dr. TEPPER. No, sir.

Mr. RYAN. All, right.

Mr. DAVIS. All right, Mr. Boone.

Mr. BOONE. Would you tell us something about the $12.5 for Nimbus request, the first item, integration structure and testing?

Dr. TEPPER. I might point out that the Nimbus funding that is for 1964 covers four research and development spacecraft. The fiscal year 1964 funding will have to cover the completion and launch of the first two, A–4 and A–5, and the starts on the third and fourth which are due to be launched in calendar 1965 and 1966. So the funding that you see there really apply to the four Nimbus. We consider these in pairs, the first two and second two.

The integration structure and testing operations is essentially the contract that we have with General Electric. It involves the support of a tremendous number of people at GE. At this time there are over 250 people I would estimate at the plant involved in this activity. The cost estimates is roughly divided in half between the completion of the first two and the start of the next two.

Mr. BOONE. Fiscal year 1965 should go down?

Dr. TEPPER. Through fiscal year 1965 we will have launched the third one and we would be still working on the last one. So there might be a small decrease due to the fact that we would be just winding up with the last one.

Yes, it would go down. But I wouldn't imagine it would go down very much.

Mr. BOONE. Your development costs should go down, too.

Dr. TEPPER. Oh, yes.

Mr. BOONE. How about the power supply amount, 2.8?

Dr. TEPPER. That is roughly divided between a little over 1 million for the first two and about 1,800,000 for the start on the next two.

Mr. BOONE. You mentioned earlier that this was a marginal system. the power supply might be marginal for future activities.

Dr. TEPPER. Yes, sir.

Mr. BOONE. Will a little more time help you here in coming up with a better power supply? These are sizable expenditures over the past several years, for power supplies, are they not?

Dr. TEPPER. Well, when I said marginal, I meant we don't have a big reserve as we have on TIROS, so far as power is concerned. We have enough power on Nimbus to do the things we have to do, but our margin is not very great.

As a matter of fact, I mentioned to this committee, that we are looking to the possibility of nuclear power, auxiliary nuclear power sup-

port to assist in this regard—not to replace but to assist the solar power paddle problem, so that we would have more of a margin.

Mr. BOONE. Are you changing the current panels because of radiation in space?

Dr. TEPPER. Yes, sir, we have changed to those solar cells that are more resistant to the radiation damage.

Mr. BOONE. May we go to the next item: 6.5 for control subsystems. Tell us something about that.

Dr. TEPPER. We hope that the control system is pretty well on its way for the first two. We have invested quite a bit in it. This is primarily a start on the control system for the next two Nimbuses, three and four.

Mr. BOONE. Are these a new development, the three and four?

Dr. TEPPER. The control system as indicated here is not a new development. But as you know, we have had to degrade a little bit the accuracy of pointing for the first two, due to the problem we have with control, and we like to try to bring this back up again.

But this isn't a development in the sense of a complete new system or a complete new item. This wouldn't be included in this area, under this heading.

Mr. BOONE. Are you contracting now with a separate contractor for this work?

Dr. TEPPER. Control system?

Mr. BOONE. Yes.

Dr. TEPPER. Yes, this is General Electric.

Mr. BOONE. Can you give us a breakdown of the contractual dollars for 1963 for GE?

Dr. TEPPER. I can do that for the record, yes.

Mr. BOONE. For the record; yes.

(The information requested, is as follows:)

Nimbus: Detail on GE contract commitments, fiscal year 1963 budgeted amounts:

Integration and tests	$5,000,000
Controls	5,900,000

Essentially all of the budgeted amounts have been committed to GE for these items as of March 31, 1963.

Mr. BOONE. The next item is PCM telemetry, which continues to go up—well, I shouldn't say that, but it is a considerable expenditure of 3 years. It seems to me that some off-the-shelf equipment should be available for this.

Dr. TEPPER. Well, actually this breaks down to only $100,000 for the first two and about $750,000 for beginning fabrication of the next two. So we are really going into the third and fourth satellite in fiscal year 1964. We have just about finished on the first two. These are the devolpment of essential flight hardware in this area.

Mr. BOONE. Over a 3-year period you would have about $3 million for PCM telemetry. This is a considerable expenditure, is it not?

Dr. TEPPER. Yes, sir.

Mr. BOONE. And you are going to get two systems for $850,000, is that right?

Dr. TEPPER. No. The numbers that I am quoting for the third and fourth are just a first payment on the satellites.

The third and fourth satellites have enough improvements in them and enough sophistication that we estimate that their cost will be equivalent to the cost of each of the first two.

So we are not going to go down in the cost of the individual satellites through the research and development series.

Mr. BOONE. After the development is over, how much will the PCM telemetry cost for a Nimbus satellite?

Dr. TEPPER. I couldn't answer that. I would have to supply that information to you.

Mr. BOONE. You have no estimates?

Dr. TEPPER. No, sir.

(The information requested is as follows:)

It is estimated that the unit cost per PCM telemetry subsystem based on the present configuration will be approximately $265,000 after the development phase is completed.

Mr. BOONE. Would you continue with the command part?

Dr. TEPPER. Well, except for the camera system, which still requires a little over $1 million to complete, the first two flight articles, the rest of the funds that we have not yet discussed apply mostly to the third and fourth R. & D. spacecraft.

Mr. BOONE. You are still developing new camera equipment for Nos. 3 and 4?

Dr. TEPPER. The cost there is essentially for fabrication of the cameras for Nos. 3 and 4. I don't think there will be any major developments with regard to the camera system for 3 and 4.

Mr. BOONE. We should have paid the development cost previously, should we not?

Dr. TEPPER. Yes, sir.

Mr. WYDLER. I don't understand, Mr. Boone.

You mean to tell me, Doctor, that the camera systems for Nos. 3 and 4 are going to cost approximately $2½ million each? Is that what you are saying?

Dr. TEPPER. Yes, this is what the figures show.

Mr. WYDLER. That is for that complex of three cameras?

Dr. TEPPLER. This covers redundant systems and also includes supporting equipment and ground equipment that goes with it.

Mr. BOONE. That is for ground equipment also?

Dr. TEPPER. Yes, the ground equipment that receive the information from these systems.

Mr. BOONE. Well, now, that is not a part of the data acquisition, that is down below?

Dr. TEPPER. The data acquisition is to integrate this ground equipment and make it work and to operate it.

Mr. BOONE. May I suggest, Mr. Chairman, we ask for a breakdown of the camera subsystem expenditures in 1963, to show just how this is broken out?

Dr. TEPPER. All right, sir.

(The information requested is as follows:)

Nimbus: Detail on camera subsystem contract commitments, fiscal year 1963 (budget amount, $5,450,000):

As of March 31 essentially all of this budgeted amount has been committed to the following contracts:

RCA:[1] Onboard and ground station equipment for advanced vidicon camera subsystem (AVCS), $4,565,000.

RCA: On-board automatic picture taking subsystem (APT), $560,000.

Fairchild-Stratos: Ground station equipment for APT, $325,000.

[1] Of the total amount in this RCA contract about 15 percent is for ground equipment and 85 percent for on-board equipment.

Mr. DAVIS. Now do I understand your testimony to apply to all of these line items, beginning with PCM telemetry, and going on down maybe through spectrometers—does your testimony go to all of those items?

Dr. TEPPER. The statement that I made, that the expenditures were essentially for the third and fourth, apply essentially for everything starting with PCM telemetry to the end of the list, scientific experiment, with one exception, the camera system development, of which about $1 million, is still required for the first two Nimbus.

Mr. DAVIS. All right, sir.

Dr. TEPPER. The items indicate the expenditures toward the third and fourth, yes, sir.

Mr. BOONE. Mr. Chairman, I have one additional question.

Your request for personnel in this area shows an increase of 103 people for fiscal year 1964. Will you tell us what these people are going to do and what type of people you are trying to procure for your work?

Dr. TEPPER. Well, as Dr. Seamans has indicated, these personnel figures include support people as well as direct personnel. So we would have to look at it from that point of view.

Mr. BOONE. I think what concerns the committee is that the average salary still turns out to be about $10,500, in spite of the fact that we are hiring support people. And generally support people are at some salary bracket lower than that.

Dr. TEPPER. Of this 100, roughly 65 percent would be direct personnel. And these are the personnel largely of the Aeronomy and Meteorology Division, the division which handles the meteorological systems program.

These are roughly broken down into areas of program management and the three major technical branches that do the various types of support activities of the kind that I have mentioned, and, of course, clerical and secretarial.

In answer to your question, I would say that these are essentially engineering type people. And if I had to break these 65 people in numbers, I would say that 60 of them would be engineers, technicians, and the rest would be of clerical and the secretarial level.

Dr. SEAMANS. There is a breakdown of the manpower required in volume 1, on page 8, under the Goddard Center, which shows that of the 319 people, 86 are involved in supporting research and technology, 121 on TIROS, and 112 on Nimbus, for the fiscal year 1964. These are also broken out into direct and support personnel.

Mr. BOONE. Well, I noticed I believe it is in volume 2 there were 19 additional people to be applied to the TIROS program.

Dr. SEAMANS. That is right.

Mr. BOONE. Isn't TIROS being phased out here after fiscal year 1964 anyway?

Dr. TEPPER. Well, we are talking about fiscal year 1964.

Mr. BOONE. These are needed immediately for TIROS, is that right?

Dr. TEPPER. Yes, in order to do the things that we were talking about, in doing the experiments on TIROS that we referred to.

Mr. BOONE. And if you didn't get them, why you would just shove it out to 1965, is that right?

Dr. TEPPER. Well, it is always difficult to answer that question yes or no. We think the experiments should be done. We would have to look and see whether there would be something else that we would want to drop, in order to maintain this experimental work with TIROS. We consider these experiments quite important and we would certainly try to press to get them done, but probably at the expense of some other type of a program.

Dr. SEAMANS. Let me just state one point here if I may, Mr. Chairman. When a project is approved or modified, we approve both R. & D. funding and the manpower allocation that is involved. If it should turn out that insufficient manpower is available for one reason or another, we would not normally go ahead with that project.

We do not approve a project and later ascertain there isn't sufficient manpower. We consider this factor as part of our approval process.

Mr. BOONE. The reason for my question was: As I understand it, fiscal year 1963 should be the peak year for Tiros activity. So certainly there are available people there to continue Tiros activity, in accordance with the current level.

Dr. SEAMANS. What the table shows, as I indicated, is that in 1964 there are 117 people in Tiros and in 1963, 104; and in 1964, 121. It shows a dip and then an increase. I suspect that the increase is due to the fact that these personnel are not only conducting the R. & D. program but are responsible for the operational Tiros in which the contract funding will come from the Weather Bureau but the manpower will show in our own institutional support.

Dr. TEPPER. I think, Mr. Boone, you were referring to that schedule slide, which showed the three in calendar 1963, and then two in 1964. That was calendar year. But if you look at the launch schedule in fiscal year 1964 in Tiros, you would find it was pretty heavy insofar as number of satellites that would be launched and prepared for launch during that period. So it is not a leveling off period at all, but a very active period.

Mr. BOONE. One additional question, Mr. Chairman, if I may.

Mr. DAVIS. [Nods.]

Mr. BOONE. I notice the meteorological sounding rocket program is just about doubled in funds.

Dr. TEPPER. Yes.

Mr. BOONE. Do you fund for the Fort Churchill activity in NASA?

Dr. TEPPER. I don't think so. No.

Mr. DAVIS. For the record, will you state what Churchill activity means?

(The information requested follows:)

Anticipated expenditures for meteorological sounding rocket experiments at Fort Churchill

Meteorological sound rocket systems	1963	1964
Experiments, equipment, and support for large rockets:		
Rocket grenade experiments	$85,000	$125,000
Sodium vapor experiments	60,000	125,000
Pitot static tube experiments	----------	----------
Field services and support [1]	----------	----------
Total experiments, equipment, and support for large rockets	145,000	250,000
Large rockets	90,000	144,000
Total, direct R. & D. costs	235,000	394,000

[1] These services are provided by the range at Fort Churchill. Meteorological systems is not charged for them.

NOTE.—These funds in fiscal year 1963 were spent with the following contractors:
Rocket grenade experiment: Texas Western University and Superior Engineering Co. of Michigan.
Sodium vapor experiments: Geophysics Corp., of America, Massachusetts.
Large rockets: Nike—Army Ordnance; Apache, Cajun—Thiokol Corp.; Fins—Atlantic Research Corp.

Dr. SEAMANS. Fort Churchill is in Canada. It is a sounding rocket station that is very advantageously located for certain types of measurements. NASA has contributed to the development of the rocket facilities at that site particularly because of certain rehabilitation costs stemming from a large fire several years ago.

Mr. BOONE. Well, my question really is related to coordination within NASA on sounding rocket shots. Is this part of your program? If they are making sounding rocket firings, why then do you show nothing about it in the weather satellite program?

Dr. TEPPER. If who is doing it?

Dr. SEAMANS. NASA is carrying out a sounding rocket program that is primarily devoted to our space science activity. We are making measurements that are of interest to the meteorological community. On the other hand, we also have sounding rocket launchings that are devoted entirely to meteorological work. The total NASA sounding rocket program is coordinated between Dr. Tepper's office and the Office of Space Science under Dr. Newell, specifically under Dr. Naugle in geophysics and astronomy.

Mr. BOONE. I had a recent press release that showed sounding rocket activity in the same altitude ranges that were mentioned earlier by Dr. Tepper, I believe.

Dr. TEPPER. Oh, that is quite possible.

Mr. BOONE. And it seems to me that the same—well, at least the same rocket should bring back the same sensory information. You should be not only coordinated, you should be planning the program together.

Dr. TEPPER. The answer is, we are.

Mr. BOONE. I didn't get that from your first response.

Dr. TEPPER. Well, perhaps I misunderstood the nature of your question.

But this program is coordinated. Dr. Newell has assigned this responsibility to Dr. Naugle in Dr. Newell's office and we work closely with the people in Dr. Naugle's office in regard to the firings. They are aware of what we are doing and we are aware of what they are doing.

Dr. SEAMANS. Some of the instrumentation obviously has to be different to get the different kind of data that are required. But the launch pads and various rockets can obviously be used, depending upon the payloads that are required.

Mr. BOONE. Thank you, sir.

Mr. DAVIS. Mr. Wydler, do you have any further questions?

Mr. WYDLER. Just—if I might, Mr. Chairman. I know we are overtime. But I will appreciate it.

When Nimbus is actually in the sky, how much of the time will it be operating?

Dr. TEPPER. It will be operating 24 hours a day.

Mr. WYDLER. It will continuously operate for the 6 months of its life, is that what I am to understand?

Dr. TEPPER. Yes, it will be operating continuously.

Mr. WYDLER. In other words——

Dr. TEPPER. During the daylight it will be taking cloud cover pictures and during the night it will be taking radiation measurements and housekeeping measurements of the satellite itself. It would be storing the data and transmitting them to the command and data acquisition stations.

Mr. WYDLER. But do I understand that during daylight hours, in other words, during hours when it can take pictures, it will be taking pictures continuously? There will be no periods when it will have to stop taking pictures to recharge or anything of this nature?

Dr. TEPPER. That is right; yes, sir.

Mr. WYDLER. All right.

Mr. DAVIS. One further question in line with that. What is meant by the term "day-night television"?

Dr. TEPPER. This is a television system that can operate at low light levels. In other words, a television system that might use moonlight or starlight in order to take television pictures.

Right now we rely on a radiometer, which is a different thing entirely. It measures temperatures. But we are interested in developing a system that will actually take pictures, television pictures, at night.

Mr. DAVIS. I see.

Dr. TEPPER. And this is the day-night television.

Dr. SEAMANS. You see, the Nimbus is in essentially a polar orbit, such that it comes over the Equator each time it comes around local noontime. This orbit is in essentially the plane of the Sun, so as it comes over you get a good daylight picture.

Well, we also want to be able to get information when the Nimbus is on the back side of the Earth as seen from the Sun. By having this capability, we can get other interesting kinds of information, of interest to the meteorologist.

Mr. DAVIS. I see.

Now, one final question I would like to ask of Dr. Tepper and that has to do with the recent conference and agreement in Rome. I personally am interested in this and I feel sure that the American public is quite interested. And that is you certainly must have cleared with the Department of Defense the area within which you felt free to make agreements with Russia, before you went to Rome?

Dr. TEPPER. Well, before we went our working group studied the problem and we discussed our results with many agencies of this Gov-

ernment, including the Department of Defense, as to what things we would discuss and what would be our position. And this was done with their full knowledge and concurrence. And the agreement followed that policy statement development very closely.

Dr. SEAMANS. Of course, it should be realized that the State Department is the agency of the Government responsible for agreements of this type. For that reason, Dr. Dryden was working very closely with the State Department, but keeping the Department of Defense fully informed.

Mr. DAVIS. Well, the Department of Defense might have something to say about it, though, if the national security got involved.

Dr. TEPPER. Yes, sir.

Dr. SEAMANS. Absolutely.

Mr. DAVIS. And then there is this question. It would seem to me as a layman that in the event of a sudden outbreak of hostilities between Russia and the United States, that the fact that they might have very recent weather information would enter into the military picture right heavy.

Now, how do you view that possibility from your point of view?

Dr. TEPPER. Well, I can respond as an individual here, since this is I think outside the scope of the agency responsibility.

But we can immediately stop sending pictures when this happens. We certainly would stop sending pictures at this time.

Right now we do not permit anyone else access to the satellite. We control the satellite ourselves and we intend to keep it that way.

If we find for any reason that the access has been compromised, and this is possible, of course—even the best codes are compromised sometimes—we can modify the code, change it, or shut the thing off completely, so that nobody else can get this information.

So that I feel that the control of our satellite by ourselves is adequately taken care of.

The nature of this control has been discussed with the Department of Defense, and they know about it.

Dr. SEAMANS. Let me just add to that, if I may.

The direct readout feature, of course, is of great interest to the Department of Defense, as well as to meteorologists throughout the world.

The system has built into it the capability of reprograming from the ground the times when that readout takes place.

Mr. DAVIS. I see.

Dr. SEAMANS. So that in the event of hostilities or near hostilities, we can change the pattern so that we would not give to everybody throughout the world cloud cover information that might be of value to a potential enemy.

Mr. DAVIS. I see.

Dr. TEPPER. Mr. Chairman, in that regard I have here a test picture taken by this system, that Dr. Seamans referred to. The system was operating as if it were in a satellite, although this picture was taken from the ground. But this is the end product of the system, and you might like to look at it.

Mr. DAVIS. Yes.

Mr. BOONE. One question, Mr. Chairman. Are you sending ground data along with cloud cover pictures? Is the Weather Bureau making this available to Russia?

Dr. TEPPER. Yes. Let me first explain that through the WMO, the World Meteorological Organization, there is a normal exchange of regular routine, conventional weather observations among the countries of the world. So this is not a new feature.

The communications link that we discussed with the Soviets does include a feature for transmitting some of this material, conventional data, also, together with the satellite data, particularly when it is related to the type of satellite pictures or satellite data that we are sending, in order to make the combined information more useful.

Mr. DAVIS. On behalf of the subcommittee, I want to thank you, Dr. Tepper, for your very excellent testimony, including your formal statement, and you, Dr. Seamans, for coming to be with us again.

So far as I know now, this will conclude the weather satellite portion of the hearing; however the subcommittee may submit additional questions in writing.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION,
OFFICE OF THE ADMINISTRATOR,
Washington, D.C., May 20, 1963.

Mr. W. H. BOONE,
Staff Consultant, Committee on Science and Astronautics,
House of Representatives, Washington, D.C.

DEAR MR. BOONE: The attached document contains answers to questions in your letter of May 15, 1963, concerning costs and intended use of leased buildings and the proposed meteorological research facilities at Goddard Space Flight Center.

We hope this information will be useful to the committee.

Sincerely yours,

J. S. BROWN,
Assistant Director, Office of Legislative Affairs.

Enclosure.

The following information is submitted in response to the May 15, 1963, request from the Committee on Sciences and Astronautics of the House of Representatives:

1. What are the yearly rent and overhead costs for the meteorological research facilities now located in Silver Spring, Md., and Hyattsville, Md., that will be relocated at the new laboratory that is planned at Goddard Space Flight Center?

The Colemont Building is provided through GSA, the yearly rental cost including overhead is approximately $60,000. As no facilities are currently being leased in Hyattsville, it is our opinion that the inquiry is in reference to the Beltsville location; namely, the Minneapolis-Honeywell Building. This building houses personnel engaged in sounding rockets and meteorological systems effort. The meteorology personnel are presently utilizing approximately 20 percent of the total area. Applying this percentage of total cost, the following amounts are applicable in response to the question:

Description	*Total cost*	*20 percent*
Rental of building	$56,500	$11,300
Utilities	38,200	7,640
Total	94,700	18,940

2. Are there any other facilities that will be relocated at this building? If so, what are their yearly costs and what is the duration of the leases for these buildings and are these leases in time phase with the scheduled occupancies of the new laboratory?

No. However, personnel currently housed in the Research Projects Laboratory and who are performing related and mutually dependent meteorological systems efforts will be relocated in the new laboratory. The space vacated will be used by the original intended user, the Space Sciences Division. It must be stressed that this is not "extra" space.

3. What is the occupancy date?

April 1965.

4. Are there other facilities available in the Government that might be used which would not require the construction of this new laboratory building?

There are no existing Government facilities in the areas which would provide adequate laboratory and office space for the Aeronomy and Meteorology Division. As the tracking and data operations for the Nimbus satellites will be accomplished at the central range and operations building at GSFC, it is essential that the active Nimbus control center (to be located in the new laboratory) and supporting and relating research and development staff be in close proximity in order to insure the necessary support for a successful Nimbus program.

5. What is the estimated total cost of this facility?

The total estimated cost of the laboratory is $4,103,000. As all of our CoF projects are budgeted on the "turnkey" concept, the estimated cost includes all currently known requirements.

Additionally the Department of Defense was asked to comment for the record on work being carried out by DOD agencies in the field of meteorological satellites. Their response is as follows.

OFFICE OF THE SECRETARY OF DEFENSE,
Washington, D.C., May 23, 1963.

Mr. W. H. BOONE,
Technical Consultant, Committee on Science and Astronautics,
House of Representatives.

DEAR MR. BOONE: In response to your letter to me of May 15, 1963, concerning information to be included in the printed hearings of this year for the NASA authorizations, I have been advised by representatives of Defense Research and Engineering of the following information:

The Department of Defense does not have any space meteorological satellite program duplicatory of, or complementary to, the current NASA or Weather Bureau meteorological satellite programs which those agencies have undertaken to fulfill their assigned responsibilities for a national weather system. Of course, in discharging program and operating responsibilities assigned to DOD, and known to NASA, the DOD occasionally measures parameters analogous to one of the many inputs required for accomplishment of the extensive Commerce/NASA national weather program.

As to future planning, the DOD, as a user of weather satellite data, has become increasingly concerned regarding the continual slippage of Nimbus, the Nimbus level of reliability and cost effectiveness when available, the implications of implementing international agreements on weather satellites, and the corresponding necessity to work out a development policy and program fully satisfactory to both the Defense Department and the National Aeronautics and Space Administration, based on past experience and current technical opportunities.

Accordingly, the DOD in conjunction with the Department of Commerce has initiated a fundamental reexamination of the weather satellite program, including the interaction of technical possibilities and operational goals. The results of this review will be presented to NASA shortly.

The Department of Defense has worked with NASA representatives on this matter, hoping to insure that current and future developments in this field are fully responsive to the needs of DOD and Commerce jointly.

Sincerely,

GROVER K. COE,
Colonel, U.S. Air Force,
Deputy Director, Office of Legislative Liaison.

The committee will now adjourn.

(Whereupon, at 12:13 p.m., the subcommitte was adjourned.)

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1964 NASA AUTHORIZATION

TUESDAY, APRIL 2, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON APPLICATIONS AND
TRACKING AND DATA ACQUISITION,
Washington, D.C.

The subcommittee met at 10 a.m., pursuant to adjournment, in room 214–B, Longworth Building, Hon. William Fitts Ryan (chairman of the subcommittee) presiding.

Mr. RYAN. Will the subcommittee come to order?

Today the subcommittee begins hearings on that part of the NASA budget request related to the NASA communications satellite program.

The 1964 NASA budget request states that "NASA will support the continuing improvement, development, and expansion of the uses of communications satellite systems through research, development, and flight tests. NASA will not only play a primary role in support of the Space Communications Corp., but will also support all industries supplying components for future communcations satellite systems."

This appears on page RDO 7–2 of the budget estimates, volume II, fiscal year 1964.

NASA's budget request is for $55,771,000 for fiscal year 1964.

The implications of this statement deserve careful consideration. Last year Congress created a Communications Satellite Corp. for profit which was expected to lead to the expeditious development of a commercial communications satellite system. The decision to rely on private investment for the financing of the system was made, as one supporter explained, because "private enterprise would have more flexibility, greater speed, more initiative, greater risk taking than the Government would."

For fiscal year 1963 NASA has programed $43,715,000 for research and development of communications satellites. NASA has requested $51,100,000 for the same purpose in fiscal 1964.

The size of the proposed budget suggests that NASA intends to continue an active role in research and development.

This poses major policy questions. Should the taxpayers, through NASA, undertake any research benefitting the stockholders of this profitmaking corporation or should the corporation itself finance the research?

If there is justification for public expenditures on research and development, how are the responsibilities and objectives of NASA and the Communications Satellite Corp. to be demarcated? Have any provisions been made for reimbursement to the Government?

In addition to NASA and the private profitmaking corporation the Department of Defense has a communications satellite program.

What assurance is there that there is not duplication between NASA and the Department of Defense?

During this hearing the subcommittee will seek to explore these questions and to determine how the public interest can best be protected.

This morning it is a pleasure to have Dr. Seamans, the Associate Director of NASA with us, and I understand that Dr. Seamans has a prepared statement. The committee would be delighted to hear from you, Dr. Seamans, after which I understand that Mr. Jaffe has a presentation to make and we will call upon him after we have heard from you.

Dr. SEAMANS. Thank you, Mr. Chairman.

STATEMENT OF DR. ROBERT C. SEAMANS, JR., ASSOCIATE ADMINISTRATOR OF NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. Chairman and members of the subcommittee:

Mr. Jaffe and Dr. Tepper, of the Office of Applications and I are prepared to review for you the programs of the Office of Applications.

I will present a general introduction and discussion on future satellite applications and industrial applications. Mr. Jaffe will review for you the communications systems program. Dr. Tepper will discuss for you the meteorological systems program.

Before continuing with my statement, I would like to introduce Dr. George L. Simpson, Jr., who came to the agency from the University of North Carolina, where he was very active in the field of regional scientific development. He holds the position of Assistant Administrator for Technology Utilization and Policy Planning. In this position he is responsible for directing NASA's industrial applications program.

Following my presentation, Dr. Simpson and I will be available for further elaboration on this area if you desire.

Our applications program is defined on this first chart, shown in figure 12. The program falls into four areas: communications systems, meteorological systems, future applications, satellites, and industrial applications. Noted under each area are the major activities which represent approved flight programs or programs we believe will be recommended for further development.

In communications systems, Echo I, and Echo II represent our passive communications program. Here satellites act as simple reflectors for communications signals transmitted from earth. Echo I, initiated in 1959, has nearly completed its communications research objectives. Echo I, a 100-foot-diameter inflatable sphere, still orbiting the Earth, is visible around the world under favorable conditions. We are continuing to make periodic measurements of its reflective characteristics. Echo II, a 135-foot-diameter inflatable sphere made of more rigid material than Echo I, is expected to be ready for flight later this year. Echo II will provide a larger, more nearly spherical, longer lived target for passive communications research than was provided by Echo I.

The active communications program is represented by Relay, Syncom and Telstar. Active communications satellites receive elec-

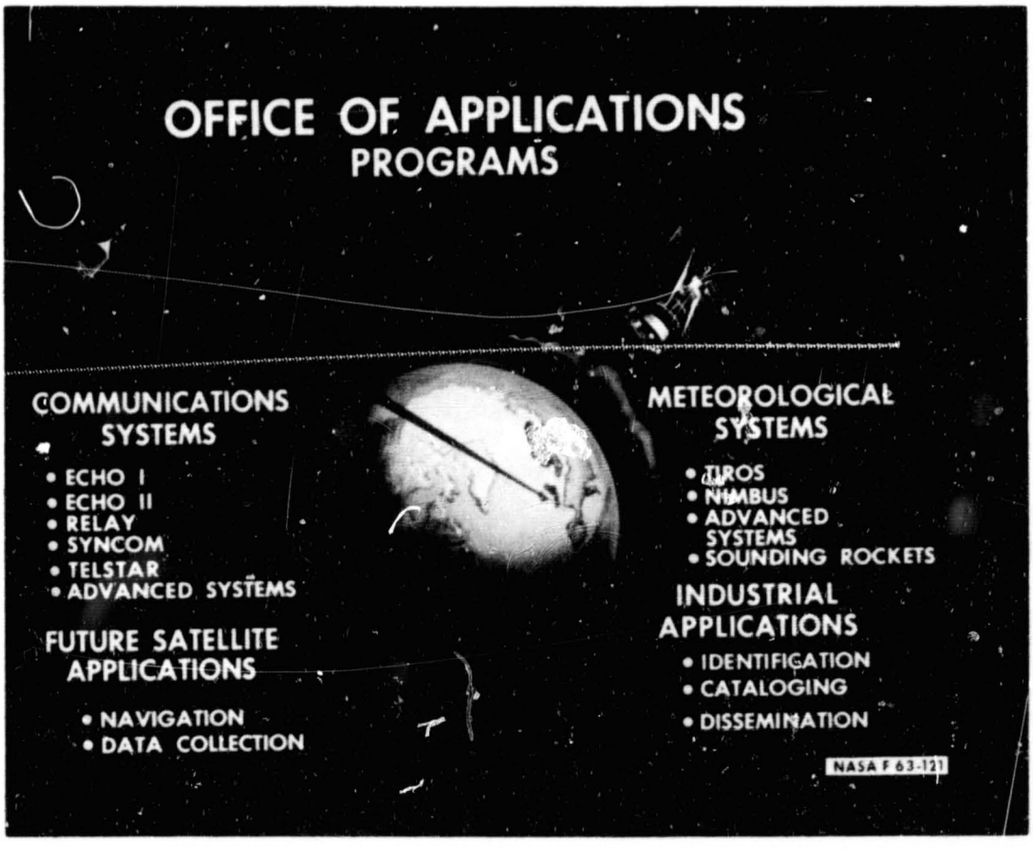

FIGURE 12

trical signals from a station on Earth, amplify the signal and return the amplified signal to a distant Earth-based receiving station. The first of the Relay satellites was put in orbit last December. It was not possible to carry out the intended communications experiments the first several weeks of flight due to electrical trouble. This was corrected and it has been possible to conduct successfully TV and all of the planned telephone experiments between the United States and Europe as well as with South America.

Mr. Jaffe will discuss the Relay project with you in more detail.

One of the prime objectives of the Syncom satellite project is to assist in the development of techniques for establishing a spacecraft in the 24-hour orbit. The Syncom spacecraft has limited communications capabilities; a few telephone channels, no television capability. The first Syncom was launched in February 1963. This was our first effort to put a satellite in the 24-hour synchronous orbit. As you know, contact with the satellite was lost about 5 hours after launch. However, it has been determined, through the use of optical trackers, that Syncom is in a 24-hour orbit. Mr. Jaffe will discuss this matter too.

Telstar has proven to be a very successful project in the active communications satellite program. As you know, the satellite is a private venture designed and developed by the American Telephone & Telegraph Co. and launched by NASA. NASA also assists in tracking and data handling. The agency is reimbursed for its launch, tracking, and data-handling expenses. The first satellite was

launched successfully in July 1962. After 4½ months of operation there was a malfunction of its command system. Extensive analysis has provided a means for restoring Telstar to full operation for a while but the difficulty has recurred and the satellite is not operable at the present time. The American Telephone & Telegraph Co. has decided to orbit a second Telstar this spring.

In advanced systems we are conducting studies that will enable us to improve the 24-hour satellite concept over the state-of-the-art technology incorporated in Syncom. We anticipate a follow-on, advance synchronous communications project and are engaged in studies that will assist in defining design and development efforts.

In meteorological systems, you are, of course, familiar with Tiros, the very successful meteorological satellite from which we have and are continuing to obtain meteorological data. We and the Weather Bureau plan to continue this program until the follow-on Nimbus program gets underway.

The Nimbus system provides a considerable technical advancement in meteorological satellite systems. We will be able to provide a more continuous and a greater coverage of weather data with Nimbus than is possible with Tiros. The prototype weather sensory section of the satellite is currently being assembled and the full prototype spacecraft will undergo environmental tests this summer. If all goes well, we will be able to orbit the first Nimbus by the end of this year or the early part of next year.

Advanced meteorological systems include studies of such concepts as the 24-hour meteorological satellite. Sounding rockets are used in the meteorological systems program to explore and measure the atmosphere above sounding balloon and below satellite altitudes.

In the area of Future Satellite, Applications, we are concentrating our attention in two areas: Navigation satellite systems and data collection satellite systems.

In the field of navigation we are particularly interested in the application of the Navy's transit navigational system to civilian use. The transit satellite, designed to aid in the navigation of military shipping, should be operational soon.

It is our hope that here is an opportunity to take advantage of efforts expended by the Department of Defense. We will be working quite closely with the Navy in evaluating the kinds of equipment required by merchant mariners to make full use of a navigational satellite. The equipment required should provide sufficiently high precision and be of low cost to justify shipboard installation by civil mariners.

This chart, shown in figure 13, was prepared to illustrate the operation of Project Transit. The satellite is tracked and these track data are sent to a computing center. Orbital parameters are determined at the center and sent to an injection station for transmission to the satellite.

The ship at sea receives position and orbital information from the satellite. From these data the position of the ship can be determined by simple onboard computations.

Data collection is a very interesting possible application of satellites. A data satellite could collect information from a large number of remotely located and automatically operative sensor units. This figure (fig. 14) indicates some of the data collection systems that could be

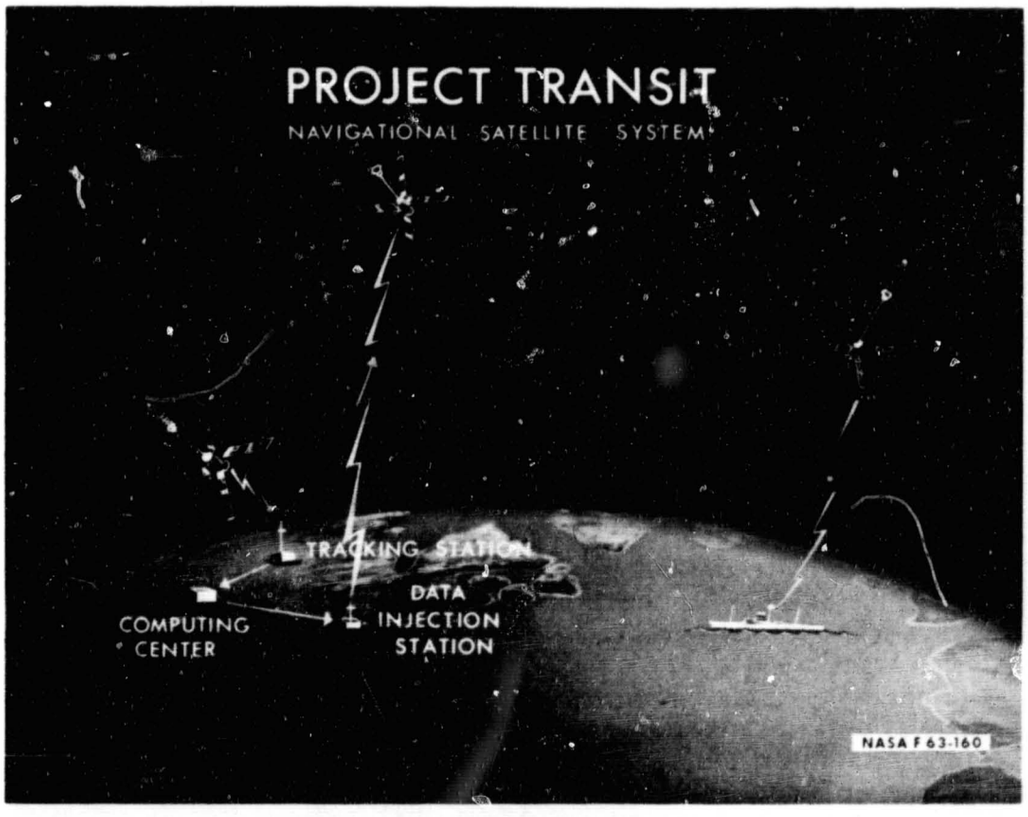

FIGURE 13

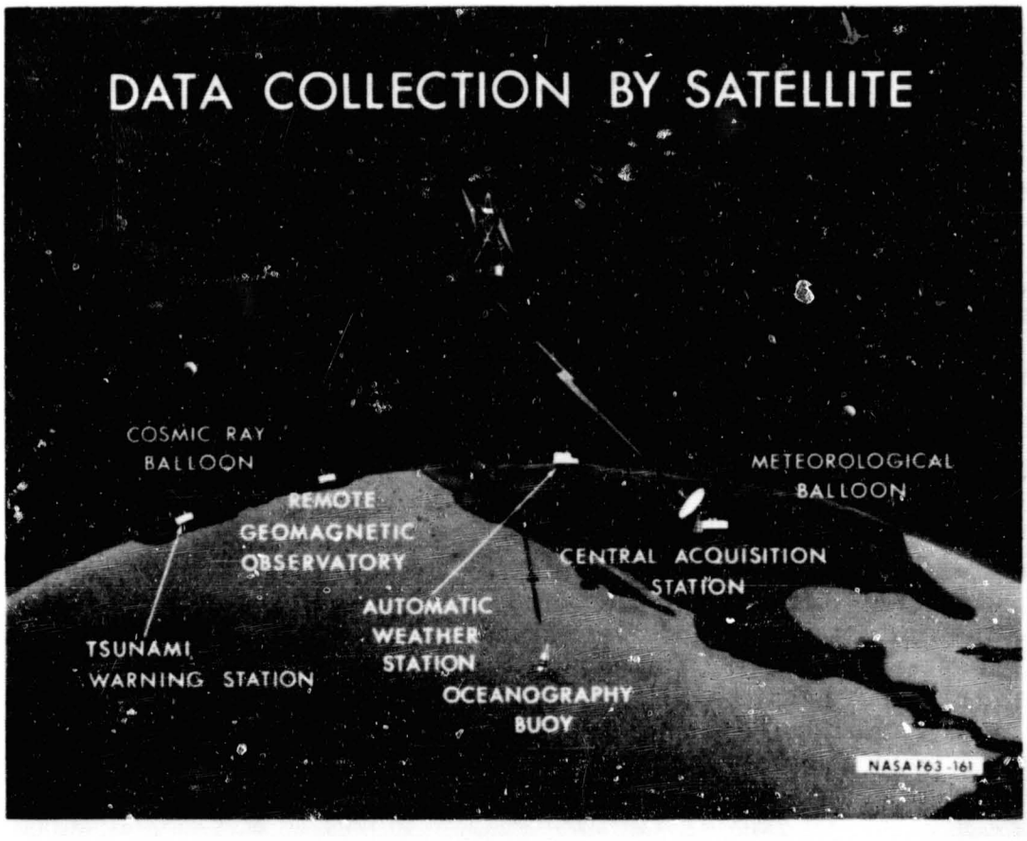

FIGURE 14

serviced by a data satellite system. These include cosmic ray balloons, tsunami warning stations for giving early warnings of tidal waves, remote geomagnetic observatories, oceanographic buoys, automatic weather stations, and meteorological balloons. We believe such systems could be integrated with the satellite system such that as the satellite passes by, the remote data transmitter sends its information to the satellite. These data are received and stored in the satellite on magnetic tape. As the satellite comes over a data recovery station, the satellite-borne magnetic tape data are transmitted to the station and in turn transmitted to a central processing center which then distributes the data to its users.

A number of agencies, weather and oceanographic, have expressed interest in the possibility of using such a system, and during the forthcoming fiscal year we plan to look in some detail into the feasibility of such a system.

We should be able to determine, as a result of these studies, whether or not the development of a data-collecting system is warranted.

NASA's industrial applications program was initiated during the last half of 1961. At that time, it was determined that the only effective way to meet the requirements of the Space Act—for the widest practicable and appropriate dissemination of information gathered in the space program—would be to carry out the specific industrial applications program.

Since the inception of the program, it has been carried in the Office of Applications as part of the Office's broad responsibility. This program is being shifted to the Office of the Assistant Administrator for Technology Utilization and Policy Planning headed by Dr. George L. Simpson, Jr. This move is designed to give increased emphasis to the program which NASA has been developing for the past year to accelerate the industrial utilization by the civilian economy of the scientific and technological advances resulting from NASA's space program. The integration of the Industrial Applications Division, under Dr. Simpson, will result in close coordination of the identification of industrial applications and the information dissemination activities of Dr. Simpson's Office.

In the industrial applications program, we have identified the objectives indicated on the next chart, shown in figure 15. First, we are concerned with the identification of innovations. That is, new or improved ideas, materials, methods and technology developed or utilized in the course of NASA's total research and development activities.

These arise in NASA's in-house centers or their contractors' laboratories and shops. Once these innovations are identified, the second objective is to catalog them in appropriate industrial technical areas so that they can be stored and retrieved as needed in response to industrial inquiries for information. The NASA field centers participate fully in these activities, and the data retrieved through the industrial applications program are available in all centers.

The next sequential steps are adequate dissemination and transfer of this knowledge. A NASA innovation is of little benefit to the businessman, whose productivity it may affect, unless he is aware of its existence and potentialities. Therefore, we have to develop a reasonable mechanism by which contractors, commercial organiza-

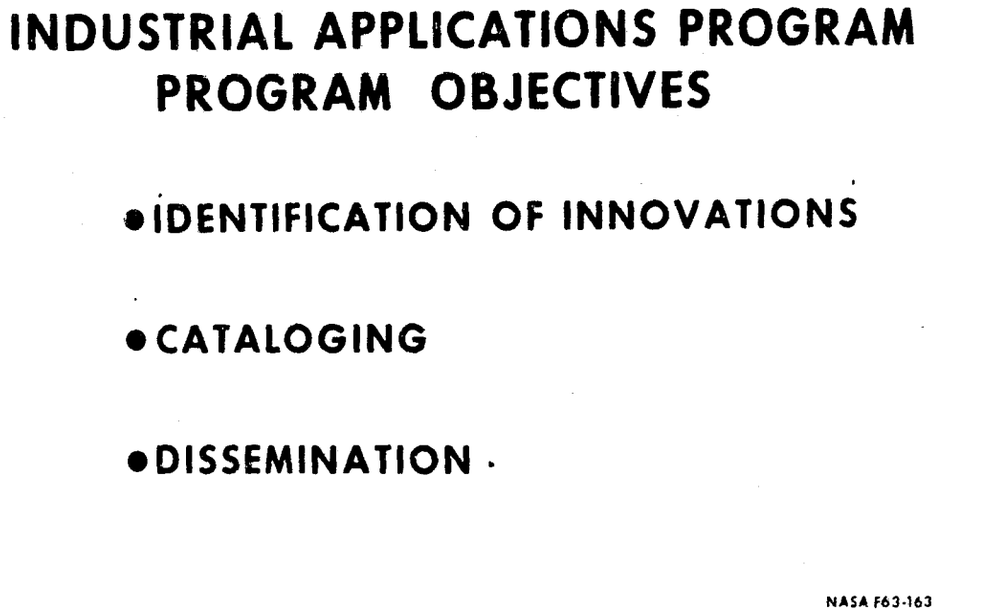

FIGURE 15

tions, universities, and other laboratories have ready access to knowledge concerning NASA's innovations. In this way they can determine for themselves whether their adaptation would be of value. The procedure we have adopted for meeting these objectives is outlined on the next chart, shown in figure 16, which outlines innovation data flow for industrial application work.

As I have mentioned, innovations originate either at NASA centers or with their contractors. Documentation of sufficient information to evaluate the innovation is forwarded to NASA headquarters where an evaluation and cataloging operation is carried out; the innovation is screened, analyzed for industrial potential and put into industrial language.

To help in this evaluation, the assistance of a number of contractors shown on this chart (fig. 17) has been enlisted. You see we have participating in this activity several nonprofit research institutes, one commercial research organization, and one university. The geographic displacements of these groups assist in providing NASA with an insight into the needs of the industrial community of the Nation.

The Indiana University effort is unique in that it is now starting a regional center for dissemination of space research data. The center will be staffed cooperatively by personnel on assignment from commercial organizations as well as by the university.

For over a year now, Midwest Research Institute, which concentrates its effort in six Midwestern States, in addition to participating with the other organizations in analyzing innovation data has been working on the pilot study of the dissemination program with NASA. Its staff has visited NASA centers and has been briefed on new processes, techniques, and materials which have been developed.

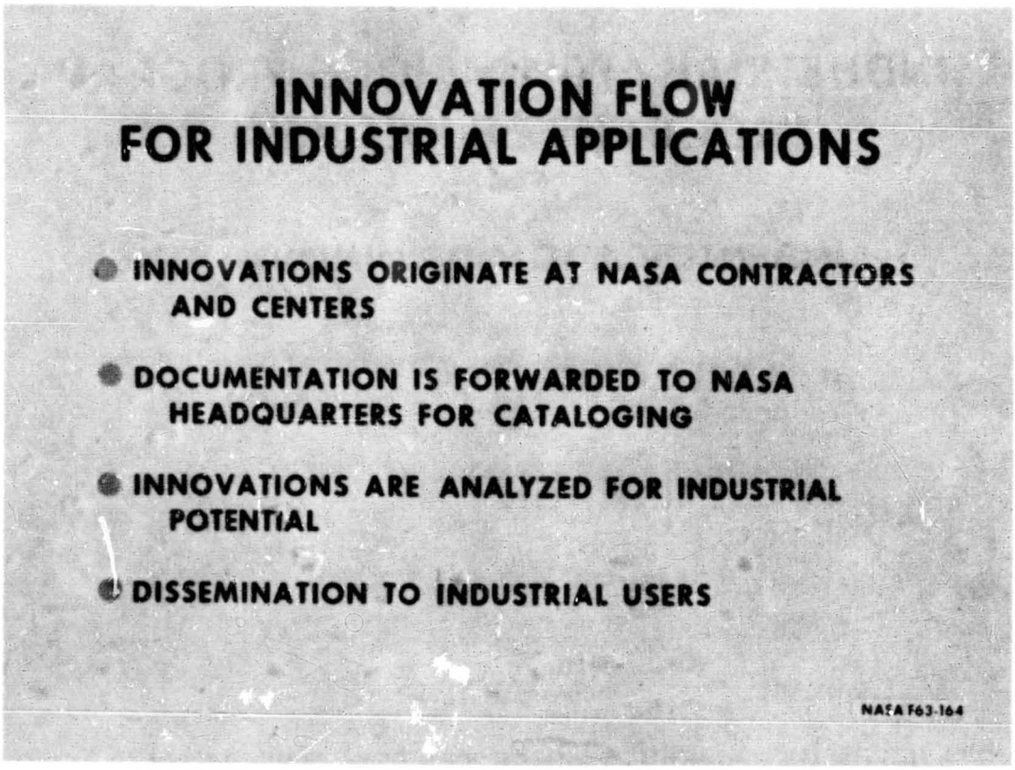

FIGURE 16

FIGURE 17

Two examples of the kinds of innovations identified are as follows:

The first is a weld seam tracker and proximity control. The Marshall Space Flight Center was responsible for developing this improved method of guiding an electric arc welding head along the seam separating two pieces of metal that are to be welded. The device, which has aroused considerable industrial interest, locates the seam or crack between these pieces and guides the weld head accurately along the crack.

Prior to the inception of this device, MSFC had found that existing techniques available to them were not successful for following weld seams between heavy gage aluminum. The proximity control senses the distance between the arc welding torch and the pieces being welded, automatically maintaining the proper distance required for the best weld.

A leading farm machinery manufacturer is investigating the use of this device for joining two channel sections into a wagon tongue box beam, thus eliminating the need for machining of the channel edges thereby reducing the costs. Two leading welding equipment manufacturers have also expressed interest in this welding technique.

The second example is the single pass welding technique being used by the Saturn project staff at Marshall Space Flight Center. To achieve desirable symmetry and shape of a weld head, particularly in cylindrical sections of large aluminum sheets, either grooved backup bars or a double pass technique were used; both costly methods.

MSFC substituted pressure-sensitive silicone adhesive fiberglass tape, pressing it into place, straddling the inner weld seam. The molten underbead was retained by the refractory tape, was properly shaped, possessed a smooth weld head, with a stong, nonporous weld, free of oxide scale inclusions.

A manufacturer of furnace and air-conditioning equipment is now using the tapes in fabricating high-pressure cylinders up to 40 inches in diameter. In addition to the cost savings, they have obtained better quality welds. Many other concerns have also expressed interest in this and other NASA-developed and NASA-utilized welding techniques.

In our present effort we will investigate promising innovations in the depth and detail needed to prepare writeups for use by industrial organizations in determining the adapatability of the new ideas to their applications. Several media for dissemination are being considered, including publications, direct contact with industry, contact through trade associations, trade journals, professional societies, coordination with State economic development departments, area development groups and others.

The space research and development effort is so broad that there will be ideas and innovations in almost every field. Products, based upon space development and produced using techniques and materials created for space use, may become increasingly evident with time in the everyday life of the Nation.

The applications program ranges over a very broad spectrum of scientific and industrial activity. We are concerned with investigations from purely scientific interest in atmospheric physics to problems associated with commercial communications satellites.

It is a very challenging area of work and it is most satisfying to our people to find that great benefits are accruing to the Nation from

meteorological and communications satellite developments, and now from industrial applications as well.

Thank you.

Mr. RYAN. Thank you, Dr. Seamans. As you know, this hearing will be primarily devoted to communications satellites but I thought that your description of the industrial applications program was excellent and we look forward to hearing about it in more detail on Thursday.

Dr. SEAMANS. Yes, sir.

Mr. RYAN. At this time I yield to Mr. Hechler who wishes to raise a question which is of some significance because of its timing today, with regard to a recent space shot. Mr. Hechler.

Mr. HECHLER. Thank you, Mr. Chairman; I just wanted to get your reactions, Dr. Seamans, and any comments you might care to make on a wire service report that the Soviet Union today alleges to have launched a space rocket destined for the Moon.

According to this wire service report, Tass says:

> An automatic station, Moon 4, weighing 1,422 kilograms or 3,130 pounds is installed aboard a space rocket. The automatic station is expected to reach the area * * * of the Moon in three and a half days. The last stage of the rocket, according to Moscow radio, was put into intermediate orbit and there was sent toward the Moon.

A further statement as it is reported by the wire service says:

> In accordance with the program for exploration of outer space, the planets of the solar system, the space rocket was launched in the Soviet Union on April 2, toward the Moon.
>
> The final stage of the rocket was preliminarily set on intermediate orbit of the Earth's man-made Sputnik. This was launched and emerged into the preset trajectory of the flight.

That is the end of the wire service report, and I wondered, Dr. Seamans, if you had any comments about this or any theories as to what this launching might signify?

Dr. SEAMANS. I am afraid, Mr. Hechler, that anything I could say would be pure speculation. I only know what you have read.

It does not surprise me personally, because we know of the Soviet's great interest in space exploration and this is one more logical step in their program.

Mr. HECHLER. In other words, you think they do have the capability to do what they say they hope to do on this particular job, do you?

Dr. SEAMANS. I don't think there is any question that they do have a probe on its way to the Moon.

Mr. HECHLER. I think the history of our space program has shown that perhaps some of these things are healthy so far as American progress is concerned. Would you not say so?

Dr. SEAMANS. Both countries are interested in exploring space and we hope that we can each take advantage of the other's work to a certain extent.

Mr. HECHLER. Perhaps we would not have been seeing so much done if it were not for the progress that has been made there?

Dr. SEAMANS. I think that is an observation that you can make as well as myself.

Mr. HECHLER. Thank you, Mr. Chairman.

Mr. RYAN. Thank you, Mr. Hechler. I understand that Mr. Jaffe has a prepared statement, Dr. Seamans?

Dr. SEAMANS. Yes, he does.

Mr. RYAN. Mr. Jaffe, I think the members of the subcommittee are familiar with the content of your statement—I read it and found it to be a very detailed exposition of the program and we are grateful to you for the effort that you have put into the preparation of this statement.

I am going to make a suggestion that your statement be submitted for the record and perhaps you would like, in a 2 or 3 minute period, to comment briefly upon your statement and then the subcommittee will raise questions concerning it and concerning the program.

Is that agreeable to you?

Mr. JAFFE. Yes, sir. If that is the chairman's desire.

Mr. RYAN. Very well then, we will be glad to hear from you at this time.

Mr. JAFFE. Thank you, Mr. Chairman.

STATEMENT OF LEONARD JAFFE, DIRECTOR, COMMUNICATIONS SYSTEMS, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. Chairman and members of the subcommittee, a major activity of the Office of Applications is our work on communications satellite systems. This first chart (fig. 18) indicates the NASA program objectives in this area. These are, first, to insure the full development and realization of communications satellite potentials through continued research, development and flight test, and, second, to assist in the early establishment of operational communications satellite systems. The fact that communications satellites are feasible has certainly been demonstrated with the Echo, Telstar, and Relay

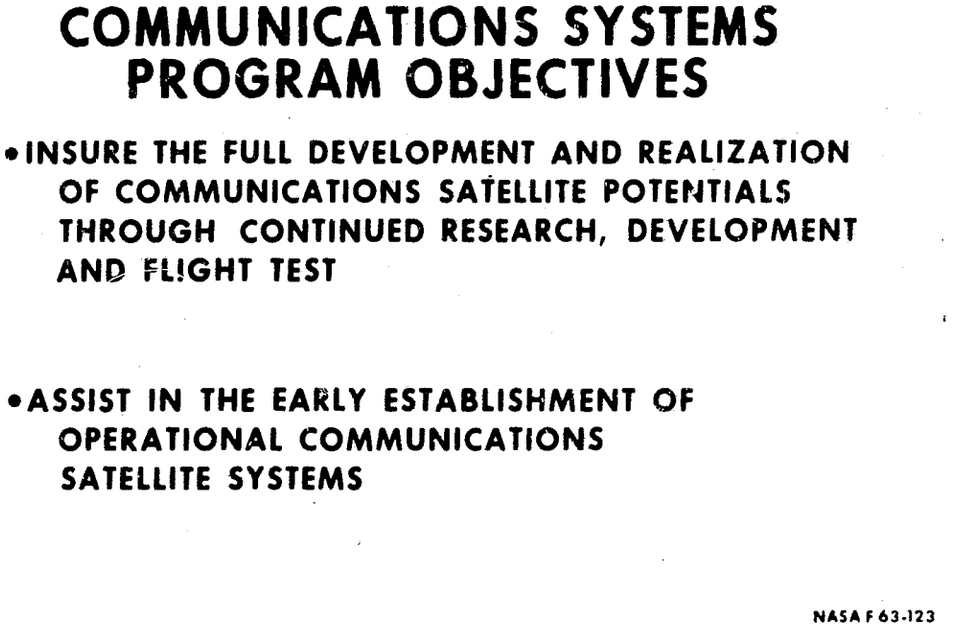

FIGURE 18

satellites. Much information and experience has been gained as a result of the last year's experiments with regard to the satellites, the space environment, and with the Earth-based elements of such systems. Much remains, however, to be done before economically practical systems can be established, but a sound foundation has been laid and all of the established interests are cooperating to the fullest extent in the research and developmental programs.

ORGANIZATIONAL INTERACTIONS

In all areas of satellite applications, NASA has many interactions with other organizations. Typical interactions already in existence in the area of communications satellites are those with the Department of Defense and the American Telephone & Telegraph Co. Shortly, a continuing liaison will be initiated with the new Communications Satellite Corp. Under the Communications Satellite Act of 1962 which, as you know, was the subject of extensive consideration and review in the last Congress, NASA is charged with the responsibilities shown on the accompanying chart (fig. 19). These include the necessity to provide technical advice to the Federal Communications Commission on communications satellite systems, to cooperate with the private corporation established under the act in carrying out research and development on communications satellite systems, to consult with the corporation regarding the technical characteristics of satellite systems, and to furnish the corporation launching and other appropriate services in support of both the corporation's research and development program and its operational systems. This means there will be a close interaction between the NASA communications systems program and the program that will be developed by the new Communications Satellite Corp.

For the moment we have only limited contact as the corporation has not as yet established a technical staff. We have had an opportunity to pass on information on the NASA program and its objectives and plans to the incorporators appointed by the President. As soon as the corporation's technical management team is formed, we expect that it will undertake to set up appropriate liaison with our program office. Launching support arrangements that will be made with the corporation should not be very different from those which we have already made with the American Telephone & Telegraph Co. for the support of Project Telstar. In that case, a project development plan and a contract were prepared which outlined the responsibilities of both the Telephone Co. and NASA for the conduct of the project. The plan included a provision for reimbursable funding for the services furnished by NASA in launching Telstar. To date, this arrangement seems to work very well. We have had, of course, just one Telstar launch, but are presently planning, at A.T. & T.'s request and under the terms of the original agreement, a second launch for this spring.

NASA's relationships with the DOD with regard to communications satellites are conducted as a portion of the general arrangements that have been established for NASA–DOD coordination as indicated on the accompanying chart (fig. 20). The major policy decisions come from the deliberations and decisions of the Space Council. They then are established as directives to the two agencies by the

NASA RESPONSIBILITIES UNDER COMMUNICATION SATELLITE ACT OF 1962

- PROVIDE TECHNICAL ADVICE TO FEDERAL COMMUNICATIONS COMMISSION
- COOPERATE WITH CORPORATION IN RESEARCH AND DEVELOPMENT
- CONSULT WITH CORPORATION REGARDING TECHNICAL CHARACTERISTICS OF SATELLITE SYSTEMS
- FURNISH LAUNCHING AND OTHER SERVICES IN SUPPORT OF THE CORPORATION'S R & D PROGRAM AND OPERATIONAL SYSTEMS

NASA F 63-124

FIGURE 19

NASA - DOD COMMUNICATIONS SATELLITE COORDINATION

SPACE COUNCIL

ADMINISTRATOR, NASA & SECRETARY OF DEFENSE

AERONAUTICS AND ASTRONAUTICS COORDINATING BOARD

UNMANNED SPACECRAFT PANEL

TECHNICAL COMMITTEE ON COMMUNICATIONS SATELLITES

NASA– DCA

ARMY– NAVY

AIR FORCE

NASA F 63-125

FIGURE 20

Administrator of NASA and the Secretary of Defense. Technical proposals which have been coordinated at the working level are brought up for review to the Aeronautics and Astronautics Coordinating Board. Under this Board, which ties together many items of joint interest to NASA and DOD, there is an Unmanned Spacecraft Panel. This Panel has, in particular, responsibilities of a coordinating nature for communications satellites, meteorological satellites, unmanned lunar and planetary exploratory spacecraft and the like. In February 1961, the Unmanned Spacecraft Panel established a Technical Committee on Communications Satellites with the objective of seeing to it that the directing officials for the various projects in the communications satellite area would be entirely familiar with the work being done by all other Government agencies so that those projects could be effectively coordinated. At the present time this Committee draws its membership from NASA, Army, Navy, Air Force, and the Defense Communications Agency (DCA). This last, the DCA, has recently been given the responsibility for the furtherance of the Department of Defense communications satellite program. The Army directed a major segment of the old Advent program and is now supporting the new DOD program as well as the NASA Syncom program. The Navy is concerned as a user with communications satellite development and is also supporting NASA's Syncom program with the U.S.N.S. *Kingsport*, a Victory ship which has been converted into a mobile station for the support of communications satellite studies. The Air Force has the responsibility, within DOD, for the launching of communications satellite systems and for the development of the satellites. In addition, frequent consultation is held between members of top management of NASA and DOD. Admiral W. F. Boone has recently been appointed to assist the Associate Administrator in the NASA–DOD coordination effort for all areas of mutual interest.

SUPPORTING RESEARCH AND TECHNOLOGY

In the communications program there is a continuing underlying activity in supporting research and technology on which we build for the future. From our theoretical studies and investigations we look for information which will assist us in giving direction to our program. Research and development is a way of progressively reducing uncertainty by buying information. Our research includes such activities as analytical studies to determine the best orbital arrangements for communications satellite systems. Here we study the factors affecting the choice of orbit for satellites that are to provide full-time communication between ground stations situated in various parts of the globe. Economic factors must also be considered along with the technical unknowns.

In another area, there is still disagreement with regard to which particular modulation technique should be used for transmission of intelligence by communications satellites. Frequency modulation systems minimize power requirements. Amplitude modulation systems require more satellite-borne power, minimize spectrum requirements, but at the same time impose severe linearity requirements on electronics subsystems and microwave generators. Pulse code modulation systems fall somewhere between frequency modulation and amplitude modulation systems. We are investigating various

modulation techniques and the utilization of higher radio frequencies for satellite communications. The results are very important to the national interest for they will assist in determining the most effective use of a most valuable natural resource, the radio frequency spectrum. As you know, the radio frequency spectrum is not unlimited in extent and the efficiency of its use can have serious implications for the welfare and economic growth of the United States. In this area, the use of single sideband for transmission of intelligence from the ground to the satellite shows advantage in terms of its efficient use of the spectrum and is being investigated.

Another research area which is being given particular attention is spacecraft antennas. Studies to arrive at the best antenna configurations for communications satellites are continuing. One such study and advanced technical development item is a phased array transmitting antenna with electronic controls to maintain its highly directional pencil-beam pattern directed toward the Earth from the spinning satellite. Such developments will also assist in conserving the spectrum and reducing the satellite power requirements. I will have more to say about this later when the advanced synchronous satellite is discussed.

We propose to continue studies concerning the space environment and its effects on satellite components and instrumentation.

In the area of operational and systems studies we propose to conduct a thorough parametric study of communications systems employing repeaters in stationary orbits. Other studies are directed toward the use of higher frequencies, and the use of high-powered repeaters in the high-frequency band. Here we will look at the future possibilities, particularly those beyond the interests of the common carriers, and required satellite configurations as well as the cost of such application. Examples of such future applications of communications satellites may be the use of higher powered satellites for air and sea traffic control and eventually, perhaps, the direct broadcasting of radio and television from satellite to the home receiver. Areas of research and development required to realize such applications will be identified during the courses of these studies.

There is no flight program currently planned in the passive satellite area following Project Echo II, which I will describe in a few minutes; however, we do intend to continue various supporting research and technology studies in the area of passive satellite techniques.

We are currently investigating materials which might be used at some future date for making passive satellites which are both lighter in weight and stronger than those heretofore available. Certain of these materials are openwork meshes which permit a majority of the sunlight to pass through, thus minimizing the tendency of solar light pressure to both deform the satellite and perturb its orbit by forcing it to lower altitudes where the aerodynamic drag is increased. We will continue our efforts to optimize these materials for potential passive satellite use.

Similarly we are developing new means for inflating such structures in a vacuum more reliably and to a more precise degree of pressurization. This effort will continue as will an investigation of other techniques for erecting large lightweight structures without inflation, thus perhaps permitting us to do away with the plastic membranes now required for the inflating systems. I might point out that this

membrane may account for more than half the weight of these advanced materials without contributing to the radio reflectivity characteristics of satellites which could be made from them.

Preliminary studies have indicated that some shapes other than spheres may be more desirable for passive satellite use. This results from the fact that a majority of the energy incident on a spherical satellite such as Echo is reflected into space rather than toward the Earth. We will study several of the structural shapes analytically and will experimentally evaluate the most suitable ones through ground tests of models.

FLIGHT PROGRAM

A portion of the supporting research and technology program is designed to bring into being critical elements or knowledge necessary to future flight programs. Sometime this year we expect to reach the flight test stage for the Echo II rigidized balloon. You will recall that last year we discussed the differences between the Echo I Mylar balloon and the Echo II aluminum laminate balloon. We conducted two tests of the Echo II structure in 1962. These were vertical shots from Cape Canaveral in which inflation procedures were tested. In the first of these the balloon burst; in the second, the balloon inflated in an essentially satisfactory manner. However, continuing studies of the radar reflections received from the inflated test sphere of the second test lead us to the conclusion that further studies of the structure and the inflation procedure are warranted before the orbital test is conducted. These studies are now underway.

This (fig. 21) shows a photo made by a camera within the Thor launch vehicle during the second vertical test. As you can see, we

FIGURE 21

have had excellent results with the testing techniques used on these sphere inflations. A film camera system is recovered from the sea down range at the end of the test. Also in the launch vehicle is a TV system which continuously televises back to the cape control point, the details of the inflation process. Instrumentation such as this will probably prove to be an invaluable tool in other programs as well for observing what goes on in space at the critical times of separation of spacecraft from launch vehicles. As a matter of fact, in the second test shot it was possible to see the sphere as it followed a ballistic trajectory until it burned up upon reentry into the Earth's atmosphere some 20 minutes after its inflation.

The Echo II sphere is expected to be flown on the orbital trajectory shown in this figure (fig. 22). You can see that it will be launched from the west coast into a near-polar orbit, and that it will go to very high angles of latitude, thus affording an opportunity for experimenters all over the world to conduct reflection and communications experiments. It is this sphere that will be used in the communications tests recently agreed to jointly by the United States and the U.S.S.R.

The active communications satellite today holds great promise for the future and is the area in which we are expending our greatest effort. As you know, this satellite is one which carries power supplies, transmitters, and receivers and so is not just a metallic reflecting surface from which the signal bounces on its way from the originating station to the receiving station—as is the passive satellite. Because it is a powered repeater, the active communications satellite can be quite a bit smaller and it is possible to use less sensitive ground

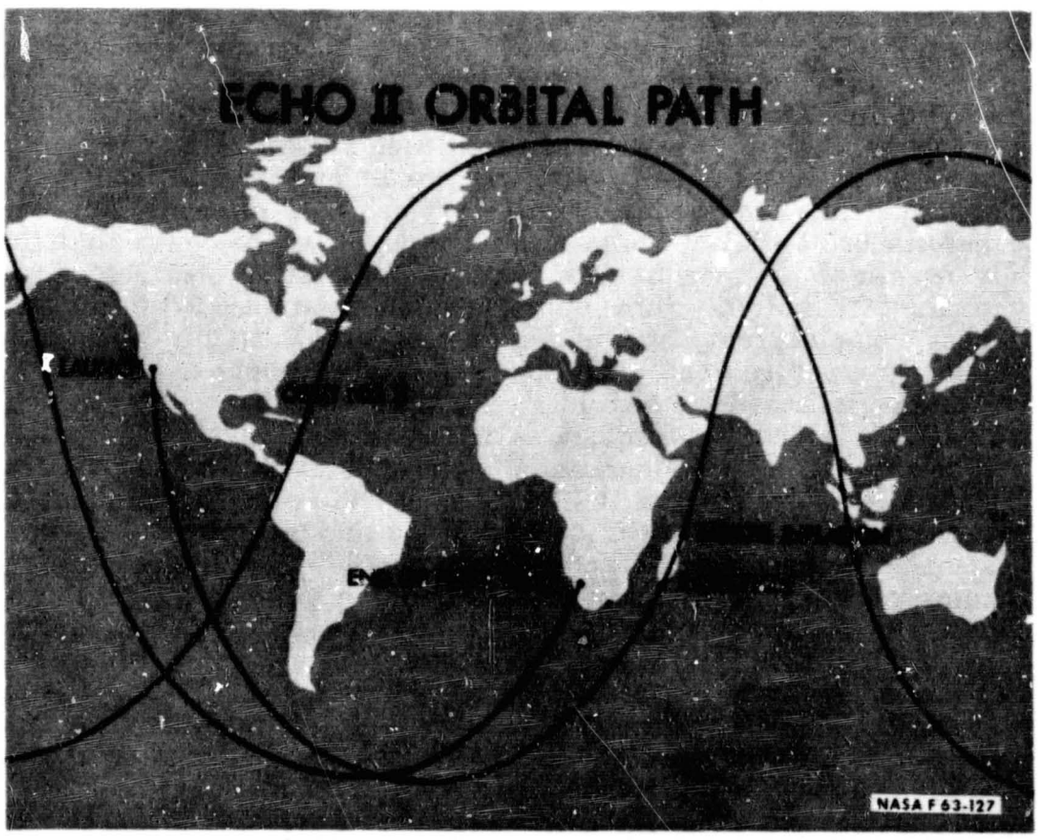

FIGURE 22

receiving equipments and less powerful ground transmitting equipments than are needed for passive satellites. It does have the difficulty that it depends for its performance on a large number of electronic components in the spacecraft. In certain designs many mechanical components are also needed. The difficulties we presently have in achieving reasonably long life with complex satellites are reflected in the performances realized with the Telstar and Relay satellites. Both Telstar and Relay were given all the possible care that one could conceive of in their design and construction. Telstar, which was designed to have a usable life of at least the 2 years that were to elapse before the automatic timer was to cut off its transmitter, failed to obey commands transmitted from the ground controller after only a few months. With the use of specially designed ground commands, Bell Telephone Laboratories engineers were able to cause Telstar to respond to its commands again for a time, but unfortunately the trouble has again occurred and Telstar is now silent. In Relay we found that after a very successful launching and the achievement of an excellent orbit, the satellite at first appeared to operate perfectly normally. After several hours in orbit, the power supply voltage dropped unexpectedly. This, it was later determined, was due to a current drain in the spacecraft caused by leakage in one of the voltage regulators. Fortunately, two completely independent sets of electronics are carried in Relay. When the leak reduced itself with time, we were able to turn on the second transponder and it performed well. Relay has been in use since early January of this year and over 500 engineering tests and demonstrations have been performed using the satellite. It is still operating, but extreme care must be exercised to control the temperature of the satellite so that the initial trouble does not reoccur.

The next photograph (fig. 23) shows in schematic form the two major orbital altitudes of interest for active communications satellite systems. The low to intermediate altitude systems are shown as a number of satellites in relatively close proximity to the surface of the Earth and the synchronous or stationary orbit satellites are shown in equatorial orbit at 22,300 miles. I am sure you will recognize that the advantages of the synchronous orbit are at least in part associated with the fact that only three operable satellites are needed to provide almost complete coverage of the whole world. (Only the polar regions are not covered with this basic synchronous system.) At the low or intermediate altitudes a large number of satellites are required. A typical analysis shows that a minimum of 40 satellites will be required to provide essentially continuous worldwide coverage.

NASA has developed in the Relay spacecraft project experimental satellites of the type that can be used in low and intermediate altitude systems. Relay and Telstar closely resemble one another in some details, yet are different in others. There are a number of technical differences in Relay and Telstar when one considers the communications transponders. Power ratings of the transmitters as well as the number of transponders available are different in the two systems. The mechanical structure is quite different. The operating frequencies are also different so that we can examine the effects on transmission of operations in more than one frequency band.

The photograph (fig. 24) shows the Relay spacecraft in final checkout on the last stage of the launch vehicle; the technicians doing the work

FIGURE 23

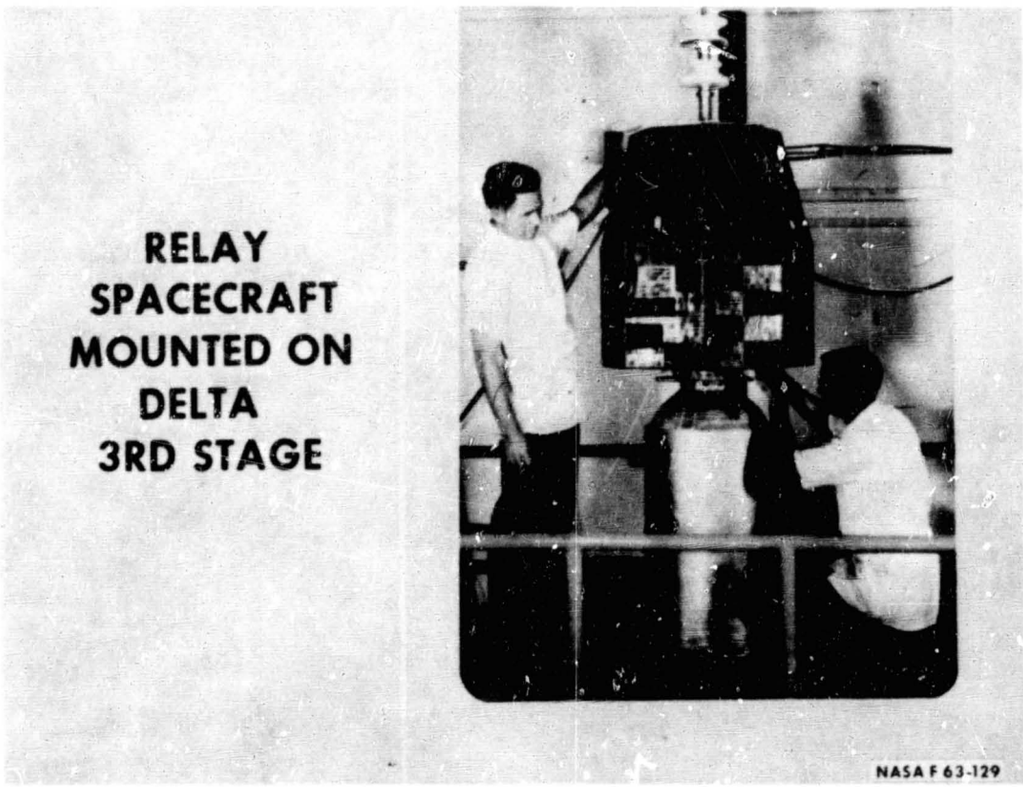

FIGURE 24

give you the scale for the size of the unit. The unit with the ringlike elements above the spacecraft is the antenna structure; it handles both transmission and reception for the communication links. There is also a telemetry antenna on the spacecraft which is not readily visible on this photograph. The solar cells are interrupted at a few points on the surface of the satellite for the installation of instruments which are added because of the experimental nature of the satellite. These instruments include radiation detectors, sunangle detectors, and components which have been included for damage experiments in the radiation belts.

On this photograph (fig. 25) we have shown the stations cooperating in the Relay experiments. The broad international interest in communications satellites is illustrated by the extent to which other countries are willing to fund ground facilities for experimental purposes. At top left is the Relay Test Station with its 40-foot antenna, located near the JPL Deep Space Instrumentation stations at Goldstone, Calif. Next is the most publicized of all ground stations, the A.T. & T. installation at Andover, Maine, built for Telstar operations. The third picture shows the 85-foot antenna of the British GPO station at Goonhilly Downs in Cornwall. Top right is an artist's conception of the 82-foot antenna for the German station at Raisting, near Munich. It should be operating by the end of this year. Lower left is the 100-foot antenna being built at the Japanese Government's Radio Research Laboratories' station about 40 miles from Tokyo. This station will be in operation in 1964. Another station will be built by the Japanese Overseas Radio & Cable Co. (KDD) about 60

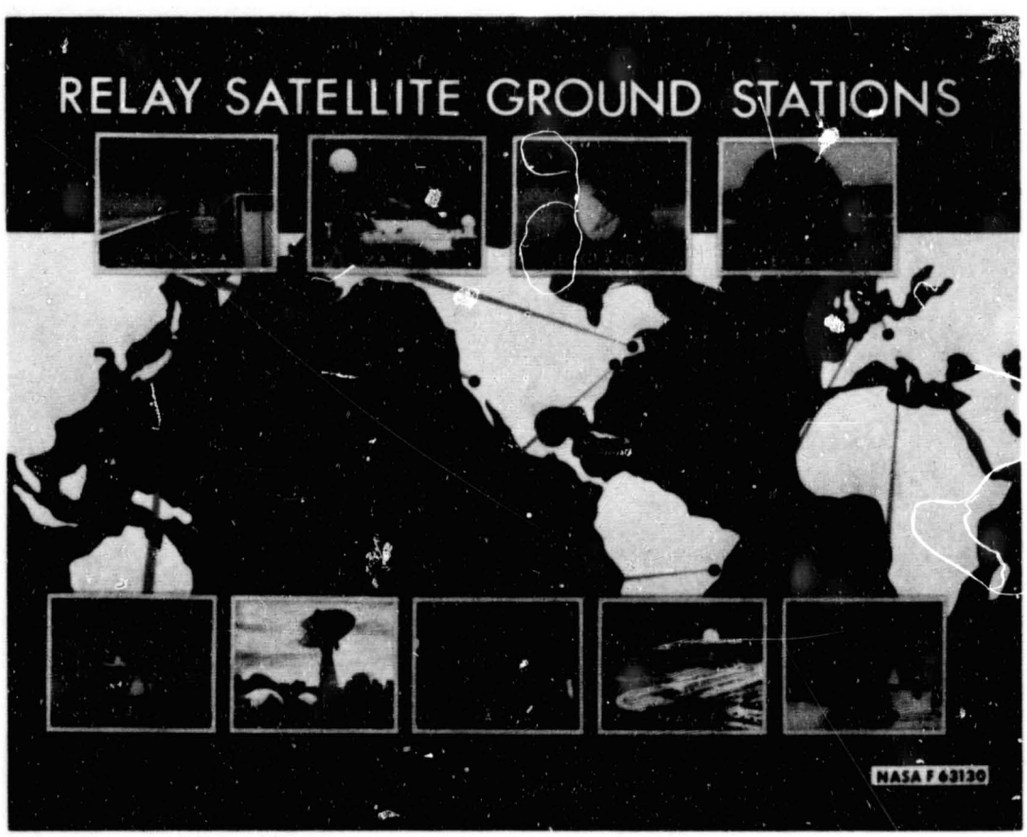

FIGURE 25

miles north of the RRL station. It will be operational in 1965, and will have a 65-foot antenna. The next picture is of the 40-foot antenna at the I.T. & T. Laboratories, Nutley, N.J., which is shared between the I.T. & T. station and NASA's Relay Test Station. Lower center is a transportable station, with its 30-foot antenna, built by I.T. & T. for their affiliation in Brazil. This station is now installed and operating near Rio. Next is the station of the French Government Telecommunications Laboratory (CNET). It was built to the same specifications as the A.T. & T. station at Andover. Finally, we have the 30-foot antenna of the Italian station at Fucino, Italy.

Several other countries have indicated interest in providing ground stations for communications satellites, including the Scandinavian countries, Canada, and India.

Both Relay and Telstar were highly instrumented to measure the effects of the space environment, particularly radiation on the components of the satellites. The accumulated data will be of tremendous value to the designers of all future applications and scientific satellities, as well as future communications satellites.

As I have indicated above, both Relay and Telstar are examples of developmental satellities for application in fairly low earth orbits. Now we come to our program for developing communications satellites for the synchronous orbit.

I have brought this photograph (fig. 26) to emphasize how thoroughly three synchronous satellites in the Earth's equatorial plane can cover the Earth's surface from the 22,300-mile orbit. Each shaded section indicates the area of visibility for a single synchronous satellite. You see that one satellite can cover South America, the

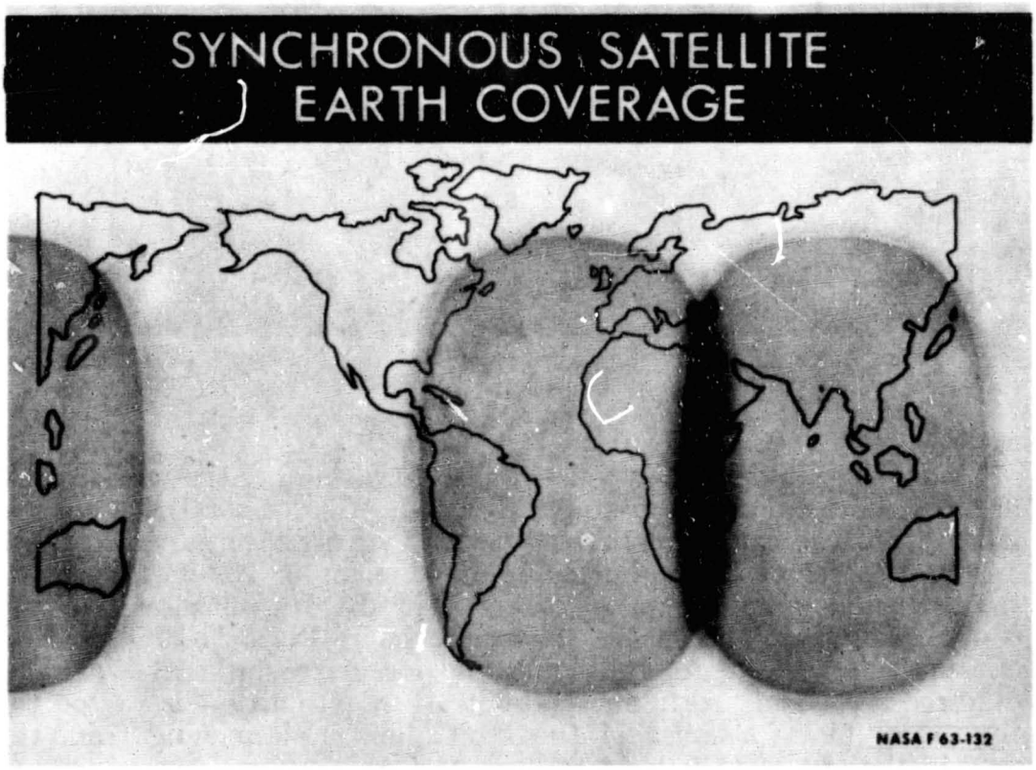

FIGURE 26

east coast of the United States, and major portions of Western Europe and Africa. Another one can tie Europe to the Far East and a third one stationed above the Pacific can tie the Western United States to Japan and Australia.

NASA has established Project Syncom as a first step toward providing experience in the synchronous orbit. Here is a photo of Syncom (fig. 27). The most distinguishing feature of Syncom is the fact that it carries within it a rocket stage. Syncom is launched by a Thor-Delta, which is in itself a three-stage rocket booster. In order to get to a 22,300-mile altitude and to arrive at a circular orbit, one needs a great deal of energy even though the satellite may be quite small. The total Syncom satellite weight is about 160 pounds. About one-half of this is associated with the rocket, which, of course, does not contribute to the communications capability.

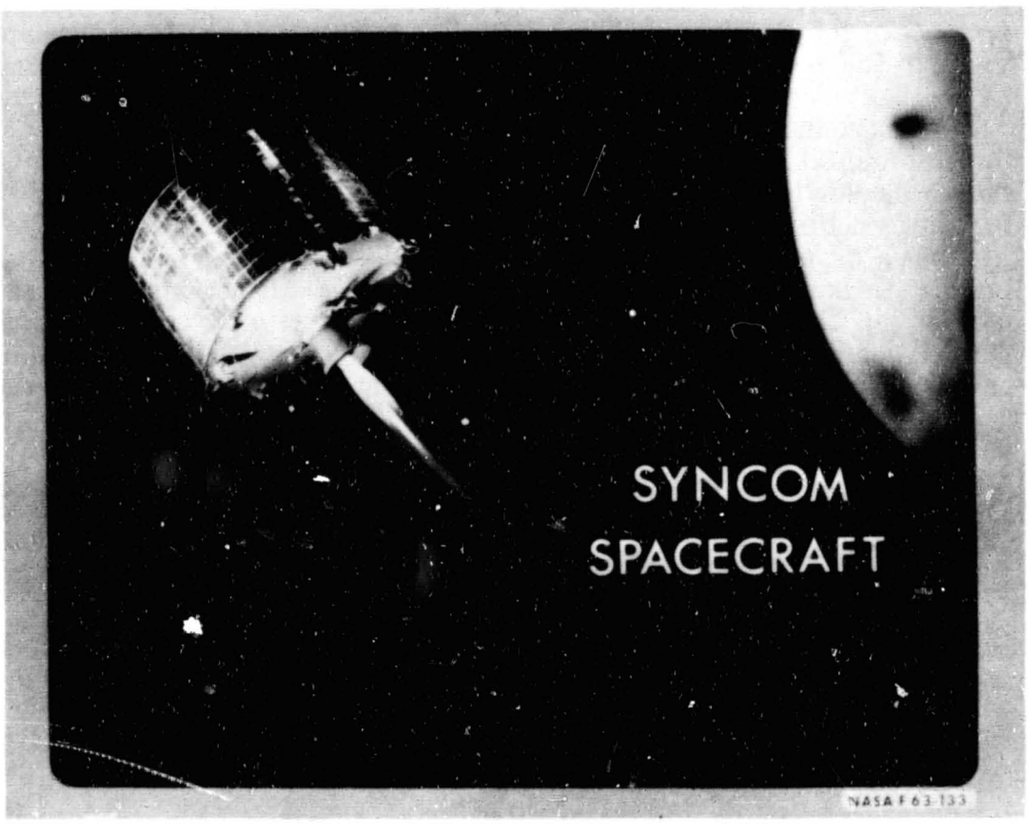

FIGURE 27

I would now like to show you the plan for attaining the synchronous orbit with the next photograph (fig. 28). The Thor-Delta vehicle starts from the cape and takes Syncom with its internal rocket into an elliptical orbit whose apogee is at a height of 22,300 miles. At that altitude the spacecraft's rocket is fired. Its purpose is to add enough energy to the spacecraft to circularize the orbit. This orbit is almost but not quite the equatorial circular orbit that would be required for a truly stationary satellite. In actuality it is 33° off the equatorial plane because of the limitations in launching from the cape of the energy that we now have available.

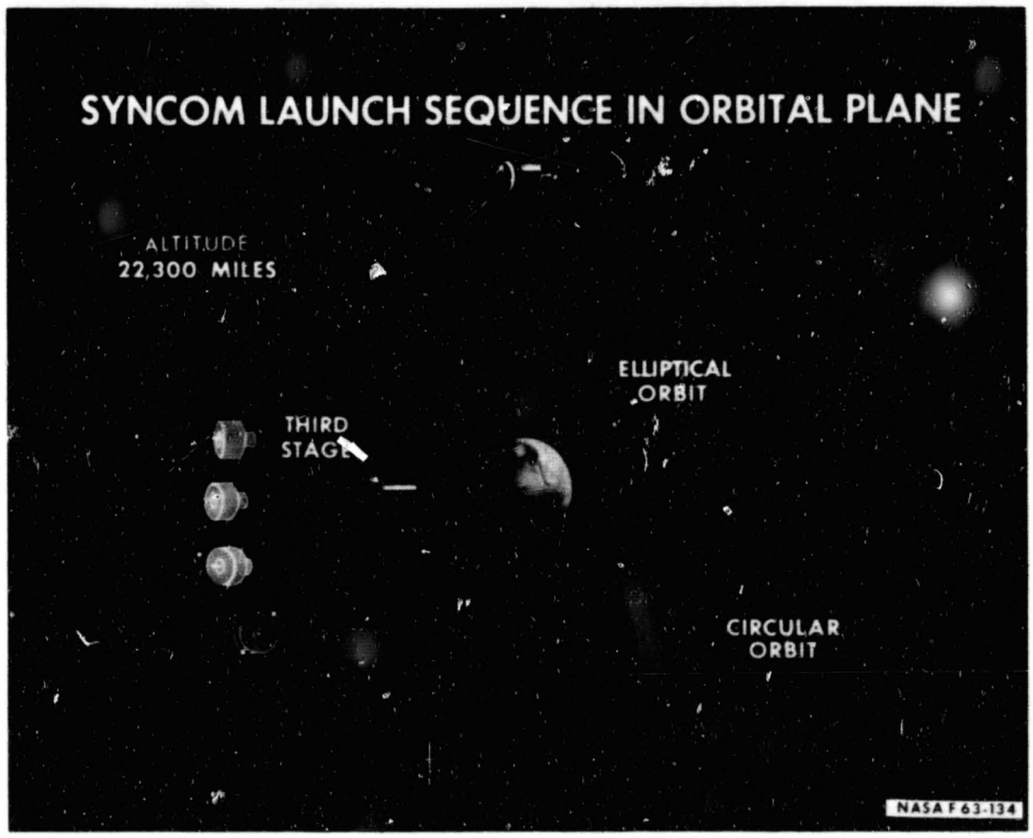

FIGURE 28

At an appropriate point on this circular orbit the ground control system is called upon to rotate the satellite so that its antenna radiation pattern is properly located with respect to the Earth. The Syncom satellite is spin stabilized. As it is turning on its axis at all times and so tends to maintain its angular position in space, it takes a fairly complex ground control system to push the satellite into the proper location with respect to the equatorial plane. The Syncom satellite carries detectors for sunlight, so it is possible to transmit directly to the ground over the telemetry channel exactly the rate at which the Syncom is spinning. It also is possible to transmit to the ground data which can be interpreted to tell just what the relation of the spin axis of the satellite is to the line to the sun. The controller device which is shown in this photograph (fig. 29) is used by the ground operator to send corrective signals to small reaction jets mounted in the satellite. These reaction jets tip the satellite in the proper direction to bring the axis to the optimum point for transmission of signals to the ground. They also can provide the forces to move the satellite around the Earth to the longitude selected for operations. This sequence is indicated to demonstrate the complexity of the Syncom mission and the number of subsystems which must work in order to complete the mission successfully.

For Syncom, we are making use of ground stations developed by the Department of Defense, as shown on this chart (fig. 30). Ground station arrangements have been a responsibility of the U.S. Army Satellite Communications Agency working under the overall project

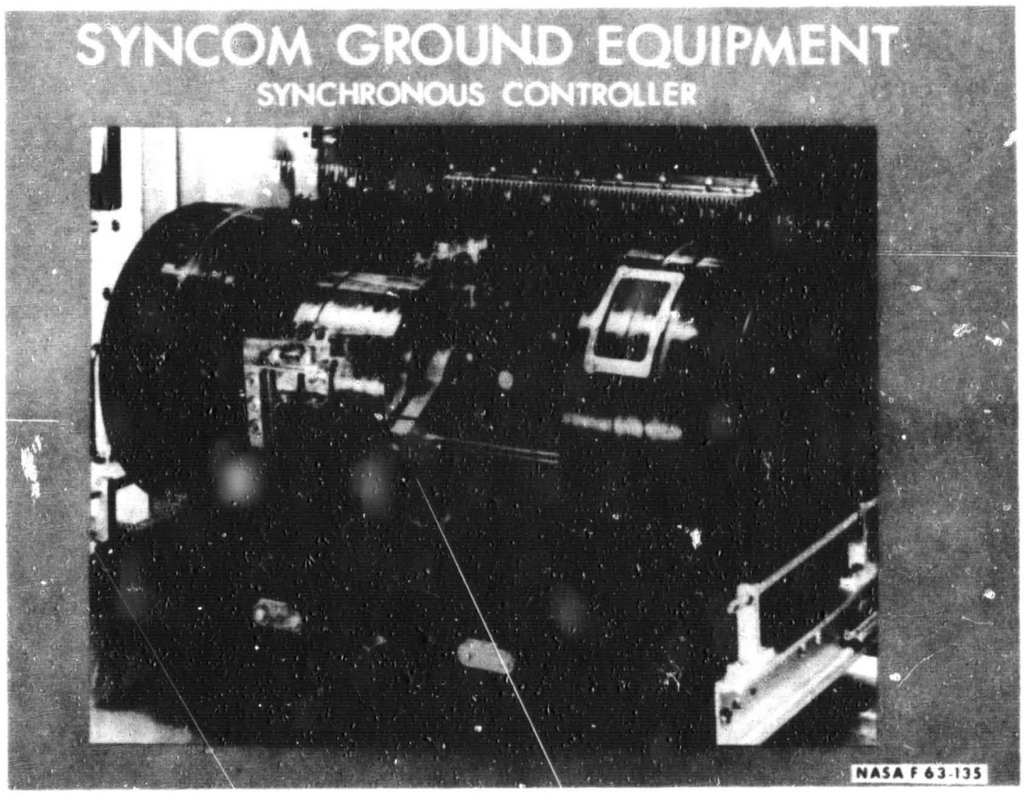

FIGURE 29

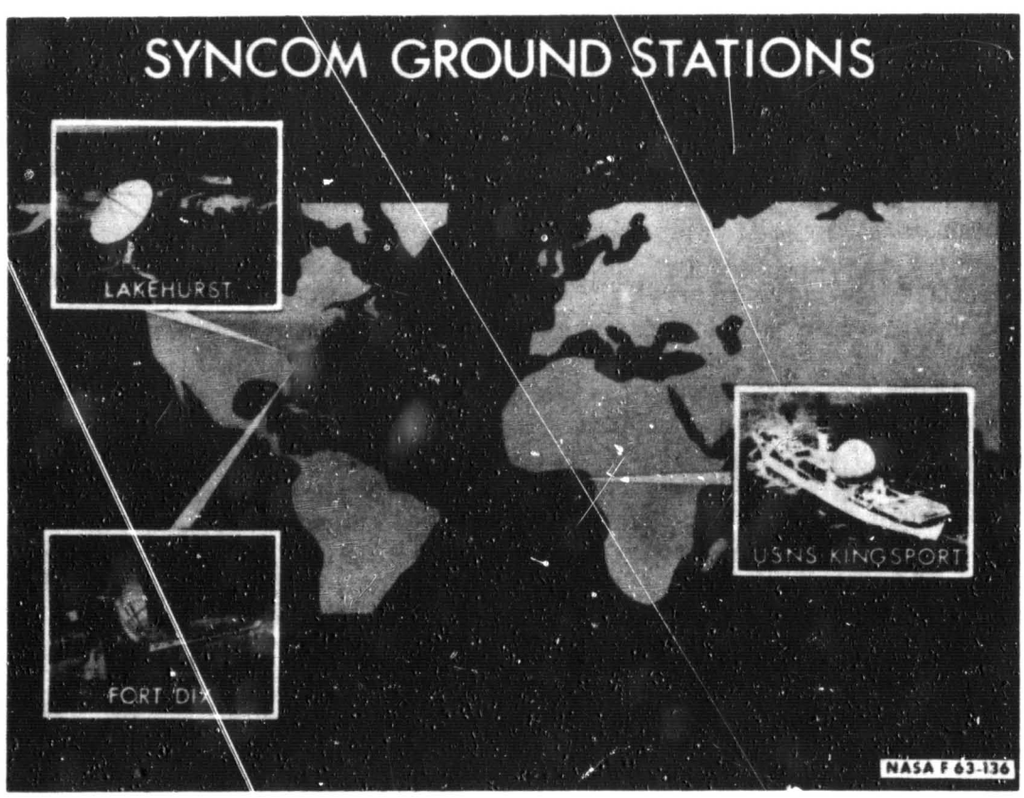

FIGURE 30

management of NASA's Goddard Space Flight Center. At the upper left of the chart is the primary Syncom station in the United States at Lakehurst, N.J., where the DOD has installed transportable equipment. The DOD fixed station at Fort Dix, N.J. (lower left), has been modified from its original Advent configuration to provide a communications backup capability for the Lakehurst station. Another Advent facility modified for Syncom is the U.S.N.S. *Kingsport* shown on the right. The *Kingsport* is stationed in the harbor at Lagos, Nigeria, where it performs the initial tracking, stabilization and orientation of the Syncom satellite, and would conduct communications experiments with Lakehurst or Fort Dix.

Syncom I was launched from the cape on February 14, 1963. The launch was near perfect and the satellite was injected into the elliptical orbit. It takes about 5 hours for the satellite to reach apogee. During this time Syncom's communications equipment was periodically turned on, and transmissions consisting of tone, teletype, voice and music were sent from the U.S.N.S. *Kingsport* to the satellite, and they were received back at the *Kingsport*, showing that the communications equipment was working well. Syncom's telemetry signals were also being received on the ship and at other tracking stations. As the satellite approached apogee, the onboard rocket was fired. Approximately 20 seconds later, telemetry signals stopped and Syncom has been silent since then. It has been established through telescopic observations that Syncom I is indeed in an orbit with a period of approximately 23 hours and 45 minutes. Thus, for the first time a satellite has been placed into a nearly synchronous orbit. Its existence, even though silent, will give us information regarding the perturbations to the orbit of such a satellite introduced by the nonspherical nature of the Earth and the gravitational pull of the Moon. Analysis of the data is still continuing to determine the cause of the failure, prior to a second launching of the Syncom program. The fact that the synchronous orbit was achieved precludes the possibility of the blowing up of the "apogee kick" rocket motor, as had originally been suspected.

Management relations for a project like Syncom are illustrative of the interactions that take place in the applications program. This chart (fig. 31) shows how our Goddard Space Flight Center, with its project manager located at Greenbelt, is responsible for the coordination of the activity of a number of subsystem managers. Directly associated with Goddard's activity is the ranging system which was built under Goddard specifications by the Space Technology Laboratories. The Syncom spacecraft itself was built by the Hughes Aircraft Co.; the launch vehicle, the Delta, is built by the Douglas Aircraft Co.; and the tracking for ordinary operations is conducted by Goddard's own Minitrack network. The U.S. Army Satellite Communications Agency is responsible for the direction of the work conducted by the Bendix Corp. on the communications ground stations. Of course the U.S. Navy participated in no small measure in establishing the *Kingsport* as a satellite communications vessel.

As a follow-on to the Syncom project, which will continue through this coming year, NASA has initiated studies on an advanced synchronous communications satellite. This satellite will be appreciably larger, will weigh on the order of 500 pounds, and will require an Atlas-Agena booster vehicle for launch rather than the Thor-Delta

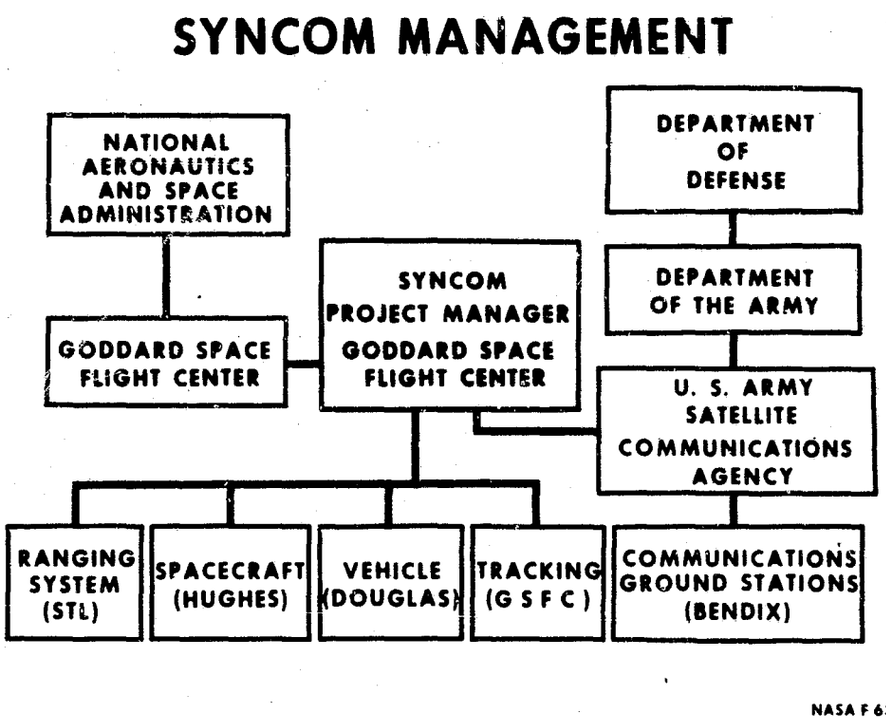

FIGURE 31

used with the Syncom. One of the major changes which we hope to introduce in the advanced synchronous satellite is the inclusion of a technique for continuously directing the radiated energy from the satellite to the Earth. The present Syncom satellite (fig. 32) is spin-stabilized, and its antenna accordingly must radiate uniformly in all directions about the satellite so that no matter what the rotational position of the satellite is, some of the radiated energy will hit the Earth. This is illustrated on the left side of the chart. Now, if we build a larger satellite with the same type of construction, the same thing would follow. However, as the satellite gets larger and more weight becomes available for us to work with, it is possible to include what amounts to an electrically driven contrarotating antenna. By this I mean that we can utilize an antenna whose radiation pattern is such that its radiated energy is concentrated in one direction. This antenna pattern must then rotate in the opposite direction to the satellite rotation so that it is always pointed at the Earth's surface. To do this takes a rather complex antenna design with a number of electronically controlled elements. We have already initiated the design and laboratory study of such a system at the Hughes Aircraft Co., as well as the development of some critical components of the proposed spacecraft. At the present time this development is coming along satisfactorily. As soon as the objectives of these preliminary efforts have been achieved, we will initiate the development of the

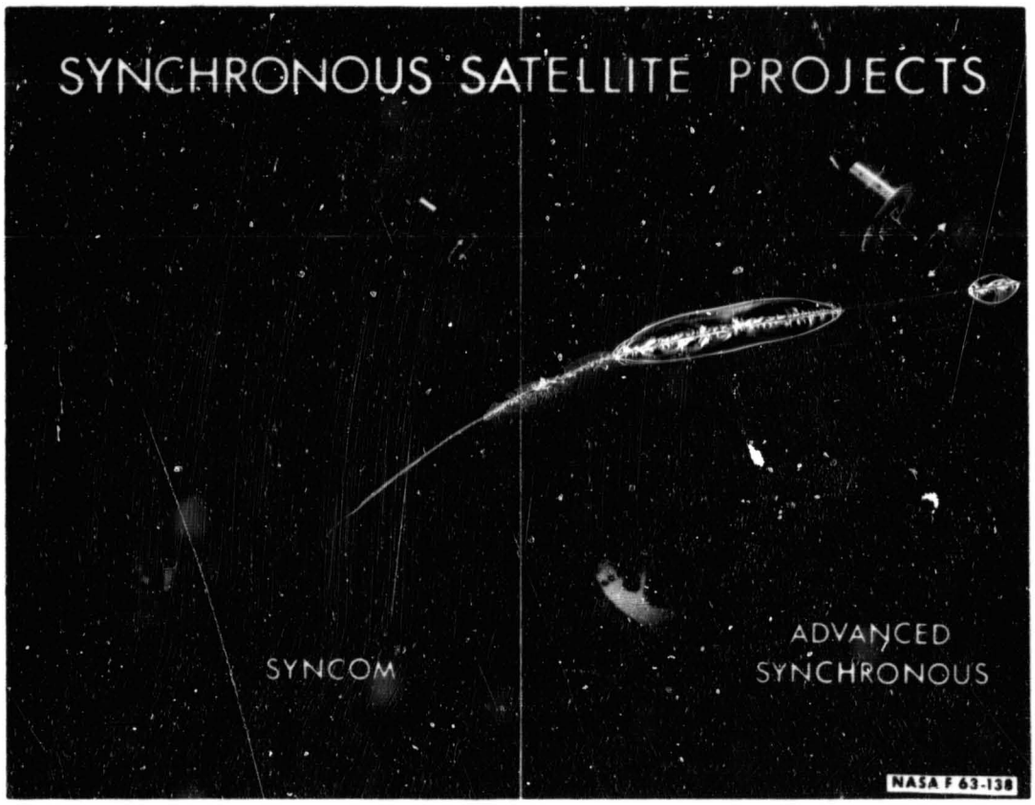

FIGURE 32

advanced synchronous satellite described. This should be well under way in fiscal year 1964. Such a spacecraft may be of considerable interest in areas other than communications satellites. This configuration is being studied for possible application to the stationary meteorological satellite requirements.

One other item of interest among many that will represent the changes between Syncom and the advanced synchronous satellite is the inclusion of what we designate as multiple access capability. By this we mean the ability for a fairly large number of independent ground stations to simultaneously use the satellite as a relay point without mutual interference. The experimental satellites with which we have been working to this date include Telstar, Relay, and Syncom, and are all essentially point-to-point relay devices. They transfer messages between a pair of stations. If another pair of stations wishes to communicate, the first pair must go off the air so that the second pair has a clear channel. In a multiple-access device graphically shown in this chart (fig. 33), we hope that it will be possible for messages to pass between a number of pairs of stations simultaneously without any interference, and there will be no restrictions as to which stations have to constitute a pair. The pairs can be made up at any time of any two stations that need a communications path. Such a capability would make possible the participation of a larger number of nations in a single operational communications satellite system.

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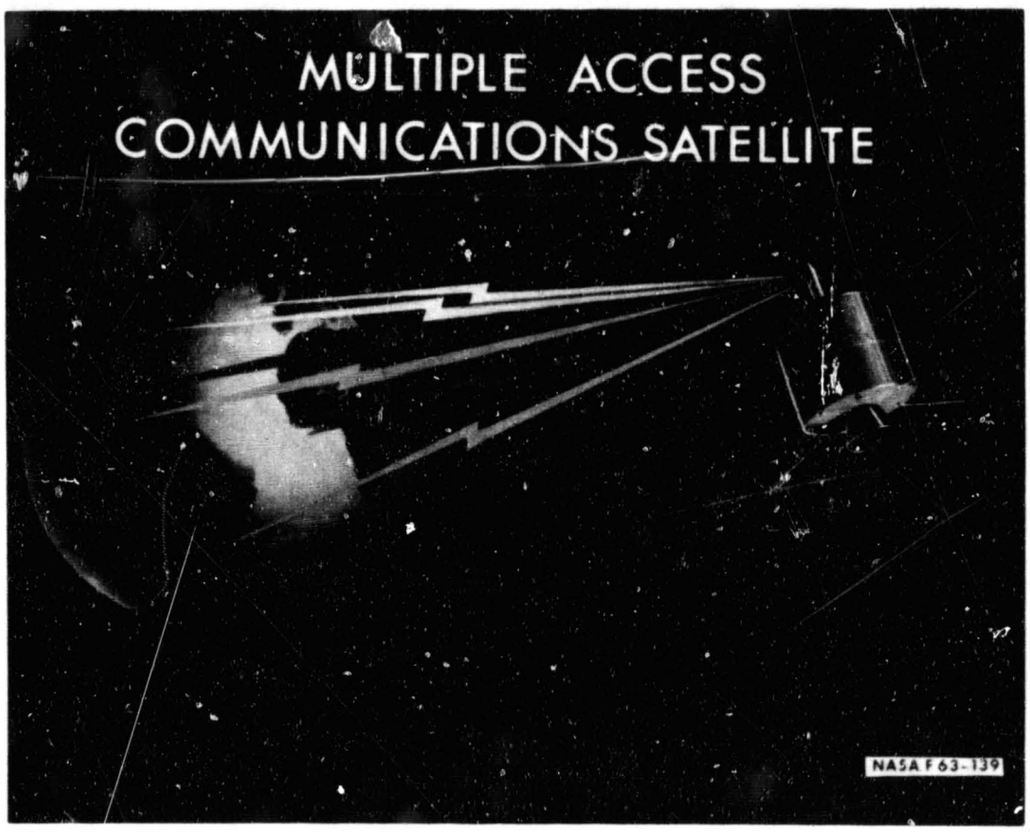

FIGURE 33

FLIGHT SCHEDULE

In summing up the Communications Systems program we have the flight schedule which is shown on this chart (fig. 34). You see that we plan for calendar year 1963 one orbital flight of the large Echo II sphere. Two more flights on Relay, a flight on Telstar sponsored by the A.T. & T., and two more flights of the Syncom satellite are all also scheduled for calendar year 1963. In 1964 we will be collecting data from the satellites launched in 1963 and we do not, at the present time, plan specific launches for that year. At the same time we will be working extensively on our supporting research and technological program in the development of improved passive satellite techniques. We will also continue our studies on intermediate and low altitude satellites, both on systems analyses aspects and specific component hardware techniques. In addition, in the 1963–64 period the advanced synchronous satellite will be under active development and it is this satellite that we show as constituting the major portion of our flight activities in 1965 and 1966, and it is, in fact, that satellite on which we propose to expend the major portion of our 1964 communications satellite development funds.

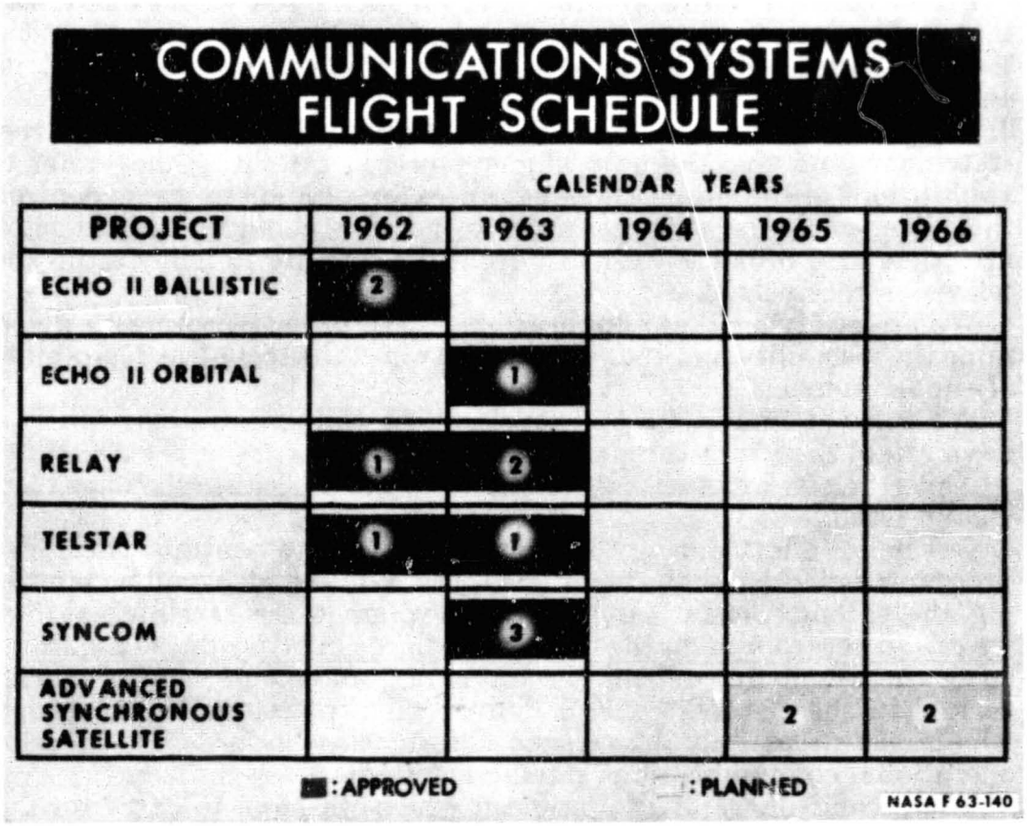

FIGURE 34

I think that we have established in the last year a program which has netted a great many results in the furtherance of the establishment of communications satellite systems.

Through Echo, Relay, and Telstar there has been a considerable foundation laid, but much remains to be done as I have pointed out in my statement, before an economically viable or economically practical system can be in fact established.

We have worked very closely with all of the interests in connection with the communications satellites systems, including the Department of Defense and A.T. & T., and we hope very shortly to establish technical liaison with the Communications Satellite Corp., of which some mention has been made here today.

We have had an opportunity in the past to lay our programs and plans before incorporators of the Communications Satellite Corp., and we have invited the technical staff—at least, as soon as it is existent—to consult with us and to become aware of the NASA programs, as, I might add, Mr. Chairman, we also would like to become aware of their plans.

We have attempted to formulate a program which, in our opinion, will not conflict with the program of the corporation.

We have attempted to formulate a program which will, furthermore, press technology ahead, above, and beyond that which we hope the corporation will undertake, and to insure the full exploitation of the communications satellite technology being made.

I have covered this more fully in my report, but I would like to say that in this regard there are a number of applications of communications satellites which perhaps the corporation is not interested in, and which it will not provide research and development toward the development of such applications. I mentioned these in my written statement, and they refer to higher powered satellites; they refer to applications of communications satellites for air and sea traffic control; they refer in the far distant future to possible communications satellites that may broadcast directly from the satellite to home radio and television receivers.

We are studying these applications. We are attempting to determine the feasibility and the practicability and the technical desirability of such systems.

We will not undertake the development of these systems until we have established that they are indeed necessary.

Nevertheless, we must pay attention to them because they are technically feasible.

Our major effort during the next year will be to continue the Relay program; as Dr. Seamans mentioned, the A.T. & T. Co. will be launching the second Telstar, and we will explore these satellites as best we can to get from them the knowledge that can be produced regarding space environment, and all the kinds of components that are being carried in these satellites, and deliver this knowledge to the people who must necessarily have such information in order to develop operational communications satellites systems.

The second phase of the program which we hope to carry on this next year is concentrated, as I have indicated in the statement, in the 24-hour altitude satellite region.

I would like to say a brief word regarding Syncom I.

Syncom I was our first attempt at reaching the 24-hour altitude orbit. The satellite responded favorably, performed well on the assigned trajectory toward the 24-hour orbit. For 5 hours we periodically carried on communications with the satellite; upon injection into the orbit, the communications failed, and we have not had communication with the satellite from that time on.

However, we have since been able to optically track the satellite, and we have determined that it is now very close to the 24-hour orbit. It has a period of approximately 23 hours and 45 minutes, and this ability to track the satellite has given us a good deal of insight as to the malfunction, or at least has given us an assurance that certain things did not happen which might cause malfunction.

The original premise that perhaps the fourth-stage rocket motor had blown up is no longer a good assumption. We are assured by the very fact that the satellite is in the 24-hour orbit that this could not have happened.

By virtue of this experience, and since the satellite is in the 24-hour orbit, and we can track it, we are able to tell a great deal about the perturbations on satellites in the 24-hour orbit. This information will assist in the design of future synchronous communications satellites. As soon as we are able to make the appropriate changes and modifications in the spacecraft, we will launch the second Syncom spacecraft.

We have in the past——

Mr. HECHLER. Excuse me, Mr. Chairman, but may I ask Mr. Jaffe: could you pinpoint that date more closely?

Mr. JAFFE. About midyear, Mr. Hechler.

Mr. HECHLER. Thank you.

Mr. JAFFE. We have undertaken a study to look into the features of an advanced synchronous satellite. This is pretty well described in the paper. It is a much larger spacecraft, and one of the important features is the development of an antenna which can be directed toward the earth, or an antenna which will radiate all of the power back toward the earth.

This development is coming along satisfactorily.

The other systems which we have been studying with regard to this advanced communications satellite in the 24-hour orbit are also proceeding satisfactorily. We do hope to review these developments shortly and to undertake the development of the next experimental program in this area.

This is the only experimental program that I know of in the 24-hour altitude synchronous orbit.

We are interested in this kind of satellite, not only for communications satellite programs, but we are very seriously looking at the possible use of this kind of satellite for meteorological purposes also.

The synchronous satellite, we feel, is much further down the road; there are many problems in the development of systems which will sustain themselves over long periods of time. These must be explored thoroughly before an economically viable 24-hour satellite can be established in an operational system.

We feel that we must push ahead very rapidly with this kind of exploration and development.

We are also looking at many other areas of communications satellites which will assist in conserving the frequency spectrum. This is a very valuable and important resource project to the United States. Its efficient use has a tremendous bearing on the future economy of the country.

The possible utilization of communications satellites at higher frequencies, the efficient use of the spectrum—these are all things that must be explored and these are part of our supporting research and technological program, as well as other studies which will assist us in our programing for the future.

Thank you, sir.

Mr. RYAN. Thank you, Mr. Jaffe.

As I pointed out earlier in my opening statement, we are concerned with the total national effort in the whole field of communications satellites, and the division of that effort. That is to say, between the three agencies which are now apparently in the field: 1, NASA; 2, Department of Defense; 3, Communications Satellite Corp.

Now, until this year research and development was carried on by NASA on the one hand, and DOD on the other.

Have you any estimate of the cost up until the first of the year, 1963, of the research and development program within NASA, first, and secondly, within DOD?

Mr. JAFFE. I do not have the cost of the DOD program, Mr. Chairman. However, the cost of the NASA communications satellite program through 1963 is indicated in our budget book.

Dr. SEAMANS. It was $35 million in 1962, which was really the first year that we had heavy expenditures; $49 million in 1963, and as you indicated at the start of this hearing, Mr. Chairman, we have a budget request for $55.7 million in 1964.

Mr. RYAN. Dr. Seamans, does that include personnel costs?

Dr. SEAMANS. Yes; that does include the personnel cost.

Mr. RYAN. Supposing we strain out the personnel costs, could you give us the figure for research and development?

Dr. SEAMANS. Yes. Just research and development is $33 million in 1962; $43.7 million in 1963, and $51.1 million in 1964.

Mr. RYAN. So that that would be roughly $127 million through fiscal year 1964, is that correct?

Dr. SEAMANS. Yes. I don't have the total figures for the Department of Defense. I know that the estimate for 1963 was approximately $100 million, and I believe their budget request in 1964 is for $80 million.

This includes the total request, including ground equipment and as a matter of fact, the reason for the drop of $20 million is because they made a fairly heavy investment in the establishment of ground stations, and so on, in 1963.

Mr. RYAN. I assume that the Department of Defense is developing a military communications system?

Dr. SEAMANS. Yes; they recently have received proposals from industry for a medium altitude simple multisatellite system.

Mr. RYAN. I further assume that the Communications Satellite Corp. is expected to develop a system?

Dr. SEAMANS. Yes, they will be developing, we understand, an operational system. Of course, they are just organizing, and their plans are, at this time, quite indefinite.

Mr. RYAN. Assuming that there is a commercial system developed by the Communications Satellite Corp., and a military system developed by the Department of Defense, what legitimate area is there for NASA in this?

Dr. SEAMANS. Mr. Chairman, both the Department of Defense and the Satellite Corp. have requirements for operating a system, or implementing it by putting it into effect and maintaining it.

That is not NASA's responsibility. We are not in the business of operating systems; we are in the business of conducting research and development to advance the technology of using satellites for operational use in terms of communications systems.

Our role is to carry out research and development in support of both the Department of Defense and the Satellite Corp.

Mr. RYAN. The Satellite Corp. is a private corporation, organized for profit and to pay dividends, supposedly, to the stockholders.

It would seem to me that in the operation of a commercial satellite system this corporation would be expected to carry out its own research and development.

Now, where do you draw the line?

What is not in this program today which you are submitting to the Congress, that would be in the program if the Communications Satellite Corp. simply did not exist. Or, have you omitted anything in the program that you would have had in the program if the Communications Satellite Corp. did not exist?

In other words, are you moving ahead just as though the corporation did not exist?

Mr. JAFFE. No sir, we are not moving ahead as though the corporation did not exist.

Mr. RYAN. What is the difference?

Mr. JAFFE. We are moving ahead as though the the corporation did exist, and we are making certain estimates about the direction in which we feel that they will need.

This is conjecture, obviously, since we have not had an expression from the corporation regarding it.

Mr. RYAN. Well, let us stop right there at this moment. How can you submit to the Congress a budget request and a program based upon conjecture?

Mr. JAFFE. The NASA budget itself defines a well-considered technical program and includes a statement of anticipated costs in fiscal year 1964. The program has been planned based on the conviction of need for striking a balance between those facets that NASA should assume responsibility for and technical opinion about what the research and development effort of the corporation may be after they organize themselves and build up their technical staff.

Mr. RYAN. You have not, and NASA has not, apparently, sat down with the incorporators, or the officers of the Communications Satellite Corp., and determined, No. 1, in what area of responsibility this private corporation is going to be working and, No. 2, how that relates to any program that NASA expects to carry out.

Dr. SEAMANS. Let me just say, Mr. Chairman——

Mr. RYAN. Well, is that right?

Dr. SEAMANS. No, that is not so.

We have, as Mr. Jaffe indicated, briefed the incorporators so that they are familiar with the NASA program.

Secondly, the chairman of the board, and the president of the new corporation have only recently been approved by the Congress. We have, as of March 27, written a letter to Dr. Charyk, inviting him and Mr. Welch to come to review with us what we are doing in terms of R. & D. and to discuss future plans.

So we have taken the step that you indicated.

However, only a few weeks have existed since Dr. Charyk has had this job, so that so far all the discussions have been informal. This is the first formal step that has been taken.

Now, I would like to make two points, if I may, with regard to your comments, sir. One is that we are proceeding according to our Space Act of 1958, to develop vehicles capable of carrying instruments, equipment, supplies and living organisms, through space.

Mr. RYAN. Yes, but the Space Act of 1958 was enacted before the Congress enacted the Communications Satellite Act of 1962, at which time the Congress said that the communications satellites were to be under the aegis of a private corporation.

Dr. SEAMANS. Well, I did not appreciate that the Satellite Act invalidated our act of 1958.

Mr. RYAN. It certainly seems to me that you have to read the two together, and you have to know the intent of Congress in establishing the private corporation. It seems to me that our concern is legitimately to find out where the area of demarcation is, at what point does NASA have a legitimate responsibility in this field? At what point has the Congress said that this is a matter for private enterprise, the Communications Satellite Corp., to carry on.

I will come back to your answer in which you said that the role of the Communications Satellite Corp. is operational, and the role of NASA is providing research and development.

If that is the case, then NASA is to provide all of the research and development which will then be turned over to a stock corporation.

In that event, is the public interest protected?

I think these are the questions to which we should address ourselves.

Dr. SEAMANS. I did not mean to imply, Mr. Chairman, that the new corporation would be restricted to building an operational system. They will, undoubtedly, have to carry out some research and obviously good judgment has to be applied, as you indicate, in defining the boundaries between the NASA R. & D. program and what activities are undertaken by the new corporation.

What I was about to say, however, is that much of what Mr. Jaffe has discussed is common to other systems as well.

For example, the development of the launch vehicles, the development of the injection stage to place a satellite in synchronous orbit, the development of the station keeping systems, the development of power supplies, the buildup in reliability, so that the systems can be economically viable—these type objectives are common to communications satellites, meteorological satellites, and other flight systems of interest to several Government agencies.

These are the things that NASA plans to emphasize, and we are emphasizing them, in the recommended program, the Syncom II.

Now, you have mentioned that we should read the two acts side by side, and I certainly agree. The Communications Satellite Act does have contained within it specific responsibility, however, for NASA, and this would include advising the FCC of technical characteristics of the communications satellite system; cooperating with the corporation in research and development; assisting the corporation in the conduct of its research and development program; consulting with the corporation with respect to the technical characteristics of the communications satellite system; furnishing the corporation on request, and upon a reimbursable basis, with satellite launching and associated requirements for the establishment, operation and maintenance of a communications satellite system.

These are responsibilities that are really common to both acts, and these responsibilities can only be effected if we execute the type of program we outlined to you here today.

Mr. RYAN. Mr. Wydler?

Mr. WYDLER. I just wanted to interrupt if I may, Mr. Chairman, because I do not feel that you received an answer to your original question, and I would like to hear that answer. That is, I think the chairman asked originally, what is the difference in the program being presented to the Congress this year, as a result of the Communications Satellite Act?

You indicate, Mr. Jaffe, that there is a difference, and I would like to know what it is, or what they are, if there is more than one?

Mr. JAFFE. Yes. We are including in the program those elements which we feel will advance the state of the art for future application and for the future betterment of communications satellite systems.

We are not undertaking in any way, to develop spacecraft that might exist in the immediate future, and which we would expect the corporation to undertake.

Our program is aimed as those things which must be started now to provide for future systems.

If the corporation did not exist, I am sure that our program would take on an entirely different character, and that we would begin to develop operations systems based on existing technology of this date.

So that these are elements that are not included in the program.

Mr. RYAN. You have experimented with Relay; you have experimented with the A.T. & T. Telstar in seeking to establish a feasible communications system.

Now, it has been understood for some time, I believe, and certainly it has been attested to before this committee, that ultimately, the most effective, the most efficient and probably the most logical system, is a synchronous satellite system.

If this is so, clearly it is known to the incorporators of the Communications Satellite Corp. The object is to have the most efficient and the best system for communications satellites.

If that system is to be a synchronous system, then we come back to the question of whether or not this development should be carried on by the taxpayers, through NASA, and handed over to a private corporation, or whether this is an area in which the private corporation could contract and handle. After all, you are going to be contracting for studies and for research, and for some hardware. Most of this is done through contracts with industrial corporations, in carrying this program forward, is not that correct?

Dr. SEAMANS. We are not certain whether the synchronous satellite system will be the most economically viable. There are a variety of trade-offs which must be evaluated and analyzed. One factor is that it is more difficult to place a payload in synchronous orbit. This means it is more costly to put it there, and also later in time in terms of reaching an operational status.

There is also the matter of time delay between transmission and reception from synchronous altitude, which is under study, and which is not yet resolved.

There are other matters that I could discuss with you, but the point is that we must have a two-pronged program in this country. We must continue both the medium and the synchronous altitude satellites, until these questions are resolved. As Mr. Jaffe said, we obviously don't know that the corporation will elect to do.

We have gone over our program with the Department of Defense. It was their judgment, that as a result of the Telstar and Relay, it would be possible to proceed immediately with the medium altitude system. We elected to go on to and to concentrate on the more difficult job, namely, the synchronous satellite system. As I mentioned earlier, this system is furthest downstream, and I think that the same discussions we had with the Department of Defense will be valid at the time that we have an opportunity to review this with the new corporation.

Mr. Chairman, you brought up one question that I would like to answer, namely, "Why should the Government be involved in research and development; why should not the Satellite Corp. pay its own way?"

This is certainly a matter that must be reviewed carefully by the Congress.

I would just like to say that first, there is a precedent for this kind of operation in that both NASA, and its predecessor NACA, have traditionally carried out the aeronautical research which definitely

advanced aeronautics in this country, and supported a variety of industries, namely, the aircraft companies and the airlines.

Mr. RYAN. Was any one of them a monopoly? They were competitive, were they not?

Dr. SEAMANS. They were competitive that is true, but the stockholders of those companies definitely benefited from the research and development carried out by the Government. I would also submit that you must bear in mind in your decisionmaking, the question of how important you feel it is to have a communications satellite system at an early date.

Mr. RYAN. On that point, all of the arguments in support of the Communications Satellite Corp., before the Congress, were based and predicated on the proposition that private industry could do this faster and more efficiently than the Government, and that it would be more flexible, as was said in my opening statement, have more flexibility, have greater speed, more initiative, and greater risk taking, than the Government would.

In fact, the Communications Satellite Corp. was presented as a means by which private enterprise would succeed in being first in communications satellites in the world.

Dr. SEAMANS. We are obviously for private enterprise, Mr. Chairman, and we thoroughly endorse the Satellite Act, but I believe that what you say was not predicated on complete withdrawal by NASA from all communications-satellite effort. I believe it was predicated on a vigorous R. & D. program by NASA being continued.

Mr. RYAN. Let us assume for the moment that there is a legitimate area for NASA, and let us look at the relationship between NASA and the Weather Bureau. Do you see any analogy between the NASA meteorological satellites program and the Weather Bureau program and the NASA program in communications satellites, and the potential program of the corporation?

Dr. SEAMANS. Yes; there are obviously similarities and differences. The similarity is that in both programs NASA has the responsibility for conducting research and experimental programs. But in both cases NASA has responsibility for launching payloads into orbit.

We have and will continue to launch payloads into orbit for the Weather Bureau, and we will do the same thing for the Satellite Corp. In each case our responsibility is for operating a ground station to predict orbits and matters of that sort.

One of the differences is, in the case of the Weather Bureau, that we also will be responsible for the fabrication and the testing of the payload itself. In the case of the Communications Satellite Corp., they will ultimately have the responsibility for the fabrication and testing of the payload that they are putting up, for the operational system.

Another difference is one which you have already expressed, Mr. Chairman, namely that the Weather Bureau is a Government agency and the corporation is privately financed and operated for profit.

The CHAIRMAN. So that the weather program is a Government program and carried on by two Government agencies.

Dr. SEAMANS. That is correct.

The CHAIRMAN. Are there any questions by members of the committee?

Mr. DAVIS. There is one question I would like to ask, Mr. Chairman, and that is:

It is not envisioned, is it, that Communications Satellite Corp. could undertake such things as spin tests and balancing, preparatory to launching? I just can't conceive that they could develop that much technological capability within a short period of time.

Dr. SEAMANS. Yes; they will have to build up their competence in time, Mr. Davis, but they are a long, long way from having that competence now.

They will have to build up a team of people who understand this technology; they will have to build up facilities, and they will have to raise the capital.

I am sure we would find, if we did not do the research and development, that there would be a very appreciable delay in the implementation of the operational system.

Mr. DAVIS. We had testimony last week from Dr. Singer of the Weather Bureau, to the effect that the Weather Bureau does do quite a bit of its own research and development. They have a laboratory—I believe he said that "laboratory" was not the best word for it, but that is what they called it—which has approximately 100 men at work on the weather satellite, in deciding what instruments they would use as sensors, and such things as that.

Also, it is true that NASA has a meteorological laboratory with, perhaps, 200 men at work at Goddard, on the NASA aspects of weather satellites.

Now is it your judgment that a parallel situation will present itself as respects communications satellites, with the private corporations being expected to do its own research and development, and NASA also could be expected to maintain parallel research and development?

Dr. SEAMANS. Let me first clarify one point with respect to the Weather Bureau.

It is the Weather Bureau's responsibility to make decisions relative to the requirements for meteorological satellites, and to do this they must have people who are knowledgeable in the instrumentation that can be placed in orbit.

However, they are not developing the instruments, nor the payload, nor the spacecraft. This is NASA's responsibility.

Mr. DAVIS. Well, I will say that I subscribe to that. I would say that I entertain the same view that you are now expressing.

However, Dr. Singer went so far as to say the Bureau was having something to do with the configuration of the weather satellites, and it was my opinion, up until I heard him say that, that NASA should be the one to decide such things as that. But, perhaps the Weather Bureau would be in its proper domain as long as it was defining and testing such things as sensors, camera, or infrared systems.

I am interested to hear you affirm now that it is NASA's function to decide configuration, and to fabricate and decide if it can operate within an environment such as this.

Dr. SEAMANS. I believe we are very effectively working with the Weather Bureau, and we very much respect Dr. Singer. This may be a matter of semantics.

Mr. DAVIS. Yes.

Dr. SEAMANS. But I would be very concerned if the Weather Bureau got into too much of the hardware development. I think it would be a very great danger of major duplication if that took place.

I have not read his testimony, so I cannot really say anything more.

Mr. DAVIS. Well, I will say that this was not a prepared statement, it was extemporaneous, and I rather doubt that he thought the matter through very thoroughly.

The principal thrust of inquiry at the time was whether or not there was duplication in research and development, between the Weather Bureau Laboratory and NASA's Laboratory. That was the principal point in discussion, and he was, in a way, justifying the fact that they did have a laboratory while not downgrading NASA's Laboratory.

Dr. SEAMANS. Well, we have to take into account, obviously, human nature, in managing our program, and there may be a tendency on the part of the Weather Bureau to get over into component development, so I would say we also have to be very careful that we do not go too far into areas of weather prediction and analysis.

I think that this is something which takes constant vigilance, and I am sure you realize this, on the part of both agencies.

Coming back to your fundamental question, though, "Is this the same relationship that one could expect with the Satellite Corp.?"—I don't think that it is exactly the same, because I think—I know—that the Satellite Corp. has got to get into actual communications, hardware, that it is putting up there in space, and to do this they must run ground environment tests. They must build hardware, and they must test it and make changes in order to develop the equipment that will give the fidelity and reliability required for a viable system.

Mr. HECHLER. Mr. Chairman, I have a question I would like to put to Dr. Seamans.

Obviously, we understand that both NASA and the Weather Bureau are going to benefit many private enterprises throughout the country in fields that they are undertaking. Would you not agree?

Dr. SEAMANS. Well, we believe that that is so, yes.

Mr. HECHLER. And the basic difference is that instead of benefiting a whole number of them, as the Weather Bureau and NASA's activities in the meteorological satellites do, that in the case of the communications satellites, you are narrowing the benefit to one or two identifiable corporations.

Dr. SEAMANS. Mr. Hechler, I did not have an opportunity to respond to that point, which is a very important one.

Mr. HECHLER. Yes.

Dr. SEAMANS. I would certainly expect that the Satellite Corp., in turn, would go to the electronics industry for the various elements that are to go into the communications satellite, and I would feel that the NASA program in R. & D., does give the total electronics industry a more competitive position than they would have if we did not have our program.

In other words, the total industry is the beneficiary; not just the Satellite Corp.

Mr. HECHLER. Subcontractors?

Dr. SEAMANS. Subcontractors, yes.

Mr. HECHLER. Thank you, Mr. Chairman, that was all.

Mr. RYAN. Are there any further questions?

Mr. BOONE. I would like to ask Dr. Seamans, is it not a question, then, of who puts up the money, rather than NASA performing peculiar research work in their own inhouse laboratories? By that I mean, since most of your funds, and I believe it is stated about 95 percent of the moneys are let out to industry——

Dr. SEAMANS. 90 percent, I would say.

Mr. BOONE. 90 percent. Then industry is really performing the work of improving reliability and improving components, and that sort of thing. So it is a question, is it not, of whether NASA puts up the money for this, or whether the Satellite Corp. puts up the money for it, isn't that right?

Dr. SEAMANS. It is a question of funding; it is a question of management; it is a question of free access to information coming from the program.

Ninety percent of the work in either case, at least 90 percent, would be done by private enterprise. If NASA does as we strongly recommend, a certain amount of the work would then be done by the Government.

Mr. RYAN. So the question, as Mr. Boone has said, is really: "Who is going to pay for it, the taxpayers, or the stockholders?"

Mr. HECHLER. Well, it is a question, too, Mr. Chairman, of the public interest, with respect to the information acquired—whether it is going to be disseminated by NASA as a Government agency, to all the people, or perhaps, held closely by the corporation. I don't know if that represents your judgment, or not, Dr. Seamans?

Dr. SEAMANS. Well, it does, and that was one of the points that I was attempting to make, Mr. Hechler.

There is also the broader question of how important we feel, as a nation, it is to implement a system of this sort.

We, as you know, already have contracting arrangements with a number of foreign countries, England, France, Germany, Italy, Brazil. Ground stations have been provided, or are being provided in each one of those nations.

Now, are we going to, in effect, stand still in our experimental program, or are we going to move ahead aggressively, as we believe we should?

Mr. RYAN. The testimony being that only the Government can move ahead aggressively. All right——

Dr. SEAMANS. No, the testimony is that only, at this time, can NASA move ahead with the kind of program that I have indicated. Dr. Charyk and Mr. Welch, two men, could not proceed this way at this time.

Mr. RYAN. Do you know what their salaries are?

Dr. SEAMANS. Yes, but their salaries do not affect Mother Nature too much.

Mr. RYAN. What are their salaries?

Dr. SEAMANS. I understand that their salaries are in the neighborhood of $80,000 to $100,000.

Mr. RYAN. Each?

Dr. SEAMANS. Each.

Mr. RYAN. Mr. Jaffe, I would like to come back to your statement on page No. 1, where you say that the NASA program objective is to insure full development and realization of communications satellite potentials.

Now, that is exactly the question that we have been discussing. Does that mean that NASA is going to assume the risk, or is any risk going to be placed upon this corporation?

Mr. JAFFE. As Dr. Seamans has said, we have responsibility under the Space Act——

Mr. RYAN. Just a moment. You also say the objective is to assist in the early establishment of operational communications satellite systems. And it is your opinion, as I take it from Dr. Seaman's testimony, that without NASA's active and aggressive role, we will not achieve the kind of system that we desire, when we need it— and one further thing:

At the bottom of the page, you say:

> Much remains, however, to be done before economically practical systems can be established, but a sound foundation has been laid.

Now, what is your best estimate as to the time when a commercial system, assuming NASA carries out its program, as has been outlined here—What is your best estimate as to the time when a commercial system will be operable?

Mr. JAFFE. My answer, if I may answer this in parts, Mr. Chairman, would be this:

First of all, with regard to my statement that we are to assist in the early establishment of operational communications satellite systems, we have responsibility under the Communications Satellite Act of 1962, to assist the corporation in the establishment of operational systems and in the execution of their R. & D. program. We will do so. We will assist by launching their satellites, either for research purposes, or for the establishment of the operational system.

Mr. RYAN. Do you restrict the word "assist"?

Mr. JAFFE. Assist?

Mr. RYAN. Yes. Do you restrict the definition of the word "assist", to mean only launching a satellite?

What is your definition of the word "assist"? Just to launch, or is it to do something much broader?

Mr. JAFFE. Oh, no, no. We will assist them, as we have assisted A.T. & T. in the launching of the Telstar, when we had given them technical assistance, and so forth.

Mr. RYAN. It has been NASA's contention that A.T. & T. is a private function, and A.T. & T. has paid for the Telstar.

Mr. JAFFE. That is correct.

Mr. RYAN. Isn't that correct?

Mr. JAFFE. Yes.

Mr. RYAN. Well, why should not the Communications Satellite Corp. do likewise?

Mr. JAFFE. I would like to submit that we would fully expect them to do, sir; we fully expect to undertake work in the development of the operational communications satellites——

Mr. RYAN. Well, just a moment now. What have they told you they are going to do? What talks have they had with you? What discussions have you had with them and what plans have you formulated?

Mr. JAFFE. I would like to repeat what Dr. Seamans has said: We have had an opportunity to present our program to the incorporators. This has been done, and we have requested Dr. Charyk to work with us in providing liaison between our technical staffs and

to get together and talk about their plans and our plans, so that we can arrive at the programs which will be mutually beneficial to the Nation.

Mr. RYAN. Well, that's lovely. But specifically what plans have you made that would be mutually beneficial to the Nation? Who has talked with you; what kind of organizational setup have you at this point?

Have you gone to the corporation and said:

> We are going to spend $51 million in 1964 fiscal year on such and such a program; we want to know how much money you are going to fund for programs in communications satellites? We know that you have a $5 million line of credit with the banks, and we know that you have already drawn $500,000. We want to know now from you, the Communications Satellite Corp.—the chairman and the president—what your plans are, because we have got to go to the Congress and ask for $51 million, and we are going to be asked: "All right, how does this relate to the Communications Satellite Corp.? How does it relate to the Department of Defense?"

That is basically what we are asking.

Have you talked to the corporation about this?

Dr. SEAMANS. Let me say, first of all, Mr. Chairman, that Dr. Charyk has been a very busy man getting through a very important assignment with the Air Force. As I said earlier, he has only been involved in the Satellite Corp. a very short time.

I have met with him personally, and indicated very informally the kind of program that we have in mind. The letter than I referred to earlier puts this on a more formal basis, and I would like to read to you two paragraphs, if I might:

> It has been necessary for NASA to develop its program in advance of consultation with the corporation.

I go on to say that the presentation of NASA's program to the interested congressional committees will give rise to questions concerning the corporation plans, and the entire subject of coordination and cooperation between the corporation and NASA, and I conclude:

> We are prepared, at your convenience, to brief you and your associates on the details of NASA's research and development program in the communications satellite field.

I say that we hope the corporation will soon be staffed to the point where we can begin with the process of consultation and coordination which the Communications Satellite Act of 1962 contemplates.

Mr. HECHLER. Mr. Chairman, I think it is probably correct, and correct me if I am wrong, that the members of the corporation have not yet been confirmed by the Senate?

Mr. RYAN. Just the incorporators—the chairman of the corporation and the president, are now salaried employees of the corporation.

Dr. SEAMANS. That is my understanding.

I may be wrong on that——

Mr. JAFFE. No, that is my understanding.

Mr. HECHLER. I think your statement there, Dr. Seamans, shows a great deal of vision as to what the committees are going to get into.

[Laughter.]

Mr. RYAN. Mr. Wydler?

Mr. WYDLER. It seems to me that what this really comes down to is this, gentlemen:

If I may suggest it, it seems to me that what is really happening here is that NASA sits down and decides what they need in the way

of a program in the communications satellite field, and then they determine that, and they determine how much it will cost, and they come in and ask this committee to recommend to the Congress.

The only question I think that we are asking is:

Since there is a private corporation now in this field, are they really supposed to be doing something in addition to this program that NASA is outlining, or should they, in fact, be coming in to pay part of this bill that NASA is proposing to incur? Is at least part of that responsibility a responsibility of that agency, or is NASA simply going to do everything within this area that it feels it needs to do in the way of budgeting and then whatever this Communications Satellite Corp. wishes to spend, it will?

I think that this is the real problem and philosophy that we are facing here, and that is what is bothering me, and I think some of the members of the subcommittee.

Does this corporation have some responsibility as to this actual amount of money that NASA is asking in its budget? That is what I would like to have you speak on—particularly how you think it is going to work, if not this year, in the years to come?

Dr. SEAMANS. Well, I would just like to make it clear that it is not "what NASA needs"; we are not the end result.

If you look at our Space Act, article 5, it states that NASA has the responsibility for the preservation of the role of the United States as a leader in aeronautical and space science and technology, and in the application, thereof, to the conduct of peaceful activities within and without the atmosphere.

So, we believe that Congress has given us the responsibility to see that this country is in the forefront in all possible areas of space science and the applications of the technology.

Now, I would like to step back for a moment, if I might, and say a few words about where this sort of begins and ends.

First, I would certainly agree that it is not our responsibility, based on this, to follow through and operate a system. You must sort of consider the total process, starting with the basic concept of how these various elements might be put together to make a system, and the work on individual components, and the work on the various functions that are important and may be important to such a system.

For example, successful launching and the orbital injection for satellite systems requires detailed work along the lines I have mentioned. We must see whether these techniques work; run a reasonable number of experiments, get data and feed it back and tie in with the basic assumptions.

I believe that this is NASA's responsibility in this area. I would believe that the Satellite Corp. has got to phase in to this picture, using the work that we do on components and testing as a jumping off point for the design and development of various prototypes, for the launching of the prototype equipment and ultimately for the implementation of the total system.

They will have a great deal to do in the development of the prototype, and in the implementation of the operational system.

This will be a very expensive proposition for them because they will have to reimburse the Government for the launching operation, so I believe that they are going to have a difficult time, not only to gather the people and get the facilities, but also to raise the funds to do their part of the job.

Mr. HECHLER. Is it not entirely possible that some of this budget request that NASA is putting in for, if the Satellite Corp. moves a lot faster, and exerts the kind of leadership that is needed, that you may be able to yield some back and it may not be necessary to spend it?

Dr. SEAMANS. Well, this is a very hard question to answer, Mr. Hechler.

Mr. HECHLER. Well, budgeting is conjectural, and we are certainly dealing in an area of uncertainties. But if it should develop that the Satellite Corp. would be able to recruit personnel, and be able to exert the kind of leadership in this field of communications satellites that is necessary, I should think it is entirely feasible that some months hence you may be able to reduce this projected budget for communications satellites which NASA is presenting.

Dr. SEAMANS. That question is extremely difficult to answer, and could only be answered after a review of the type indicated in Mr. Webb's letter to Dr. Charyk.

Mr. HECHLER. But you would think it is entirely possible?

Dr. SEAMANS. It certainly must be explored, and my own view is that if there is an area, it is in the area of actual communication electronics. I believe that NASA has got to really concentrate most heavily on those things that are sort of common to all systems.

Mr. HECHLER. Yes, but what are your rockbottom priorities here? What do you absolutely need that the Satellite Corp. couldn't possibly do?

Dr. SEAMANS. Well, I wouldn't say that there is a rockbottom in this case, Mr. Hechler. They would certainly find it very difficult, however, to develop launching vehicles that would inject a payload into whatever orbit is required.

Mr. RYAN. Dr. Seamans, that is all very true, if I may interrupt Mr. Hechler, but if we refer to volume No. 5 it outlines research and development requests and it is not talking about launch vehicles. It is talking about supporting research and technology for all programs of communications satellites systems, including the advance synchronous satellite flight programs and programs that are still in being—the Echo and Relay.

Now, what Mr. Hechler is really asking, I think, is, What is it in the communications area——

Mr. HECHLER: "Without which."

Mr. RYAN. Without which.

Dr. SEAMANS. Without which the Satellite Corp. could not proceed, is that the question?

Mr. HECHLER. Yes.

Mr. RYAN. And there again, can the Satellite Corp. do what NASA is doing? It is all contracted out anyway, is it not? The corporation is the middleman and NASA is the middleman. Who is going to pay for it?

Dr. SEAMANS. It is much more than just a question of financing, Mr. Chairman, it is the question of technical leadership.

Mr. RYAN. Right. But is not the theory of this corporation that only private enterprise can pull together the leadership and the technical team that can move in this area, and that the risks will be undertaken by private enterprise, and not by the Government?

Dr. SEAMANS. I agree, Mr. Chairman, but we also have a team of people who are there, and the corporation will have to start, and I can foresee they may have some difficulty.

Mr. RYAN. You have the competence, yes.

Dr. SEAMANS. We have been building up that competence.

Mr. RYAN. Right, but going back to Mr. Wydler's question, are you going to sell that competence to the Communications Satellite Corp. or are you going to give it away to them? Have you sat down with them, and have you explored how you are going to divide the costs, so that NASA can be reimbursed for its competence, and these years of experience, and the research and development, that you have contracted at the cost of $127 million as you testified earlier today.

I really think it is incumbent upon NASA to come forward with a formula which shows how the Government is going to be reimbursed by this private corporation that is going to make a profit and is going to pay stockholders dividends for all its services, or is NASA going to sit back? If so, I know nothing with more certainty in this area of uncertainty than that the stockholders will be delighted if NASA does the work, and develops a system to the point where it is operational, and then turn it over to them to operate and collect the dividends.

Mr. HECHLER. Well, is that not what the Government did in the case of the railroads and canals in the old days? [Laughter.]

Mr. RYAN. Well, I hope that before we finish this hearing, Dr. Seamans, you can have a real report to the committee on all the discussions you have had and all the proposals that you have for sharing costs.

This is an area where NASA is going to move ahead and, at the same time, provision for reimbursement must be made for more than the services of launching vehicles.

For instance, when Mr. Buckley was before the committee, I asked for a breakdown of all the moneys that had been spent on the Telstar, beyond the launching, and beyond the fuel which was used to put up Telstar, including tracking and the acquiring of data.

I hope we will have that. What we are driving at this morning is that NASA has not really sat down and thought things through, with this corporation, now that it is here. And this may make a great difference as to how we view your $55 million proposal.

Now the question which I did not get an answer to earlier, and I think it is important, is how many years away, really will it, before there will be any operational communications satellite system.

Is it 5 years or 7 years, or 10 years, or how long?

We are very optimistic, and Dr. Dryden said recently that if the corporation got started it would take 5 years for a low-altitude system.

Is that a fair estimate, or was he being optimistic, in your opinion?

Dr. SEAMANS. I think that is a good estimate, provided NASA plays the kind of active role that we are proposing here today.

Mr. RYAN. All right. Now, if NASA does not, how long would it take?

Dr. SEAMANS. Well, this is a very difficult thing to estimate, Mr. Chairman, because we don't know what buildup the new company will be able to effect, and I would estimate that there would be a delay of 2 or 3 years, anyway. Perhaps Mr. Jaffe would like to give you his views on the subject.

Mr. RYAN. Very well.

Mr. JAFFE. I think that is a correct estimate, Mr. Chairman. I think it is somewhat optimistic, based on our experience. We, of course, hope that the corporation would move as rapidly as it can.

There is just so much time required from the inception, to work out a statement of specifications for the system, before you can launch anything.

We have had certain experience with this, and we have used this experience in coming up with our estimate of how an operational system could be brought into being.

Our estimate of this time is also based on the fact that we assume the corporation will avail itself of the experience that has been gained through Relay and Telstar and pattern this first operational system after the experience which we now have in our hands, and will be accumulating during the next year.

Now, if it depends on entirely new technology, then this estimate does not hold.

Mr. ROUSH. I didn't hear your answer, Mr. Jaffe, but are all of these estimates directed to a low altitude system?

Mr. JAFFE. Yes.

Mr. ROUSH. And what would be your estimate for a high altitude system, such as Syncom?

Mr. JAFFE. This really is a very difficult answer to give, Mr. Roush. We have had one attempt at a synchronous altitude system. We have a satellite up there, but it doesn't work. There are a tremendous number of sequences which have to work in a synchronous satellite system, and a tremendous number of subsystems—a large number compared with those in a low altitude system.

It is very difficult to answer the question on how long it would take to get an operational system, until you have done it the first time, and we haven't done it the first time yet.

Mr. ROUSH. I have had one feeling, although you have not said it, that you favor a low altitude system.

We have not an estimate as yet, and we are still taking your low altitude system for an operational communications satellite system, is that right?

Dr. SEAMANS. We don't favor either the low altitude system, or the synchronous system. We feel it is possible to implement an operational system sooner at the lower altitudes, but certainly there is not enough data available at this time, to make a decision as to whether the ultimate system should or will be a synchronous or medium altitude system.

Mr. ROUSH. Thank you, that's all I have.

Mr. RYAN. Mr. Davis?

Mr. DAVIS. I would like to ask a question, Mr. Chairman. I am a little bit concerned about the American effort on the Moon probe.

I recall last year we had a pamphlet from the Sperry-Rand Corp. on a proposed spacecraft, and they called the entire project, "Project Green Cheese."

I have here an engineering review put out by the Sperry-Rand Corp. in the summer of 1962, and in it appears an article by Sol. K. Fenster and William Peters, in which it said that the projected lunar studies for the next 5 years are being directed primarily toward conducting instrumented research on the Moon, and the data that isobtained

to be telemetered back to earth. It says that this technically is limited because only those specific physical properties can be examined for which instrumentation has been provided and if a lunar sample is returned to earth, much more thorough analysis can be conducted because such investigation will not be confined to the speculations based on telemetered information.

Now, what I would like to ask about that is this—but before I come to my question, a little prospectus on this "Green Cheese" concept was distributed last year, in which the candidates for a launch vehicle were outlines, and in which it was stated that probably the best one would be the Titan II Pilotstar, which might be available in 1964, provided that the tests of the Pilotstar in 1962, in the third quarter, received the go-ahead.

Now, what is the present status at NASA on the program with respect to the Moon probe, and particularly is there anything in the works that might bring back a soil sample, or are you still sticking to the plan of getting telemetered information?

Dr. SEAMANS. The present program includes the Ranger which has as its objective, or primary objective, TV information. It would be a crash landing on the Moon with some very rugged instruments that can sustain the project, so that we could get back certain data from the lunar surface, but it will be very limited.

Following the Ranger, we have the Surveyor program, which will soft land on the Moon, and which will measure a variety of different things, with information being telemetered back.

We do not have in our program a probe which will send back some soil from the lunar surface. We do have a number of contractors who proposed to us about a year ago. I don't remember which ones they were, although I think one was the Sperry-Rand Corp. We did take a look at the feasibility of bringing back some soil which could then be carefully analyzed here on earth.

There were several problems, of course, and one which is the principal one, is large-scale recovery from this small probe, which has to be fired back by a sort of artillery rocket from the lunar surface, placing it on the correct trajectory, reentering, and recovery.

We have considered each one of these kinds of problems, and have weighed them against our total requirements. Frankly, we have the policy of trying to minimize the number of projects, and to put more emphasis on the ones we do have.

We feel that this is necessary to get ahead faster, so that we decided not to go ahead for this particular concept.

Mr. DAVIS. Now, what is the timetable on the Surveyor project?

Dr. SEAMANS. That timetable, of course—as you know, we have fired three Rangers as lunar impactors, and these were all unsuccessful.

We have revamped the program and the next Ranger is scheduled for the end of this year.

We have brought the industrial contractor in and have made some organizational changes at the Jet Propulsion Laboratory and are concentrating on the carrying out of the redesign of Ranger.

The Surveyor schedule is undoubtedly tied in to the Centaur. The first three launches of Surveyor will be engineered accordingly, and we will get some information on the Moon. But the ultimate vehicle that lands on the lunar surface, and that sends back all of the data that we want, is scheduled for some time in 1965.

Mr. DAVIS. Then all of the information that Ranger might send back would be by television, is that correct? There would not be any other means?

Dr. SEAMANS. Television and seismic elements of the lunar surface in a frangible ball.

Mr. DAVIS. And Surveyor would bring back more information?

Dr. SEAMANS. Yes, there are several things—first of all, you have better television information.

There is TV operation—in operation after the landing with a 360° sweep, and also the ability to sweep and look in a particular direction with zoom lens.

Then as to the soil sample, there is a device that can dig down on the lunar surface up to about, I think, 6 feet, and bring up a sample, analyze it, and relay the information back through the radiometers, and there are other types of instruments that are both scientifically important, as well as important to the men who will be landing on the Moon in this decade.

Mr. DAVIS. Would you consider it unlikely that the Russian's spacecraft would be able to do any more than our Surveyor would be able to do?

Dr. SEAMANS. Well, of course, that is hard to estimate, because I don't know how they are designed.

Mr. DAVIS. You would say it was extremely improbable that they have actually launched a spacecraft capable of returning a soil sample from the Moon back to Earth, would you not?

Dr. SEAMANS. It is always a possibility, that I would not rule out.

It depends on how they have planned their program, and I am really in no position to judge.

Mr. DAVIS. Thank you, Dr. Seamans. That is all.

Mr. RYAN. Now, Dr. Seamans, to just return to the less spectacular, Mr. Jaffe's statement says that:

All of the established interests * * *

At the bottom of page 1 and the beginning of page 2:

* * * are cooperating to the fullest extent in the research and developmental programs.

I just wonder, somewhat rhetorically, whether the Communications Satellite Corp. is within the definition of "Established interests." Then, the statement says:

A continuing liaison would be initiated with the new Communications Satellite Corp.

I am wondering what initiative NASA should take right now, to sit down with the corporation and work out a formula for the reimbursement to the Government, for both R. & D. costs which NASA incurs. And I am not now talking about launching or fuel. I am only talking about research and development.

Dr. SEAMANS. Well, I would again like to refer to the letter of March the 27th, that I referred to before, as an indication that we are anxious to get together with this corporation and discuss with them the matter of the reimbursement. This is important, I agree, and in the case of Telstar, the formula included not only payment for the launch vehicle and the fuel, but for all identifiable incremental costs. We did not attempt to break down the capital investment at Cape Canaveral, and have them pay for their share of the launching pad,

but they did reimburse us for those people both at Goddard and in our tracking stations, for the time that they spent working on this particular satellite operation.

Now, if you get into the area of, say, supporting research, which I think you mentioned earlier, this is the same kind of area that NACA was involved in in aeronautics.

Mr. RYAN. I understand your argument. But what I am talking about now, in 1963, is whether or not you plan to sit down with these officers of this corporation and attempt to work out a reimbursement formula for supporting research and development, or do you feel that that is not proper?

I gather this morning that you feel that the analogy is so close to NACA that the Government should continue this, but I would like to draw your attention to the fact that this is a private corporation. It is a monopoly, and it was organized for the specific purpose of putting the United States first in communications satellites, and to show that private enterprise could do it.

Now, it seems to me that this is an area that ought to have your attention. Has there been any planning beyond the fiscal year? Right now you are coming in asking for $51 million. You are asking for more money than last year when you asked for approximately $43 million.

Dr. SEAMANS. Yes.

Mr. RYAN. Now, what do you anticipate in 1965?

Dr. SEAMANS. I can't give you the exact figures, Mr. Chairman, but there have been projections, and this would include a definition of the supporting research and technology on approximately the same level of effort plus the runout costs on the Syncom project. I think this will be about the only projection that we will have for 1965 presently.

Mr. RYAN. Incidentally, have you discussed with the attorneys for NASA, the legality of the Government subsidizing a private corporation—have you a legal brief in your files on this question?

Dr. SEAMANS. We are not subsidizing the corporation, Mr. Chairman.

Mr. RYAN. Is this not a subsidy?

Dr. SEAMANS. There is no money being transferred to the Satellite Corp.

Mr. RYAN. What is being transferred to it?

Dr. SEAMANS. Information and data. The same information——

Mr. RYAN. Who is paying for it?

Dr. SEAMANS. The U.S. taxpayer is paying for it—just as was the case——

Mr. RYAN. Is that not a subsidy to the corporation?

Dr. SEAMANS. Well, if you use it that way, if you use the definition that way of course our total industrial application program is a subsidy to all of the U.S. industry so that if we are taking that legal interpretation that is perfectly true and proper.

Mr. RYAN. Right—if you make general information available, but I am talking about the transfer to one single corporation.

Dr. SEAMANS. Transfer?

Mr. RYAN. Yes—I know that the time is running short but I would like to ask this question: You say:

NASA will not only play a primary role in support of space communications satellite corporation but will also support all industries, supplying components for future communications satellites.

Now, may I ask what that means?

Dr. SEAMANS. I will explain what that means very simply—the Satellite Corp. is going to be developing an operation system—the Department of Defense is already in the process of selecting contractors for an operation system and I am sure that the first system will not be the last one—so that the development of this operational system will mean that we will have to draw on the total electronics capabilities of this country. What we do will be made available to the total industry so that they will be able to perfect better components for the users.

Mr. RYAN. Well, I think the time is very short, and we should have some review of the figures.

Mr. RUMSFELD. I would like to ask some questions on that Mr. Chairman.

Mr. RYAN. Well, suppose we let Mr. Boone just run down the figures—would that be agreeable to you, Mr. Rumsfeld?

Mr. RUMSFELD. Well, if you feel you have the time, Mr. Chairman, but there are one or two things I would like to take up.

Mr. RYAN. Do you have some questions on particular items?

Mr. RUMSFELD. I would prefer to just ask two or three questions because I don't think there is enough time to go through them item by item.

Mr. RYAN. Go right ahead.

Mr. RUMSFELD. Well then, referring to pages 21 to 23 of volume 5, and in line with Mr. Ryan's earlier questions, do you envision that this total budget which is just for R. & D. and which is put in at $51 million, would increase roughly by the same amount between 1963 and 1964 as compared with 1964 and 1965?

I hope you can answer this briefly and I will try to keep my questions short.

Mr. JAFFE. No, sir.

Dr. SEAMANS. Our costs are under the $51 million figure, I believe.

Mr. JAFFE. That's right.

Mr. RUMSFELD. In other words, you do not envision the establishment of a new area like this in the Syncom which is going to put an additional $41 million, I believe it was, next year?

Mr. JAFFE. No.

Dr. SEAMANS. Well, you see, the advance Syncom II program will last over a period of several years with the level of effort remaining essentially constant, but slightly reduced in fiscal 1965.

Mr. RUMSFELD. But some of these items concern me. On page 21 the intermediate altitude satellite—$2 million is listed for 1963 and $2 million for 1964. This is 3 or 4 items down. What portion of that $2 million for 1963 was spent or has been allocated this year?

Mr. JAFFE. I would have to supply that information.

Mr. RUMSFELD. Would you do that, please?

Mr. JAFFE. In response to a question by Mr. Rumsfeld re the portion of $2 million fiscal year 1963 funds that has been spent or allocated toward the intermediate-altitude satellite.

Submission: None of the programed $2 million of fiscal year 1963 (see vol. V, "Fiscal Year 1964 NASA Budget Estimates," p. 21) in-

termediate-altitude-satellite studies funds have been committed, obligated, or expended.

A portion of it is already committed but we will supply that for the record; yes, sir.

Mr. RUMSFELD. I would appreciate it if you would.

Some of these items I noticed on Echo and Relay and Syncom and Advance Syncom; in regard to data reduction and analysis. This is a continuing item where some of the others—many of them—are not.

Mr. JAFFE. Yes.

Mr. RUMSFELD. In addition, as far as the Advance Syncom is concerned, you go up to $1 million data reduction and analysis.

You envision this not being present in 1965; do you, at all?

Mr. JAFFE. That will be present in 1965 and one of our major concerns and efforts in this satellite program is to determine the rate of degradation of the systems that we do put up in space so that once satellites are launched there is a continuing operation of acquiring data from the satellite and making analysis of these data through the life of the satellites.

Mr. RUMSFELD. So that we can assume that the cost will have gone down a little between 1963 and 1964 anyway, but will stay at a level fairly close to what we see in 1964; is that right?

Mr. JAFFE. For data processing and analysis; yes.

Mr. RUMSFELD. And with respect to these ground-station operations, the same situation exists where you have a continuing cost of Relay of $1 million-plus and on Syncom $2 million-plus?

Mr. JAFFE. That is correct.

Mr. RUMSFELD. Is that right?

Mr. JAFFE. Yes, sir.

Mr. RUMSFELD. And this will go down but stay at a level fairly close to this; is that correct?

Mr. JAFFE. Yes; for the life of this satellite, or satellites.

Mr. RUMSFELD. And with respect to the personnel requirements I understand there has been a reduction in the personnel requirements. I notice that there has been an increase in the NASA headquarters personnel, however, in the communications field; is that correct?

Mr. JAFFE. That is correct.

Mr. RUMSFELD. Why is this?

Mr. JAFFE. This is true partly because of the establishment of the DOD program on the intermediate-altitude satellite. Because the intermediate satellite is an active flight program that will be taken care of by the efforts of the DOD and perhaps the Communications Satellite Corp.

Mr. RUMSFELD. I see.

Mr. JAFFE. We omitted this item from the NASA active flight programs. As to the responsibilities of headquarters because of the coordination requirements with the DOD and the corporation we fully expect an additional load that will cause a small increase in the headquarters personnel complement.

It makes it necessary.

Mr. RUMSFELD. Well, you say "small"—what is——

Mr. JAFFE. I believe we are going from 32 to 38.

Mr. RUMSFELD. I see. In this fiscal year, 1963, the authorization was $85.37 million, whereas the programed amount is $43.7 million.

Would you discuss that, please?

Mr. JAFFE. Yes; there are two reasons for this reduction in programed expenditure as opposed to or vis-a-vis the authorization. One was the cancellation of the Rebound project. This was a project to launch three spheres into the orbit in which each would be spaced by some controlled manner and it was decided that this was beyond the state of the art and we have canceled the Rebound project.

A second factor is that we have abandoned plans to actively take part or establish an intermediate-altitude system on the assumption that this would be taken care of by the DOD program and perhaps the Communications Satellite Corp. So those are two areas we are not undertaking now.

Mr. RUMSFELD. And this is the reason for the reduction in the programing? I think it is $42 million——

Dr. SEAMANS. The second item was the substantial one—the advanced medium-altitude satellite system.

Mr. RUMSFELD. Where is this money; what is the status of this excess, this $42 million?

Dr. SEAMANS. Well, this money that you refer to, this was reprogramed within NASA and you cannot identify the dollars as going from this project to some other project particularly. This was discussed with the full committee here about a month ago when we were describing all our programing actions.

Mr. BOONE. This was not reprogramed within the communications satellite area?

Dr. SEAMANS. That is correct, Mr. Boone.

Mr. BOONE. Do you have some idea of the carryover from 1962–63—funds that will be carried over into 1964?

Dr. SEAMANS. The total carryover from 1962–63 was of the order of $10 million. This is out of a $1.7 billion program and the carryover from 1963 to 1964 will be, likewise, a very small amount.

Mr. RYAN. Could we have for the record, gentlemen, a breakdown of NASA's commitments and obligations for fiscal year 1962 and fiscal year 1963?

Dr. SEAMANS. I would be happy to supply it.

(The information requested is as follows:)

In response to a request by the chairman, Mr. Ryan, that NASA submit for the record the NASA commitments and obligations for fiscal year 1962 and fiscal year 1963 in the communications satellite area, the following table is submitted:

Commitments and obligations—Communications systems as of Feb. 28, 1963

Fiscal year	Commitments	Obligations
1962	$31,120,000	$30,730,000
1963	22,486,000	17,842,000

Mr. RYAN. In this communications field.

Mr. WYDLER. I just want to say that in connection with this hearing this morning, the chairman has talked about this communications satellite bill that was passed last year. I was not a Member of Congress at that time and I did not hear all the discussions that went on, on the floor and in debate on this bill, but I heartily subscribe to the idea that free enterprise can do this job and can, with all due

respect to NASA, get it done better, in my opinion, than the Government can.

But I think it is important that you let free enterprise get into this picture for a different reason. Nor do I merely feel that they ought to pay their fair share, but I feel they are not going to operate in this field unless they are made to do just that. That is to say, pay their fair share and unless they are going to be given a part and an opportunity to operate as we know free enterprise can operate, by making them invest some money in this program and feel some responsibility for it.

This is also going to mean that they are going to have to know what is going on in this program and the other programs and have a part of them, so that they will be able to make themselves responsible and make this responsibility mean something to the actual operations of NASA.

Now I would like to ask just one question: When do you think that NASA will be able to get out of this communications satellite program? Have you ever given that any thought?

I realize that this is not something that will be happening this year, but have you ever thought about when NASA will get out of this program?

Dr. SEAMANS. When you say "get out of it," we have already indicated that there will be some reduction in the fiscal year 1965, probably, and this may be further reduced in subsequent years.

However, I think that it would be a great mistake for NASA to rule itself out of such an important area, because I would just like to stress that we are not just supplying information to one company. We are doing something that has value to a lot of different corporations as well as to the Department of Defense. The synchronous satellite has some very great values from a Defense Department standpoint because it does minimize certain of the tracking and data handling problems associated with lower orbit satellites. I personally think it would be a great mistake to give to one corporation the entire and full responsibility in this expanding area.

Mr. WYDLER. Don't you think, Dr. Seamans, that the time will come when you are going to—or NASA is going to actually break out of this field altogether and I would like to hear from you when such a date comes.

Mr. JAFFE. I would like to elaborate on that a little bit. One, we fully expect private industry to become involved and take over a role in private research and development that they need to provide the systems they need for common carrier services.

This is what the law was established for and intends them to do.

I point out in my written statement that there are some systems, some future systems, which NASA will have to do some work on, or someone else will, which are beyond the interests of the common carrier, such as the broadcasting system. This is not within their purview, as I understand their mission.

We will continue to look at the technology and perhaps in the future undertake programs to develop the technology for these kinds of systems.

There is an additional point here: The Communications Satellite Act, as Dr. Seamans has pointed out, levies upon NASA certain responsibilities, to the FCC, to the corporation, to the State Department.

Those are mainly in the areas of providing technical assistance and consultation and providing technical advice. To fulfill its role, NASA will have to stay involved in this field of research to a certain extent.

Now the extent certainly depends on how much of the role the corporation undertakes and how much effort they undertake.

We will have to remain proficient in this area, however, and we will have to advance the state of the art in order to provide this kind of advice to the FCC and to the State Department and to the corporation and to industry.

Mr. WYDLER. Well, I have the answer.

Mr. RYAN. And the question in my mind is: "Where is the line of demarcation between financing the state of the art and financing the project and technology of this corporation?"

Well, I think we have had a very interesting hearing. I know, unless there are any further questions at this time, we will look forward to your return and I hope we can then take a little more time on this issue also. We have not gone into the question of the Department of Defense program and how that relates to NASA, but the House will be in session in just 5 minutes.

Mr. RUMSFELD. Well, will there be any indication, Mr. Chairman, when Mr. Jaffe and Dr. Seamans will develop some further facts for our consideration?

Mr. RYAN. I think you can see, Dr. Seamans, that there is great concern in the committee that, before we are asked to report the authorization bill to the floor including this $51 million for research and development, we have some concrete statements and proposals from the corporation and from NASA on the question of the division of responsibility and division of the financial burden.

Dr. SEAMANS. Yes; on the financial statement, you asked a question somewhat rhetorically as to the division. We feel the division is that NASA's responsibility is for a sound experimental program and research and that the corporation's responsibility is for the development of prototype equipment and for the operation of the actual system.

Mr. RYAN. And assuming that is the proper division, then the question remains as to who is going to pay for it.

Thank you, Doctor.

(Whereupon, at 12:07 p.m., the subcommittee was adjourned.)

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1964 NASA AUTHORIZATION

THURSDAY, APRIL 4, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON APPLICATIONS AND
TRACKING AND DATA ACQUISITION,
Washington, D.C.

The subcommittee met at 10:02 a.m., pursuant to call, in room 214–B, Longworth Building, Hon. J. Edward Roush (a member of the subcommittee) presiding.

Mr. ROUSH. The committee will be in order.

The subjects under discussion this morning may have the most potential for economic improvement resulting from our space program. These important factors are entitled: "Advance Application Satellites, Industrial Applications," and although they lack the spectacular titles of some of the other subjects, they include such important characteristics as possible navigational improvement, aircraft control, production methods, savings of time and material, new processes, R. & D., myriads of other technological advances that will enhance our economic program.

Although the budgetary estimates for fiscal year 1964 are not large as governmental budgets go, we do consider it of sufficient interest and potential to ask you gentlemen to present some of the results of the program to us, as well as the discussion of the fiscal year 1964 budget request.

We are very happy to have with us again Dr. Robert C. Seamans, Jr., Associate Administrator, NASA, Dr. George L. Simpson, Industrial Applications and Advanced Applications, NASA, and Alton B. Moody, Industrial Applications and Advanced Applications of NASA. These will be the witnesses during the first hour of the proceedings this morning.

Dr. Seamans, unless you have some introductory remarks, we will proceed with Dr. Simpson.

STATEMENT OF DR. ROBERT C. SEAMANS, JR., ASSOCIATE ADMINISTRATOR, NASA; ACCOMPANIED BY DR. GEORGE L. SIMPSON, INDUSTRIAL APPLICATIONS AND ADVANCED APPLICATIONS, AND ALTON B. MOODY, INDUSTRIAL APPLICATIONS AND ADVANCED APPLICATIONS

Dr. SEAMANS. Let me say a few words about Dr. Simpson if I may.

Mr. ROUSH. Certainly.

Dr. SEAMANS. He came to NASA 7 months ago from the University of North Carolina where he has been very active in the field of regional scientific development. In his capacity here at NASA as the Assistant Administrator for Technology Utilization and Policy Planning, he is

responsible for public information, data storage and retrieval, our educational programs, as well as the industrial application programs.

We have recently made an organizational change in which the industrial application program was shifted from the Office of Applications to Dr. Simpson. The group in headquarters under Mr. Fong responsible for this effort have been transferred and now report to Dr. Simpson.

I would now like to have Dr. Simpson to report on the program.

Mr. ROUSH. Dr. Simpson, we are delighted to have you. Your reputation, which is good, has preceded you. We are glad to have you involved in this.

I believe you have a prepared statement.

Dr. SIMPSON. Yes. May I read it?

Mr. ROUSH. Yes. Please proceed.

Dr. SIMPSON. Dr. Seamans has already given you an introduction to NASA's industrial applications program. With your permission I would like to take a few minutes to elaborate on this area in view of the interest which you have expressed.

NASA is committed to a hard, driving effort to transfer the useful fruits of our research and development effort to the private sector of the economy in as quick and as useful a way as possible.

We are committed, first, because the Space Act requires it. NASA is directed to—

> Provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof.

We are also committed because we are mindful that a large part of the nation's R. & D. effort is occupied by the Federal agencies; and that it is essential that the maximum value be wrung out of this part of the total effort.

The requirements for space exploration begin in the field of anatomy and run through virtually the whole gamut of scientific and technological interest, through new power sources to zero gravity. Further, those things which are made for space travel receive no compromises from that harsh environment. Which is to say that a very large part of the total space work is at the very leading edge of the state-of-the-art; and that in another large part the state-of-the-art must be extended.

It is reasonable to think that an effort of such size, range and sophistication, extending over a number of years cannot fail to have major scientific and economic consequences: consequences that begin as scientific and technological advances and then are converted into new techniques of manufacture, new systems of organization, and new products and services.

The space effort will be, we think, altogether comparable in its effect on the American economy to that of World War II. Our objective is to maximize, to facilitate, to speed up this effect.

We are moving in a variety of ways toward this objective. At NASA headquarters a group under Mr. Louis Fong works steadily on this problem. At each of the NASA field centers an industrial applications officer studies the work in progress there and reports to Mr. Fong on new devices, processes and techniques that show potential for application elsewhere.

The Midwest Research Institute is carrying on a pilot study that is of considerable interest. Institute staff have visited the NASA

centers and identified a large number of potential applications. Midwest has selected the most promising of these applications and, by visits to central cities in six States, has introduced them to business and industrial leaders.

As an illustration, I cite the following from Ames Research Center: In its effort to simulate the conditions under which a space vehicle reenters the atmosphere, the Ames Research Center adapted for its use a stirred arc gas heater. This heater employs a radial magnetic field to rotate an electric arc at high velocity between two circular water-cooled electrodes. Rotating the arc not only reduces electrode erosion to a minimum but also makes possible much higher heating efficiencies.

MRI in its translation of this item to industrial use, estimates that the use of this arc heater, as advanced by Ames developments, to convert natural gas into acetylene may result in a considerable reduction in the cost of producing acetylene. There are added possibilities for use of this faster, high efficiency heater in the chemical and metalworking industries.

The major input thus far is from NASA's in house effort. We are taking steps to increase the quantity of reports from industrial contractors.

We are in the process of broadening this work to include a number of additional research institutes. A number of universities are also at work on this problem.

We are trying other approaches. It is clear that one of the most essential goals must be that of bringing the industrial research people into direct contact with our research and development effort, so that they will study this effort closely and in terms of the interest of their own companies. To the fullest possible extent we want to remove the middleman from this situation.

As we study this problem it also becomes evident to us that we must take steps that will establish on a more permanent and longer-range basis the interest of a community or region in this matter of application. We plan to encourage the organization of local groups that will commit themselves to perhaps a 5-year effort to study carefully the needs and the potentials of their regions and seek ways of bringing new processes and new products into the regions.

In addition to applications to industrial uses, we also feel that a potential exists for the transfer of parts of the NASA effort to the solution of many of the problems of metropolitan areas, such as water and air pollution.

We are aware that past experience indicates severe problems in the transfer of Government research and development efforts to private use. However, we feel that the Nation's well-being requires a major effort to determine whether these problems can be solved.

Thank you, sir.

Mr. ROUSH. Thank you, Dr. Simpson.

Referring to your last paragraph, I believe your office is comparatively new.

Dr. SIMPSON. Yes, sir.

Mr. ROUSH. Could you indicate to us in a little more detail what some of these problems are that you refer to, and more precisely what you are doing to solve those problems?

Dr. SIMPSON. The problems are essentially those which have to do with the transfer of new developments. Industrial and scientific people tell us their experience has been that it is often uneconomic for them to do this; that there is considerable difficulty in transferring people from Government research and development work to private work, this kind of thing.

We feel that if we can bring these people from industry directly into contact, which is what we are attempting to do, with the fallout or the research and development effort which NASA or any other Government agency is carrying on, that there is a greater potential here than they have heretofore come to be willing to invest their funds in exploiting.

Mr. ROUSH. How do you go about bringing them into direct contact?

Dr. SIMPSON. Our first way is through the reporting system which we are establishing, reports which come from the NASA Centers to headquarters and which are then distributed.

Second, the Midwest Research Institute has gone into six States in the Midwest, conducting meetings of business and industrial people, and in effect put on a show or fair.

Beyond this, we are encouraging industrial people to come to the Centers themselves. One company, for instance, has already agreed to send a group to two of our Centers for several days. We are asking them in effect to go and examine what is going on in these Centers in terms of their own interest.

I mentioned community interest. Last week we held a conference in Oakland. The group there of business and industrial people, together with representatives from the University at Berkeley, agreed to establish a permanent, an ongoing committee to work at this problem in terms of the needs of that area.

Mr. ROUSH. Is the conference you have set up in Chicago in the early part of May, has that been planned by your office or is that——

Dr. SIMPSON. It is a joint enterprise actually. Our main focus is on the third National Conference on Peaceful Uses of Space. The Chicago people themselves with our cooperation have extended this to include a wide variety of items, one of which is this matter of industrial applications. Frankly, we are urging them to do this, hoping that they will develop a follow-on group that will work in the interest of the entire Midwest region.

Mr. ROUSH. I gather your attack is really a two-pronged attack, one conducted by your office and the other is the encouragement of industry to also approach NASA and seek out information, is that correct?

Dr. SIMPSON. Yes, sir I would emphasize the latter.

Really our basic objective is to indicate or show to industry that there is something here of value. The maximum amount we can turn over to them, or the maximum number of ways that we can develop for them to approach this program, is really what we are looking for.

Mr. ROUSH. Referring to these industrial applications, are those merely fallouts of the laboratory that must be recognized, or do you have engineering personnel who seek out the improvements?

Dr. SIMPSON. At each of the Centers there is one or more people of a technical background who actually go into the laboratory at the workbench level and seek these out.

As you might expect, it would be impossible to expect the people working on the Saturn, for instance, to give a lot of time to this themselves. So we have people in the centers who stay with these programs and who, on the basis of direct investigation and contact, seek to identify innovations.

Mr. RUMSFELD. Could I ask a question on this point?

Mr. ROUSH. Yes.

Mr. RUMSFELD. You said with respect to this Chicago Space Month that you are hoping that they, meaning I presume the people who have set up this conference in Chicago, will develop a followup group. Could you elaborate on what you are talking about and how you in NASA would work with such a group, what your function would be in such a program?

Dr. SIMPSON. Yes. What we would hope would be this: That a group would be established in the Chicago area, a combination of business, industrial and university people, who would then seek to examine the NASA program and to examine their own resources, their own interests, to see where there is a meeting.

For instance, we would hope this group would first of all mobilize the interest of industrial people in the midwest area, perhaps through an inventory or whatnot.

We would also hope that these people would support work in the university or in Armour Research Foundation, or through some group of their own, that is to say, which would pick up innovations as we identify them and begin to initiate some development work on them. There is a wide gap here between potential and economic use.

Then we would hope this group would be a focus or contact for us to work with, that they could send teams or a task force to the Centers or to our people here in Washington. What we really want is a bona fide effective group working in this area, particularly drawing out again the economic interest of the people there. We want them to look at what we have in terms of their own moneymaking interest.

Mr. RUMSFELD. There was a statement made before this subcommittee on Tuesday, I believe, discussing the Armour Research Institute and its new Center. How would it specifically fit into such a program?

Dr. SIMPSON. I am not familiar with the statement. In this case, for instance, there is no reason why a midwestern group could not give a contract to Armour Research Foundation to study the specific spill-out items we are identifying, or even for the Armour people themselves to come directly into the Centers to look at these things and then make their findings available to people in the Chicago area on any basis that they established.

Mr. RUMSFELD. What is the specific device for identifying these spill-out items you refer to?

Dr. SIMPSON. The device is simply a technical person in the Center who lives with the Center research and development program and who follows them closely by, as I say, going directly into the laboratory. In his own judgment and in talking with the people performing the work, saying this looks as if——

Mr. RUMSFELD. You don't identify them. Some non-NASA person identifies them?

Dr. SIMPSON. These are NASA people. On the other hand, the Midwest Research Institute brought their own people into the

Centers. We have done both. The permanent structured program is carried on by NASA people. At Huntsville there is an industrial applications officer with some staff. Today I assume he is in a laboratory looking at what is going on, examining it for potential application.

Mr. RUMSFELD. I won't pursue this further. I would like to find out later exactly how this works, because I must confess I don't understand.

Mr. WYDLER. I don't understand it either. It would help me to understand it if you could give me an illustration by taking one particular identifiable application item and tell me how you get that to industry, what you expect industry to do with it, how NASA would be in the picture after industry has it for its practical development. Can you do that with one item you have had in the last year?

Dr. SIMPSON. Perhaps Mr. Fong would join me on this.

Let me give the general flow here of this stirred arc gas heater, for instance, that was identified in the Ames Laboratory.

In this case it could have been by a Midwest Research man or it could have been identified by our staff man there as a new development. They know this because they know what the people at Ames are doing.

They examine the program and go into the laboratory and make themselves a part of the on-going research program. This potential application was identified, described, and sent to Washington on what is called a flash sheet.

This comes to Mr. Fong's office. He has a process by which he himself and his staff look at these things, give them some evaluation, and write them up in an orderly way. Then I think Mr. Fong may very well get some outside consulting help from one of the research institutes for further evaluation.

Then we undertake to make this available to industry through the normal sources of publication, trade journals and this kind of thing.

I must say I think we feel we are only at the beginning, particularly with regard to the dissemination of these.

Mr. WYDLER. You did this up to the point that you have described this to me now?

Dr. SIMPSON. Yes.

Mr. WYDLER. You did make this available through trade journals and other means.

Dr. SIMPSON. I would like Mr. Fong to speak to this particular point so I don't mislead you on what has happened in any particular case.

Mr. FONG. I might say we——

Mr. ROUSH. So that we might have a proper identification in the record, would you give your full name and title, Mr. Fong?

Mr. FONG. My name is Louis B. C. Fong. I am the Director of the Office of Technology Utilization, formerly known as Industrial Applications.

I might address myself to this last question relative to how we disseminate this information. We haven't engaged in our full-fledged dissemination program yet. It will be done in late spring.

With regard to the specific question on dissemination, the item is evaluated through several levels, and then given to the Office of Scientific and Technical Information, where we plan to use existing channels of communication to industry. As Dr. Simpson said, these include

trade journals, professional societies, seminars, and certainly through other Government agencies where it is possible.

Mr. WYDLER. In other words, in this particular case that was being described, no dissemination was made, do I understand?

Mr. FONG. The stirred arc gas heater was disseminated to 3,000 people in the Midwest on a seminar basis.

Mr. WYDLER. What does the seminar basis mean?

Mr. FONG. This is a series of meetings in the Midwest area in six States. The Midwest Research Institute calls a meeting of the industrialists, 200 or 300 at a time, and talks to them about the ideas which have been identified from NASA.

Mr. WYDLER. Is there any industrialist that is trying to develop this stirred arc into a practical useful item?

Mr. FONG. Not this specific item, since it requires a considerable amount of resources and a considerable amount of investment.

Furthermore, we are developing some additional technical data to make it more realistic. We have other items that we can speak about that have been transferred to industry.

Mr. WYDLER. If you don't mind, Mr. Chairman, I would like to hear about one of them. This is what I was trying to get at. Maybe Mr. Fong can do that for us, if you feel we have the time. I think I would picture the whole thing better.

Mr. ROUSH. If Mr. Fong can give us a concrete example, fine.

Mr. FONG. Perhaps one good example is the use by Marshall Space Flight Center of what they call a single pass welding technique. This is a technique which permits you to weld fairly large pieces and fairly thick pieces without the need of going over it twice, once on each side. This is done by using a silicon fiberglass backup tape in lieu of backup bars and does save considerable expense in labor and time.

A midwestern company is now using this in sealed pressure tanks. The technique is something that they learned about through the Midwest Research Institute and got some additional data about from the Marshall Space Flight Center.

This information was disseminated through the Midwest Research Institute. There is another item of general interest, the soldering technique which was developed way back in the aerospace development effort. It started before the Marshall Space Flight Center, with the Von Braun team in the Jupiter program, and later was extended in the space reliability program.

Mr. WYDLER. To go back to the first instance you gave. You wrote this up and disseminated it to this company which finally decided to utilize it, is that correct?

Mr. FONG. First, it was picked up by the Midwest Research Institute and verbally disseminated, and later provided to the company on a written basis.

Mr. WYDLER. What is the name of the company?

Mr. FONG. This company is the Western Supply Co., Tulsa, Okla.

Mr. WYDLER. This company adapted it for use in its manufacturing process?

Mr. FONG. Yes.

Mr. WYDLER. Did they do that on their own, or did they do that with the cooperation of NASA?

Mr. FONG. This was a technique they could almost pick up without too much direct assistance from NASA. NASA furnished the information and the specifications.

Mr. FULTON of Tennessee. Before we get off this subject I think it would be good to have inserted in the record a list of the techniques that have been made available, or a list of byproducts from the Scientific Research Center going on in NASA, if that be provided for the record.

Mr. ROUSH. Can this be provided?

Dr. SIMPSON. Yes, sir.

Mr. ROUSH. Have you developed a catalog or listing of these various items which you provide for general dissemination?

Dr. SIMPSON. Yes, sir; we have a list.

(The information requested is as follows:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION,
OFFICE OF TECHNOLOGY UTILIZATION,
Washington, D.C., April 11, 1963.

Reference the stenographic transcript of hearings before the House Subcommittee on Applications and Tracking and Data Acquisition, April 4, 1963, page 732.

As requested by Representative Fulton, a list of techniques which have been made available is provided for the record.

Rapid sequence camera
Dynatube connector
Silicon solar cells
Battery-powered tools
Sintered alumina cutting tools
Air bearings
Aluminized mylar film
Beryllia heat sinks
Pyroceram
Nonlubricated bearings
Protective coatings
Explosive forming
Filament winding
Welded wire packaging
Magnetic pulse forming
Stirred arc gas heater
PERT Cost system
Reliability of electrical soldering
Printed cables
Frangible tube energy absorber
Chain rubber drive
Single pass welding technique
Release coatings
Weld seam tracker

As Mr. Fong says, we are in the process of working out a standard way of dissemination here, which is an answer to the second part of your question. We do have a catalog started, I believe with somewhere between 500 and 600 potentials. I may emphasize the word "potential." We have a list of these. Many of these have already been evaluated. We have perhaps 50 that are under very serious consideration.

Mr. ROUSH. It seems to me this is an item that lends itself to good public relations for NASA. And in addition to disseminating perhaps technical information to industry, are you undertaking to use this as a public relations gimmick?

Dr. SIMPSON. I would say we are not unmindful that this is a good thing for NASA. We are not attempting to capitalize on it heavily on public relations.

I would say also we are going rather slow in what we claim, or what we are trying to put out. We will, of course, give it full expression.

Mr. HECHLER. I think Mr. Fulton's question and your observation are very pertinent. I think that this is a very, very important phase of NASA's work. I believe that more should be made available to the public on precisely what you are doing.

Many times the expression is made that what we are putting into the space program in terms of the taxpayer's dollar is coming back to us in increased value in industrial applications. This broad statement is made, but when you start to document it sometimes it is difficult.

I think it would be to NASA's great benefit and to the benefit of people all over the country if this were publicized to a greater extent.

I hope that NASA would give serious attention to Mr. Fulton's question in preparing these data for the record.

Dr. SIMPSON. Yes, sir.

Mr. HECHLER. It will not only help the people throughout the country but it might even help NASA with its authorization.

Mr. RUMSFELD. With respect to these flash sheets, how many of these go out on a given item? What are we talking about in numbers? Is this in terms of a mailing list or whatever your method of dissemination may be, and I would like to have a copy of one to see what we are talking about.

Dr. SIMPSON. As we are working at this now, we are thinking about a release number of about 1,600 individual recipients. Of course, many of these are news media of one kind or another, trade journals, and so on. What we are doing is trying to cover every possible interest.

Mr. RUMSFELD. If an individual wrote in, would you add them to your list?

Dr. SIMPSON. Yes, sir.

Mr. RUMSFELD. And something like a research center would automatically be on the list?

Dr. SIMPSON. Yes, sir. If we seem a little cautious here it is because we don't want to overstate what we have until we have a goodly number of substantial achievements.

Frankly, it is extremely difficult to identify these things, to describe them. Some of the more important factors are going to be processes, techniques, organization systems, as well as devices. We want to be sure that what we have is sound and really quite worthwhile before we make too much of it.

Mr. RUMSFELD. Will you make available to each of the members one of these flash sheets?

Dr. SIMPSON. Yes.

Mr. RUMSFELD. I don't know if you would want it in the record. I would like to see one.

(The information requested is as follows:)

AUG 16 1962

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
INDUSTRIAL APPLICATIONS FLASH SHEET

IDENTIFYING NO. (Assigned by Installation Applications Officer): M-FS-7

TO: Code FF (2 copies)
NASA Headquarters
Washington 25, D. C.

FROM: (Applications Officer, NASA installation)
Arthur W. Thompson, MSFC

This form is to be completed for each innovation used in NASA work. DEFINITION: for the purposes of this form, the term INNOVATION is defined as "*A means of accomplishing a work objective either more effectively than before, or for the first time.*" The term includes the development, invention, discovery, modification or new use of a device, process, material, system, or technique.

1. INNOVATION CREDITED TO
John Cresap, M-ME-F

2. NAME OF INNOVATION: Fiberglass Tape for Backing-Up Welds
WHEN FIRST USED: 1962

3. DESCRIPTION OF INNOVATION (Include (a) present use, (b) functional details, (c) unusual features, (d) significant dimensions, (e) quantitative comparison to superseded means, (f) environmental factors that affect use, (g) cost, if significant.)

The Manufacturing Engineering Division of Marshall Space Flight Center has performed much fusion welding of aluminum sheet, using the tungsten electrode inert gas (TIG) and consumable electrode inert gas (MIG) methods. Frequently, it has been necessary to use grooved backup bars underneath the seam to be welded, in order to achieve the desired symmetrical position and shape of the weld bead and prevent puddle runout, particularly when the sheets are out of alignment.

Desiring to replace these metal backup bars, MSFC has been testing fiberglass tape as a substitute. The tape can be obtained with or without adhesive backing. When adhesive backed, it can be pressed into position straddling the seam. The non-adhesive type can be securely held with transverse adhesive tape strips.

Minnesota Mining & Mfg. Co. Tapes No. 361 and 865, referred to as pressure-sensitive silicone adhesive glass cloth, meeting specifications MIL-T-4053 with regard to quality, were tested as replacements for backup bars for welding ½ inch thick 2219-T87 plate. Good results were obtained. The molten aluminum underbead (900-1200°F) was successfully retained and shaped by the tapes, with no weld contamination and with no adverse effects on weld porosity or strength. Henko Resin Company's "Volan A" tape was also tried. Permacel's P-21 adhesive glass cloth electrical tape was used as an additional support for the other tapes. The tapes can be commercially obtained in rolls up to three feet wide. The widths used in these tests ranged between 1½ to 2 inches. 3M Co. will manufacture these tapes to customer's specifications with regard to required stiffness, closeness of weave, etc.

(Attach available drawings, sketches, photographs, or other defining material. Identify related reports, etc.)

4. PATENT APPLICATION
☐ FILED ☐ WILL BE FILED ☐ UNDER CONSIDERATION ☒ NOT TO BE FILED

5. SUGGESTED APPLICATIONS (Include those that would be feasible if the innovation were modified.)

Applications are all fusion welding of sheet and plate metals when the weld is performed from one side only, when a normally-shaped weld underbead is desired.

FOR INNOVATIONS MADE BY A NASA CONTRACTOR

6. CONTRACTOR | CONTRACT NO.

CONTRACTING OFFICER | NASA TECHNICAL REPRESENTATIVE

7. FLASH SHEET PREPARED BY: H. L. Martin, R-RP-A — DATE: August 9, 1962

FORWARDED BY INSTALLATION APPLICATIONS OFFICER: Arthur W. Thompson — DATE: August 9, 1962

8. Space for use of NASA HQS.

NASA FORM (REV. JUN 62) PREVIOUS EDITIONS ARE OBSOLETE. (Use additional sheets as necessary)

FIGURE 56a

Mr. ROUSH. Is it possible to get innovations from contractors considering their proprietary interest in research?

Dr. SIMPSON. About 10 percent to date have come from contractors. We are working on this problem through the procurement process, the contracting arrangements. There are serious problems here, both of proprietary interest and the fact that contractors don't like to take on any more work than they have to.

Mr. ROUSH. Is it a matter of taking on more work or trying to protect their own interest?

Dr. SIMPSON. Both. I would say it leans toward the proprietary.

Mr. ROUSH. Do the present NASA policies help or inhibit getting the innovations from industry?

Dr. SIMPSON. I would say our impression is that they inhibit, that is to say, industry obviously wants to protect itself to the fullest possible extent. I don't know there is any more beyond that to say so long as the Government has to protect its own interest in these matters.

Mr. ROUSH. Where you have uncovered an innovation do you conduct operations and cost analysis studies carrying the idea into production so that you can inform the industry in a more complete fashion? Or do you go that far?

Dr. SIMPSON. We hope not to go that far. I must say I think we will feel our way along here and do what seems to be necessary under the circumstances. What we hope is that we won't have to do much of that.

Mr. ROUSH. I hope my colleagues will forgive me.

Could you describe in detail the work that is planned for Indiana University?

Dr. SIMPSON. I will ask Mr. Fong to go into that, since he has been working closely with that group.

Mr. FONG. We have jointly established with the Indiana University the Aerospace Research Application Center. We made a grant to the Indiana University to the extent of $150,000. They will mount a cooperative effort with industry and attempt to explore various ways to solve this transfer problem. They will be working directly with industry.

They have 30 member industries at last count, which joined the Center on a membership basis of $5,000 for each industry, so they essentially have matched our $150,000.

We feel that this close working relationship between the Graduate School of Business, which will provide the managerial and administrative talents as well as the multidisciplinary background of the university, and the engineering and technology talent from industry, will result in some very quick and fast transfers. We then hope to use the techniques on a nationwide basis.

This is the gist of the Indiana Application Research Center.

Mr. ROUSH. Is there also planned another grant in the sum, I have a figure here of $143,000 for predoctoral students?

Dr. SIMPSON. I would guess, sir, that is under the training program, graduate training program, which is another item.

Mr. ROUSH. It is not associated with your particular program.

Dr. SIMPSON. Not directly.

Mr. ROUSH. You couldn't have picked a better university.

I might add the president of the university did service in West Virginia. Dr. Starr, and the Indiana University School of Business is a very fine school.

Any further questions?

Mr. HECHLER. Dr. Simpson, space is a real big business. I sometimes wonder whether small businesses throughout the country are sharing in the type of information industrial applications can afford.

Perhaps the history has been that this comes down through the larger corporations and your larger prime contractors. But what efforts are being made, and do you think could be made, to make sure that these industrial applications are made available to small businesses throughout the country?

Dr. SIMPSON. To date our efforts, the efforts of the Midwest Research Institute, for instance, are aimed partly at this objective. The very fact that they go to the Centers and then go back and tour the States and distribute invitations broadly indicates attention to this problem. This I think is another reason for our hoping we can get local organizations involved in this for this purpose.

In our plans we are making for dissemination we intend to take this into account. I think we must work very closely with the other Government agencies concerned with this problem.

I would say overall our greatest contribution here as we go forward would be simply to demonstrate that there are ways of making this transfer from the Government research and development effort, and that this is a resource which is perhaps more valuable to the small businessman than to the large company.

Mr. HECHLER. Thank you.

Mr. ROUSH. In addition to Indiana University and Midwest, as I recall there were maybe six or eight others, I don't believe there are any other universities or groups involved in this particular program.

Could you supply for the record—I believe it was in your testimony, Dr. Seamans, the other day—a list of these various groups, a description of the work they are doing for you and the amount of money that has been allocated to their phase of the work?

Dr. SIMPSON. Yes, sir.

(The information requested is as follows:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION,
OFFICE OF TECHNOLOGY UTILIZATION,
Washington, D.C., April 5, 1963.

List of research institutes assisting in evaluation effort

Armour Research Foundation	$46, 241
Arthur D. Little, Inc	49, 650
Battelle Memorial Institute	36, 280
Midwest Research Institute	216, 657
Southern Research Institute	39, 000
Southwest Research Institute	40, 645
Stanford Research Institute	49, 600

STATEMENT OF WORK FOR MIDWEST RESEARCH INSTITUTE

The contractor will provide the necessary facilities and personnel to aid and encourage the industries of the States of Missouri, Oklahoma, Kansas, Arkansas, Iowa, Minnesota, and Nebraska to participate in space technology, in order that the industries will be strengthened by application of this technology, the exodus of technical people trained in the area will be reduced, and increased employment of higher skills and improved income levels will become available throughout the region. The contractor will—

(*a*) Participate in the NASA industrial applications program in conjunction with other participating organizations.

(*b*) Identify within the NASA research and development program those technical innovations which may have potential application and value in the civilian-industrial economy.

(*c*) Assist in activities related to the appraisal, adaptation, and further developments of technical innovations and the dissemination of industrial

applications information by such means as may be appropriate to the subject, and as may be mutually agreed upon by NASA and the contractor.

STATEMENT OF WORK FOR OTHER SIX PARTICIPANTS

The contractor will provide the necessary facilities and personnel to assist in the NASA industrial application program with the basic objective of evaluating technological developments resulting from the Nation's space effort. The contractor will—

(*a*) Participate in the program in conjunction with other participating organizations.

(*b*) Identify within the NASA research and development program those technical innovations which may have potential application and value in the civilian-industrial economy.

(*c*) Assist in activities related to the appraisal, adaptation, and dissemination of industrial-applications information by such means as may be mutually agreed upon by the contractor and the technical representative of the contracting officer of NASA or the designee of such technical representative. The contractor shall disseminate information assembled under this contract on the widest practicable basis consistent with the purpose of the NASA industrial applications program and within the limitation of cost of this contract. It is understood that the contractor will not engage in actual development activities under this contract. However, the contractor will report to NASA instances where further development of technological innovations or information could reasonably lead to commercial or industrial applications.

Mr. ROUSH. Is the Defense Department involved in your program at all?

Dr. SIMPSON. No, sir, I don't think so.

Mr. ROUSH. To your knowledge does the Defense Department have a similar program?

Dr. SIMPSON. Not to my knowledge.

Mr. WYDLER. In that connection, is there any coordination with the Defense Department before a particular item is released for general use by the public?

In other words, my question is, How do you know at the time you are going to release this new idea to the public that it may not have a military value, the military may not want it released or may want it maintained as a secret? What coordination is there on that level?

Dr. SIMPSON. Any information that we release is unclassified at its source. We make no effort to check this out with the Department of Defense.

Mr. WYDLER. Mightn't there be a danger that you may release something, with good motives of course, that might turn out to have a military value that would better remain secret?

Mr. FONG. I might state that at each Center when the applications are identified, each Center has its own security situation and looks at these ideas from the military application potential.

We have already identified an item that has military potential. It has been coordinated directly with DOD through our own liaison office, Admiral Boone's office. It was not a classified item.

Mr. WYDLER. This is done?

Mr. FONG. We certainly do.

Mr. ROUSH. Referring to the backup book RDO 9–1, could you tell us, Dr. Simpson, how much of the $3,500,000 you are asking for will be contracted out?

Dr. SIMPSON. I think virtually all of this will be out on contracts.

Mr. ROUSH. Going down to your personnel, you have a request for an increase of 44 over last year. Are these people devoting their full

time, or will they devote their full time, to work in your office, or do they have other duties?

Dr. SIMPSON. These will be full-time people, either in headquarters or in the Centers.

Mr. ROUSH. In setting up the budget for your office would you care to tell us how much you actually requested?

Dr. SIMPSON. I did not have this responsibility at that time.

Mr. Fong.

Mr. FONG. I think what is represented here is what we requested.

Mr. ROUSH. That is unusual. You floor me.

Dr. SEAMANS. Let me say it was the feeling of Mr. Webb, Dr. Dryden, and myself, that this is an extremely important area, and that the budget request made by Mr. Fong and Mr. Stoller was sound and consequently it was approved in the full amount.

Mr. ROUSH. I agree with you. I thought perhaps you could use a little more. This is one area where I think we have a very practical matter to deal with, and one where we can reap a harvest from this space program.

I am pleased myself to know, Dr. Seamans, that you did approve the full amount these people were requesting.

Are there other questions?

Mr. RYAN. I was interested, Doctor, in your reference on page 5 to the possibility of transferring this potential for industrial use to some of the problems facing our metropolitan areas. You mentioned air pollution. Could you elaborate on that? Are we at a stage where we can make a stab at dealing with this problem of air pollution through NASA developments?

Dr. SIMPSON. I don't know that we are at the stage of direct action at this moment. We feel the work going on in this area, and waste disposal, may be of some value.

Perhaps Mr. Fong knows of something. I don't know of any effort that is immediately transferrable at this time.

Mr. RYAN. Are we at a point where it would be advisable for officials of metropolitan areas to sit down and meet with NASA and would they learn anything that would be applicable to their efforts?

Dr. SIMPSON. I think so. In Oakland last week there was a meeting on space science and urban life. There were a number of officials and other people concerned with metropolitan problems. I think the general consensus there was that we are at this stage and there must be a continuing relationship established here. That group out there has established such a committee. We expect to pursue this in other areas as well.

In answer to your question, yes, sir, the people who work at these problems seem to feel so, and so do we.

Mr. RYAN. I think it would be beneficial, for instance, could you be helpful to city officials if they spoke with you on this question now, or is it too far away?

Dr. SIMPSON. I think it would be worthwhile for those people to see what we are doing at this stage and to establish a way of keeping in touch with it.

Suggestions were made, which we will follow up, that we must work also with the various national groups that deal with these problems, for as wide a dissemination as possible.

I think it would be quite worthwhile for people concerned with these problems to establish a working relationship with us.

Mr. RYAN. I am going to suggest that to Mayor Wagner of New York City.

Mr. HECHLER. I don't want to let this opportunity pass without indicating that water pollution is a matter of prime concern not only in the metropolitan areas but to rural areas.

I would hope that the substance of your remarks would apply equally to water pollution.

Dr. SIMPSON. Yes, sir.

Mr. HECHLER. Would you care to elaborate on that?

Mr. FONG. I think in our study of the closed ecological system, where we have to sustain the life of an astronaut in space for a considerable period of time, we are looking at methods of water purification which might be applicable to the rather sticky problem we are faced with today on detergent feedback through our streams and rivers.

This may be an example of where we can make a contribution to this water pollution problem.

Mr. HECHLER. In addition to a visit from Mayor Wagner you will receive many visits from West Virginia mayors.

Mr. ROUSH. If there are no further questions, I want to express the appreciation of the committee, Dr. Simpson, for your appearance here, and also for the work you are doing. We are very conscious of what this may mean, not just to NASA but to the Nation as a whole.

I trust that next year when you come back you will be able to again give us a glowing report and show a great deal of progress in your particular work. I know you will.

Dr. SIMPSON. Thank you, sir.

Mr. ROUSH. We will now hear from Mr. Alton B. Moody, Chief, Future Applications, Satellites.

Dr. SEAMANS. Mr. Moody is in the Office of Applications. He is a Director of our advanced studies, studies that might lead to the use of satellites for such things as navigation and data gathering. He will discuss with you the kinds of studies that we are carrying out.

Mr. ROUSH. Mr. Moody, our time is limited here. We have only about 15 minutes for you. You may proceed with this in mind.

Mr. MOODY. Thank you, Mr. Chairman.

Mr. Chairman and members of the subcommittee, in his introduction to the Office of Applications hearings on Tuesday, Dr. Seamans stated that in Future Applications, Satellites (fig. 57), we are concentrating our attention in two areas: Navigation satellite systems and data collection satellite systems. I will present a brief summary of what we have accomplished to date and what we are planning for fiscal year 1964.

In navigation we have signed an agreement with DOD assigning to NASA the responsibility for determining the suitability of the Transit navigation satellite system for nonmilitary use. This will involve testing of equipment provided by the Navy, and such further development of receiving and computing equipment as justified.

In order to provide a yardstick for these tests, we have been conducting a study to establish navigation requirements of nonmilitary ships and aircraft.

FUTURE APPLICATIONS SATELLITES

NASA F 63-159

FIGURE 57

We are finding that one all-weather navigation system providing worldwide coverage would be desirable, but that to have wide acceptance it would have to be moderate in cost of user equipment, easy to operate with minimum training of personnel, have high reliability, be capable of being maintained by personnel already available, be capable of meeting the needs of a wide variety of users, both at sea and in the air, and have a long useful life.

These requirements might be met reasonably well by any of three ground-based electronic systems if they were extended to provide worldwide coverage, or by means of a navigation satellite system. (fig. 13, p. 3131).

We are also exploring the possibility that such a satellite system might be extended to provide, for all classes of users, both on the surface and in the air, traffic control or surveillance functions, search and rescue capability, and weather routing advice, for safe and expeditious movement of traffic.

A preliminary investigation indicates that such a requirement might be satisfied by a navigation satellite system using cooperative ground stations, as an integral feature of its normal operation.

We shall shortly begin a study to determine the best of several possible techniques, the hardware requirements, and the data handling requirements of such a system. This study should be completed by the end of fiscal year 1963. If the results of this study are favorable, we plan to proceed with a design study of such a system.

In the area of data collection, we have had informal discussions with several oceanographic and meteorological activities and are about to begin a study to define in detail the requirements. In coordination with this study, a second study will be conducted to determine the data handling requirements of such a system.

Briefly, it would involve interrogation by one or more satellites of transponders within the earth's atmosphere. These transponders would be associated with sensors located on floating buoys, balloons, icebergs, and at remote land stations. The location of the stations would be determined and various kinds of data would be collected. (fig. 14, p. 3131).

Oceanographic, meteorological, magnetic, and cosmic ray information are samples of data that might be collected in this manner. The information would be stored on magnetic tape in the satellite and returned to earth by command from one or more data retrieval stations suitably located.

These studies should be completed before the end of fiscal year 1963. If the results are favorable, a design study would follow. (fig. 58).

Both of these projects illustrate the operating procedure adopted for future applications. Before a flight program will be undertaken, several questions must be answered affirmatively:

1. Is there a requirement?
2. Is the requirement sufficient to justify the expenditure of the funds needed?
3. How would such a system operate?
4. Is the design feasible and within current state-of-the-art?
5. Is a satellite system the most promising solution?

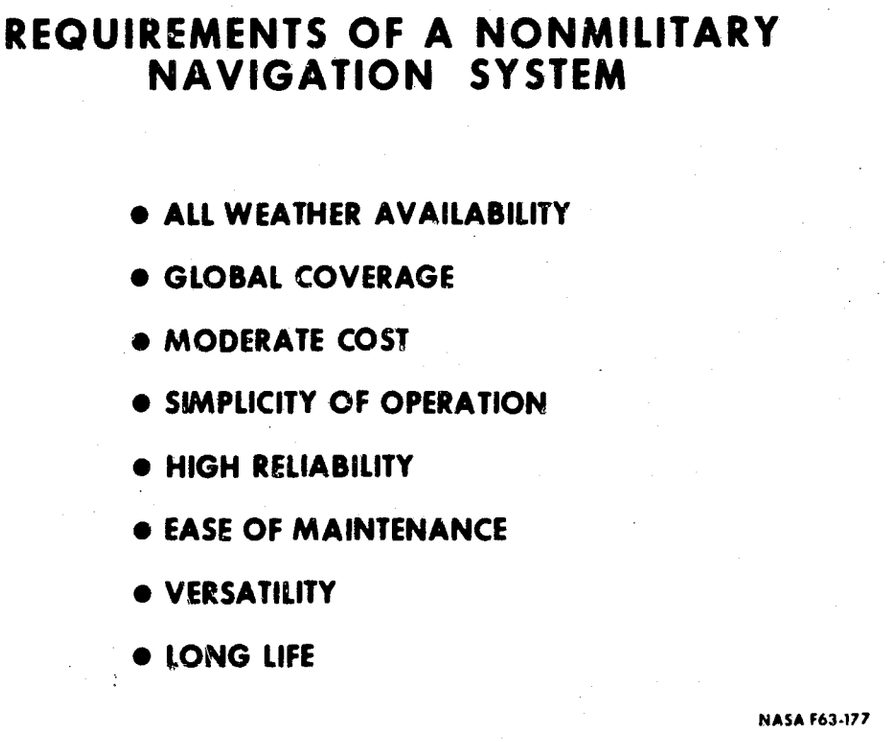


FIGURE 58

By answering these questions serially, we are not committing funds very far downstream and can turn back at any point if the results are unfavorable.

Thank you.

Mr. ROUSH. Thank you, Mr. Moody.

Mr. Boone.

Mr. BOONE. Mr. Chairman, I think Mr. Moody is aware of the work the Navy has done in the past, particularly on the Transit system.

Are you sure the Navy hasn't already done these things that you are going to do?

Mr. MOODY. We have no indication they have.

Mr. BOONE. Did you ask the Navy to do these for you, for example?

Mr. MOODY. What are you referring to specifically?
Dr. SEAMANS. To the Transit program——
Mr. BOONE. The Transit program primarily, yes.
Mr. MOODY. The testing of Transit equipment?
Mr. BOONE. They have had this under development for at least 5 years to my knowledge. It seems to me that some of the activity regarding civilian uses or commercial uses have probably researched rather fully.
Mr. MOODY. We have been in rather frequent contract with the Bureau of Naval Weapons, who have been conducting this development. This was at the request of Secretary Wakelin, who asked that we contact them directly, and we have discussed this with them on various occasions. We are coordinating the effort.
They have told us, that is, the Bureau of Naval Weapons now, that they did have some equipment which is under development, which is designed for use in surface Navy ships. It is this equipment that they are desirous we test out for, to see whether it would meet the nonmilitary requirements.
Mr. BOONE. Are you buying additional models of equipment or do you ask them to supply this equipment?
Mr. MOODY. We have asked them on what basis they would like to supply this. They are preparing an answer on that for us now. Informally, they said they hoped it would be made available to us without cost on a loan basis.
Mr. BOONE. Do you have access to all the former experiments that they have performed, to be sure that you are not replowing old ground?
Mr. MOODY. I don't know whether we do or not. We have had access to all that they have made available to us. That is, we have been on the mailing list to receive copies of the report and they are aware of what our interest is.
Mr. BOONE. Is it the function of NASA in this particular task to develop equipment and then, say, turn it back to the Navy or Coast Guard to operate?
Mr. MOODY. Any equipment that we might develop would be user equipment, receiving equipment, not equipment having to do with the use, the operation of the system itself.
We feel that we should first explore very thoroughly this question you raise as to what has been done within the Navy before we would proceed with development of any equipment. This is what we are expecting to get from the letter in preparation now. It is the principal reason why we haven't proceeded with any development ourselves until we have explored this thoroughly.
Mr. BOONE. Do you intend to utilize as much of their equipment as possible, or will you have another system in space providing this information?
Mr. MOODY. We are looking first into what their system might do to see to what extent it will meet the requirements. We would not consider putting up an additional system unless there was a definite need for a system to meet the requirements that were not anticipated under the military requirements.
Mr. BOONE. Thank you, sir.
Mr. HECHLER. Why should there be a difference between military and civilian requirements? Specifically what are they?

Mr. MOODY. I could mention several. One is a matter of cost. With the nonmilitary the economic factors are always uppermost in their minds.

In addition to this, there is a matter of maintenance——

Mr. HECHLER. We would hope the military also would consider cost.

Mr. MOODY. Maybe it can be justified another way, Mr. Chairman.

There is the matter of maintenance. The military have more qualified people aboard ship that could maintain this type of equipment. The nonmilitary have very few, if any at all.

There is a matter that in the military ships this equipment may be used to update an inertial system. No such system is available in the nonmilitary ship.

The accuracy requirements may in some cases be different. This would vary with the type of ship. I think these are the principal ones. There are some minor ones.

Mr. RUMSFELD. If it is not classified could we identify the equipment that you are talking about in the Navy?

Dr. SEAMANS. It is based on the Transit satellite.

Mr. RUMSFELD. What about the navigation system?

Dr. SEAMANS. That is the so-called Sins system.

Mr. WYDLER. Do I understand from your statement that the things that you are trying to do this year are listed on page 3, to find out if there is a requirement, and two, if the requirement is sufficient to justify the expenditure of funds needed?

Mr. MOODY. We have a study underway now which will be completed in mid-June which will do several things. It is identifying the nonmilitary requirement, that is, what is short, or lacking in the present navigation situation. Also, it will look into the possibility of meeting these unfilled requirements by nonsatellite techniques which might already be available.

Mr. WYDLER. This is a study. For this you say you need 21 people to make that study?

Mr. MOODY. No. Are you speaking of fiscal 1964?

Mr. WYDLER. Yes.

Mr. MOODY. This 21 includes support personnel. The number that would be directly working on this would be seven. These would include both this area and the area of our data collection, plus any new studies that may arise during the year.

Our area relates not only to development but investigation of possible new use. So we spend some time listening to people with ideas and exploring various possibilities to see whether a formal study should be undertaken.

Mr. WYDLER. This personnel requirement is based partly on the thought that you expect you are going to have other things that you are going to be working on which are not listed here, is that right?

Mr. MOODY. This is based primarily on these two. There is another aspect that is important and should be included, and that is the coordination with the various people who might use either one of these systems.

This is particularly true in the case of data collection system, where we would be dealing with quite a large number of different types of users.

In oceanographic interest alone, there are a number of different types of oceanographers. Their activity, of course, must be coordinated too.

You might say we don't want to end up with a system that nobody is prepared to use.

Mr. WYDLER. Let me suggest this to you. What will you do if you decide there is no requirement? Would you need all these people?

Mr. MOODY. We would then divert them to exploring other possible applications.

Mr. WYDLER. You would find something for them to do?

Mr. MOODY. Yes. We surely would.

Mr. HECHLER. Mr. Moody, how many of these 21 are professional and administrative, and how many are clerical?

Mr. MOODY. Of this number only seven would be directly related with this program specifically. Of these, five would be professional and two clerical.

Mr. HECHLER. I notice in dividing this $232,000 by 21 I come out with a figure of slightly over $11,000. I wonder if you have any comment on that?

Mr. MOODY. In headquarters personnel, who deal not only with the studies but also with the coordination, we do need a rather high-level type individual who will not only be able to, of course, handle the job itself but also command respect among the top oceanographers, meteorologists, and so forth, of the country, someone who is well versed in his field and have the various qualifications that we need.

Mr. HECHLER. Of the 21 how many are professional and how many clerical?

Mr. MOODY. I think in this it is rather difficult to state specifically because the other 14 are simply headquarters personnel who are engaged in the general operation of headquarters. It is rather difficult to identify specifically which ones might be assigned to this particular program.

Dr. SEAMANS. We can submit this for the record if you wish.

Mr. HECHLER. All right.

Mr. ROUSH. Mr. Moody, I believe that in fiscal year 1963 no funds were budgeted for your Office. Could you tell us where the $800,000 came from which you did spend?

Dr. SEAMANS. I believe in this case these were funds that we had under the heading of "Supporting Research and Technology" in the Office of Application.

Mr. MOODY. This Office had not been established when this budget was put in. They were within the general funds for the Office of Applications.

Mr. WYDLER. Could we find out what the million dollars is for?

Mr. MOODY. For fiscal 1964?

Mr. WYDLER. Yes.

Mr. MOODY. In an area where each step must be taken, and that defines the next one, it is rather difficult to say specifically where it all will be used. It will involve primarily though three areas. One will be to finish the studies relating to the navigation project and actually to come up with a design for such a system if this appears justified.

Mr. WYDLER. That will be a contract amount?

Mr. MOODY. Yes.

The second one would be the same sort of thing for data collection.

The third is simply a small amount of $300,000 we have in for contingencies of new ideas that are developed. This is part of our responsibility.

Mr. RUMSFELD. Mr. Chairman, I am still a bit confused about the personnel situation.

You indicate that only 7 out of the 21 are going to be engaged on this project specifically. That leaves 14 who you indicate are going to be general support personnel in the headquarters staff.

Mr. MOODY. That is correct.

Mr. RUMSFELD. If they were going to be things other than particularly related to this program wouldn't they be listed elsewhere? You are going to have 14 people supporting the 7 in the headquarters on this specific project, is this not correct?

Mr. MOODY. This is simply our share of the general headquarters overhead, if you can call it that.

Mr. HECHLER. This doesn't appear elsewhere in the budget?

Dr. SEAMANS. These people only appear in one case. These people appear high, and that is why I would like to submit it for the record.

Mr. RUMSFELD. Let's go back to fiscal 1963 where you had eight. Were the people using the $800,000 which wasn't——

Mr. MOODY. Two professional and one clerical.

Mr. RUMSFELD. Out of eight——

Mr. MOODY. That is all that has been specifically assigned to Future Applications.

Mr. RUMSFELD. There is five and three?

Mr. MOODY. That is correct.

Mr. RUMSFELD. It is beyond me.

Mr. BOONE. Mr. Chairman.

Is this generally true, Dr. Seamans, throughout the whole personnel accounting in NASA?

Dr. SEAMANS. We have attempted to identify in each area those people who were either working directly on the specific projects or who are responsible to support this effort indirectly in the form of procurement, for example, a small part of the procurement office.

Mr. BOONE. I believe the charts that are in volume I, I happen not to have volume I with me, would show eight people this year in Mr. Moody's office.

Dr. SEAMANS. It would show some of them direct and some indirect.

Mr. BOONE. Indirect are those that are elsewhere in the organization?

Dr. SEAMANS. That is correct.

Mr. BOONE. That is true in all cases?

Dr. SEAMANS. That is right, and also in the centers. We split them out as direct and indirect. It appears that the indirects are high in relation to the direct.

Mr. RUMSFELD. Dr. Seamans, would you say this proportion generally runs throughout NASA, 7 to 14?

Dr. SEAMANS. No, it doesn't. Yesterday we were discussing the meteorological area, say, at Goddard. The ratio there was something like 30 to 35 percent, as I remember it, indirect; and somewhere around 65, 70 percent were direct.

Mr. RUMSFELD. What is so unique about this that you would have such a disproportionately high number of nondirect, indirect?

Dr. SEAMANS. I can't answer that question. That is the reason I would like an opportunity to review this with Mr. Moody and our headquarters people and submit it for the record.

Mr. HECHLER. I believe it would also be helpful in addition to this field if you would give us a prepared statement for the record indicating the way in which you have allocated direct and indirect personnel in all fields across the board. I think that would be helpful for an understanding of the way personnel costs are allocated in the budget.

(The statement requested is as follows:)

The 21 personnel shown in the fiscal year 1964 NASA budget estimates in support of the Advanced Applications, Satellites, are distributed as follows:

Direct personnel		*Supporting personnel*	
Chief, Advanced Applications, Satellites	1	Pro rata distribution of NASA headquarters staff offices (i.e., those other than program offices)	10
Advanced Applications, professional personnel	4		
Advanced Applications, clinical support	2	Total indirect	10
Subtotal	7		
Pro rata distribution of Office of Applications staff positions	4		
Total direct	11		

The way in which NASA allocates direct and indirect personnel in all fields across the board is as follows:

Each NASA program office first established, with the NASA installations, the projects or efforts to be undertaken at each location. Knowing the planned workload, each installation director then determined the number of "direct personnel" required to conduct each project within the schedules, funds available, and desired method of doing the work (i.e., in-house, by contract, or a mixture of both). "Direct personnel" include both the scientists and engineers working directly on projects, and the procurement specialists, financial managers, and contracting officers assigned to the project teams.

Installation directors also estimated their requirements for supporting personnel in the administrative services, shops, and general management areas who are required to support the operation of the installation, but who are not readily identifiable with specific projects. After review by the director, the supporting positions were then distributed statistically by the projects and programs of the installation.

The total installation personnel requirements were forwarded to headquarters, where they were consolidated and reviewed by the Associate Administrator and his staff. Consolidated estimates were then sent to the Bureau of the Budget for further review and a final decision on the personnel level to be included in the President's submission.

After receiving the Bureau of the Budget's personnel allowance (32,500 permanent positions in fiscal year 1964), final allocations of personnel positions were made by the Associate Administrator to the installations. Each installation director again developed position estimates on the basis detailed above, but within his assigned personnel resources.

These estimates, with final minor adjustments to reflect program changes and transfers of project assignments between locations, are presented in the fiscal year 1964 NASA budget estimates.

Mr. MOODY. I might add that this is a new area that would involve possibly more support initially than it would as it got further into the program. Also by the nature of the program it is handled by a number of fairly small contracts. Almost as much work is involved in processing a small contract as it might a large one. This I think has to do primarily with the fact that the program has just been

getting underway, and as it proceeds we will expect the ratio to improve.

Mr. ROUSH. If there are no further questions——

Mr. WYDLER. There is, Mr. Chairman.

Has the $800,000 for 1963 all been expended?

Mr. MOODY. No, we expended $325,000. The balance, $459,000 we had kept in reserve for the purchase of transit equipment, which it later turned out we didn't need. These funds are now being programed to another area.

Mr. WYDLER. Being what?

Mr. MOODY. It is being transferred to another one of the office applications programs.

Mr. WYDLER. You only spent $300,000 of that $800,000 last year?

Mr. MOODY. $325,000.

Dr. SEAMANS. Right now we are reviewing with the Department of the Navy a possible program that has been described by Mr. Moody. It could or could not involve the purchase of some equipment. Until this decision is made we are holding in reserve those funds for this possible use. At this time these funds have not actually been reprogramed into another area.

Mr. WYDLER. They are unspent, though?

Dr. SEAMANS. They are unobligated and unspent.

Mr. WYDLER. At this moment we have no idea that we are going to expend them?

Dr. SEAMANS. We have to make a decision first as to whether it will be profitable to proceed with the plan that we had in mind at the time we put this budget together.

Mr. WYDLER. How much did you request originally, Mr. Moody, for fiscal year 1946?

Mr. MOODY. $1 million.

Mr. WYDLER. You got your full request?

Mr. MOODY. Correct.

Mr. WYDLER. How many personnel did you ask for?

Mr. MOODY. Nine I think it was. We got seven.

Mr. WYDLER. You didn't count the administrative personnel?

Mr. MOODY. No.

Mr. WYDLER. Thank you.

Mr. ROUSH. If there are no further questions, we thank you, Mr. Moody, for appearing before the subcommittee.

I shall yield the chair at this time to Mr. Ryan.

Does this meet with your approval, Mr. Hechler?

Mr. HECHLER. It certainly does.

Mr. ROUSH. Mr. Ryan will take over at this point.

Mr. RYAN. Good morning, Dr. Seamans.

Dr. SEAMANS. Good morning, Mr. Chairman.

Mr. RYAN. On Tuesday when we adjourned we had, I think, spent a fruitful morning session discussing some of the inherent policy questions which exist in the proposed NASA communications satellite program. And we had talked about the role of NASA in the future in view of the creation and existence of the Communications Satellite Corp., the question as to whether or not the taxpayers through NASA should continue to finance research and development in this field or whether the Communications Satellite Corp. should undertake this

research and development if there was an area of legitimate NASA activity.

We raised the question as to whether or not there should be a formula for reimbursing NASA for its expenditures on behalf of the Communications Satellite Corp.

We also were about to explore the question of whether or not there was duplication between the programs of NASA and the Department of Defense.

I think when we ended the hearing I said that the question still remained: Who is going to pay for this, the taxpayers or the stockholders of the Communications Satellite Corp.?

I think it would be fruitful to discuss that question a little more this morning, but also to refer to the specific budget proposals which NASA has laid before the Congress in terms of looking at each item and determining whether or not this is an item which could be better carried out by NASA, the Communications Satellite Corp., or DOD.

I understand, Dr. Seamans, that you have a statement which you would like to present before we proceed with the questioning by members of the committee, is that right?

Dr. SEAMANS. I actually have two statements. One summarized the views that we were expressing last Tuesday with respect to the Satellite Corp., and another that relates to our coordination with the Department of Defense.

Proceeding with the summary of our views: The development and full exploitation of the possibilities of communications satellite systems are immensely important to the Nation's economy and to its prestige.

Although the United States has pioneered in this field and demonstrated its feasibility to the world, the U.S. position of leadership will soon be lost if we do not press ahead vigorously in the establishment of the first operational system, and if we are not the ones to indicate the direction for continuing improvement and extension of the services and capabilities.

Not only will the Nation's economy benefit from the use of communications satellites and the revenues produced by their use, but it must be recognized that the potential foreign market for equipment will turn to the leading nation in this new technology.

To insure that the United States does indeed retain the leadership that it now enjoys, the planning, the organization, the establishment of operational systems, and the continued advances in the technology must be supported and nurtured carefully by both private interests and all of the agencies of Government concerned.

The Communications Satellite Corp. was established to build, organize, and operate a commercial, operational communications satellite system, and will need to carry on applied research and development at their own expense directed toward the components of this system.

Not only must the corporation decide on the kind of satellite system which initially shows the most promise of economic return and provide the organization and finances to build the system, but it must also negotiate with and make arrangements with the numerous nations interested in having a stake in communications satellite systems of the future.

The problems are immense and we can expect the corporation to move as rapidly as possible to achieve their goals. Although the

incorporators have not yet been confirmed by the Senate, we have proposed to Messrs. Welch and Charyk that we begin discussions.

(The information requested is as follows:)

MARCH 27, 1963

Mr. JOSEPH CHARYK,
President, Communications Satellite Corp.,
Washington, D.C.

DEAR MR. CHARYK: As you know, the National Aeronautics and Space Administration is directed by the Communications Satellite Act of 1962 to cooperate with the Communications Satellite Corp. in research and development "to the extent deemed appropriate by the Administration in the public interest." It is also the duty of NASA under the act to assist the corporation in the conduct of its research and development program by furnishing, at the corporation's request, such satellite launching and associated services "as the Administration deems necessary for the most expeditious and economical development of the communications satellite system."

Having in mind the national policy expressed in the act to achieve a commercial satellite system "as expeditiously as practicable," NASA has proceeded during the months since the act was passed to formulate a research and development program designed to advance the state of the art of communications satellite components, and to determine the comparative feasibility of alternative approaches to the achievement of an operational system. While NASA's program entails a major effort in the synchronous orbit field it also includes continuing research and development with passive systems and with active repeater satellites, such as Relay, operating at medium altitudes.

It has been necessary, of course, for NASA to develop its program in advance of consultation with the corporation. It is not unlikely, however, that the presentation of NASA's program to the interested congressional committees will give rise to questions concerning the corporation's plans and the entire subject of coordination and coooperation between the corporation and NASA.

We are prepared, at your convenience, to brief you and your associates on the details of NASA's research and development program in the communications satellite field. We hope that the corporation will soon be staffed to the point where we can begin the process of continuous consultation and coordination which the Communications Satellite Act of 1962 contemplates.

Sincerely yours,

JAMES E. WEBB, *Administrator.*

COMMUNICATIONS SATELLITE CORP.,
Washington, D.C., March 28, 1963.

Mr. JAMES E. WEBB,
Administrator, National Aeronautics and Space Administration,
Washington, D.C.

DEAR MR. WEBB: I am delighted to have your letter of March 27 with your expression of interest in initiating discussions on items of common concern to NASA and the Communications Satellite Corp. My call to you on Tuesday was actually for the purpose of suggesting a possible initial meeting between Mr. Welch and me and you and Dr. Dryden sometime next week. As you probably know, Mr. Welch will assume his duties as chairman of the corporation on April 1 and we are both anxious to meet with you as soon as possible in order to establish a basis for our future working relationships.

One of the first items of direct concern to us is, of course, the present and proposed NASA research and development program in areas related to the communications satellite program. We, therefore, very much welcome your kind offer to brief us on details of your program in this field. This will provide us with a sound basis for initiating our own plans and programs in fulfillment of the objectives of the Communications Satellite Act to establish "in conjunction and in cooperation with other countries as expeditiously as practicable, a commercial communications satellite system."

I followed up on the matter with Dr. Dryden this afternoon and understand that a date for a meeting has been established on Friday, April 5, at 2:30 p.m. We shall be looking forward to the pleasure of this discussion with you.

Sincerely,

JOSEPH V. CHARYK, *President.*

As I discussed at the Tuesday hearings, I am attaching to my statement the full letter from Mr. Webb to Dr. Charyk.

Mr. RYAN. That is the letter of March 27?

Dr. SEAMANS. That is correct.

At present, and in fact for an indefinite period into the future, NASA's role is to carry on experimental activities directed toward future systems in much the same fashion as Government agencies now perform exploratory R. & D. for civilian aircraft and power industries, for example, aeronautics activities of NASA; the National Experimental Center of FAA; the Atomic Energy Commission. Unless the Government accepts this responsibility, particularly during the formative period, the United States will not long remain dominant in this new industry.

An independent exploratory research and development program by NASA must continue if NASA is to maintain an authoritative capability to carry out its continuing responsibilities in the communications satellite area.

These responsibilities are to insure the continued preeminence of the United States in peaceful applications of space technology (sec. 102(c)(5), National Aeronautics and Space Act of 1958); to advise the Federal Communications Commission on technical characteristics of the communications satellite system (sec. 201(b)(1) of the Communications Satellite Act); to consult with the corporation with respect to the technical characteristics of the communications satellite system (sec. 201(b)(4), ComSat Act); and to advise the State Department on technical feasibility of particular routes (sec. 201(2)(3), ComSat Act).

Further justification for an independent Government program lies in the stipulation of the ComSat Act that NASA will—

> * * * cooperate with the corporation in research and development to the extent deemed appropriate by the administration in the public interest * * * (sec. 201(b)(2)).

Elements of public (national) interest certainly include service to less developed areas, and techniques for improving spectrum economy.

In addition, there are communications satellite areas which are not within the purview of the corporation, R. & D. which must obviously be done by the Government.

Examples of such areas include: exploring use of higher frequencies to extend the frontiers of the frequency spectrum; investigation of high-powered satellites which would permit use of very small ground facilities which might be carried on ships, emergency mobile land units, and aircraft (this capability could result in an application of communications satellites to air and sea traffic control procedures); incorporation into stationary communications satellites equipments to provide for other observations in the national interest such as scientific experiments or meteorological sensors; and investigation of high-powered broadcasting satellites which could broadcast radio or television programs directly to all the home receivers in a very large area on the Earth.

NASA must execute its program in close coordination with the program of the corporation, as well as that of the DOD to avoid unnecessary duplication.

NASA will not undertake to perform research and development on the operational systems desired by the corporation unless requested by the corporation to do so at the corporation's expense.

NASA will provide for the launching of operational communications satellites for the corporation on a reimbursable basis (all identifiable additional costs to the Government will be charged to the corporation).

NASA will continue a research program as indicated. A close review of the proposed NASA program will reveal that many of the items or technologies being pursued as a part of the communications satellite program are of very general and urgent interest in many other areas of space flight, exploration and application. They are being developed under the communications satellite program because of the early promise of application in this area.

To summarize: The objectives of the NASA communications satellite program are to—

(*a*) insure that the technology required for the establishment of operational systems becomes available at the earliest possible date in concert with the corporation and DOD;

(*b*) study and technically assess the applicability of communications satellites for other than common carrier utilization;

(*c*) insure that the technical possibilities for the full exploitation of the potential of satellites to meet communications requirements of the future are clearly established; and

(*d*) meet NASA's responsibilities as outlined in section 201(b) of the Communications Satellite Act of 1962.

Thank you.

Mr. RYAN. Do any members of the committee have any questions on the statement before we proceed to the second statement which Dr. Seamans has?

I have several thoughts but one I would like to express.

You suggest the Communications Satellite Corp. should decide on the system which shows the most promise of economic return. It seems to me that if this corporation has a responsibility beyond that to its own private investors, it should also be concerned with the system which offers the most promise for the full development of communications satellites.

I think that you raise one of the serious questions, that is, whether or not once this corporation has a system which it is using and upon which it is receiving an economic return, the question is whether or not it will be willing to abandon that system and move forward to develop a more efficient and a more feasible system. Once there is an investment in a particular system I think there is going to be a real reluctance to do more.

I think also that your statement tends to treat DOD and the Communications Satellite Corp. on the same footing. I remind NASA that the Communications Satellite Corp. is a private monopoly organized for the benefit of its stockholders, whereas DOD is an agency of the Government, just as NASA is.

I assume you want to talk now of the relationship between NASA and DOD?

Dr. SEAMANS. Yes, Mr. Chairman.

I have indicated in the past the close coordination between NASA and the Department of Defense in the area of communications satel-

lites. I would like to review the methods by which we carry out this close coordination.

NASA's overall relationships with the Department of Defense in this area are conducted as a portion of the general arrangements that have been established for NASA–DOD coordination as shown on my first chart.

The major policy issues are reviewed by the Space Council. A very good example of this was the review carried out in May 1961, at which time it was decided that NASA should proceed with an augmented communications satellite program.

Technical proposals which have been coordinated at the working levels in the respective agencies are brought out for review to the Aeronautics and Astronautics Coordinating Board. Under this Board, which ties together many items of joint interest to NASA and the DOD, there is an Unmanned Spacecraft Panel. This Panel has in particular responsibilities of a coordinating nature for communications satellites, meteorological satellites, unmanned lunar and planetary exploratory spacecraft, and the like.

In February 1961 the Unmanned Spacecraft Panel established a Technical Committee on Communications Satellites with the objective of seeing to it that the directing officials and project managers for the various projects in the communications satellites area would be entirely familiar with the work being done by all other Government agencies, so that those projects could be effectively coordinated. This group has met 16 times since its inception.

At the present time, this committee draws its membership from NASA, Army, Navy, Air Force, and Defense Communications Agency.

The DCA has recently been given responsibility for furtherance for DOD communications satellites program. The Army is now supporting the new DOD program, as well as the NASA Syncom program by providing ground stations for these efforts. The Navy is concerned as a user of communications satellites and is also supporting the NASA Syncom program. The Air Force has the responsibility within the DOD for the launching of communications satellite systems and for the development of their satellites.

In addition to frequent consultation between the top management of NASA and the Department of Defense regarding the respective communications satellite efforts, Adm. W. F. Boone has recently been appointed to assist the Associate Administrator in the NASA–DOD coordination efforts in all areas of mutual interest.

As we indicated at our last meeting, the programs in communications satellites of NASA and of DOD have been coordinated to effect an overall comprehensive and nonduplicative program in the national interest.

The DOD has established an active flight program in the area of medium altitude communications satellites, and NASA has dropped the consideration of a flight program in this area. The NASA Syncom program is the only program in the synchronous satellite area, and the DOD is following this with great interest.

This division of effort in flight programs was established during the coordination which takes place in the budgetary preparations. The division of effort in these flight programs does not preclude studies by the DOD of synchronous communications satellite systems nor studies by NASA of medium altitude systems, but it does mean that

neither agency will undertake duplicative, expensive flight programs in these respective areas.

As we have already said, DOD is actively participating in the Syncom program and they are providing the ground stations for the experimental program, using the Syncom satellites, and they are responsible for operating these stations. These stations are indicated on the next chart.

Two stations, on the east coast of the United States at Lakehurst, N.J., and Fort Dix, are provided and operated by the Army.

The U.S.N.S. *Kingsport*, a Victory ship which has been converted by the Navy, is providing NASA with invaluable assistance by providing the necessary coverage required in the region of Africa so that the critical process of injection of the Syncom satellites into the 24-hour orbit can be monitored.

All three of these stations will be performing the many communications tests involving the Syncom satellite which are now planned.

Management relations for a project like Syncom are illustrative of the interactions that take place between various agencies involved in the applications program.

The following chart shows how the Syncom project is organized. It indicates that Goddard Space Flight Center, with its project manager, is responsible for the overall project and for the coordination of the activities of all the supporting agencies and contractors.

In this project, the U.S. Army Satellite Communications Agency is responsible for the work done by their contractors in the development of the ground stations and for the execution of the communications tests involving the use of the Syncom satellites.

As we have indicated, the U.S. Navy is participating in no small measure through the use of the U.S.N.S. *Kingsport*. In this particular instance, the U.S. Navy is responsible to the project through the U.S. Army Satellite Communications Agency.

That concludes my formal statement. We are now prepared to answer any questions that you may have.

Mr. RYAN. As I recall, Dr. Seamans, the Army was very much involved in a program called Advent, a program which was designed to develop a military communications system which was a synchronous system. I think considerable funds were expended by the Army in that program.

Do you know how much the Department of Defense put into that Advent program, and can you tell us what happened to it, where was the failure and at what point did NASA pick up a synchronous program and the Department of Defense abandoned one?

Dr. SEAMANS. Let me say that the Syncom project was initiated before the cancellation of Advent. As a matter of fact——

Mr. RYAN. The Syncom project is within NASA?

Dr. SEAMANS. Yes, it was jointly approved by NASA and DOD and was established before the cancellation of Advent. In part, it was propitious since it provided an opportunity for the Department of Defense to utilize the ground facilities that they were at that time developing for Advent. This is the reason that Fort Dix, for example, is involved in the program. It is the reason that we selected the frequencies that we did in order to be able to standardize on the ground environment.

As to the cancellation of Advent, this is a matter with which I was not directly connected, and if it is one on which you wish detailed information it must be provided by the Department of Defense.

There were problems with the spacecraft itself, and there were also problems with the launch vehicle; namely, the Atlas-Centaur.

Mr. RYAN. Is any, and to what extent if there is, effort that DOD put into Advent usable by NASA in its program, or has that financial effort been largely wasted?

Dr. SEAMANS. I would like to have Mr. Jaffe answer this more completely.

As I have already indicated, the ground station effort has been brought over directly into the Syncom program. Upon the cancellation of Advent as an active flight program, some $5 million remained in the budget, and these have been used at the General Electric Co. at Valley Forge for very detailed studies of the components and the sybsystems in Advent. This will be of general value to all users of communications satellites and other types of satellites as well.

Mr. RYAN. $5 million in the Defense Department budget?

Dr. SEAMANS. Yes.

Mr. JAFFE. I wanted to reiterate we did make use of the Advent facilities and this saved us a great deal of time in preparing for the Syncom program. The reliability studies that were done under the Advent program are of significant value to us, both in Syncom and in our other communications satellite programs.

Mr. BOONE. I think one thing that has been of concern to the committee has been the system aspect, and I think this is partially the problem that was just raised by the chairman.

NASA has responsibility under your act, and I believe under the Satellite Corp. formation bill, to advise them on system activity. Up to this point you have primarily been engaged in project activity, not necessarily working toward an operational system. The Advent program, of course, was an operational program.

Could you explain to the committee how you would furnish system engineering to the Satellite Corp., since most of your work at this time has been really on projects.

Dr. SEAMANS. The words in the act state that "The NASA shall advise * * * on technical characteristics of the communications satellite system," and I interpret this to mean that we will be prepared to discuss such things as satellite stabilization, methods for injection in particular orbits, types of power supplies that might or might not be used.

I have not myself interpreted this as making specific recommendations with regard to a total operational system.

Mr. JAFFE. There are, however, some system studies which we do, not in an attempt to define the system but more in an attempt to define our program direction, to determine for us the directions of research which ought to be carried on. These studies, sort of parametric studies, which attempt to define the problem areas, could be of assistance to the corporation and the DOD in helping to define system problems for them.

Mr. BOONE. Are you the focal point in the executive branch for discussions with the Satellite Corp. on all research and development activity in the executive branch? In other words, do they have access to the Defense Department, or must they go through you?

Dr. SEAMANS. They will certainly have direct access to the Department of Defense. Because the Department of Defense is working in this area, and also because the Department of Defense may be part user of such a system, just as they are users of cables today.

Mr. BOONE. I was thinking mainly of R. & D., not from the point of view of a use. For example, the military department now has a system development for operational use in process. But you do not. So, certainly, there are some studies, facts, and there will be some experimentation that would be of immense value to the corporation. Do they go through you? Do you pull this out of the Defense Department and forward it to the corporation?

Dr. SEAMANS. I would anticipate they would work directly with the Department of Defense.

Mr. BOONE. Your job would be primarily on components and improvements reliabilitywise and activities regarding launch and so forth; is that right?

Dr. SEAMANS. Yes; and methods for developing a satellite that can maintain its stability in orbit for longer periods of time.

There are various techniques that could be used, various internal sensors can be used, jets that can be used to control the orientation, various horizon sensors, things of that sort are part and parcel of our program.

This information will be available to the Satellite Corp. as well as to all others involved in space activity.

Mr. BOONE. It would seem then that the bill doesn't require in your mind a modification to allow them to go directly to the Defense Department? I don't know why NASA was singled out.

Dr. SEAMANS. NASA was singled out not on an exclusive basis but because we will have specific responsibilities to provide certain services. One of them was not, as I understand it, to be an intermediary between the corporation and the Department of Defense.

Mr. BOONE. Do you feel that the Technical Committee on Communications Satellites could supply you the information you need to furnish?

Mr. JAFFE. The Technical Committee has been providing or exchanging such information. It has recently been requested to put together a compendium of requirements on the part of both DOD and NASA. A bibliography of already existing documents is being prepared as a result of this. So there is an exchange of this kind of information, and a cross-fertilization of the ideas as a result of this.

Mr. BOONE. I believe, Dr. Seamans, you indicated that the Committee has met 16 times. Is this over what period of time?

Mr. JAFFE. Since early 1961—2 years.

Mr. BOONE. Is this an appropriate forum and is it meeting sufficiently often to transfer the type of information you need?

Mr. JAFFE. I think it is.

Mr. BOONE. I mean between you. Are you giving them the data they need and are you getting the data you need?

Mr. JAFFE. So far as I know all information regarding the projects that are underway are being interchanged at these Committee meetings.

This is, as Dr. Seamans has stated, a committee to exchange the problems incurred or realized in the existing programs, to exchange the results of the existing program and indicate progress, so that there is this cross-fertilization on the projects that are ongoing.

Mr. BOONE. You have an agreement with the Defense Department to do synchronous work and you do the medium-altitude work?

Dr. SEAMANS. Not exactly as you have stated it. The agreement that did result in the budgetary process last fall, is that DOD felt they could implement a medium altitude system sooner than they could a synchronous system. They felt time was important. For that reason they decided it was appropriate that DOD proceed with an operational system at medium altitude based on work that had already taken place on Telstar and Relay, and that we should do advance work at synchronous altitude, which may, in fact, be the ultimate operational system. This remains to be seen because this technique is still in an experimental state.

Mr. BOONE. I believe the Defense Department witnesses before the committee have indicated they are going for procurement, a minimum of R. & D. I think of concern to the committee is that there would be a gap in the development or the research that might be required for medium altitude, the spread from medium to synchronous altitude development.

Dr. SEAMANS. As my statement stated this morning, we will continue the review and there may be additional work required by NASA, for example, an extension of the Relay program that might lead to a more efficient or a more reliable system at medium altitudes.

Mr. BOONE. Are you doing work with the Defense Department that contributes directly to their medium altitude system?

Dr. SEAMANS. All of our work has been made available to them, but I don't believe we are actually participating in that project, are we?

Mr. JAFFE. No.

Mr. BOONE. Do you have military people in your office, that is, the Communications Satellite Office, directly concerned with Syncom? Are they somewhere in the chain, maybe at Goddard, maybe at other localities?

Dr. SEAMANS. We have people in our office reporting to Mr. Jaffe who have been assigned by the DOD to work with us. Colonel Warren, who is here, is an example.

The actual management of Syncom is vested in Goddard and it is out there that Mr. Jones is the project manager, and perhaps Mr. Jaffe might indicate the makeup of that office and how it directs the total activity, including that of the Army and Navy.

Mr. JAFFE. The project management team is a Goddard team. The direct liaison with the Army Communications Satellite Agency and the Navy is accomplished through a working group on Project Syncom per se, where all the effort, all the plans are made jointly with the Army Communications Satellite Agency and with the Navy personnel responsible for the U.S.N.S. *Kingsport*.

Mr. BOONE. The formation of the technical committee, is made up of what level, what strata of people in the organization? Are you a member, for example?

Mr. JAFFE. Yes, I am. We have both program director level personnel involved and project management level personnel involved.

Mr. BOONE. I would like to change to another subject.

To quote one of your answers of the other day, in which you said in response to the chairman's question about funding by the corporation, you said:

> I would like to submit that we would fully expect them to fund work that they placed upon us.

Would you like to expand on that statement a little bit? How you want to do this? What policy and procedure you might want to use in arriving at it?

I believe Mr. Jaffe made the statement.

Dr. SEAMANS. This was included in the statement I made today, that we expect them to pay their own way for those things that are directly related to the implementation of the operational system.

Mr. RYAN. That comes down, Dr. Seamans, to a definition of what is directly related.

Suppose we go to the items in the budget. I call your attention to RDO 7–3 and the statement there that NASA will lease or build ground stations, command stations and special ground equipment for some of its communications projects.

What are your plans to expand ground stations, telemetry stations, special ground equipment, and for what projects?

Mr. JAFFE. In the existing programs you are probably aware of the fact that we do make use of the stations that have been provided at Andover, Maine, by the American Telephone & Telegraph Co., and by the International Telephone & Telegraph Co. at Nutley, N.J.

We will in the future and are now using stations that are provided not only for communications satellites but for other data acquisition purposes for the NASA experimental program. These will not be solely devoted to communications satellites but will perform a joint function for both this program and for other programs of NASA.

There will be a continuing requirement for ground stations to acquire the data from the satellite and to test the satellites that will be launched in the experimental program.

Mr. RYAN. Specifically, on which communications project do you expect to build ground stations?

Mr. JAFFE. We do not expect to build ground stations specifically for the communications satellite project at this time. I don't believe there is any——

Mr. RYAN. That is what page 7–3 says.

Dr. SEAMANS. 7–D——

Mr. RYAN. RDO 7–3.

Mr. BOONE. Volume 2, of course.

Mr. JAFFE. We are currently planning the use of a facility that will be installed at our Rosman site, Rosman, N.C., which will be a facility which is installed for scientific satellite data acquisition as well as for communications satellite experimental purposes.

This is the only facility that we plan on implementing or augmenting for this program. This will be used in the Syncom or the advanced Syncom program.

In addition to this we do intend to use the existing facilities of the common carriers, if you will, insofar as they can be made available to the research program of NASA.

Mr. RYAN. The statement is inaccurate when it speaks of leasing or building ground stations for some of the communications projects? What you are saying is you intend to build one station in North Carolina which will be useful not only to communications satellites but to other NASA programs.

Now, is the cost of that reflected in the submission for communications satellites, or is it reflected in some other part of the budget?

Mr. JAFFE. I would like to indicate that the statement refers also to telemetry and command stations. There is a peculiar requirement

for such satellites as Syncom for a command station. These are small stations from which commands are sent to the satellite for control of the satellite. These will have to be built, yes.

Mr. RYAN. How many?

Mr. JAFFE. For the advanced Syncom program, probably two.

Mr. RYAN. At what cost?

Mr. JAFFE. There is an item for range and range equipment indicated in the advance synchronous program on RDO 7–9 of $2 million. This is a component of the system, and an item, telemetry and command system, $600,000.

Mr. RYAN. That 600,000 item, and the other——

Mr. JAFFE. $2 million right below that.

There is also an additional item of equipment for ground stations. These are project peculiar equipments. These are items which are peculiar to the particular experiment which may have to be supplied to the existing ground stations, such as specific receivers, transmitters, and feeds. A sizable item is shown here above this, $1.1 in 1963 and $4.9 in 1964. Operations of the ground stations will amount to about $1 million in 1964.

Mr. BOONE. In that regard, Mr. Chairman, you cannot use any existing facilities to do this or to modify existing facilities? You have to build a new station, is that right?

Mr. JAFFE. As I pointed out, we intend to use existing facilities. The facility that we will use at Rosman will be a facility which is being installed for other purposes, for scientific satellite purposes.

Mr. BOONE. You said you had to build two new——

Mr. JAFFE. The new facilities will amount only to telemetry and command stations, $600,000, and the range and range rate instrumentation that go into these command stations of $2 million.

There is a sizable amount of equipment that we will have to buy to implement this Rosman facility for communications as well as for the scientific satellites. This is the item marked "Equipment for Ground Stations." This is communications satellite equipment peculiar to the satellite program that will have to be provided to this Rosman facility.

Mr. BOONE. Is construction of buildings included in this request?

Mr. JAFFE. I don't believe construction of facilities are included.

Mr. BOONE. You don't contract out with the contractor for turnkey operations, is that right?

Mr. JAFFE. No, sir. The facility itself is under a fiscal year 1963 construction item.

Mr. RYAN. Would you classify these items then, the $2 million for range and range-rate equipment, the $600,000 for telemetry and command stations, the $1 million for ground station operations, the $4.9 million for equipment for ground stations; would you classify those items as operational?

Mr. JAFFE. No, sir. These are experimental equipments associated with these experimental satellites.

Mr. RYAN. Are they part of the operation of the satellite?

Mr. JAFFE. In that sense, yes, they are necessary to the execution of the experiment and may be considered operational from the experimental standpoint. They are required for the control of the satellite, for the execution of experiments with the satellite.

Mr. RYAN. They would also be required, would they not, for the control of a satellite that had been perfected?

Mr. JAFFE. If this happened to be the satellite which was the one that would be used in an operational system.

Mr. RYAN. Do you mean we are going to have a separate telemetry, command station, and separate range equipment for each center, and then a fully developed one for the satellite?

Mr. JAFFE. We are developing this equipment for this particular satellite because it is really the first of its kind.

Mr. RYAN. Are you not developing equipment which you expect will also be useful in further experiments and in an operational system?

Mr. JAFFE. They will be used——

Mr. RYAN. Further commercial operational systems?

Mr. JAFFE. This depends on the commercial operational system. They may or may not be. If the commercial corporation or the commercial system rather, does use this system or portions of it, they may use portions or all of this equipment, yes.

Mr. RYAN. What plans have you then to establish now at the beginning of this program a means for reimbursement to NASA and a formula so that you will know how you could ask Communications Satellite Corp. to reimburse you?

Mr. JAFFE. We do not envisage, it is my understanding, reimbursement for developments which have taken place in the past or developments which will be provided independent of the commercial corporations' request or their desires.

Just as we are not charging A.T. & T. in our current contract with them for the past development of the vehicles which are being used. We are charging them only for identifiable additional costs incurred as a result of their efforts.

Mr. RYAN. Charging A.T. & T. for the use of command stations, telemetry, ground stations——

Mr. JAFFE. We are charging them for the use of NASA facilities being used in the Telstar program.

Mr. RYAN. Beyond the launch facilities?

Mr. JAFFE. Yes, sir.

Mr. RYAN. We have asked for a breakdown of those charges. I do not believe they have been submitted to the committee yet.

(The information requested is as follows:)

Reimbursements A.T. & T. to NASA, actual and estimated

	Telstar I (actual as of Dec. 31, 1962)	Telstar II (estimated)
Launch vehicle and launch	$2,500,000	$2,500,000
Tracking and data acquisition	281,213	117,020
Other services	55,019	36,150
Personnel support (Goddard mostly)	52,772	28,000
Total	[1] 2,889,004	[1] 2,681,170

[1] Payment checks, based on billings presented by NASA, have been received from A.T. & T. in these amounts. Final settlement will take place when all reimbursable costs have been determined.

Dr. SEAMANS. In the case of the Telstar we are using our world tracking net to determine the exact ephemeris of Telstar, and the time spent by NASA personnel and NASA contractors in direct support of Telstar is chargeable to them.

Mr. WYDLER. Do I understand the situation to be that as of the present moment you have no agreement with the Communications Satellite Corp.; is that right?

Dr. SEAMANS. That is correct.

Mr. WYDLER. As of this moment we really don't know what you are going to expect of them or what they are going to expect of you, is that right?

Dr. SEAMANS. We are not going to expect anything of them, let me make it clear——

Mr. WYDLER. I mean in the way of remuneration of what you do. You are going to expect money, aren't you?

Dr. SEAMANS. We have our program here, which is a required program on a national basis. This is a program that must be carried out. As I indicated, we have offered to meet with them at their earliest convenience. We have had a reply from Dr. Charyk that he wants to meet to get started with the planning.

Until a corporation decides what services they wish of either a R. & D. nature or an operational nature, it is impossible for us to say what additional work NASA might be doing which would then be chargeable to the corporation.

Mr. WYDLER. I am trying to be helpful, Dr. Seamans. I am not criticizing. I am trying to see if you can answer the questions you are being asked today. This is what bothers me. You are being asked today to do something which it doesn't appear to me that you can be in any position to do, and you won't be in a position to do it until after you have spoken and had these conferences with the Communications Satellite Corp. This is what I am trying to drive at.

I think the questions today are being directed to exactly what the role, defining the role of NASA and the corporation, and you haven't even attempted to do that as yet with the corporation. You don't know what agreements will be reached with them.

What I am trying to suggest is that I think probably we are premature in asking these questions. We are not going to get satisfactory answers to them now.

Dr. SEAMANS. We have drawn a parallel with our experience on Telstar to indicate the manner in which a corporation can reimburse the Government for services.

Mr. WYDLER. I realize that. We are dealing with theory at the present time.

Dr. SEAMANS. We can also state the policy that any item of work carried out by the Government in direct support of the operational system must be reimbursed.

Mr. WYDLER. I think what the chairman is trying to do, and I think what the subcommittee is trying to do here, is see that the Government is being treated fairly.

It would appear to me we won't know that until we know what agreements NASA has made with the corporation. Possibly all we can find out from you today is what you expect to ask the corporation to do. We don't know whether they are going to agree to it, whether this is something where you can only ask and they can agree or they can ask and you can agree. We won't know what we are dealing with until after those conferences are held. This is what I am trying to get at.

In other words, are we wasting time by you trying to answer these questions as to details of what the corporation is going to pay for and

what NASA is going to pay for until we know what the two of you have agreed to pay for.

Dr. SEAMANS. I think the discussions we have had on Tuesday and today have been helpful. It is true that we can't give you specific answers until we have a specific program.

Mr. WYDLER. I think the answers we are getting aren't specific. Mr. Chairman, I don't know how you want to handle it. I have no objection to the questions. They are good. I don't think you are going to get answers to them.

Mr. RYAN. I think if we succeed in prompting NASA to give some real serious thought to this whole question then we have served a useful purpose. Here we have a recommendation for $51 million for research and development, a large part of which is inevitably going to benefit the corporation and its stockholders. What we are trying to find is where you draw the line between what you referred to the other day as advancing the state of the art and that part of these expenditures which are really in a very real sense operational. Synchronous satellites will be operational before long and the corporation will be using them unless they have such an investment in the medium altitude that they feel no public responsibility to move to a better system. I think that is what we are concerned with. It is 12 o'clock. I don't think we can spend any more time on this. Mr. Boone.

Mr. BOONE. Mr. Chairman.

Briefly, I have here the hearings before the Senate Committee on Commerce of which there was some information submitted after the hearing, which indicated that $41.145 million of your 1964 request contributes toward the Communications Satellite Corp. activities. Is this a correct interpretation? Are you familiar with the submittal I mentioned?

Dr. SEAMANS. I am not.

Mr. JAFFE. I have not seen this number.

Mr. BOONE. One of the questions in the hearings of the other day was, what portion of your budget contributes to the Satellite Corp.'s activities? I don't believe this was answered at the time because of other matters. Can you answer that now or would you like to submit that for the record?

Dr. SEAMANS. I myself don't feel that you can make a categorical statement, that so many dollars are specifically for this purpose. I don't think they are. I think a great deal of our program is bound to benefit the Satellite Corp. The work that we are doing on launch vehicles, launch pads, tracking stations, the whole technology that is involved in space over the past 4 and 5 years is going to benefit this corporation. We feel that what we have here under communications satellites is in this category. It is general work that needs to be done, and the corporation will benefit from it as will many other users.

Mr. BOONE. I happen to agree with you, Dr. Seamans. But I think you might want to reconsider putting something in the statement here later in view of this comment.

Dr. SEAMANS. I will be happy to review and see if we wish to make a statement.

Mr. BOONE. I suggest that you do that. The committee is going to be asked this question later on in reference to the budget.

(The statement requested is as follows:)

EXPANSION OF DR. SEAMANS REMARKS ON APRIL 4, 1963

In his testimony on February 19, 1963, before the Subcommittee on Communications of the Committee on Commerce, U.S. Senate, Dr. Dryden stated, and I agree, that "None of the funds budgeted for the National Aeronautics and Space Administration for the fiscal year 1964 is earmarked for direct assistance to the Communications Satellite Corp." The sum of $41.145 million is the amount requested for fiscal year 1964 to pursue the advanced synchronous communications satellite concept which Mr. Jaffe and I have previously discussed with you.

Many peoples, governmental agencies, and industrial firms will benefit from the advantages that will flow from successful achievement of communications satellite technology. The program is not specifically directed toward the exclusive advantage of any one organization. All data and information that derives from the NASA effort, as has been the past practice, will be made equally available, through many established dissemination mechanisms.

Mr. RYAN. I have one thought that I think NASA should concern itself with, which relates to the overall question of concentration within industry and one danger that I see in Communications Satellite Corp., that is, that many of the principal stockholders in this corporation who are going to benefit from whatever success economically the corporation has are also contractors for NASA. I think that has some implications which NASA should concern itself with. It is the problem of the contractor getting a double return. He is under contract to NASA for developing this communication satellite equipment, and then at the same time being a stockholder of the corporation and receiving the benefits in that fashion. Has any thought been given to that within NASA?

Dr. SEAMANS. I am afraid I can't comment on that.

Mr. RYAN. You can't comment or you don't know if any thought has been given to it?

Dr. SEAMANS. I don't know. I cannot specifically answer your question.

Mr. RYAN. I suggest it is a policy area that I think should be of great concern. Any other questions?

Mr. WYDLER. The only thing here, Mr. Chairman, do I understand that 50 percent of the stock of this corporation is going to be owned by the public?

Mr. RYAN. 50 percent is available to noncommunication people, either corporations or individuals and 50 percent is reserved for communications carriers.

Mr. WYDLER. Thank you.

Just one last question. It would appear to me that this particular program might fit very well with the program for navigational satellites. Couldn't it very well be that one satellite could do both of these jobs?

Dr. SEAMANS. In the future——

Mr. WYDLER. Has this been thought about?

Dr. SEAMANS. Yes. I tried to emphasize that in my statement this morning, that the kind of work we are doing on the spacecraft may very well have application to meteorological satellites or navigation satellites, data-gathering satellites, but the initial thrust in this area at the synchronous altitude is on communication because this is, as I said, is where the payoff may come first.

Mr. WYDLER. It seemed to me it would be particularly true if you had a satellite system that would reach any point on Earth with a

signal for communication purposes, that it would certainly be able to reach any point on Earth with a signal for navigational purposes as well. I would think it would follow logically. That is all.

Mr. RYAN. Dr. Seamans, thank you.

Mr. Boone of our staff will submit some written questions which we would appreciate NASA answering for the record concerning the details of some of the budget items.

(The request was as follows:)

APRIL 29, 1963.

Mr. PAUL G. DEMBLING,
Director of Legislative Affairs, National Aeronautics and Space Administration, Washington, D.C.

DEAR MR. DEMBLING: In connection with the recent NASA authorization hearings on communications satellite, the Subcommittee on Applications and Tracking and Data Acquisition requests the following information to supplement the information previously furnished.

1. A brief description of each budget item in excess of $200,000. If the item is composed of tasks, a brief description of each task is desired with the appropriate dollar allocation indicated.

2. An indication of the procurement and delivery time phasing and schedule where appropriate.

3. A statement of contract dollars and in-house funds on each of these items.

This information will be included in the hearings as substantiating data for the authorization request. It is requested that this information be furnished to the subcommittee by May 10, 1963.

Sincerely,

W. H. BOONE, *Technical Consultant.*

ADDITIONAL INFORMATION ON NASA BUDGET ESTIMATES FOR FISCAL YEAR 1964

COMMUNICATIONS SATELLITES

High gain reflective structures $200,000

It is exceedingly difficult and expensive to make precise and valid measurements of the radio reflective characteristics of large inflated structures on the ground so that their potential usefulness in space can be predicted. It is, naturally, very expensive to launch them into orbit so that measurements may be made of their characteristics in the space environment. This program was initiated to develop methods of making these radio reflectivity measurements on the ground, using in some cases, small models of the large structures, and in other cases, pieces of the full-scale structures so that we may evaluate new structural shapes and materials that are being developed for improved passive satellites of the future.

This work has been started under contract with Conductron Corp., Ann Arbor, Mich. The existing contract is a negotiated sole source contract and was based on an unsolicited proposal. This effort will be continued and additional in-house work will be initiated in fiscal year 1964.

Division of expenditures: 29 percent in-house; 61 percent contract.

Advanced passive satellite studies $1,200,000

The usefulness, in terms of communication capacity, of passive satellites, is directly related to the size of those satellites, as is also the weight. These studies are directed toward increasing the size of satellites while staying within the weight-lifting capabilities of our boosters, by developing new, lighter weight materials for making the large spheres, and by simulating the spheres with other shapes which may be more efficient than spheres in reflecting the radio signals toward the ground. Studies are also being initiated of techniques that might be used to control the position of passive satellites to make the operational use of them easier.

Materials improvement.—Studies of improved materials have been conducted under contracts with G. T. Schjeldahl Co., of Northfield, Minn., and the Geophysics Corp. of America at their Viron division in Anoka, Minn. These contractors were selected on the basis of a competitive procurement. Efforts under these contracts will continue into fiscal year 1964.

Structures development.—In this area two new starts are planned in fiscal year 1963 to continue into fiscal year 1964. One will be a competitive procurement of studies of nonspherical structures and the other will be a negotiated sole-source contract based on an unsolicited proposal resulting from some company-funded studies.

Erection systems development.—Large, very light structures of mesh and nonspherical structures require erection systems different from those used in the Echo II type of satellite. This effort will investigate novel methods for erecting the lighter or nonspherical structures.

Division of expenditures: 3 percent in-house; 97 percent contract.

Intermediate altitude satellite studies $2,000,000

This effort will be a new contractual start and will consist, basically, of the following tasks directed toward establishing technology in areas having particular application to intermediate altitude satellites:

Application of radioisotope power supplies study.—Study of the problems involved, and feasibility of radioisotope power supplies in spacecraft. This is of particular interest in the case of spacecraft operating in intermediate and lower altitudes where extensive eclipsing (shadowing of the spacecraft by the Earth) occurs.

Attitude control systems study.—Study of the problems involved in, and feasibility of use of, gravity gradient as a basis for passive control of a satellite's orientation, with respect to the Earth's surface. This has more application to the intermediate and lower altitudes because the gradient is stronger there.

Integration feasibility study.—Study of the problems involved in, and feasibility of, integrating an isotope power supply and gravity gradient orientation system into a communication satellite having multiple access (i.e., more than one pair of ground stations can use at a time) wideband (i.e., many telephone channels) capabilities.

Design and engineering model study.—Design and fabrication of an engineering model of the satellite studied in the integration feasibility study.

This work will be done entirely by contract or contracts based on a bid competition. It has not yet been determined how the work will be divided from a contractual viewpoint, nor whether there will be a single contract covering the whole effort or several separate contracts, each covering one or more of the tasks outlined above.

Electronically steerable antennas $100,000

This effort will be directed toward study and investigation of means to steer satellite antenna beams electronically, without any mechanical motion. This type of technology has great applicability because of the problems which have been encountered in mechanical satellite stabilization and antenna beam steering. Appropriate techniques evolved for electronically steering spacecraft antennas would permit antenna beams to be pointed as desired without use of moving parts, which have proved to be troublesome in space from the point of view of lifetime. This effort was started in house in fiscal year 1963. Competitive procurement procedures to initiate a contractual effort are currently in process.

Isotope thermoelectric power supply studies $200,000

This effort includes the investigation of thermoelectric materials (not isotopes) for isotopic thermoelectric power supplies from the point of view of use in satellites. Parameter studies and laboratory tests will be performed to determine the optimum materials for this application, and the trade-offs available in weight, reliability and cost for different materials. This effort is a continuation of work being started in fiscal year 1963. Competitive procurement procedures to initiate contractual effort currently are in process.

TECHNICAL AND OPERATIONAL STUDIES

Technological studies $350,000

Solid state microwave power amplifier.—This work will cover investigation and development of solid state techniques applicable to amplification of microwaves with power outputs adequate for space-Earth communications. It will represent work to improve technology. Present technology is to use vacuum tubes in output amplifiers in space-Earth communications. There are problems in their use, in that they are inefficient, bulky and heavy,

fragile, and require high-voltage power supplies. Evolution of solid state technology to permit substitution of solid state devices such as transistors for vacuum tubes in spacecraft output amplifiers should largely obviate these problems. This effort will be accomplished on a competitive contract.

Propagation studies above 10 kilomegacycles.—This effort will be a new start covering work on the effects of the atmosphere on propagation of radio waves at frequencies above 10 kilomegacycles. Most space communication is now done in the so-called space window where absorption and atmospheric and cosmic noise are at their minimum. Crowding of the spectrum in this area and the general increase in satellite transmitter powers may make a move to higher frequencies extremely desirable, if not mandatory from a frequency conservation point of view. Before such a move can be evaluated, more information is needed on propagation at the higher frequencies. It is expected that this work will be a university investigation.

Economic implications of communications satellites..... $100,000

This effort will cover studies and investigations of the national need and economic implications of the use of satellites for future communications systems. The study output is intended to provide information which will assist the Government in its direction of future research and development. This is a continuation of work begun in fiscal year 1963 with the Rand Corp.

Technological and operational factors related to active and passive communications satellites..... $300,000

This effort will cover studies devoted to identifying those technological and operational factors which are of major importance in designing communications satellite systems. These studies result in parametric analyses of systems of various composition, power, orientation, orbital altitudes, etc. Such studies indicate advances required in satellite and booster technology which are most urgent and the requirements on satellite systems imposed by the various users. This work will be devoted largely to active satellites, since the work in passives was completed in fiscal year 1963 with the publication of an encyclopedic report on the subject. This is a continuation of a contract with the Rand Corp.

Modulation techniques..... $100,000

This effort will cover study and investigation to determine the types of modulation (i.e., the way in which message, conversation, TV picture or the like is impressed on a radio signal) best suited for use with satellites which are required to pass traffic between a large number of ground terminals simultaneously (usually called multiple access capability). Although modulation is not the only factor involved in achieving a multiple access capability, it is an important one which has not been adequately studied. This effort is of importance to the Nation in that it is particularly directed toward the conservation and efficient utilization of an important national resource—the radiofrequency spectrum. It is a continuation of work being started in fiscal year 1963. Competitive procurement procedures to initiate this work are currently in process.

Materials development..... $100,000

This effort will continue prior years' work on the testing of materials and components for reliability and long life. Materials and electronic piece-parts will be evaluated under simulated space environments.

Low noise spacecraft receiver..... $200,000

This effort will be directed toward adapting low noise receiver techniques (parametric amplifiers and masers) for use in spacecraft. The communications link from the ground to the spacecraft is now relatively easy to do with large antennas on the ground; hence, low noise receivers on the spacecraft have not been essential. The advent of higher power satellites, permitting use of small receiving antennas on the ground will require a substantial improvement in spacecraft receiver sensitivity if the potentialities of small ground stations are to be exploited. It will continue work started in fiscal year 1963 on which procurement procedures for a bid competition are in process.

Division of expenditures: 20 percent in-house; 80 percent contract.

RF to RF conversion..... $150,000

This effort will be applied to investigation of the problem of direct frequency conversion and amplification at microwave frequencies without passing through

an intermediate stage. In the present technology, a spacecraft would receive a signal on one microwave frequency, convert this frequency to a much lower one, amplify the signal at the lower frequency, then reconvert it to a new microwave frequency for transmission. This complicated procedure is used because of greater amplification, stability, and current efficiency at the lower efficiency. Preliminary investigations indicate that the intermediate stage can be eliminated, reducing size and complexity. This is a continuation of work being started in fiscal year 1963. Competitive procurement procedures to initiate this work are currently in process.

Division of expenditures: 5 percent in-house; 95 percent contract.

Echo (rigidized sphere)..... $200,000

The effort in fiscal year 1964 will consist of radar observations of the Echo II satellite after launch, and reduction interpretation and analysis of the radar data to determine size, cross section, and smoothness of the satellite and its effectiveness as a reflector of radio energy. This will continue evaluation of the satellite through fiscal year 1964.

Division of expenditures: 5 percent in-house; 95 percent contract.

Relay..... $1,900,000

Relay ground station operations..... 1,150,000

Lease of non-Government-owned ground stations..... 350,000

Utilized for conducting communications experiments, specifically the facilities on the A.T. & T. 68-foot horn space communication station at Andover, Maine, and the I.T. & T. 40-foot dish space communication station at Nutley, N.J.

Operational support of Relay ground test stations..... 800,000

Nutley test station..... 450,000
Mojave test station..... 350,000

The Nutley test station shares the use of the 40-foot dish antenna of the Nutley space communication station. These costs are largely those of personnel for test station operation. The above effort is planned for completion in fiscal year 1965.

Coordination planning and documentation..... 350,000

These funds will cover continuation of the effort on an existing sole source contract which NASA has with Space Technology Laboratories for coordination and planning of the Relay program, operational support of the Relay operations office, and provision of instruction manuals for the Relay test stations.

Communications rentals..... 175,000

This effort covers the leasing of teletype and telephone lines between the Relay operational control center in Maryland and the Relay ground stations in California, New Jersey, Maine, England, France, Italy, Japan, and Brazil.

Data reduction and analysis..... 225,000

These funds cover procurement of magnetic tape, reducing data to the form in which it can be easily analyzed and, finally, the analysis of the data which is then documented. Approximately 5 percent of this effort is in-house. The bulk of the analysis is being conducted by sole source contract with the San Diego branch of the University of California, and represents analysis of the radiation data measured by the Relay spacecraft.

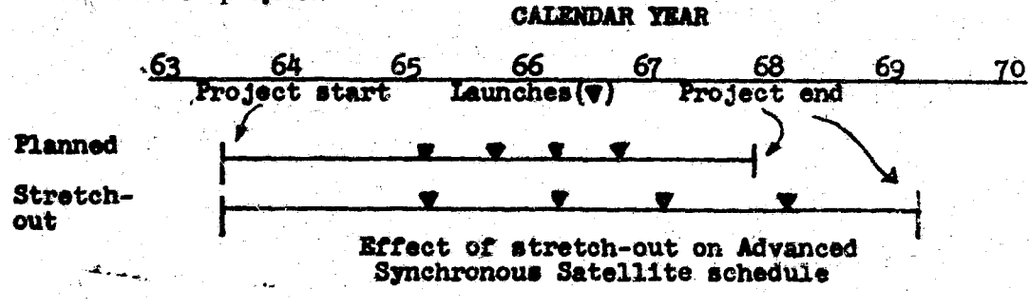
Syncom	$4,000,000
Spacecraft	500,000
These funds will be used to cover the design, development, and fabrication of 1 prototype and 3 flight model spacecraft being procured from Hughes Aircraft Co. The bulk of the funding for this contract was paid for by prior fiscal year appropriations. The funds indicated here are largely for the services of Hughes in supporting the remaining Syncom launches.	
Range and range rate equipment	410,000
These funds are to complete the existing contract with Space Technology Laboratories for the design, development, and fabrication of 3 range and range rate stations. The bulk of this contract was funded with prior fiscal years' funds.	
Syncom ground station support and environmental test	2,215,000
Ground station support includes training of ground station personnel and staffing of each ground station, procurement of spare parts for maintenance and station operation during postlaunch communications experiments, logistics support, and transportation of stations domestically and overseas.	
Transportation of stations domestically and overseas — 250,000	
Spare parts for operation and maintenance of stations — 600,000	
Operational staffing, training and station support — 1,165,000	
Logistics support — 200,000	
The above effort is planned for completion in fiscal year 1965.	
Data reduction and analysis	875,000
These funds cover procurement of magnetic tape, reducing data to the form in which it can be easily analyzed and finally, the analysis of the data which is then documented. Approximately 5 percent of this is in-house.	
Magnetic tapes — 75,000	
Data reduction — 500,000	
Data analysis — 300,000	
Advanced synchronous communications satellites	40,000,000
Atlas-Agena launch vehicles (3 orbital flights and 1 backup)	12,500,000
The funds listed are to cover the increments due on these vehicles in fiscal year 1964 only. The cost per vehicle is approximately $7,500,000; complete vehicle funding is planned to be completed in fiscal year 1966.	
The $12,500,000 requested for fiscal year 1964 for Atlas-Agenas will provide that year's increment for the funding for 4 vehicles.	
Spacecraft	16,640,000
This effort is to perform the 1st year's work on the advanced synchronous spacecraft. It will be based on work by Hughes Aircraft Co. in fiscal year 1963. The exact method of procurement has not been determined.	
Equipment for ground stations	4,960,000
The ground station tasks will result in modification of the stations listed for use with advanced synchronous satellite program. The costs cover procurement of special-purpose equipment to be utilized in the modification, including special antenna feeds, FM transmitters, telemetry receivers, communication receivers, TV monitors, TV recorder, and spare parts.	
Ground station operations	1,000,000
Ground station operations will cover operational planning and training of the operating staff for each communications and telemetry and command station.	

Reliability studies	$500,000
A contractor other than the spacecraft contractor will be selected to perform reliability analysis and monitoring of the spacecraft contractor's reliability and quality assurance procedures.	
Switching circuit	300,000
To purchase standard multiplexing terminal equipment capable of being employed with the advanced synchronous ground station equipment when in the multiple access mode to provide for interconnection of satellite communications traffic from the ground station with conventional circuits terminating at the ground station.	
Telemetry and command	600,000
It is planned to use the three telemetry and command transportable ground stations of the Syncom project. The above funds will be used to contract for modifications to these stations in order to have them compatible with the advanced synchronous satellite project.	
Range and range rate equipment	2,000,000
This will cover the modification and procurement of range and range rate ground equipment under a single contract.	
A total of four complete range and range rate equipments will be used. The three existing Syncom range and range rate equipments will be modified for use in this program. The fourth station is new equipment. Estimated cost to modify each of the three existing equipment is $350,000.	
Data reduction and analysis	1,000,000
This would cover the purchase of magnetic tape, and preparation by a contractor for data analysis, including training of personnel, purchase, or, if necessary, development of the equipment necessary for rapid and semiautomated processing and recovery of the data.	
This work will be done 5 percent in-house and the remainder on contract.	

CONSIDERATION OF EFFECTS OF STRETCHOUTS ON THE ADVANCED SYNCHRONOUS SATELLITE SYSTEM

The exact costs of stretchouts on a program cannot be evaluated without a detailed review of all project cost and time estimates in the light of work assignments and workloads in the contractor's plant. These are not available, nor is adequate time available in the preparation of this paper to have such an analysis performed on the advanced synchronous satellite. Our considered opinion is that stretchouts to cover the same amount of work will always result in higher runout costs with only one exception, which is where premiums are being paid to expedite work. (This latter case does not apply to the advanced synchronous satellite work.)

Consider a stretchout in which the original first launch date is retained but the launch frequency is changed from two to one per year. This would result in a total program length of 5½ years for the advanced synchronous satellite effort, as compared to 4 years as now scheduled for the same number of launches. The chart shows graphically the time relationship between the planned and the "stretched out" projects.



Effect of stretch-out on Advanced Synchronous Satellite schedule

A very real problem in evaluating this type of stretchout is that it is unlikely that technical talent of the caliber required for the work could be retained through a "dead space" of 6 months out of a year between launches, without generating additional, and costly, engineering work. It is also unlikely that such personnel, if retained, could be directed to other work for such a short term as 6 months, three times in 3 years. The estimated cost of continuing the spacecraft contractor's supporting effort for an additional 18 months is $4,500,000. A reasonable cost estimate for conducting ground station operations of this type is $2 million per year. The cost of operating with the spacecraft for an additional 18 months will be $3 million. It is estimated that the additional vehicle and launching cost associated with an 18-month stretchout is $300,000. To recapitulate, the additional estimated costs, at runout, of an 18-month stretchout in the advanced synchronous satellite launch schedule is:

Spacecraft and support	$4, 500, 000
Ground station operations	3, 000, 000
Launch vehicles	300, 000
Total	7, 800, 000

Information on fiscal year 1963 expenditures on Syncom line items—Ground station support and environmental test data reduction and analysis

Item	Budget, fiscal year 1963	Amount spent	Remainder
Ground station support and environmental test	$3, 481, 000	[1] $1, 800, 000	$1, 681, 000
Data reduction and analysis	865, 000	0	865, 000

[1] $1,000,000 obligated; $800,000 committed.

A question has been asked if the unspent remainder cannot be applied against the fiscal year 1964 funding requirement shown for each line item. It cannot. The unspent balance of $1,681,000 for ground station support, and $200,000 of the unspent balance for data reduction and analysis have been reprogramed to meet the costs of revision of Syncom flight models 2 and 3 and the prototype; $455,000 from data reduction and analysis will be reprogramed to meet unprogramed additional costs of the telemetry and command stations, and $35,000 will be reprogramed to pay for rental of facilities required for the extensive test program resulting from the Syncom I failure. Of the $175,000 remaining in data reduction and analysis, after these reprograming actions, $75,000 is required for purchase of magnetic tapes, and $100,000 for services of observatories in the optical search for Syncom I.

(Whereupon, at 12:05 o'clock p.m., the subcommittee adjourned.)

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1964 NASA AUTHORIZATION

TUESDAY, APRIL 9, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON APPLICATIONS AND
TRACKING AND DATA ACQUISITION,
Washington, D.C.

The subcommittee met at 10 a.m., pursuant to recess, in room 214–B, Longworth Building, Hon. William Fitts Ryan (chairman) presiding.

Mr. RYAN. The committee will be in order. Dr. Seamans, it is a pleasure to welcome you again to the subcommittee.

In a previous hearing on March 19, NASA presented its personnel and operation of installations program for fiscal year 1964. At that hearing we did not have an opportunity to discuss several NASA contracts which, in effect, augment NASA personnel. Dr. Seamans said then that he would be glad to return to discuss the Bellcomm contract and the General Electric contract. Bellcomm provides systems engineering advice and competence and General Electric provides engineering studies for integration, reliability assessment, and checkout.

These contracts raise several important policy questions. Among them is the question of whether or not NASA should develop this competence in-house rather than enter into cost-plus-fixed-fee agreements with outside corporations. Could not the same result be achieved in-house at less cost to the taxpayers?

NASA should be clearly responsible to the President and Congress for the management and control of its program. To what extent are management and policy decisions being delegated to contractors?

Last year NASA justified the Bellcomm contract on the ground that it was not able to pay salaries comparable to industry and was not authorized to have sufficient excepted positions. What steps has NASA taken in the last year to obtain authorization to hire highly skilled scientific and engineering personnel?

There is also the question of conflicts of interest and whether or not these corporations are being placed in a preferred position vis-a-vis their competitors.

I believe that JPL also falls into this general personnel area. I hope the testimony will include a discussion of JPL contracts and any similar arrangements which augment NASA personnel requirements.

The committee is concerned that NASA policies be consistent with good management principles.

Now, Dr. Seamans, I believe you have a prepared statement, and we would be glad to hear it.

STATEMENT OF DR. ROBERT C. SEAMANS, JR., ASSOCIATE ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Dr. SEAMANS. Mr. Chairman and members of the subcommittee, I welcome the opportunity to discuss with the subcommittee NASA's contractual arrangements with industry for the provision of special assistance in the overall technical aspects of the manned space flight program in two areas—systems engineering and checkout, reliability assessment, and integration.

As you know, the Subcommittee on Manned Space Flight has already received a considerable amount of information in the areas of present interest. Mr. Holmes addressed himself to both of these subjects in his testimony on March 6 and 7. On March 20, that subcommittee heard testimony from Dr. John A. Hornbeck, president of Bellcomm, Inc., and Mr. Richard L. Shetler, general manager of the Command Systems Division of General Electric and acting general manager of the GE Apollo support department. Members of the Manned Space Flight Subcommittee also visited the Apollo support department headquarters in Daytona Beach, Fla., on March 29, for a review in depth of the General Electric work areas—checkout, integration, and reliability assessment.

I would now like to review briefly with you the Bellcomm and GE efforts in support of Project Apollo and then to answer any remaining questions you might have.

The systems engineering function includes the determination of systems specifications and conceptual designs of major elements of the program; the review of ongoing programs to identify and evaluate possible alternative courses of actions; study of the impact of funding, schedule, and technical changes on the overall program; development of the overall reliability and system test plans; and preparation of long-range plans, implementation of long-range studies, and participation in project development plans for future manned space flight projects.

Typical of this type of activity was the selection of the mode of flight for the first manned lunar landing, in which the Office of Systems occupied a central role. This is one of the offices that reports directly to Mr. Holmes. As this committee knows, three possible ways of implementing the program were studied in great detail—direct ascent, Earth orbit rendezvous, and lunar orbit rendezvous.

The Office of Systems reviewed the data available and defined the additional studies required to provide missions data. These studies were conducted both at NASA Centers and by contractors under the direction of the Office of Systems. By June, the results of all the previous study activity had been analyzed against the criteria of mission success, safety, schedule, cost, complexity, and growth potential. The analysis of more than a million man-hours of technical work showed that lunar orbit rendezvous was the most desirable mode of flight.

The Office of Systems now has about half of its planned total complement of 125 members of the technical staff on board.

In February 1962, NASA requested the American Telephone & Telegraph Co. to assist in this systems engineering effort. We asked A.T. & T. to provide an organization of experienced men able to

employ the most advanced analytical procedures necessary to develop the factual bases needed by responsible NASA officials to make the wide range of decisions required for the successful execution of the manned space flight program.

A.T. & T. responded to this request by forming Bellcomm, Inc., in March 1962.

As of this date, Bellcomm consists of 97 technical people and a supporting staff of 64. In terms of educational background of the technical staff, 24 percent have a Ph. D. degree, 46 percent an M.S. degree, and 29 percent have a B.S. degree.

Bellcomm will continue to grow, and we anticipate that by the end of this year their organization will comprise about 250 people—two-thirds technical personnel and the balance administrative staffing level.

For the 18-month period ending September 30, 1963, the estimated amount of our contract with NASA is approximately $8½ million.

Mr. HECHLER. Dr. Seamans, you mean "by our contract," Bellcomm's contract with NASA?

Dr. SEAMANS. The estimated amount of NASA's contract with Bellcomm is approximately $8½ million.

Bellcomm provides skilled and experienced assistance to enable NASA systems engineering to exercise its responsibility and authority in an effective manner.

It is important to note that the Bellcomm organization assists and supports a technical office within the Government rather than an administrative office. This important distinction makes it possible for the Government to properly carry out its total technical responsibility, utilizing a contractor for assistance, but maintaining the final technical, engineering, and procurement judgments within the Government itself, to be made by Government employees.

Bellcomm's capital stock, which at present is $700,000, is owned jointly in equal amounts by the A.T. & T. and the Western Electric Co.

The board of directors comprises a chairman, Mr. R. R. Hough, vice president, engineering, A.T. & T.; and eight others, two from A.T. & T.; two from the Western Electric Co.; two from the Bell Telephone Laboratories; and two from Bellcomm, Inc. It was intended at the outset that the board be a working board in both a technical and business sense. For this reason it contains highly qualified technical people and people with extensive business experience.

The president of Bellcomm, John A. Hornbeck, and the heads of its two technical divisions, came from Bell Telephone Laboratories.

Its vice president and general manager came from the long lines department of A.T. & T. The other officers are comptroller and a secretary-treasurer, the former from A.T. & T., and the latter from the Western Electric Co.

In February 1962, NASA selected the General Electric Co. to play a supporting role in Project Apollo—to concentrate on checkout, reliability assessment, and integration.

We might briefly review some of the reasons why such support is required. To carry out a manned lunar landing mission, it is necessary to verify the readiness of all of the needed system elements to properly perform. In order to develop high confidence in our readiness to make the next step in a mission, we must carefully check out

each piece, part, unit, subsystem, stage, spacecraft module, space vehicle, and ground facility.

Within the framework of organization for the Apollo project, no single contractor could do the entire job of developing checkout equipment and procedures, and supplying the equipment for a uniform programwide approach. Therefore, NASA asked General Electric to begin this work under letter contract NASw-410.

The knowledge gained in the uniform design of checkout equipment and procedures is the same information required to insure detailed integration of major systems, such as the electronic, electrical, and mechanical linkages. The checkout process of necessity delves into almost every system in great detail. Consequently, it was decided to combine the integration assignment with that of checkout.

Another related task is reliability assessment. The success of Apollo will require detailed knowledge concerning the present and projected reliability of the critical system components. This knowledge must be continuously acquired throughout the design, manufacturing, test and operational phases of the program to enable NASA to make an informed judgment about system reliability and safety levels.

The first phase of the work consisted of a series of studies aimed at more specifically analyzing and defining the scope and content of the work. The study phase was completed last fall. The implementation phase of work was begun immediately and continues. Negotiations on a definitive contract have proceeded, and we are confident that agreement on all of the provisions of this definitive contract will be reached in the near future.

In the implementation phase, GE's work will be in two broad categories. There will be continuing engineering support, which will be required by the Office of Manned Space Flight and the NASA Centers in their respective areas of responsibility for integration, reliability assessment, and checkout. Secondly, GE will furnish specially designed checkout hardware, including that which will provide for the integrated launch control and checkout system.

General Electric engineering support is now building up as needed at the Manned Spacecraft Center, the Marshall Space Flight Center, and the Launch Operations Center. The organizations at each Center call upon the Apollo support department at Daytona Beach, Fla., where a staff has been established to support across-the-board tasks. Common use of the Daytona Beach services assures a common approach to checkout, reliability assessment, and integration.

As the program progresses, General Electric will gradually increase the proportionate scope of the Daytona Beach effort as the engineering center of gravity shifts from concept and design to the production of checkout equipment. As the reliability and quality data begin to build up, the General Electric central data effort will also grow. Integration support effort by General Electric will continue at the NASA Centers and at the GE headquarters to provide assistance to NASA throughout the life of the program.

It is important to understand the difference between systems engineering, an activity that requires a relatively small organization of very highly qualified individuals, and checkout, reliability assessment, and integration, which because of the massive amount of technical detail which must be handled, require large manpower efforts.

In systems engineering, we have developed the system concept and are now writing the overall specifications for Project Apollo. You should recognize that a portion of these specifications will include the general requirements on the checkout system definition of the requirements for reliability assessment, and technical monitoring of the program. Bellcomm supports NASA in this work.

We have asked General Electric to provide support in areas in which the details require many people. GE is implementing the checkout system, beginning hardware production, and undertaking comprehensive work in integration and related data gathering and processing, which will help to insure that the overall systems engineering requirements are being met in detail.

Thank you.

The CHAIRMAN. Thank you, Dr. Seamans, very much.

I am sure that the members of the committee are delighted to know that Mr. Brainerd Holmes, Director of Manned Space Flight, is with you this morning.

We welcome you, Mr. Holmes, to this hearing.

Mr. HOLMES. Thank you, sir.

The CHAIRMAN. One of the concerns of this committee, and a proper concern, has been the question of personnel.

There is one question which I would like to pose, and which is a general one as follows:

What efforts is NASA making to build up an in-house capability in terms of systems engineering, in terms of the subject matter also, of the General Electric contract?

To what extent do you find the present civil service policies of the Federal Government inhibit effort to build up in-housing capability?

Has NASA in the past year asked the Bureau of the Budget, or the Congress, or the executive department, to increase the number of exempt positions so as to give NASA a greater range of flexibility in acquiring this personnel?

Would you want to address yourself, generally, to this question, Dr. Seamans, before we get down to specifics?

Dr. SEAMANS. Mr. Chairman, as I indicated in my prepared statement, we are building up the Office of Systems, in headquarters. This group is headed by Dr. Shea, a most experienced and an accomplished systems engineer. In addition, we are building up systems competence in several of our laboratories which permits Dr. Shea to assign tasks to these laboratories in support of his overall responsibility.

It is true that systems personnel are in short supply in this country. It has been difficult to recruit these personnel for this major undertaking.

We know there is a need for additional excepted positions at NASA with one prime requirement to further develop this capability.

We have submitted a request to the Bureau of the Budget for more excepted positions, and this is now under review by the Director.

The CHAIRMAN. How many excepted positions does NASA have at the present time?

Dr. SEAMANS. At the present time we have 425 positions authorized. In addition, we have 13 Public Law 313's.

Mr. HECHLER. I would like to ask a question, Mr. Chairman?

The CHAIRMAN. Yes, Mr. Hechler.

Mr. HECHLER. Dr. Seamans, I would like to get clear your philosophy on this.

By asking for the excepted positions, does this indicate that NASA feels that this work could be done more economically and more expeditiously in-house, or I wondered, if you could define a little more clearly what objectives you have in terms of where you feel this work could be done better?

Dr. SEAMANS. If I might make that clear, Mr. Hechler, the request for increased number of excepted positions is not entirely nor even primarily for systems engineers and designers.

It is our feeling that we do need to enhance this competence within NASA, but at the same time we feel that the Bellcomm is serving, and will continue to serve, a very useful function.

I don't see it as an either/or proposition.

Mr. HECHLER. Perhaps Mr. Holmes would care to add to this?

Mr. HOLMES. I would be glad to comment on it. Certainly, as NASA grows in its total complement of personnel, which has been a tremendous growth, it must grow in its experience and maturity in management. Many of these management people are people who will require excepted positions.

The problem for the systems engineering effort is how to go to the Moon. This facet of the manned lunar landing program is perhaps the most difficult engineering job ever undertaken by man. It is certainly one of the most important, if not the most important.

Our objective in seeking systems engineering support was not to establish a commercial organization, which would have the responsibility both to do the analysis needed, and to make the final judgments. We felt very strongly that the final judgments should be made in Government, since our goal was going to call for almost a decade of effort, involving many billions of dollars, and many technical minds.

Therefore, as Dr. Seamans has testified, we established this in-house systems engineering organization. It necessarily had to be small relative to the total task—both due to the limit on these excepted positions, and the difficulty in hiring experienced people in this category. Part of the reason for the difficulty in hiring people in this category is due to the salary levels in Government not being comparable to those in industry, but that is not the only part of it. Part of it is due to the fact that many people prefer to stay and work in industry.

Therefore, we built up a small internal organization to make final judgments on systems engineering problems, and established Bellcomm to do the analysis and support work necessary to the making of these judgments. Bellcomm, a commercial organization, is to conduct assigned technical analyses and to provide systems engineering support, which will allow Dr. Shea's staff of "in-Government" people to make recommendations to my office as to how we should go to the Moon.

This unique concept differs from the pattern that has been used widely in the past where systems engineering has been undertaken and advice given to an administrative office. In that type of situation the technical direction of the program lies in non-Government groups. In the relationship between NASA and Bellcomm, the authority to make decisions is fully retained by NASA. Technical direction of the program lies clearly within NASA and is not delegated to a non-Government group.

Mr. HECHLER. Dr. Seamans, of course, our concern is also expenditure and the reduction of the amount of expenditure, and whether there is any possibility that funds could be saved for the Government without sacrificing efficiency and forward progress.

The CHAIRMAN. As I understand it, Dr. Shea is in charge of the Office of Systems, is that correct?

Mr. HOLMES. Yes. Dr. Shea is Deputy Director for Systems of the Office of Manned Space Flight and in this capacity he is in charge of the Office of Systems.

The CHAIRMAN. How many NASA employees are there in the Office of Systems? By this, I don't mean the clerical employees, but scientific or engineering personnel?

Mr. HOLMES. The present complement is about 60, and we hope to grow to 125 total, not including the integration and checkout directorate.

The CHAIRMAN. Of that 60, what is the salary range. What salaries are you paying these 60 people?

Mr. HOLMES. The majority of this relatively small technical staff are GS–15's or in excepted positions. As you know, for GS–15, the starting salary is approximately $14,500.

In the excepted positions, the salaries vary from $17,500, I believe it is, up to $21,000. I believe that Dr. Shea's systems staff includes approximately 12 excepted positions. Dr. Shea's own salary is $21,000, which represents the high.

The CHAIRMAN. You said that you had approval, Dr. Seamans for 450 excepted positions. Have you, in fact, hired 425?

Dr. SEAMANS. No; we still have approximately 25 unfilled posi-, tions—25 or 26.

Now, these have all been allocated to either headquarters offices or our field centers, and there are some very definite and specific requirements, and in some cases they are actually in the process of negotiating with specific candidates. We also must have a minimal reserve so that we can take at least a few additional key people.

The CHAIRMAN. Among the 400 which you now have how many would you say had systems engineering abilities?

Dr. SEAMANS. I am sorry but I can't answer that.

Could you answer it, Mr. Holmes?

Mr. HOLMES. One has to recognize that these systems engineers are distributed in our many centers, as well as in each program. This dispersal makes it a difficult question to answer. I would think a broad answer might be 20 to 25 percent, but it gets very deeply into semantics—what is systems engineering, and what is a man designing in the way of a system which would cover this area. As you know, there are various categories; the definition varies even within the trade.

The CHAIRMAN. Well, how many of them would have the ability and background to work under Dr. Shea in his program?

Mr. HOLMES. I would say it would probably be in the order of 10 percent, or less; probably less than 10 percent in terms of experience, in the particular line of broad systems engineering.

The CHAIRMAN. Roughly 40 to 50, then?

Mr. HOLMES. Yes, I think that 10 percent, or less would be a reasonable estimate. I would say that about 40 would have the

unique, broad systems engineering experience required by Dr. Shea's group. [Laughter.]

The CHAIRMAN. Dr. Seamans, how many excepted positions have you asked the Bureau of the Budget to approve?

You stated that you had made a request?

Dr. SEAMANS. Yes. We have requested an additional 325 excepted positions, which would take us to 750.

The CHAIRMAN. When would they become effective if the authority became effective?

Dr. SEAMANS. Well, that depends, of course, on the action of the Bureau of the Budget, and, again, on what action the Congress takes.

The CHAIRMAN. Well, at the most optimistic point, from your point of view?

Dr. SEAMANS. Well, we need additional positions today, so that the most optimistic, and I know that this is not realistic, but if this were presented to this session of the Congress, I would hope that this might be made available at the close of the business of this Congress.

The CHAIRMAN. You feel that there is a real need in this current calendar year?

Dr. SEAMANS. We feel that there is a great need for these positions, and we so stated in correspondence to the Director of the Bureau of the Budget, Mr. Chairman.

The CHAIRMAN. What is the highest salary that you would be able to pay under this proposal?

Dr. SEAMANS. Of the 425 positions that we have now, 30 of these are in the $20,000 to $21,000 category.

We have requested 10 additional in this category, so that we would be able to have 40 people on the $20,000 to $21,000 category. The remainder would go from $17,500 to $20,000.

The CHAIRMAN. How many employees has Bellcomm at this point?

Dr. SEAMANS. The number was 97 with a supporting staff of 64.

The CHAIRMAN. Of these 97, could you give us any idea of the salary range that Bellcomm is using to pay them?

Mr. HOLMES. I don't have that information with me, Mr. Ryan, but I could get it for the record, if you would like to have it.

The CHAIRMAN. Do you have any estimate in your own mind?

Mr. HOLMES. Yes; I would think it would be under $20,000—that sort of figure. That is the typical average. Certainly, I am basing that on my experience of what you would have to pay to hire such people in industry, rather than my actual knowledge of what their real salaries are. I would have to get that for the record, but the key officers of that company would certainly have much more than that, in industry.

The CHAIRMAN. Mr. Hechler?

Mr. HECHLER. If the Civil Service had the proper salary scales, would you prefer to do this work yourselves?

Dr. SEAMANS. Well, perhaps Mr. Holmes would like to answer this.

Mr. HOLMES. I think I would answer it this way, Mr. Hechler.

First, we would choose to build in-house strength, and it would be much easier to build Dr. Shea's technical staff if the Civil Service did have a higher salary scale.

On the other hand, I doubt that money alone would solve the problem of finding the collective experience, skill, and maturity that

one could get in the corporations of this country—such as A.T. & T., in this case—provided in setting up Bellcomm. Through Bellcomm, we have seasoned experience immediately available, at a critical stage in our program. Otherwise, it would take years—5 years at a minimum, probably 10 years—to build up an experienced systems engineering group that is already accustomed to working together. As you know, we cannot afford the luxury of such delays.

If, indeed, we were working in such a way and were organized in such a way in this country—which I think is impossible, given the accelerated growth that we have enjoyed over the years—that you did have a status quo and that you did know what you were going to do exactly next year, then you could plan for it, such as industry can. If one had such a group of people available, then one would obviously enjoy much more of an advantage, since it would be a group of people who know each other and have had the experience of working together.

Mr. HECHLER. Well, I suppose another advantage would be, you would have an organization that would not have to appear before congressional committees.

Mr. HOLMES. I think that it is certainly a unique and beneficial experience.

The CHAIRMAN. It flows both ways.

Now, going back to this question of the maturity of this group, the maturity of the Bellcomm management. Exactly how many of the management personnel in Bellcomm are or were with A.T. & T., or were Western Electric personnel, and to what extent did this nucelus exist, and to what extent does the corporation go outside and recruit people?

Mr. HOLMES. The senior staff of Bellcomm is either from Bell Telephone Laboratories, or has worked in the systems engineering field for many years. The staff offers not only great maturity, but also a great depth of understanding from working together in this field. In view of this experience, which is a tremendous asset to support our systems effort; a large percentage of Bellcomm's key subordinates come from either Bell Telephone Laboratories, or the Western Electric Co.

The CHAIRMAN. How many are on the staff that you referred to?

Mr. HOLMES. There is a technical staff of 97, as Dr. Seamans mentioned in his testimony.

The CHAIRMAN. And how many on the staff nucleus—you said that the key people were Bell Telephone Co. people?

Mr. HOLMES. It depends on the supervisory level. If one starts with the president, Dr. John A. Hornbeck, there are two key directors. One is Julian West and the other is Dr. Lewis. They are in charge of Bellcomm's systems engineering and systems studies, respectively. Bill Whittaker is Bellcomm's vice president and general business manager. That is the key staff, but there are, of course, many subordinates who are also key people, who came from Bell Telephone Laboratories.

In order to get highly qualified and experienced people on board, a large percentage of Bell System people were taken in. However, that percentage is becoming less and less, and we are getting people now from the aerospace projects to fill out the overall picture.

I hope that I answered the question that you asked me.

The CHAIRMAN. Yes, I think so.

So that you have your four key people, plus the subordinate staff and the supporting people, and they are recruiting the rest of the personnel to comprise the Bellcomm complement?

Mr. HOLMES. Yes, sir.

The CHAIRMAN. Mr. Rumsfeld?

Mr. RUMSFELD. Is it correct to say that technically, the figure of, let us take a number—50 percent of the in-house staff could be interchangeable. That is to say, 50 percent of the Bellcomm group, in knowledge, background, and experience, are doing work that is very similar in some cases?

You indicated that Bellcomm is doing the analysis, they report to the in-house group for further evaluation and analysis, and then they report to you.

It strikes me that a good percentage of those people would be interchangeable. Is that not correct?

Mr. HOLMES. Yes, I think that is right. Whether it is 50 percent or not, I don't know. Certainly, there are people who have had experience with the development of equipment and hardware, and the scheduling of the development of that hardware, in addition to time scheduling, and funding; people who have that broad experience, plus considerable technical training and analytical training, are able to perceive and conceive conceptually. That description would apply not only to the people at Bellcomm, but also to our in-house organization. Thus they would be interchangeable in experience. However, they wear a mantle of responsibility which is very different. Thus, much of what they are doing would not be interchangeable.

Mr. RUMSFELD. Right, but to a certain extent, their work which they are doing, is in some cases, identical, and in some cases, very similar, wouldn't that be true?

Mr. HOLMES. Identical, or at least similar talents are required to do the work. However, the work itself is different. It tends to be much broader in meeting the requirements on the Government side, whereas it is more analysis of assigned tasks on the Bellcomm side.

Mr. RUMSFELD. Well, in that you have the situation where side by side you have industry working with Government employees of similar backgrounds and capabilities and abilities, and you have also what you have indicated to be a rather dramatic difference in salary level, and it strikes me that you either already have met some very serious problems, or such will be met by you very shortly.

What do you see in the next 2 or 3 years, in the way of problems, with this matter, as far as the flow of personnel is concerned, from one to the other concern, or into, or out, of each?

Mr. HOLMES. We are not too troubled about that situation arising. It is a very good question, and is one to which we have given considerable thought. However, we did have a clear understanding with the people who joined our organization that we did not expect them to join us, and then apply to Bellcomm. We have a clear understanding with Bellcomm that we could not expect them, except in very special cases which I would review myself, to hire people from NASA.

Mr. RUMSFELD. Well, you feel that you do have some control, to some extent, on whom Bellcomm hires?

Mr. HOLMES. Yes, we have an understanding with Bellcomm that they will not hire NASA people, unless it is in some very special case, which would be very carefully reviewed.

Mr. RUMSFELD. I see.

Mr. HOLMES. And I think that there is another reason. Although it is true that these two groups of people are working side by side, making different salaries, this is possible because there is the psychic reward of giving to the country if you are working for the Government, and a feeling of a broader responsibility and challenge that you could not possibly get in industry. Some people feel that this intangible satisfaction is sufficient compensation.

I think most of them do not expect to spend their lives doing it. Most of them expect to do it perhaps for a tour of 5 years and then go back into industry.

Again, on the credit side, there are concrete advantages that compensate for the lower salary. They do gain valuable experience working for the Government on such a complex and far-reaching program. They could not possibly get this scope of training in industry. Therefore, there is an additional advantage.

I might say that I am getting the same training, and perhaps Dr. Seamans agrees that he is, too.

Dr. SEAMANS. I certainly am—every minute of the day. [Laughter.]

Mr. RUMSFELD. Along this same line, sir, would you say that in the event that the Bureau of the Budget turned down your request for additional excepted positions, that you would possibly, very simply still have this capacity of switching to some extent the responsibilities of the in-house group to the Bellcomm group, by expanding Bellcomm?

You understand, I am not suggesting this, but, just in the event that you are turned down, couldn't you, under existing provisions and regulations of the law, do this?

Dr. SEAMANS. We have overall national objectives, and we are going to do everything in our power to meet them. However, we recognize there are a variety of restrictions.

Of course, we are going to make our best effort, but I am certain that our program would be impaired if we did not receive the additional excepted positions we have requested.

Mr. RUMSFELD. How long ago did you make this request of the Bureau of the Budget?

Dr. SEAMANS. We submitted it formally early in March, in a letter.

Mr. RUMSFELD. And when do you anticipate you will receive a reply?

Dr. SEAMANS. I know that they are reviewing it in the Bureau of the Budget.

They must not only consider NASA, of course, but also the Department of Defense and other agencies, and they are in the process of discussing this within the context of the total executive branch at this time. I am afraid I cannot give you a date.

Mr. RUMSFELD. But your answer is that if they did turn you down and you could not get the increased amount of employees that you wished that Bellcomm—say you wanted an individual that you particularly wanted to participate in this program, and you could not get any other excepted positions, that Bellcomm could hire him at the higher salary?

Dr. SEAMANS. He could not participate in the same manner in the program if you did that.

Mr. RUMSFELD. But it is a pretty gray line, is it not?

Dr. SEAMANS. No, I don't think it is.

If Dr. Shea hires a person to take a certain responsibility, reporting to him, then that man could not wear a Bellcomm suit. He must be a Government employee, or he could not undertake that same responsibility.

Mr. RUMSFELD. Thank you.

The CHAIRMAN. Would you submit for the record, please, Mr. Holmes, and Dr. Seamans, a breakdown of the salaries of the 97 technical people and the supporting staff of 64 on Bellcomm's staff, as existing today?

Dr. SEAMANS. Yes, we can supply that for the record.

The CHAIRMAN. A salary breakdown.

You must have that?

Dr. SEAMANS. Well, whether I can get it specifically for each individual, I don't know, Mr. Chairman.

The CHAIRMAN. You don't have to supply the name. But how many positions at such and such a salary.

Dr. SEAMANS. Oh, yes.

Mr. HOLMES. Certainly.

The CHAIRMAN. I mean, from the total payroll, numerically speaking.

Let me ask you this:

What is the salary of the chairman of Bellcomm, and the vice president?

Mr. HOLMES. I don't have that information, Mr. Ryan.

The CHAIRMAN. Could you supply it for the record?

Mr. HOLMES. I think we can, yes.

(The information requested for the record is as follows:)

Bellcomm salary distribution

	Number	Positions and number	Salary range
Officers	2	President	$40,000.
		Vice president and general manager.	$38,000.
Technical staff	[1] 96	2	$30,001 to $36,000.
		14	$20,001 to $30,000.
		69	$10,001 to $20,000.
		10	Under $10,000.
		1	Consultant.
Administrative staff	[2] 63	3	$20,001 to $30,000.
		7	$10,001 to $20,000.
		53	Under $10,000.
Total	161		

[1] Excluding the president.
[2] Excluding the vice president and general manager.

The CHAIRMAN. In other words, the key officers, the list on page 4 of your statement. I think it would be interesting to know what their actual salaries are. Are they full-time employees of Bellcomm, and are they devoting their full energies and time to this project, or are they also carrying on duties for other Bell projects or for A.T. & T., and so on?

If you could clarify that for us?

Dr. SEAMANS. My understanding is that they are full-time employees of Bellcomm, working exclusively on the Apollo project or on related NASA programs.

Mr. HOLMES. Yes; that is correct. Bellcomm is a separate group, completely committed to our program. It was established as a separate corporation and it does not do any work inside the Bell System. Bellcomm's function is to provide us with systems engineering support.

I would like to correct something that I said that may have left the wrong impression. I believe we may be able to get the salary of the president of Bellcomm, but I do not believe we could give you the salaries of the board of directors. Those people sit as the board of directors, and naturally are not salaried employees of Bellcomm.

The CHAIRMAN. No; I am talking about salaried employees.

Mr. HOLMES. Yes; I think that would be all right for the president and, without names, a general picture.

The CHAIRMAN. I am talking about the salaried president and the salaried officers.

Now, at the time that you entered into your agreement with Bellcomm, was there any understanding on the part of NASA and on the part of Bellcomm, as to what the salary level would be for the personnel in the Bellcomm Corp.?

Dr. SEAMANS. They were to be salaries consistent with the salary spread in A.T. & T., Western Electric, and the Bell Telephone Laboratories; salaries consistent with their normal practice.

The CHAIRMAN. Well, that could be a wide range.

For instance it is my understanding that the chairman of the board of the new Communications Satellite Corp., is to draw something like $120,000, and the president, something like $80,000.

Would you tell me if you expect the salary range would equal that in the Bellcomm Corp.?

Dr. SEAMANS. No, I would say that I would not expect that the salary range of Bellcomm Corp. would be anything like that. I don't actually know what the figure is, but in the Bellcomm it is part of the A.T. & T. Co.

The CHAIRMAN. In any event, there was no specific understanding between NASA and Bellcomm as to what the salaries would be within Bellcomm Corp., when you entered into the agreement?

The CHAIRMAN. In terms of dollars and cents?

Dr. SEAMANS. Not in terms of dollars and cents, except that from the standpoint of the Bell System. Characteristically, their salary schedules are conservative in nature compared to other industries, such as Aerospace. It was understood that these people working within the Bell System, and who came to Bellcomm, would not receive increases in salaries other than what would be normal and fair in terms of disruption of their homes, moving to Washington, and reasonable compensation for increased responsibility.

The CHAIRMAN. What is the cost of this contract for this fiscal year?

Dr. SEAMANS. I think the figure is $7.9 million for fiscal year 1963.

The CHAIRMAN. And what do you anticipate for fiscal year 1964?

Dr. SEAMANS. $12 million.

The CHAIRMAN. And for fiscal year 1965?

Dr. SEAMANS. I don't have that firmed as yet.

I think it will be in the neighborhood of $12 to $15 million again, but we expect to level off at around 170 technical people.

Mr. HOLMES. Yes, and of course, that is almost totally salaries and supporting expenses. It should level off at $12 million, unless there is an unexpected change to increase the number.

The CHAIRMAN. Last year I believe, Mr. Holmes, that you said it was NASA's intention to phase out this contract. At what point do you intend to start phasing it out?

Mr. HOLMES. We will certainly not be phasing it out until we are much nearer to the Moon than we are today. We are just now starting to reap the benefits of all this work.

Spending $12 million a year on systems work in a program in which you commit the Nation to $3 or $4 billion a year. I think is most economical. All of the $3 or $4 billion might be wasted if the systems engineering were done in an unsound fashion.

As far as phasing it out is concerned, I agree that I did comment on that; I think I was asked about the Bell Telephone System at that time. Until we can build an in-house competence to do this work, or until such time as the systems engineering problems are solved, or, indeed, until we have accomplished our mission, or changed our national idea on that mission, we would not be able to start phasing it out.

I think that our ideas last year embraced a period of 5 years, or something like that. I think that was our thought.

The CHAIRMAN. I see.

Then have you changed your mind and you do not now intend to phase it out, but to continue it at this level of $12 million a year until such time as we have, in fact, placed the first man or woman on the Moon?

Mr. HOLMES. I think that we must continue, until we are satisfied that the systems engineering work is done properly or circumstances are such that we have, in one way or another, implemented our plans to the point where it becomes possible to hire in-house Government people to do the total work.

The point that I really wanted to make was that in my present thinking we would be attempting to build the Bellcomm organization up so that we can get some of the questions answered in respect to systems engineering for this program.

The CHAIRMAN. Well, it was my clear belief last year, after going into this situation, that, as of a year ago, if NASA had 75 systems engineers in-house to do this job, that they could do it. If you multiply $25,000 by 75—that was the testimony—you would have $1.8 million or, if you assume $50,000, that would be $3.7 million.

Even if you went up to $50,000 for 75 systems engineers, it would still be only one-quarter of your $12 million.

Mr. HOLMES. However, we couldn't do a job that we would expect 125 in-house people and 170 Bellcomm people to do with just 75 engineers.

I think that reference to 75 was to very senior, key people who would manage the supporting staff and the junior systems engineers.

The CHAIRMAN. But don't you believe that, if you did have this in-house complement and you had the authority to hire them, you could do it for about half the cost, roughly $6 million, instead of $12 million?

Dr. SEAMANS. I would question whether it would be half.

You don't include in your figure any more than personnel benefits and salaries.

Within the Government there are overhead expenses that run roughly 100 percent of the salaries, direct salaries.

The CHAIRMAN. Well, who is paying these Bellcomm expenses? Who is paying for the travel of these employees of Bellcomm, throughout the country?

Dr. SEAMANS. NASA is.

Mr. HOLMES. The $12 million includes all these services. It would not be half if done by NASA alone—it probably would be less. But it probably is impossible to do.

Mr. RUMSFELD. Could you give us the specific number of people who have moved from Bellcomm to NASA, or from NASA to Bellcomm, since you have had this side-by-side arrangement?

Mr. HOLMES. I think the figure is zero.

If we might state it as zero, and I will correct it if I am wrong, but if there is any change, it may be just one, or something like that. It certainly is not a major change.

The CHAIRMAN. I am interested, Mr. Holmes, in reading the testimony of Mr. Hornbeck, which was given before the Manned Space Flight Subcommittee, that Bellcomm was engaged in many things, including the study of meteoroids, radiation, solar flare, lunar surface data, and determination of sites, which might be appropriate for lunar landings.

It struck me that this was a much broader field of endeavor than systems engineering.

How do you define systems engineering, or is this Bellcomm outfit really going to get into questions as far ranging as the character of the terrain of the Moon?

Dr. SEAMANS. They must go into all environmental factors to determine the characteristics of the Apollo vehicle. They must concern themselves with environmental conditions on the lunar surface; for example, the slope of the terrain will determine such things as the landing gear on the lunar excursion module and the location of the center of gravity. These are all things that are encompassed in system design, all inputs of the system design and these are boundary conditions that must be taken into account and evaluated.

Do you have anything to add, Mr. Holmes?

Mr. HOLMES. No; except that I think that we define systems engineering as the total task. If we say that Bellcomm has started this total task, then we have to include everything in the total mission—the total profile of landing on the Moon, which includes your cislunar environment. It includes the lunar surface characteristics; it encompasses your overall requirements for hardware and includes, perhaps, incremental Delta V's, which means, how much extra fuel for velocity change is needed at any given point in the mission.

All these factors have to be in the specifications to put more meat on the bones. Information on definitive design is brought together from the centers. Ultimately these pieces comprise the total specifications on the equipment that we must build and the systems that we must pull together in order to perform this engineering task.

The CHAIRMAN. Supposing Bellcomm wanted to do any other work—does Bellcomm have any contract with any other entity?

Mr. HOLMES. Yes; the charter allows them to do special studies. Whether or not one exists now, I do not know. I think if there is it is probably an outstanding contract with the space technology labora-

tories to furnish certain data. In general, these studies have been small. Most of these systems study contracts have come either directly from Dr. Shea's organization, or from the centers, and by far the largest dollar value of these contracts have been contracted for by our centers.

Mr. HECHLER. Changing the subject slightly, I wonder if you have presented a thorough enough argument for having this done independently.

I would like to give you a full opportunity to present some additional arguments, if there are any.

Dr. SEAMANS. I will mention several, and I am sure that Mr. Holmes has additional reasons with the Bellcomm contract.

It gives a measure of flexibility; we would not have this otherwise.

If there are any special problems, Bellcomm can draw upon competence throughout the Bell System.

Secondly, it does give us some checks and balances, if you will, on specific technical evaluations.

This is, as Mr. Holmes has said, the largest development undertaking of all time, and the systems work is the most important part, in the sense that a relatively small amount of effort influences extremely large expenditures of dollars.

So you have an opportunity to have several groups look at the same technical problem before a final decision is made by the Government. I think this is a very healthy situation and contributes to our confidence in the program.

Mr. HECHLER. Would you care to add anything to that, Mr. Holmes?

Mr. HOLMES. No, I think that Dr. Seamans has covered it, Mr. Hechler. I might add one comment. I think that one of the significant reasons is the maturity that one gains, both individual maturity and organizational maturity, from an organization that has already worked together. The information of Bellcomm gave us the immediate benefit of a nucleus of experienced systems engineers, already attuned to working together.

Mr. HECHLER. Of course, I recognize the persuasiveness of your argument that the $12 million investment is fairly small in terms of the amount you expect to spend in relation to the billions of dollars that we are spending on the whole lunar effort.

On the other hand we should not ever get to the point where we feel that $12 million is considered so small that we say: "What is that among friends?"

Mr. HOLMES. No, sir.

Mr. HECHLER. Can you achieve more economic results, for example, by persuading some of the Bellcomm people that they, too, could make some sacrifice for the country, and yet get this twofold benefit, perhaps, from training and working for the Government?

I wonder if, thereby, we might save some of this $12 million, and if we can, we want to be sure that we will take every step to try to save every penny we can.

Dr. SEAMANS. You are absolutely correct, Mr. Hechler. We want to carry out all parts of this mission as economically as is possible but we need to do it well.

However, I think there can be a very great administrative problem between these two groups, if one is recruiting from the other, no matter which way it goes.

I would say that the argument you have just used could apply to every system, equally, throughout this country, to build up direct support for Dr. Shea's office, but I would question the desirability of hiring from one of those——

Mr. HECHLER. No, I am not suggesting that. I am just suggesting that you could approach these people at Bellcomm with the same argument, and say: "Wouldn't you rather sacrifice a little bit to get this job done quicker and more economically?"

That was the question that I was posing.

Dr. SEAMANS. I think you will find that is exactly the argument that is used. That, plus the argument that you have an opportunity to look at the total industry, and you have a wonderful opportunity to see how the different companies carry out their systems analysis. You definitely can learn by working in the Government much more than you can by working for the corporations.

The CHAIRMAN. Mr. Boone?

Mr. BOONE. Mr. Holmes, or Dr. Seamans, perhaps you could give us some idea of what the cost of the contract is, over and above what it would be if you had Government people.

For example, the overhead that you have to pay for Government people, as well as for the additional items that you are concerned with, say your fee. We know that there is some salary differentiation, but could you give us some idea of this—what your fee is, and how much such things are—such things as telephone expenses. I would think you would have to provide telephone services for them, but you also have to provide them for the Government people, so if you could go into that matter and give us a little discussion on it, it might help the committee.

Dr. SEAMANS. There is a 7.9-percent fee. There is a difference in salaries that we have indicated, particularly at the top level, and I cannot give you the exact ratio, but the figure of 2 to 1 was mentioned, and I am sure it is not as great a difference as that. Maybe it is in the order of 20 to 30 percent.

The CHAIRMAN. Would the $7.9 million for fiscal year 1963 represent the total cost of the Bellcomm operation to the Government?

Dr. SEAMANS. Yes; that includes the fee.

The CHAIRMAN. Would that provide to Bellcomm this 7.9 percent?

Dr. SEAMANS. 7.9, but that is included. I don't have the figure here, but I would be happy to supply that.

The CHAIRMAN. What I want to know is this: Does this 7.9 figure include the travel and overhead?

Mr. HOLMES. The $12 million figure——

The CHAIRMAN. No; the $7.9 million figure.

Dr. SEAMANS. 7.9?

The CHAIRMAN. For fiscal 1963.

Dr. SEAMANS. The 7.9 for fiscal year 1963 includes all costs to the Government—travel, overhead, general administration, fee—according to my understanding.

Mr. BOONE. Do you pay for such things as telephone on a direct reimbursement basis, or do you have an overhead figure added to cover these things and travel, and so forth?

Mr. HOLMES. This is the total figure for the Government?

Mr. BOONE. Yes.

Mr. HOLMES. We add no overhead to that, but they do have within that figure a figure for both G. & A.—general and administrative expenses, as well as their contract charges, which total up to this.

Mr. BOONE. Then there is overhead computed in this cost, which is included in your 7.9?

Mr. HOLMES. Yes; overhead is included in the fiscal year 1963 requirements.

Mr. BOONE. I see.

Are there retirement benefits and such things?

Mr. HOLMES. Yes, the normal Bell System benefits and such are all included in this amount.

Mr. BOONE. And this total contract is funded through the Apollo mission program, is that correct?

Mr. HOLMES. It is contained as an item in the budget item, yes.

Mr. BOONE. Which is not in the purview of this committee, I believe.

Mr. HOLMES. That is correct.

The CHAIRMAN. When Bellcomm sublets a contract, the subcontracts then are also included in the $7.9 million for fiscal 1963, is that right?

Mr. HOLMES. Yes; that is correct.

The CHAIRMAN. And to what extent do you expect subcontracting to take place during the sixties?

Mr. HOLMES. The subcontracting would be on a very modest scale—only where a special talent exists in some particular element of industry which would complement the Bellcomm work. In that event it would probably be advantageous to have a subcontractor do the work and receive direction from Bellcomm, rather than directly from Dr. Shea's office. Any subcontracting by Bellcomm would be to a very minor extent only.

The CHAIRMAN. Is Bellcomm doing business, and by that I include some subcontracting work, doing business with any other firm or corporation, or is it entirely or exclusively tied to NASA?

Mr. HOLMES. Bellcomm is not exclusively tied to NASA by charter. As it happens, they are concentrating on our work, but by their charter they can do work for other organizations on special assignments.

The CHAIRMAN. What I mean is: They don't do work for outside corporations, do they? Have they done any work for outside corporations?

Mr. HOLMES. None.

The CHAIRMAN. Do you have any plans, or do you know of any plans on the part of Bellcomm, to do work for outside corporations?

Mr. HOLMES. None.

The CHAIRMAN. Do you not think that this would represent a conflict of interest, and do you not think you should write into your contract an agreement or requirement that they should undertake no work for outside corporations?

Mr. HOLMES. If the work was restricted to some other agency of the Government, and if Bellcomm was entirely on top of their job for us, I don't think that there would be conflict of interest.

I might point out that it is my understanding on Aerospace Corp.'s relationship with the Air Force that their charter states that Aerospace could take work from other organizations—from NASA, for instance—if they could man it. I don't think that there would be any conflict

of interest in that case, and nor do I think there would be in the case of Bellcomm.

Mr. RUMSFELD. Well, is not the Aerospace contract based on a cost-plus basis?

Mr. HOLMES. The Aerospace-Air Force contract was very similar. But when you are talking about cost plus, there is the question of the type of talent involved, because you are paying for special ability. On the other hand, you have a cost plus in relation to paying for fabrication and materials, and so forth.

Mr. RUMSFELD. Well, to summarize, would you say that this statement would be incorrect:

For a fee, this corporation has released a small handful of top employees to form Bellcomm and then to go out and recruit additional employees, and to subcontract if they deem it advisable, and the individuals are to get their normal salaries, plus the expenses and this fee, plus the opportunity and advantage which is gained, particularly in the case of General Electric, for the future Apollo hardware, plus the opportunity to do outside work.

Is this unfair to summarize it this way?

Dr. SEAMANS. Well, I think in this case there is an implication that there is something wrong here, and I don't think——

Mr. RUMSFELD. You realize that I didn't mean to imply that.

Dr. SEAMANS. There is an implication that the company is reaping some very large returns from a very small investment which I do not feel is the case.

Actually, they are releasing, to do this work, some of their very able people who, if they were not working on this, would certainly be directed to other jobs that would, perhaps, be more beneficial to A.T. & T. perhaps from a hardware standpoint.

On top of that, they are taking some risk.

They are taking some responsibility, and it is necessary for the top management of A.T. & T. to insure they are providing very competent service to the Government. They are involved in tasks which affect the success of the program in a very major way and their prestige as a competent technical organization is also at stake.

Mr. HOLMES. May I comment that I think, as far as Bellcomm is concerned, that those first three words are where the statement goes wrong. I would like to explain why.

You start out, "For a fee," and actually in the case of Bellcomm, Mr. Kappel considers that the group is making a contribution. In the first place, he didn't actually want a fee. He didn't necessarily want to give the talent and efforts of the corporation in this manner. I think it was Mr. Webb who believed, quite properly, that if you have a business or a corporation, or an industry working for the Government, you don't do it on a nonprofit basis. If you are asking a company to come and do some work for the Government, they deserve a fair and reasonable profit. That is the way we structured our policy in this case.

So, it really was not for a fee.

A.T. & T. viewed our request as an obligation that they owed as an industry intimately serving the U.S. Government. A.T. & T. felt that it could, and should, contribute to our effort. I really believe that our relationship with Bellcomm is operating in this manner.

Mr. RUMSFELD. Well, I certainly agree that if the Government is dealing with industry there certainly should be a profit for industry, or else industry is going to become part of the Government.

I asked this question simply because the testimony this morning I think gives rise to this sort of query, and I thought it would be important to have for the record your response.

Mr. HOLMES. Yes.

The CHAIRMAN. Did you consider at the time you set up Bellcomm, setting up a nonprofit organization, Dr. Seamans?

Dr. SEAMANS. Yes, sir; we considered this possibility. However, it was our judgment that it would be much more desirable to enlist the services of a going and competent corporation with existing resources on which they could draw in support of NASA.

This also gives us the flexibility to cut down on the support at a later date, or even to eliminate it altogether, depending upon our requirements.

Of course, once a nonprofit corporation is established for such a purpose, it tends to become permanent in nature.

The CHAIRMAN. I was really interested in the remark, Mr. Holmes, that you made about the benefits to the Government, of this contract.

I think we also, however, should not ignore the fact that this contract certainly concentrates the know-how and competence in the hands of a subsidiary of two of the very giant corporations of this country.

I think we should now turn to a consideration of the General Electric contract, which, although it appears similar on the face, I believe has certain marked differences.

I understand, and please correct me if I am wrong, there are basically two functions involved in the General Electric contract: One, the checkout function and, secondly, the reliability function.

I perhaps have oversimplified it, and you might care to describe it in layman's terms for us?

Mr. HOLMES. Yes; I think that is correct. I think we could add one more task, if you will, and that is the integration function. If one sees checkout as being the fundamental concept of that contract, and adds reliability and integration, and takes these functions as a whole, the statement does adequately describe the work we have given the General Electric Co.

With a program that has as many elements as the Apollo program, we at NASA felt that it was essential to have an integrated approach to checkout.

Many major systems, in my experience, have gotten into trouble and have had overruns in dollars or schedule slippages because of the failure to take an integrated approach to integration, checkout, and reliability.

Our approach to General Electric with their broad base of experience and a great potential to do many different tasks was along these lines:

Join with us in this contract to work for NASA, to establish an integrated approach to testing and checkout of all the many systems and subsystems, and many facets of the hardware when they arrive at Cape Canaveral, and when they are integrated together.

It has been our experience that if one does take this broad approach to checkout or to tests, one is in a position to judge the reliability of the equipment that is being produced. The group which does the

testing to determine the success or failure of all these many facets is making a basic contribution to the success of the entire program.

To perform these intricately interwoven functions, one has to understand all of the equipment and how it is ultimately joined together. The organization that has that knowledge is a logical point of responsibility for integration, or for marriage, of the interface drawings. The mechanical interface simply means the place where two components, produced by two different manufacturers, must fit together. All these interrelationships are analyzed by General Electric in their integration responsibility to assure that these parts are correct, and the subsystems and systems, and different areas mesh together so that they will mate properly when they arrive at Cape Canaveral.

The CHAIRMAN. So that the integration function is more closely related to checkout?

Mr. HOLMES. Both reliability and integration are related to the fact that they are doing the overall integrated checkout for the program.

The CHAIRMAN. You have one contract with General Electric?

Mr. HOLMES. Yes, sir. There is only one contract.

The CHAIRMAN. Do you have two contracts, or perhaps three?

Mr. HOLMES. We have only one contract.

Dr. SEAMANS. The contract is for three tasks—integration, checkout, and reliability assessment.

The CHAIRMAN. Where is that record? Which page is it? On what page is this $150 million—for our record here?

Dr. SEAMANS. In the budget book it is in volume 2, RD04–1, but as far as the hearing that I referred to, that was "House Authorization Hearing 3563," volume 2, pages 78 through 168, and this was actually what appeared on page 163.

The CHAIRMAN. In other words, the estimate in the book on RD04–1 of $153 million is incorrect?

Dr. SEAMANS. No—that is accurate, but the $153 million covers more than the General Electric contract, that is my point. The $153 million budgets for NASA's total effort for integration, checkout, and reliability.

The CHAIRMAN. Are there any contracts similar to the GE contract?

Dr. SEAMANS. No, there are not any comparable contracts, but there are other companies that are building a certain amount of checkout equipment.

Mr. HOLMES. Each center, such as the Marshall Space Flight Center or the Manned Spacecraft Center, has the responsibility for developing checkout equipment, working with the General Electric Co. When equipment either exists or can be bought off-the-shelf, so to speak, by the Center, from some other company, GE, of course, does not produce it again. In these cases, we furnish the equipment to General Electric as a Government-furnished item of equipment. The estimate of $153 million for fiscal year 1964 includes all the integration and checkout program effort. I think that, although we have not defined it completely, an estimate of $100 million to General Electric is probably as good an estimate as we could make at this time.

The CHAIRMAN. That is the total contract, including the development of hardware?

Dr. SEAMANS. Yes.

Mr. HOLMES. That is for 1963; yes.

Dr. SEAMANS. Well, and 1964.

Mr. HOLMES. Yes, I meant to say fiscal year 1964.

The CHAIRMAN. And there is no other anticipated expense to NASA under this contract, with GE, over and above the approximately $100 million?

Mr. HOLMES. For fiscal year 1964?

Dr. SEAMANS. That is correct.

The CHAIRMAN. What percentage of that $100 million is gross profit to General Electric?

Mr. HOLMES. We have not yet negotiated the fee for the contract with General Electric. For a rough approximation I think one could estimate having a 6-percent fee, so that would be 6 percent of the $100 million.

The CHAIRMAN. Could we assume that it would be less than 7.9?

Mr. HOLMES. I think we should assume that General Electric's fee would be less than the Bellcomm fee. It is characteristic, and I think properly so, when one is buying a purely engineering service, to pay a higher fee than when there are subcontractors producing equipment and so forth.

The CHAIRMAN. Would the 6 percent be on top of the $100 million, or would it be included within the $100 million?

Mr. HOLMES. The $100 million estimate is not the exact figure, but if it were exactly $100 million, then that would include the profit. In other words, the $153 million that was mentioned before, would include everything.

The CHAIRMAN. Would that include the construction of facilities in general? You have several facilities to be constructed.

Mr. HOLMES. No; this is only research and development money, Mr. Ryan. It does not include facilities that the Government might construct. As far as the General Electric facilities are concerned we do not pay for those, under either budget.

The CHAIRMAN. Are there facilities being built for this operation at Daytona Beach?

Mr. HOLMES. Yes—but those are General Electric Co.-owned facilities and, of course, are not in NASA's budget.

The CHAIRMAN. And NASA is not paying for that?

Mr. HOLMES. That's right.

Mr. WYDLER. May I ask either the Chair or the witness: Was there not recently a trip made to Daytona Beach?

The CHAIRMAN. Yes; by the Manned Space Flight Subcommittee.

Mr. WYDLER. Made to this particular installation.

Dr. SEAMANS. On March the 20th.

The CHAIRMAN. Unfortunately the minutes are not available of that proceeding.

Dr. SEAMANS. I beg your pardon, March the 29th.

Mr. WYDLER. Yes; they visited the installation, as I understand it, is that correct?

Dr. SEAMANS. That is correct.

Mr. WYDLER. And they were briefed on the purposes of the installation, and inspected it?

Dr. SEAMANS. Yes; that is true.

Mr. WYDLER. Thank you.

The CHAIRMAN. What do you expect the fiscal year 1965 contract to cost?

Mr. HOLMES. I think that an estimate of approximately $150 million would be as good an estimate as we could make at this time for the integration and checkout program.

I would think that certainly more than two-thirds of that estimated amount would be for the General Electric contract.

The CHAIRMAN. Could you estimate how much—you have said in 1964 the G.E. cost will be a hundred million, and could you say for 1965 what you expect the General Electric to cost?

Mr. HOLMES. For fiscal 1964, since we are not able to give a definitized figure, the $100 million is a good round figure. It may be $125 million—I can't be completely accurate at this point in time, of course. For fiscal 1965 I would think the figure would still be around $125 million, out of the $150 million total estimate—I would think that would be a reasonable estimate.

The CHAIRMAN. And you are expecting the contract to run how many years?

Mr. HOLMES. We think that this contract will run in one form or another until we are on the moon. Therefore, it will probably continue through the decade.

Dr. SEAMANS. I would say that the heavy development cost will start to taper off prior to the actual launching of the lunar expedition.

That is to say, all the equipment must be there, at complex 39, at the time of these flights. We will still be getting very active support on the part of G.E. and they will continue with reliability analyses as well as helping in the integration, but there are bound to be changes that will occur right up to the times of the flights.

The CHAIRMAN. Could you estimate what the cost of this contract will be to NASA up to the time of the landing?

Mr. HOLMES. Our estimated costs at this time run in the order of over $600 million.

The CHAIRMAN. Do you think it will go as high as $1 billion?

Mr. HOLMES. No—our estimates total something over $600 million—$635 millions to be specific.

The CHAIRMAN. Yes, Mr. Rumsfeld?

Mr. RUMSFELD. I touched on this earlier, but I would like to have a little more discussion on this: Since G.E. is a hardware manufacturer this brings up the question as to the relationship between this company and future hardware contracts on Apollo—specifically that, but possibly other areas too. Do you feel that General Electric is given a rather substantial lead in this respect and since we have just been going through this TFX situation, and other contract problems in this country, don't you think it is important to understand this relationship?

Dr. SEAMANS. Well, this is an excellent question and one that has received attention by the top management of NASA to insure that General Electric does not get a preferred position on major procurements. At the same time, attention has also been given to be sure that they are not necessarily and severely jeopardized as to their opportunities.

We do have worked out with them an exclusion policy—such that they cannot propose bids on major modules and stages for the lunar exploration.

Would you like to add to that?

Mr. HOLMES. Yes I would. We initially recognized, of course, that there might be some difficulty with respect to General Electric Co.'s entree, if you will, to other corporations on the Apollo project. We agreed with them that they would not be eligible to bid on major Apollo systems, major subsystems or, indeed, any special components where their knowledge of this field from this contract would help them in presenting a bid.

As a result of that agreement, General Electric did not bid on the lunar excursion module, where they have an advantage, and they also did not bid on the mission control center, where we admitted, strictly speaking, they could bid. However, we felt that, because of their experience, they would be an awfully low bidder in their proposal—able to bid lower than everybody else. General Electric has not bid or been in any favored position for doing business on projects concerned with Apollo.

Dr. SEAMANS. May I just read from this NASA circular, that has just gone out to all of our centers in this regard, Mr. Chairman.

The subject is "Restrictions on contracting with General Electric Co., where competitive advantage may exist."

It states:

Policy: General Electric Co. shall be considered for contract awards on the same basis as any other company except that it will not participate in certain aspects of the NASA–Apollo program; specifically General Electric shall not be permitted to participate in the Apollo program as a prime contractor or first-tier subcontractor for launch vehicles or spacecraft stages—

which is the point I made earlier.

a supplier of nonstandard major system components for the above items, in connection with which development work is required that does not require information as acquired by the General Electric Co. in the performance of its contract prior to the release of such information to industry.

And so on.

The CHAIRMAN. Mr. Rumsfeld?

Mr. RUMSFELD. Do you feel that G.E. is thoroughly satisfied with that situation and they do not feel they are being harmed by this inability to bid?

Dr. SEAMANS. One of the reasons that we prepared this was to provide guidance to each of our centers so that they would know what the situation was with respect to G.E. and so that there would be no misunderstanding on anybody's part.

The CHAIRMAN. When is that dated, Dr. Seamans; the date on that circular?

Dr. SEAMANS. Three-three-seven.

This has not actually gone out to the centers. I guess the date here is April 16. However, this information has been transmitted to the centers.

The CHAIRMAN. Would you submit that for the record, please?

Dr. SEAMANS. Yes.

(The information requested for the record is as follows:)

NASA CIRCULAR

No. 280.
Reference: 3–3–7.
Effective date: April 16, 1963.
Subject: Restrictions on contracting with the General Electric Company where competitive advantage may exist.

1. PURPOSE

This Circular establishes NASA policy restricting participation of the General Electric Company in certain NASA procurements.

2. APPLICABILITY

This Circular is applicable to NASA Headquarters and field installations.

3. DEFINITION

For the purpose of this Circular, the following definition will apply:

Apollo Program means the development and fabrication of a multimanned Apollo spacecraft to achieve a lunar landing and return mission, together with its associated launch vehicles.

4. BACKGROUND

In February 1962, NASA entered into a letter contract (NASw–410) with the General Electric Company for the overall integration, checkout, and reliability of the Apollo Space Vehicle System. In performing the contract, the General Electric Company will have access to the kind of information regarding certain NASA plans and programs and data generated by other Apollo contractors that could give the General Electric Company a competitive advantage over other firms in some NASA procurements. Accordingly, by agreement with the General Electric Company, certain restrictions will be observed in future contracting with the General Electric Company.

5. POLICY

a. The General Electric Company shall be considered for contract awards on the same basis as any other company except that it will not participate in certain aspects of the NASA Apollo Program. Specifically, the General Electric Company shall *not* be permitted to participate in the Apollo Program as:

(1) A prime contractor or first-tier subcontractor for launch vehicles or spacecraft stages;

(2) A supplier of nonstandard major system components for the above items, in connection with which developmental work is required, when design requirement information is acquired by the General Electric Company in the performance of Contract NASw–410 prior to the release of such information to industry for competitive study or implementation procurements;

(3) A supplier of nonstandard checkout equipment other than under Contract NASw–410.

b. (1) An exception will be made to the above restrictions and the General Electric Company will be permitted to participate in any of the above procurements in any individual case where the Administrator or Deputy Administrator determines that General Electric possesses a unique capability, the utilization of which is required in the national interest.

(2) It is part of the understanding with General Electric that in other procurements, whether or not under the Apollo Program, where General Electric may occupy a particularly advantageous position because of its work under Contract NASw–410, the Administrator or Deputy Administrator may request General Electric not to participate.

c. The policy described in subparagraphs a and b shall not affect existing contracts with the General Electric Company.

d. NASA personnel will ensure that the General Electric Company receives an equal opportunity to participate in NASA procurement except where the exclusion policy described above specifically and clearly applies.

6. PROCEDURES

a. Where it appears that application of the policy stated in paragraph 5 to a particular procurement will result in the exclusion of the General Electric Company, the following action will be taken:

(1) If the procurement is to be made by a NASA prime contractor or subcontractor, such contractor will refer the matter within 24 hours to the NASA contracting officer.

(2) If the procurement is to be made by NASA or has been referred to a NASA contracting officer in accordance with subparagraph (1):

(*a*) The Director of the NASA field installation will make a determination as to whether the General Electric Company is to be excluded, except that if he lacks information on which to base such a determination, he will request that the determination be made by NASA Headquarters. Any such request will be signed by the Director of the NASA field installation and submitted to the Director of Manned Space Flight, NASA Headquarters. A copy of each request will be furnished to the Director, Procurement and Supply Division, NASA Headquarters.

(*b*) In cases where the General Electric Company is believed to possess a unique capability to perform a procurement which may fall under the exclusion policy, the Director of the NASA filed installation will refer the matter to the Director of Manned Space Flight, NASA Headquarters, requesting an exception to the policy. A copy of each such request will be furnished to the Director, Procurement and Supply Division, NASA Headquarters.

b. Where a determination by the Director of the field installation will result in the exclusion of the General Electric Company, such cases will be reported to the Director, Procurement and Supply Division, NASA Headquarters, within 24 hours. These reports will contain the following:

(1) A description of the procurement, including the extent of available competition;

(2) A citation of the pertinent provisions of this Circular; and

(3) Any additional information to justify the applicability of the restriction to the particular case.

c. Action taken in accordance with this Circular should be expedited and the General Electric Company notified promptly in order to permit the company either to submit a timely proposal or to be advised of its ineligibility prior to investing in a proposal effort.

d. Contracting officers will insure that all of their major prime contractors under the Apollo Program have copies of this NASA Circular, as this Circular supersedes previous instructions on this subject (see paragraph 7). (Local reproduction of this Circular is authorized for this purpose only.)

7. RECISION

This Circular supersedes the following:

a. The NASA Headquarters (BR) TWX on this subject sent to the Directors of all field installations on December 17, 1962; and

b. The NASA Headquarters (BR) letter on this subject sent to the procurement officers of all field installations on March 1, 1963.

8. EFFECTIVE DATE

This Circular is effective April 16, 1963.

ALBERT F. SIEPERT,
Director of Administration.

The CHAIRMAN. What prompted this circular? Was it a feeling on the part of General Electric that they were being excluded from contracts by either your other contractors or by your centers?

Did GE complain to NASA that the agreement entered into originally was being too tightly construed?

Dr. SEAMANS. I think that General Electric Corp. felt that the interpretation by NASA centers was too restrictive, but at the same time there was recognition on the part of NASA personnel, including the management of GE, that there were some areas from which GE would have to be excluded.

This was recognized at the start of our discussions with the GE officials—that they would have to be excluded from the major developments for Apollo.

The CHAIRMAN. Does this indicate in effect a change of policy on the part of NASA toward General Electric?

Dr. SEAMANS. No, sir, I would say that this was understood and as a matter of policy, at the start of our negotiations—however, to document it, and to process it, and to think it out finally and definitize such a matter, takes considerable thought to be sure that it is a fair and equitable policy.

The CHAIRMAN. Well, I certainly feel that there is reason for concern in respect of the General Electric matter because this contract does put them in a preferred position and it seems to me that NASA should take very great care to see that it does not take advantage of its position.

I am concerned that perhaps NASA is now backing away from its original policy and has eased the restrictions on General Electric because of complaints coming to it from General Electric during the course of the past year.

Dr. SEAMANS. No, sir. I don't believe that is so. I think it is just a very fair and well thought-out policy with General Electric.

The CHAIRMAN. In other words, this circular letter must have been prompted by the failure of General Electric to secure a contract or an opportunity that it thought it was eligible for.

Was there a specific case involving a contractor which prompted NASA's communication saying that NASA would make a determination on eligibility?

Dr. SEAMANS. No—this was part of the negotiations which had been carried with General Electric, leading to this definitized contract which we will have in short order, and the need for NASA's centers and senior personnel to fully understand the implications of the contract and the agreement made with General Electric.

The CHAIRMAN. By saying that, what you are excluding General Electric from doing is contracting on the Apollo system itself but not on other aspects of your NASA program—is that correct?

Dr. SEAMANS. That's right because they are in a preferred position on the part of the Apollo major contracts, but they are not in a preferred position in such areas as our unmanned spacecraft.

The CHAIRMAN. What about Gemini?

Dr. SEAMANS. They are not working on the Gemini program.

The CHAIRMAN. Suppose they were bidding on part of the Gemini program, then?

Dr. SEAMANS. Well, they actually do have a subcontract to McDonnell Aircraft for the fuel cells for the Gemini spacecraft.

The CHAIRMAN. Don't you think that the knowledge gained from this contract with NASA strengthens the competitive position of GE in relation to the rest of industry in respect to the other contracts as well as to the Apollo system itself?

Dr. SEAMANS. Well, there is a completely separate procurement there. I don't see any relationship with this checkout reliability analysis and the integration contract.

The CHAIRMAN. Mr. Rumsfeld?

Mr. RUMSFELD. This is a very difficult area, I would think, to conclusively draft each possible problem which might come up in the

future, and it seems to me the important thing is that you are, as you obviously are, aware of it and are addressing yourself to it as you have.

The test, of course, will be in the execution and application of these provisions which are being circularized by you in this letter.

Mr. HOLMES. Yes. I think it should be clear, however, that the circular repeats what we spelled out to General Electric in our initial negotiations—that is to say, the exclusion from prime systems bidding for Apollo.

I think it also ought to be made clear that the major contracting for Apollo has already been done, with the exception of a very few items. Nearly all of it is history and if one examines the record, it will show that we have applied the agreement directly to every procurement.

Mr. RUMSFELD. I am sure it will be examined thoroughly.

Mr. HOLMES. Yes.

Mr. RUMSFELD. Along this same line, but possibly not as clear cut, is the problem where there is a free interchange of information.

Have you found a reluctance on the part of other companies to supply information to any of your contractors in specific areas because of a feeling that there may be a danger of a competitor acquiring some of the expertise that they lacked previously?

Mr. HOLMES. No—I think we have not. I would like to point out that I have very little sympathy for companies that have this attitude. It is only in a very few cases that we have found anyone taking the position of proprietory right because, for the main part, these contractors are working for us on Government money and most of the developers are working on Government money. If we are paying for that work, we are entitled to have the knowledge and distribute it, as we see fit, to advance the programs most economically and efficiently. We have had very few problems in this regard and I know of no problems which were justified.

Mr. RUMSFELD. Well, when you say that you know of very few, this means that you know of some. Would you describe specifically an instance for us and discuss that?

Mr. HOLMES. I don't think I could identify any specific instance beyond my general comments.

I can't honestly say that I can tell you of any specific instance where there has been a complaint by a company working on Apollo, or where Apollo contractors have been asked for information in respect to the GE work and there has been any difficulty.

Dr. SEAMANS. Let me say this: We have recognized the importance of free interchange of information between the contractors, particularly with GE for this specific purpose. During the very early stages of the negotiations with GE we kept the top executives of the other corporations informed of the role that we expected GE to play, so that they understood the importance of this responsibility. We had particularly in mind that they would understand the importance of GE's role and would recognize that it was as much in the national interest as in their own interest to work in cooperation with each other.

The CHAIRMAN. I think these are serious conflict questions, Dr. Seamans, and certainly I hope that NASA will be continuously aware of them.

Now I believe that Mr. Holmes testified that, in addition to the checkout equipment to be manufactured under this contract by

General Electric, a certain amount of the checkout equipment was to be contracted for. Did you say that, sir?

Dr. SEAMANS. Yes—through the centers.

The CHAIRMAN. All right. Then how do you determine whether General Electric is going to do the checkout manufacturing or some other corporation is going to do it and, if the other corporation is going to do it, is that done on competitive bid—because I believe this GE contract originally was not by competitive bid, was it?

Dr. SEAMANS. That's right. Mr. Holmes might like to add to that.

Mr. HOLMES. That is correct. That is what I was mentioning earlier. In such a case the centers which were contracting for the checkout hardware would determine: one, if the hardware exists on the shelf, so to speak, from some other company or two, if some other company had a unique qualification to do the work in a better fashion than General Electric could do it. Then the Center would contract with that company and the equipment would be furnished as Government-furnished equipment to General Electric. With the exception of those cases, the checkout equipment would be developed by the General Electric Co.

The CHAIRMAN. Could you give us an example of any checkout equipment so far that has been contracted out to some other corporation?

Mr. HOLMES. Yes, but again you must recognize that this is a very broad program. I will give you some examples of checkout equipment that won't all be necessarily integrated checkout equipment.

Certain aspects of monitoring the propellant flow at Cape Canaveral will eventually become part of the integrated checkout equipment. Some special devices for propellant pumping, from the standpoint of very high-speed pumping both at the Mississippi Test Facility and at Cape Canaveral, which can be controlled and may be needed during a countdown, certainly in all likelihood will be contracted out to another company.

The instrumentation for the static test facilities at the Mississippi Test Facility will in many cases be contracted to some other contractor, when the contractor is uniquely qualified to do that work. As I said at the start, this is somewhat complicated in that all of these items cannot be directly tied down to the checkout equipment but are related to it.

The CHAIRMAN. And this was all done on competitive bid?

Mr. HOLMES. Primarily, yes.

The CHAIRMAN. And would General Electric be eligible to bid?

Mr. HOLMES. No, because if they were eligible to bid, they would be doing the work, unless there was some other reason why we are not giving that work to them.

The CHAIRMAN. On this last page of Dr. Seaman's statement I notice it lists 1,250 people under the General Electric contract. I assume that does not include any of the people involved in the manufacturing end of this?

Mr. HOLMES. That is the grand total.

The CHAIRMAN. Well, does that include the manufacturing end, then?

Mr. HOLMES. No, there are no people involved in manufacturing hardware at this time.

The CHAIRMAN. Those people working in General Electric on the production of the hardware?

Mr. HOLMES. Checkout equipment is mostly in the design and development phase, rather than in the manufacturing stage.

The CHAIRMAN. Then do you understand this personnel is expected to increase during the next decade?

Mr. HOLMES. Yes, we do expect an increase.

The CHAIRMAN. And if so, at what point will it level off and at what number?

Mr. HOLMES. I would have to get that for the record, particularly for those required for manufacturing at General Electric. I think we have something on the Daytona Beach effort but the development of plans for the manufacturing of the equipment could only be an estimate. I really don't know. I think that we might estimate the number at between 3,000 and 4,000 people, including manufacturing personnel.

The CHAIRMAN. If I understood correctly, Mr. Holmes, when you discussed this contract you testified that there was an expectation that General Electric would use between 500 and 600 people.

Has there been any reason for this increase between last year and this year from 500–600 then to 1,250 now, and then later on to be between 3,000 and 4,000 people?

Mr. HOLMES. The 500 to 600 would be the "Direct" people, not the supporting people on the contract. The current number for "Direct" is 797.

The CHAIRMAN. What is the difference between the direct and the supporting function?

Mr. HOLMES. The direct people are normally working at the center to do the design of the hardware and equipment. The supporting people are the people who are payroll people, accounting people, general overhead people, secretaries, reproduction people—the supporting activities that normally go with an engineering outfit.

We are at the present time thinking in terms of a 1-to-1 ratio—one direct person and one supporting person, such as someone in the model shop or one of the secretaries.

The CHAIRMAN. Out of the contracted 3,000 to 4,000 people, how many will be direct or engineering people?

Mr. HOLMES. The figure of 3,000 to 4,000 is a figure that I took to identify the ratio if it stays the way it is now. That is only one for one, or perhaps less—eight-tenths of a support person for one direct person.

The CHAIRMAN. Could you give us for the General Electric contract the same kind of breakdown that you are going to supply for the Bellcomm on the salaries?

Mr. HOLMES. I think it would be much more difficult. We do not normally go to our contractors and audit them on personal or individual salary basis. We audit our contractors on the basis of doing business with us and what it costs us to do business with them versus what it would cost us to do business with some other corporation. I think that it would very difficult for us to do that, Mr. Ryan.

It would set a precedent under which we could go to this company, or any other company, and ask for individual salaries rather than saying, "If you bid less, being qualified to put in a proposal, you can do the work and we will audit your overhead and expenses on an audit basis."

The CHAIRMAN. Well, could you separate the employees who are involved in the nonhardware manufacturing from those involved in the hardware phase of this?

Mr. HOLMES. As far as number of people involved?

The CHAIRMAN. In terms of salaries, too.

Mr. HOLMES. I think that we could give you certain average salary ranges.

The CHAIRMAN. Would you do your best to give us some figure on the comparative phases between Bellcomm, General Electric and NASA? In relation to your application for an increase in the number of excepted positions—I think that is what we really are aiming at here.

Mr. HOLMES. Yes, sir.

(The information requested is as follows:)

General Electric Co. salary distribution

Category	Number	Salary range
Management staff	29	$20,001 to $30,000.
Do	39	$10,001 to $20,000.
Subtotal	68	
Technical engineering	404	$10,001 to $20,000.
Do	95	Under $10,000.
Subtotal	499	
Technicians and technical support, subtotal	117	Under $10,000.
Administrative staff (professional)	85	$10,001 to $20,000.
Do	131	Under $10,000.
Subtotal	216	
Administrative, secretarial, and clerical, subtotal	454	Under $10,000.
Total	1,354	

I think we should recognize that the GE salary scale should be much more comparable to that in typical industry, much like the other major corporations.

Would you not agree, Dr. Seamans?

Dr. SEAMANS. Certainly.

Mr. WYDLER. In the Office of Systems how many—or what is the ratio—between the technical and the administrative staffs?

Perhaps I should address that question to Mr. Holmes.

Mr. HOLMES. We expect to build to about 125 people on the technical staff, and about 200 total. Therefore, the ratio is about half a support person to one direct person, if you want to look at it that way.

Mr. WYDLER. Two to one?

Mr. HOLMES. Two technical people to one support in that particular operation, yes. In-house now—that is your question, is it not, Congressman?

Mr. WYDLER. Yes.

Mr. BOONE. Dr. Seamans, do you have some idea of the total number of direct personnel inside of NASA—similar to these contracts?

Dr. SEAMANS. You mean for all contracts?

Mr. BOONE. Well, I am talking about these types of support. The General Electric, Bellcomm, which are the two largest personnel supplement types of work that you have, I gather, is that correct?

Dr. SEAMANS. Well, Bellcomm and General Electric do have a special role in our program.

We also do let systems studies to industry for particular missions and we, as Mr. Holmes said, do have contracts let through our centers for certain special checkout equipment that is directly related to a stage or a module, but is not considered necessarily integral to the total integrated checkout equipment.

I am afraid I could not give you a figure as to the total number of personnel in industry who are working in this area.

Mr. BOONE. No; that is not what I was driving at. For each of your centers, for example, or at some of your centers, you will have people who perform engineering services for you, or maybe furnish guards, and they are in fact supplemental civil service people at your centers.

Dr. SEAMANS. You are talking about motor pools?

Mr. BOONE. Well, a number of other things like this; for example, do you have secretaries at some of these places?

Dr. SEAMANS. I think that we have always hired our secretaries on a civil service basis; I think there may have been special cases at Marshall where people were brought in for short periods of time to help get out written material; reports, and so on.

Mr. BOONE. Maybe you could supply a dollar value figure that may be involved in this in any one year?

Dr. SEAMANS. I will do the best I can. The figure—this then actually is a different kind of support, because Bellcomm or General Electric are highly technical and specialized. I think now you are talking about janitorial services or something like that?

Mr. BOONE. That is correct.

The CHAIRMAN. Do you have any other major contracts that are comparable to the General Electric-Bellcomm arrangements, whether in connection with the manned space flight or any other part of the work?

Dr. SEAMANS. No; I don't think we do, sir, have anything quite comparable that has to have the same general recording but we do have some contractors that have done some kinds of work that takes this kind of technical, special attention.

Mr. BOONE. And you do not anticipate any, I gather.

Dr. SEAMANS. No; we do not.

Mr. BOONE. Is there a general policy publication by NASA as to how or what factors you consider in hiring outside help like secretarial services and this type of service?

Dr. SEAMANS. Mr. Young is here. He is in charge of our Office of Administration and this probably would come under his jurisdiction.

Mr. YOUNG. Jack Young, Deputy Director of Administration—Mr. Boone, our policy has been on this, I think, in accordance with the policy of other Government agencies. I think we do contract on our mission-type contracts, for various types of services that normally can be provided by private companies.

In this regard we can include the categories of such things as guard services, mowing the lawns, on the Wallops Island Station, even to collecting the garbage.

Now we have a great many of these service-type contracts, and I do not think they are unique. They are mission-type contracts, the majority of them, and are fixed in price for services, the amount of service to be rendered, and a given quality of service.

This is in accordance, as I recall, with a circular put out by the Bureau of the Budget and it is the policy to contract for these kinds of services.

Mr. BOONE. Well, there is a policy that you follow in that respect, then?

Mr. YOUNG. Yes, sir.

Mr. BOONE. And you do consider all these factors in letting the contracts?

Mr. YOUNG. Yes, sir.

Mr. BOONE. That is what I wanted to get on the record.

Mr. WYDLER. I have one general question I would like to ask Dr. Seamans but I will wait until you are through with the subject before us, because it doesn't pertain directly to what we are talking about.

The CHAIRMAN. Do you want to ask on the record?

Mr. WYDLER. Yes, but I would just as soon wait until we are finished.

The CHAIRMAN. All right.

I merely want to thank Dr. Seamans and Mr. Holmes for being here and having spent the morning with us, and filling us in on these two contracts.

It is my belief that there is a real need for the Government to contact and keep top-flight scientists and engineers in NASA, to further develop and build up an in-house capability, and speaking only personally I feel very strongly that should make every effort to get as much support as you can for your request for further excepted positions from the Bureau of the Budget. I am sure that some of the members of this committee would be helpful and glad to help you in that endeavor.

Dr. SEAMANS. Thank you.

The CHAIRMAN. I think at the same time you might find it advisable to show in those requests wherever any savings can result to the Government and I might say that I certainly believe if you had really made a fight and asked for an increase in the number of excepted positions last time, that a great deal of work which has been contracted out according to the contracts we have heard testimony on this morning, could have been done in-house and would have resulted in in-house capability and would have avoided, also, the conflict problems which I think are inherent in this kind of contract—and also the problem which is going to flow from the concentration within a handful of manufacturers of this technical field.

This is unfortunately a problem that is going to face this country throughout the space programs where building up know-how within a very small group of corporations is likely to develop adverse consequences in later decades in relation to our future economy.

Mr. WYDLER. Could you tell me, Dr. Seamans, about this matter about which I read over the weekend in the newspapers where there was a report that there had been a violent argument, or, at least, a prolonged discussion, within NASA, concerning the request for supplemental appropriation for this year's program?

Do you know about that—is that a fact?

Dr. SEAMANS. Well it is a fact that there was a discussion; it is not a fact that there was a violent argument.

Last fall the matter was discussed and, as a matter of fact, it actually was recommended by Mr. Holmes who is here, that there should be a supplemental request of some $400 million and this was reviewed by the Administration of NASA as well as by the President and Vice President.

If the supplement could have been obtained immediately, it would have permitted us to move on a faster time schedule than we could otherwise have done assuming we would be able to obtain the requested $5.7 billion for fiscal year 1964.

However, it would have caused considerable difficulty within NASA from a management standpoint. To be effective, dollars would have had to have been obligated at that time, and this could only have been done by holding back on programs other than the manned space flight program, in the same amount, because we obviously could not run the risk of overobligating in the amount of $400 million.

It was our feeling therefore that this would have materially affected other very important space programs as, for example, the communications and meteorological programs and various unmanned projects.

Mr. WYDLER. Does it now appear, then, that there will be $400 millions left out of this year's appropriation?

Dr. SEAMANS. No; we won't have anything like $400 million left. We have been obligating funds so that by the end of the fiscal year we will have a very small carryover into fiscal year 1964.

Mr. WYDLER. Well, when you say "by a very small amount," in what ratio?

Dr. SEAMANS. Well I mean in the nature of $10 to $20 million. That is what we had last year and I understand it may be the same this year.

Mr. WYDLER. And you say that Mr. Holmes recommended this last year but it was turned down—by whom?

Dr. SEAMANS. I did not concur in his recommendations for the reasons I have indicated, nor did Dr. Dryden or Mr. Webb. I agreed with his recommendation from the standpoint of the manned flight program and I felt it was very appropriate that he should have made this recommendation, Mr. Wydler, so that we could make an overall decision with respect to the space program.

Mr. WYDLER. And what was the $400 millions for?

Dr. SEAMANS. The $400 millions would have increased the budget levels for both Gemini and the Apollo programs.

Mr. WYDLER. And for what particular purpose?

Dr. SEAMANS. I think perhaps Mr. Holmes would like to reply to that, if you would care to hear from him?

Mr. WYDLER. Yes; I would be very glad to.

The CHAIRMAN. I think it is a good question and I am sorry it is late. I do recall that you went into this before the full committee earlier.

Dr. SEAMANS. Yes; I did.

The CHAIRMAN. So perhaps if you could, in the next 1 or 2 minutes, give a brief summary Mr. Holmes?

Mr. HOLMES. I think one has to look at the chronology of events and the history of what has happened.

We did not know in the fall of 1961 how we were going to go to the Moon. We were studying that question in order to understand the nature of the project. We wanted not only to determine the difficulties so that we could estimate the cost, but in order to have this country catch up in the manned space flight program area. We had made as many commitments as we could reasonably make on that program and had estimated the progress at a certain going rate.

As we continued through early 1962 and through the summer, it became apparent that the rate at which we were going would cause us to run out of funds which were available. An alternative to obtaining more money was to cut back that rate, establish firm schedules, and definitize the program that way. We were going to be using the lunar orbit rendezvous method for the initial manned lunar landing, and we could, with this knowledge, build established schedules at a certain slower rate or continue at the same rate we were going and run out of money. Obviously, we can't run out of money.

I recommended that we ought to definitize the program, on the going rate which would have necessitated an additional $400 million for fiscal year 1963. The matter was reviewed and a definitized program, consistent with the funds available, was established. The schedule was restructured within this framework.

Mr. WYDLER. What part of your program did you not approve or let as a result of the fact that you didn't ask for the $400 million supplemental appropriation?

Mr. HOLMES. We adjusted the dates for accomplishment in all areas—each area of the Saturn program, the Apollo program, and the Gemini program, consistent with the funds available.

Mr. WYDLER. Thank you very much.

The CHAIRMAN. Thank you very much gentlemen. It is always a pleasure to have you here with us.

(Additional questions submitted for inclusion in the record of hearings are as follows:)

APRIL 9, 1963

On April 9 Mr. Holmes testified that there was one contract with General Electric, and Dr. Seamans testified that it was for three tasks—integration, checkout, and reliability assessment. They testified that this contract would cost approximately $100 million for fiscal year 1964.

On page 848 of the stenographic transcript, Mr. Ryan asked, "And there is no other anticipated expense to NASA under this contract, with GE, over and above the approximately $100?"

Mr. HOLMES. "For fiscal 1964?"

Dr. SEAMANS. "That is correct."

On April 16 NASA announced that it was negotiating with General Electric for an extension of the contract to provide support services at the Mississippi testing facility including utilities, plant security, fire protection, medical facilities, and photographic services. The subcommittee requests an explanation as to why this information was withheld from the subcommittee on April 9.

MAY 2, 1963

At the hearing on May 2, at page 1083 of the stenographic transcript, Mr. Brackett, Director of Procurement and Supply Division, NASA, was asked to submit a statement as to the cost of the extension of the contract.

How did NASA decide without competitive bidding that General Electric was best qualified to provide plant and test support at the Mississippi testing facility?

Who made the decision?

Was the Director of the Office of Manned Space Flight consulted? If not, was anyone in the Office of Manned Space Flight consulted?

Was any recommendation made by anyone in the Office of Manned Space Flight?

Please submit any and all memorandums, letters, reports, and records relating to the extension of the General Electric contract.

Is any thought being given within NASA to any further extension of this contract with General Electric or to any new contract with General Electric?

Who is going to manage the NASA facility at Cape Canaveral?

Is General Electric being considered for this assignment?

The NASA response was.

Mr. W. H. BOONE,
Technical Consultant, Committee on Science and Astronautics,
House of Representatives, Washington, D.C.

DEAR MR. BOONE: The attached statement and enclosures relative to the contract extension to the General Electric Co. to provide plant and test support at the Mississippi test facility are furnished in response to the request for this information in your letter of May 10, 1963.

Sincerely yours,

PAUL G. DEMBLING,
Director, Office of Legislative Affairs.

Enclosures.

EXTENSION OF GENERAL ELECTRIC CONTRACT FOR PLANT AND TEST SUPPORT SERVICES AT THE MISSISSIPPI TEST FACILITY

The presentation by Dr. Seamans and Mr. Holmes at the hearing before the Subcommittee on Applications and Tracking and Data Acquisition on April 9, 1963, focused on the roles of Bellcomm, Inc., and the General Electric Co. (GE) in furnishing technical support for the manned space flight program. Their testimony referred to the request for $153 million for total integration and checkout under the program for fiscal year 1964. During the discussion period, Mr. Holmes estimated that "over two-thirds" of this total amount requested would go to GE (p. 850 of the transcript). He stressed that a rough estimate of $100–$125 million was the best estimate of GE's portion at that point in time.

NASA was considering the utilization of GE for the furnishing of plant and test support services at MTF at the time of the hearing, since it was evident that such utilization was a logical extension of GE's technical support under the program. However, the final recommendation from Dr. Seamans to Mr. Webb, requesting approval of the selection of GE for the furnishing of plant and test support services at MTF, was not made until April 15, 1963—subsequent to the date of the referenced hearing. Under the circumstances, it would have been premature to discuss the possible extension of GE's technical support role under the program at the hearing.

During the portion of their testimony which your letter references, Dr. Seamans and Mr. Holmes were estimating for the subcommittee the cost of GE's efforts in the specific area of integration, checkout, and reliability assessment. In the colloquy mentioned, both assumed that Mr. Ryan's question concerned the above area. There certainly was no intent to mislead the subcommittee.

In accordance with the provisions of the NASA procurement regulations, the Marshall Space Flight Center submitted its procurement plan for the proposed procurement of plant and test support services for MTF to the Director, Procurement and Supply Division, NASA Headquarters, for approval by the Associate Administrator, on March 20, 1963. The approval of the Associate Administrator was required under the NASA procurement regulations because the proposed procurement over the contemplated contract period was expected to exceed $5 million. The procurement plan, as submitted by Marshall, proposed negotiations with GE on a single-source basis. The Director, Procurement and Supply Division, referred the procurement plan for review and comments to all headquarters offices considered to have an appropriate interest, including the Director, Office of Manned Space Flight. After receipt of all comments and recommendations, the procurement plan was revised and forwarded to the Associate Administrator for approval. The Associate Administrator approved the procurement plan on April 15, 1963, and forwarded it on that date as an attachment to a memorandum to the Administrator on the "Selection of contractor for test and plant support at the Mississippi test facility." In the memorandum, the Associate Administrator requested the concurrence of the Administrator in the selection of GE as the contractor to furnish test and plant

support at MTF. A copy of this memorandum, showing the concurrences of the Deputy Administrator and the Administrator in the selection of GE, and a copy of the "Source Justification, Test and Plant Support Services, Mississippi Test Facility," which is a part of the approved procurement plan, are enclosed herewith.

The extension of the GE contract to cover the provision of plant and test support services at MTF during fiscal year 1964 is estimated to cost about $1.5 million. Depending upon the outcome of negotiations, the extension could run through fiscal year 1968, reaching an estimated annual cost of $20 to $25 million as the buildup of the facility continues and test operations begin.

It is not presently contemplated to award GE a further extension of its contract for the overall integration, checkout, and reliability of the Apollo space vehicle system (NASW-410). However, with respect to any other contract awards, GE will be considered on the same basis as any other company except that it will not participate in certain aspects of the NASA Apollo program. A copy of NASA Circular No. 280, which imposes restrictions on contracting with GE where competitive advantage may exist, is attached hereto.

As presently contemplated, the support services required in connection with NASA's management of the Launch Operations Center at Merritt Island will be divided into four packages. NASA plans to solicit competitive bids or proposals on each package of support services separately.

To: The Administrator.
From: Associate Administrator.
Subject: Selection of contractor for test and plant support at the Mississippi test facility.

1. There is attached a procurement plan proposing negotiation of an extension of contract NASW-410 with General Electric Co. to perform test support functions, including housekeeping, at the Mississippi test facility. As we have discussed many times over the past several months, selection of this contractor represents an important step in establishing this test facility as a major operating part of the manned program.

2. Since our original decision last February to utilize the corporate capabilities of the General Electric Co. for performing essential checkout, reliability assessment, and integration functions in support of the Apollo program, we have made excellent progress in defining the GE role and responsibility and in establishing this broad resource as an integral part of the program. You will recall that throughout our original and subsequent discussions with the General Electric Co. with respect to their assignments under NASW-410, we stressed the importance of having our major test complex at Mississippi reach an operational stage at the earliest possible date since the importance of this test complex to the success of the Apollo program is of the first order.

3. Definitization of our plans for the Mississippi test facility progressed over the past several months to the point where we could evaluate critically our original plans for possible utilization of the General Electric Co. for test and plant support. It has now become clear that extension of their responsibilities to encompass these assignments would be in the best interests of the space program and would add significantly to the effectiveness of the Mississippi test facility as an ongoing test and checkout complex.

4. The General Electric Co. is fully qualified to undertake this extension of their current role in integration and checkout. As we know from our early review of their corporate capabilities, they have had extensive experience in plant support operations at a number of important locations related to the atomic energy program. Their ability to bring to bear resources for test support as well as plant support functions enables us to move ahead at the Mississippi test facility without loss of important time. In addition, this selection will minimize disruptions during the critical formative period and insure us of quick reaction time in the event of test difficulties which might emerge as a result of thorough checkout and integration operations to be conducted there. Moreover, during the operational phase of Apollo, the General Electric Co.'s participation in MTF operations will provide a higher level of confidence in terms of minimizing the hazards attaching to integration, test, checkout, and launch procedures at the launch site.

5. As indicated in the justification statement included as part of the procurement plan, this selection will also make possible a very important reduction in contractor interfaces at the Mississippi test facility. General Electric will be heavily involved with the vehicle stage primes because of their existing integration

and checkout responsibilities and their assumption of test and plant support will result in an effective and viable contractor team for test operations. In particular, we will have a single contractor supplying a continuous and operationally experienced test support crew to each of the stage primes active at the site. Finally, such a selection will also minimize NASA's requirements for contract administration.

6. On the basis of these technical and administrative reasons, it has become my strong judgment that the selection of General Electric for test support and plant support responsibilities at the Mississippi test facility is a necessary and wise step for us to take and that it will be in the best interests of the Nation to carry out this negotiation with the General Electric Co. immediately.

7. Your concurrence in this selection is requested.

ROBERT C. SEAMANS, JR.,
Associate Administrator.

Concur:

HUGH L. DRYDEN,
Deputy Administrator.
JAMES E. WEBB,
Administrator.

SOURCE JUSTIFICATION, TEST AND PLANT SUPPORT SERVICES, MISSISSIPPI TEST FACILITY

A. General Electric Co. will be solicited on a single source basis to accomplish the test and plant support functions required to be performed at the Mississippi test facility. Letter contract NASW-410, dated February 26, 1962, with General Electric Co. provides that the contractor shall furnish all labor, materials, tools, equipment, and service (except such as the Government may elect to furnish) to assist NASA in the performance of checkout, reliability assessment, and integration support for the Apollo space vehicle system. This company was selected by the Administrator, and other NASA top management, as the company possessing the greatest ability to perform the work under the above contract. It was also decided at that time that General Electric would operate related test facilities for NASA if such were deemed appropriate, as for example, at the Mississippi test facility, provided that satisfactory arrangements could be negotiated with the General Electric Co. for assumption of these responsibilities. The basis and reasoning for this management selection are set forth in the statement of the Administrator, dated March 12, 1962. Again, on March 30, 1962, the Administrator stated: "We examined the companies which are not competitive in the booster business and selected General Electric because this firm had the capability of doing the inventive work needed to increase reliability through new instrumentation and storage of data from this instrumentation and, *if necessary, of operating selected test facilities for NASA.*" [Italic supplied.]

B. The mission of the test support contractor at the Mississippi test facility is clearly compatible with, and a logical extension of, the basic mission which General Electric is currently performing under NASW-410. The previous selection of General Electric to perform under contract NASW-410 was based, primarily, on the large technical staff available to General Electric; the many and varied skills represented by this staff; the extensive background and experience of this company and the fact that competition would serve no useful purpose. General Electric's experience gained subsequent to February 1962, and the national importance of the manned lunar landing program dictate the continued use of General Electric in this followup phase to its present contractual obligations. It is considered that General Electric is the single source best qualified to accomplish the test support function at Mississippi test facility and to assure that the work will be accomplished without undue delay or duplication of effort.

C. General Electric has had extensive experience in plant support operations at the Hanford works, Richland, Wash., and at the Knolls Atomic Power Laboratory, Schenectady, N.Y., under contracts with the Atomic Energy Commission, and at Evandale, Ohio, under contract with the Air Force. At these installations, General Electric is responsible for extensive research, development, and testing, as well as the attendant plant support functions. Two apparently unrelated functions; i.e., test support and general plant support, are nevertheless interrelated. The performance of both functions under the single contract would substantially reduce contractor interfaces, and minimize the need for Government personnel to administer and manage the separate contracts. We could expect the general plant support contractor to subcontract all services which

can be effectively performed by local industry. This course of action would avoid costly relocation of prime contractor personnel and would provide a quick response to the needs of the construction activity, which is the immediate requirement.

D. On the basis of improved administration and resulting general overall economy, it may be concluded that the selection of the General Electric Co. to perform the plant support functions, as well as the test support functions, is in the best interests of the Government.

Approved:

ROBERT C. SEAMANS, Jr.

Date: April 15, 1963.

NASA CIRCULAR No. 280

Reference: 3-3-7
Effective date: April 16, 1963

SUBJECT: RESTRICTIONS ON CONTRACTING WITH THE GENERAL ELECTRIC COMPANY WHERE COMPETITIVE ADVANTAGE MAY EXIST

1. PURPOSE

This Circular establishes NASA policy restricting participation of the General Electric Company in certain NASA procurements.

2. APPLICABILITY

This Circular is applicable to NASA Headquarters and field installations.

3. DEFINITION

For the purpose of this Circular, the following definition will apply:

Apollo Program means the development and fabrication of a multimanned Apollo spacecraft to achieve a lunar landing and return mission, together with its associated launch vehicles.

4. BACKGROUND

In February 1962, NASA entered into a letter contract (NASw-410) with the General Electric Company for the overall integration, checkout, and reliability of the Apollo Space Vehicle System. In performing the contract, the General Electric Company will have access to the kind of information regarding certain NASA plans and programs and data generated by other Apollo contractors that could give the General Electric Company a competitive advantage over other firms in some NASA procurements. Accordingly, by agreement with the General Electric Company, certain restrictions will be observed in future contracting with the General Electric Company.

5. POLICY

a. The General Electric Company shall be considered for contract awards on the same basis as any other company except that it will not participate in certain aspects of the NASA Apollo Program. Specifically, the General Electric Company shall *not* be permitted to participate in the Apollo Program as:

(1) A prime contractor or first-tier subcontractor for launch vehicles or spacecraft stages;

(2) A supplier of nonstandard major system components for the above items, in connection with which developmental work is required, when design requirement information is acquired by the General Electric Company in the performance of Contract NASw-410 prior to the release of such information to industry for competitive study or implementation procurements;

(3) A supplier of nonstandard checkout equipment other than under Contract NASw-410.

b. (1) An exception will be made to the above restrictions and the General Electric Company will be permitted to participate in any of the above procurements in any individual case where the Administrator or Deputy Administrator determines that General Electric possesses a unique capability, the utilization of which is required in the national interest.

(2) It is part of the understanding with General Electric that in other procurements, whether or not under the Apollo Program, where General Electric may

occupy a particularly advantageous position because of its work under Contract NASw–410, the Administrator or Deputy Administrator may request General Electric not to participate.

c. The policy described in subparagraphs a and b shall not affect existing contracts with the General Electric Company.

d. NASA personnel will ensure that the General Electric Company receives an equal opportunity to participate in NASA procurement except where the exclusion policy described above specifically and clearly applies.

6. PROCEDURES

a. Where it appears that application of the policy stated in paragraph 5 to a particular procurement will result in the exclusion of the General Electric Company, the following action will be taken:

(1) If the procurement is to be made by a NASA prime contractor or subcontractor, such contractor will refer the matter within 24 hours to the NASA contracting officer.

(2) If the procurement is to be made by NASA or has been referred to a NASA contracting officer in accordance with subparagraph (1):

(a) The Director of the NASA field installation will make a determination as to whether the General Electric Company is to be excluded, except that if he lacks information on which to base such a determination, he will request that the determination be made by NASA Headquarters. Any such request will be signed by the Director of the NASA field installation and submitted to the Director of Manned Space Flight, NASA Headquarters. A copy of each request will be furnished to the Director, Procurement and Supply Division, NASA Headquarters.

(b) In cases where the General Electric Company is believed to possess a unique capability to perform a procurement which may fall under the exclusion policy, the Director of the NASA field installation will refer the matter to the Director of Manned Space Flight, NASA Headquarters, requesting an exception to the policy. A copy of each such request will be furnished to the Director, Procurement and Supply Division, NASA Headquarters.

b. Where a determination by the Director of the field installation will result in the exclusion of the General Electric Company, such cases will be reported to the Director, Procurement and Supply Division, NASA Headquarters, within 24 hours. These reports will contain the following:

(1) A description of the procurement, including the extent of available competition;

(2) A citation of the pertinent provisions of this Circular; and

(3) Any additional information to justify the applicability of the restriction to the particular case.

c. Action taken in accordance with this Circular should be expedited and the General Electric Company notified promptly in order to permit the company either to submit a timely proposal or to be advised of its ineligibility prior to investing in a proposal effort.

d. Contracting officers will ensure that all of their major prime contractors under the Apollo Program have copies of this NASA Circular, as this Circular supersedes previous instructions on this subject (see paragraph 7). (Local reproduction of this Circular is authorized for this purpose only.)

7. RECISION

This Circular supersedes the following:

a. The NASA Headquarters (BR) TWX on this subject sent to the Directors of all field installations on December 17, 1962; and

b. The NASA Headquarters (BR) letter on this subject sent to the procurement officers of all field installations on March 1, 1963.

8. EFFECTIVE DATE

This Circular is effective April 16, 1963.

ALBERT F. SIEPERT,
Director of Administration.

The committee stands adjourned.
(Whereupon, at 12:05 p.m., the subcommittee adjourned.)

1964 NASA AUTHORIZATION

WEDNESDAY, APRIL 10, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON APPLICATIONS AND
TRACKING AND DATA ACQUISITION,
Washington, D.C.

The subcommittee met at 9:30 a.m. in room 304, House Office Building, Hon. William Fitts Ryan (chairman), presiding.

Mr. RYAN. The committee will come to order.

Today the subcommittee continues hearings on that part of the NASA budget request related to the NASA communications satellite program.

For fiscal year 1963, NASA has programed $43,715,000 for research and development of communications satellites. NASA is requesting $51,100,000 for the same purpose in fiscal 1964.

In order to evaluate NASA's budget request, the subcommittee should review the total national effort in communications satellites. We have already questioned NASA about the policy questions implicit in turning over to a private profit making corporation the benefits of publicly financed research and development. We intend to pursue this matter further when the president of the Communications Satellite Corp. appears before the subcommittee.

Today we will look into the communications satellite program of the Department of Defense. We are concerned lest there be duplication of effort between the Department of Defense and NASA. Are the two programs coordinated? What relationship, if any, is there between the Department of Defense and the Communications Satellite Corp.?

I hope that the Department of Defense is going to discuss in detail with us the system which is now under development under that department.

This morning we have the pleasure of having with us John H. Rubel, Assistant Secretary of Defense, the Office of Defense Research and Engineering.

Mr. Secretary, it is a pleasure to welcome you to the subcommittee today. I understand, Mr. Rubel, you have a prepared statement. Would you like to present that to us?

Mr. RUBEL. I think it might be useful if I did, although if you would rather that I didn't, I would be happy to forego that.

Mr. PELLY. It is not very long. I don't see why he shouldn't go ahead and read the statement.

STATEMENT OF JOHN H. RUBEL, ASSISTANT SECRETARY OF DEFENSE, (DEPUTY DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING)

Mr. RUBEL. Mr. Chairman, gentlemen: I am very happy to be here today to bring you up to date on activities in the defense communications satellite program. With the understanding that you wish to keep the statement and meeting from becoming too long, I shall omit the historical background information and simply suggest to the newer members of the committee that it was reviewed in considerable detail in my statement before the House Science and Astronautics Committee on August 17, 1962.

The defense communications satellite program is an R. & D. program directed at the development and demonstration of a military communications satellite system to be integrated into and to assist in meeting the communications requirements of the defense communications system (DCS). As I will explain in somewhat more detail later in my statement, we are currently endeavoring to definitize the character and scope of the program; the decision to proceed with full scale development has not been yet made. When it is—and I wish to make this important point at the very beginning—the defense communication satellite project will be undertaken to supplement other communication systems and capabilities, and to furnish military capabilities that cannot be acquired by any other means, or which can be supplied more efficiently and cheaply by means of a defense communication satellite system.

Today, about half of the long-line communication capacity of the Defense Department is leased from the commercial common carriers. The other half is supplied by special systems to fulfill unique military needs. The defense communication satellite system would augment military capabilities in this second category. The developments we contemplate would not alter in anyway the historic policy of the Defense Department with respect to the utilization of many other means for communication and leasing lines from private sources. These policies will continue to apply, of course, to communication capacities made available in the future by the worldwide satellite system to be created and operated by the Communication Satellite Corp.

This DOD policy toward satellite communications was set forth and widely promulgated in the statement of September 7, 1961, entitled "Industry-DOD Cooperation in Satellite Based Telecommunication," to which I have testified on earlier occasions before the Science and Astronautics Committee.

Toward the end of encouraging the rapid development and provision of commercial satellite communications facilities, the DOD is committed to the provision of technical support, advice and assistance to the efforts of private enterprise in the development of its system. However, this support is, and is expected to continue, in the form of furnishing information and technology as available, as a bonus product of the efforts of the DOD in its own behalf. No significant expenditures of DOD money, resources or effort are required or contemplated to provide this support.

Were the DOD called upon to provide material support (such as boosters and launch facilities) arrangements would be made to compensate the Government.

As I have noted, and as expressed in the White House policy statement of July 24, 1961, where the need for separate systems with characteristics peculiar to their application arises, projects must be supported to meet those needs, and the objectives of the defense communications satellite program are to develop that communications satellite system required to meet requirements peculiar to military applications which cannot be met by commercial means.

Any DOD operational system must be designed to provide long-haul trunks for the DCA, and must satisfy the requirements of the military for privacy, reliability, security, ECM resistance, access to or availability from remote or dispersed areas and applicability to and between mobile units. Some of these features, such as privacy for example, are not unique to satellite-based telecommunication systems. They can and do apply equally to communication by cable, radio, or other means.

Other features, such as availability of communications in remote areas, are advantages offered only by a satellite system.

In short, a satellite system for defense needs to be assessed on two somewhat independent grounds; first, how does it compete with other ways of doing the same job; and second, what needs can it, and it alone, fulfill, and at what cost? Two examples of such unique needs are these:

1. The first priority and most essential requirement of the military is for a very few highly survivable fully controlled circuits interconnecting a number of strategically important headquarters or installations, globally deployed. These circuits must have terminals under exclusive military control, locatable with flexibility, independent of commercial economic considerations and in many cases away from commercial and target areas.

2. An important military requirement is for the wide band data and information transmission capability and other characteristics necessary to provide for noncatastrophic degradation in the face of a hostile electromagnetic environment.

These examples, and these are only two examples, illustrate some basic differences between the characteristics of a commercial communications satellite system and the military communication requirements for the critical transattack and postattack periods. The commercial system will ultimately carry the very large bulk of day-to-day Government communications. However, to be economically feasible a commercial system must rely on high capacity links, between very active terminals in or near population concentrations. The commercial system will expect to operate in a legally assigned and protected frequency environment, and will carry a programed and predictable load.

The defense communications satellite program as currently defined was established by the Secretary of Defense on May 23, 1962, to include a medium altitude random orbit system and a lightweight synchronous system. I would like to clarify that.

The lightweight synchronous experiment is the Syncom I in which we are doing the ground part and the NASA is doing the airborne part. I will come to that later.

The organization for program management is as follows:

The Defense Communications Agency is responsible for overall program direction and coordination under the Director of Defense Research and Engineering.

DCA—Defense Communications Agency—is responsible for coordinating Army and Air Force activities and for the identification, evaluation, and resolution of interface problems between their two areas and for the interface between the Com-Sat system as a communication facility and the defense communications system. The Air Force is responsible for all the space portions of military communications satellite systems, including space vehicles, payloads, boosters, and upper stages.

The Air Force is responsible for the launch, for injection into orbit, for orbital control, and for diagnostic R. & D. telemetry. The Army is responsible for the development, procurement, and management of the ground communication complex. The Navy and its satellite communications ship are under Army management in the R. & D. phase of the program, but the ship is primarily dedicated at this time to the Syncom I program. It will also be adapted later on to the intermediate altitude system.

We have turned our attention to the medium altitude, random orbit system, which we believe has the best likelihood of early achievement.

The first objective of the DOD communications satellite R. & D. program is to demonstrate the feasibility of establishment and operation of such a system.

This system is intended to provide a means for conducting system research, development testing and evaluation, training and attaining of experience in the operation and utilization of a communications satellite system, and for working out in practice the concepts and designs on which the project will be started when approved for full-scale development.

Early in its establishment, even before it is operational in a conventional sense, it will have the capability to provide in large part the minimum essential intercontinental command and control circuits required for survival in emergencies. This capability is an essential element of its requirement.

In addition, the design and development criteria provide that this R. & D. system will be compatible with conventional military communications means, and it is intended that the system be capable of becoming fully operational with the least cost and delay after R. & D. feasibility is successfully demonstrated.

With a view to future economy, the ground environment to be developed for the medium altitude system will be designed to work with other satellite communications systems which may follow. Terminals to be developed will be capable of interconnection with terminals and centrals of the defense communications system. The requirements for a control center and a concept of operational control are to undergo a program definition phase study.

The contemplated system of control would utilize the many satellites and ground stations to create a stable system of links and trunks always available to a potential user, even though the satellites are continuously in motion and in a changing relationship to ground stations and to each other.

I might say that that brief phrase summarizes considerable testimony that I gave in connection with the medium altitude system before Mr. Karth's subcommittee last year.

The Army has called for bids to conduct the program definition on the elements of the initial ground system.

The DOD will conduct a program definition phase study on the medium altitude system prior to making firm decision to proceed. The system concept is based on the utilization of the demonstrated technology of Courier, Telstar and Relay. No innovations or unproven developments will be permitted, save only in the traveling wave tube amplifier, on which Army contractual effort is already being applied, and which requires only scaling of weight, power, and frequency to the correct levels.

Satellites of long life are absolutely essential to success and to an economically viable system.

Reliability will be assured by rigid attention to the principles of simplicity of design, use of pretested quality components, minimization of the number of piece parts, derating, and correction, or even elimination where possible, of those items which have been conspicuously troublesome and short lived in the past, such as switches and batteries. Where performance must be sacrificed—perhaps a better word that "performance" would be "capacity" in the case of a communications satellite system—must be sacrificed to secure the needed reliability, it will be; the essential need is a functional, economical system, not a spectular but short-lived demonstration.

A satellite designed to meet such ground rules might weigh between 80 and 120 pounds, have 2½ watts output, and a nearly omnidirectional antenna. Its lack of switches would give it immunity to hostile capture of control. It would be solar-cell powered, uncontrolled, or spin-stabilized—gravity-gradient stabilization might be used if proven out in time—and would be called upon initially to produce only a very modest capability—two duplex voice and teletype circuits. Growth in capacity without a concurrent degradation in reliability, would come as advancing technology made it possible.

I want to make another point here. The capacity cited is that between any pair of stations operating at any one time, but because you will have a multiplicity of ground stations or could have worldwide, you can have a lot more than two duplex telephone communications going simultaneously.

We have made various estimates how many you can have, and it is a little difficult to come up with an exact number, but it is on the order of a dozen within the total system. I want to make the point that this entire system worldwide is not as limited as this statement might have made it seem.

Mr. RYAN. There will only be two terminals?

Mr. RUBEL. At a time. There are a lot more than two terminals. Statistically you could expect to have something in the order of a dozen or more two-way telephone conversations that could be going on simultaneously between a variety of links throughout the system.

It is awfully hard to put fixed numbers on this, and it is a little difficult to put specific numbers on just exactly what the capacity is. That depends so much on the particular link you are talking about and the manner you are operating the system.

I just want to make the point that two is just the link capacity, but what the system capacity is probably varies from a low of 2 to 3 times that amount to a maximum of something on the order of a dozen at one time.

Mr. RYAN. In other words, if between two terminals that are intermediate terminals, they would be eliminated in talking to the terminals at the extremities?

Mr. RUBEL. Right. It is awfully hard to put a single number on the exact capacity. You can put a maximum and minimum on it and that is what I should have indicated here.

Mr. BOONE. This is a change from the testimony of last year or at least in the connotation of the testimony of last year; is that correct?

Mr. RUBEL. I think last year we didn't make it clear.

Mr. BOONE. I am glad you made this clear. This certainly bothered the committee, that you were only going out for two channels.

Mr. RUBEL. When we were sitting with you and some of the other folks we went into a lot more detail. When I testified on this last year, we were really just getting started and we didn't have all our thoughts well focused.

Now we are further along and I think we understand much better where we stand and I think this explanation is important in the context of this particular prepared statement.

Mr. BOONE. Last year the understanding of the committee was that there would only be two channels of communications. If this be true, it isn't worth so many millions of dollars that it takes to put this thing in orbit.

The committee was concerned that you were going to put up a satellite with the capability of only two channels when the Defense Department has the requirement for hundreds of channels ultimately.

I hope this will dispel some of the fears that some of the members may have had as to this limited view.

Mr. WYDLER. Mr. Rubel, what is the value of this system?

Mr. RUBEL. The value of it militarily?

The value militarily, assuming we do proceed with the development of the system will be—there are probably three or four headings under which I could describe it.

Mr. WYDLER. Describe it in the most important one.

Mr. RUBEL. I would say it gives you a unique, truly global, instantaneous capability to every area of the world, remote or not remote, so that we can have military communications to distant places which are militarily important but which are commercially not important at all.

Mr. WYDLER. We have that now, don't we?

Mr. RUBEL. We don't have it to the degree of reliability and immediacy that you could expect to get it here. There are many parts of the world that do not have cablegrams, they don't have any microwave links, so you are depending on high-frequency-radio communications, which are subject to outages.

Mr. WYDLER. I mean this is just a radio communications system, too?

Mr. RUBEL. No, it isn't just radio communications satellite. It is a microwave relay link.

Mr. WYDLER. I realize there is a difference in the location. It is still going to be a radio wave that is going to come down from the skies to a remote point?

Mr. RUBEL. It is a big difference. It is the difference between trying to send a radio message from the east coast to the west coast by high-frequency radio and looking at your television transmitted by microwave relays.

Mr. WYDLER. Are you saying that there are military places right now that you cannot reach by radio?

Mr. RUBEL. I am saying there are a lot of places that you cannot reach with the degree of reliability, the degree of certainty, the degree of redundancy that you could have with this system.

Mr. WYDLER. Where would such a place be?

Mr. RUBEL. Africa, southeast Asia.

Mr. WYDLER. There are military bases where we do not have a sure method of reaching by radio today?

Mr. RUBEL. It depends on what you mean by "sure."

Mr. WYDLER. I don't know what you mean.

Mr. RUBEL. That if you pick up a telephone in southeast Asia or Africa, you would be connected very quickly, just as quickly as if you pick up the phone at the command post and talk to Omaha, which you could do with this system.

Mr. WYDLER. That has a very important military value?

Mr. RUBEL. It has a very important commercial value.

Mr. WYDLER. I can understand that. Just military now.

Mr. RUBEL. Oh, sure. I think that is obvious.

Mr. PELLY. Is it subject to hostile interference similar to Radio Free Europe or something like that?

Mr. RUBEL. Not to anything like the extent that ordinary high-frequency-type communications are, although there is no such thing as a system that can't be jammed or subject to some hostile action.

This system can be designed so that you build in redundancies, extra capacities, and so forth that make it very, very difficult for an enemy to interfere with the system.

Mr. PELLY. Could they put up an interference satellite close to it that would——

Mr. RUBEL. Not in this system. That I don't think is feasible.

Mr. DAVIS. Mr. Rubel, I would like to ask you this:

The present radio communications facilities that the military have, are they subject to interference from such things as solar flares?

Mr. RUBEL. Yes. The high frequency parts are, yes.

Mr. DAVIS. It would knock them out temporarily, that is, a bad solar storm.

Mr. RUBEL. Yes, we have had that happen.

Mr. DAVIS. If you were using a communications satellite of this type, would that be immune to solar storms?

Mr. RUBEL. Yes.

Mr. DAVIS. The present military system—is that subject to being blacked out by severe thunderstorms or hurricanes or cyclones?

Mr. RUBEL. I think that would probably relate to the destruction of the ground facilities themselves.

Mr. DAVIS. So far as the radiostatic, that would not knock it out?

Mr. RUBEL. I don't think so, although there is a lot of background noise that you get from things like that that you wouldn't get here either because this is a microwave system. That is the essential distinction to make. This is a microwave system. It gives you a line-of-sight beam for communication as distinct from a broadcast

radio wave that emanates over a much wider area; and much bigger volume.

Mr. DAVIS. Well, your ordinary radio broadcast depends essentially upon a bounce from the ionosphere, doesn't it?

Mr. RUBEL. Yes.

Mr. DAVIS. You wouldn't have to rely on that at all?

Mr. RUBEL. That is exactly the point.

Mr. DAVIS. The solar flares disturbs the ionosphere; is that correct?

Mr. RUBEL. That is right.

Mr. DAVIS. And that is what knocks out your reliability?

Mr. RUBEL. Yes.

Maybe it would be best if I proceed with the rest of the statement.

Mr. RYAN. Suppose you proceed. Then we can question you on the points that come to our minds.

Mr. RUBEL. The necessary subsystem R. & D. has already been accomplished for a satellite of this description, and the remaining engineering development required to meet military specifications is a relatively short-term job.

I am describing the concept that we have at the present time. If we proceed with the development of this system, these are the kinds of characteristics that we presently envision it would have.

Approximately six satellites will be launched per booster, using the proven and increasingly reliable Atlas-Agena D. The six satellites will be ejected at slightly different velocities into an approximately 6,000 mile altitude circular polar orbit, where they will gradually spread out. The successive clusters will be injected into orbital planes spaced 45° apart.

The provision of a system of 24 to 30 pseudorandomly distributed satellites will provide worldwide service at better than 95 percent visibility for approximately 15 to 20 intercontinental links if stations are well distributed about the Earth. This system, if approved for development, promises to be the first communications satellite system in existence. It will provide an early global command/control and emergency communication system. It will furnish initial system information and comprise a useful and needed vehicle for development and testing of operational principles.

NASA is supporting the development of the Syncom I satellite, a spin-stabilized type—spinning is a relatively simple way to achieve a single-axis stabilization, and its lack of mechanical complexity—once orbital position and orientation are achieved—both promises an earlier way to achieve some of the advantages of the fully stabilized satellite such as a medium antenna gain, and offers more immediate promise of long satellite life than a fully stabilized design. The DOD is cooperating with NASA in its Syncom program by making available its communications satellite surface facilities, communications experience, and know-how.

In what is probably a model of joint space program cooperation, NASA, as well as providing overall program direction and management is responsible for the space system, its development, fabrication, launch, injection into orbit, orbital control, and telemetry and command. The Department of Defense is responsible for the communication tests and the communications environment.

The 60-foot diameter Advent fixed stations at Fort Dix and Camp Roberts have been adapted to the Syncom-type of modulation, and

the Army is developing and purchasing three transportable stations with 30-foot antennas to provide additional capability.

The USNS *Kingsport*, developed for the Advent program, has had the necessary modifications and additions made to be NASA's primary tracking, communications test, telemetry and command facility for the very critical orbital injection, adjustment, and control phase.

Communications test operations are conducted from the U.S. Army Satcom Agency's control center at Fort Monmouth, N.J., by a joint Army-Navy-Air Force group of Comsat specialists including those who have been experienced in the original Diana (Moon bounce), Score and Courier communications satellite programs. These will be in constant close contact with and reporting to NASA's program control center at Goddard SFC.

I might add, as you know, we have had one launch of the Syncom. It was not a fully successful launch, unfortunately, but all these operations I have described were successful and all these cooperative activities were undertaken.

The other space communications activities in the DOD at present are:

Moon relay: This is not currently an R. & D. matter but the first operational space communications system. The Navy is currently conducting regular schedules of communications between Anacostia, Maryland, and Hawaii. The Army and Air Force are conducting Moon bounce experiments at microwave frequencies using existing facilities.

Westford: The "orbital dipole" which was originally called "Needles," but now is called Westford program is being run at a very low level of effort at Lincoln Laboratories by the Air Force. It is intended to try twice during this year to inject and disperse a pick-a-backed container of sublimable tin dipoles. These will permit a feasibility test and demonstration. They will dissipate in a few years, so that even with major advances in the sensitivity of radio telescopes, no interference would stem from these experimental belts.

Mr. Chairman, that concludes my prepared statement.

Mr. RYAN. The subcommittee is delighted to note the presence this morning of Dr. Charles Shelton, a former member of the staff of the Science and Astronautics Committee.

We appreciate your statement, Mr. Secretary. As I said in my opening statement, we are concerned, among other things, with the question of whether or not there is a duplication of effort between NASA and DOD. In past hearings before this committee, the Department of Defense rather vigorously, particularly in 1961, advocated an Advent system; that is, a synchronous communications satellite system which the Department of Defense witnesses said would be the solution to the needs faced by the military.

It is my understanding that this proposal has been abandoned and now with the Department of Defense proceeding on a medium altitude system, I do want to ask this question:

The Department of Defense, with great assurance and confidence, told us that Advent would be a success, that it would have many hundreds of channels which would be so designed that they could carry not only military traffic, but commercial traffic, and that it was reasonable to expect this development—this was in 1961—within a short period of time.

Now, is there more reason to believe today that you will be successful in developing this satellite? What do you call it? Have you given it a code name?

Mr. RUBEL. Generally I think we speak of it as the medium altitude defense communications satellite system.

Mr. RYAN. Is this a communication system based on other systems?

Mr. RUBEL. We have drawn heavily on the technology that has evolved over the last few years, but not explicitly so. The design of this particular satellite will be unique. It won't resemble these others in all of its features by any means.

Mr. RYAN. At what point are you in the process of designing this new system? At many points in this statement you say if you make this decision.

Mr. RUBEL. Where we stand now is this. Mr. Chairman: We have gone out to industry with requests for proposals. These proposals are in the process now of being evaluated. The Air Force is evaluating proposals for the satellites, the Army is evaluating proposals for the ground equipment.

Based upon these evaluations, the Services are going to select some contractors for what we call the program definition phase. We are going to fund a program definition effort which will last for a few weeks' time, somewhere on the order of 2 months probably. At the end of that period of time, we expect to have pinned down with as much precision as we possibly can the exact characteristics of what this system would involve from a development and equipment point of view.

The decision as to whether or not to proceed with the full-scale development is going to be made after those program definition efforts have been accomplished.

Mr. RYAN. Will these program definition efforts involve any hardware?

Mr. RUBEL. The answer to that is essentially "No". Now there are some hardware efforts that we are conducting at the present time because we have identified certain long leadtime items. I mentioned the traveling wave tube amplifier which we know eventually, if you are going to transmit on these frequencies, you will want to have. It is not something you have on the shelf that you are going to use. We are supporting that kind of thing.

Mr. RYAN. Do you have a contract for that?

Mr. RUBEL. Yes, sir, there is a contract. I think it is with the Watkins Johnson Co. for developing the output tube. These technology developments, battery developments, really are not related per se to the program definition effort. That is essentially a study effort and a design effort. What we really do during the program definition phase on this project, as well as on others, is primarily to accomplish the preliminary design on which all your subsequent efforts are going to have to be based. If you can accomplish that preliminary design in enough detail and specify with enough precision what the parts are, what the configuration is of your satellites and your ground equipment, then we think we can proceed with confidence in making a decision to go ahead or not to go ahead as the case may be.

Mr. RYAN. Are these proposed study contracts funded under your fiscal 1963 budget?

Mr. RUBEL. Yes, sir.

Mr. RYAN. For what, the Army, the Air Force, the Department of Defense, the Navy?

Mr. RUBEL. Both the Army and the Air Force.

Mr. RYAN. Are these design studies going to be let by competitive bidding?

Mr. RUBEL. Yes, sir.

Mr. RYAN. Has not NASA gone into this in considerable detail over a period of years?

Mr. RUBEL. No, not the system that we are talking about here.

Mr. BOONE. Mr. Rubel, maybe you could tell us the essential difference between the system you plan and the NASA experimental system, very briefly.

Mr. RUBEL. Yes, the NASA system with which I am familiar is the Syncom I, which is a synchronous altitude satellite with which I am sure the committee is familiar.

Mr. RYAN. That is comparable, isn't it, to Advent?

Mr. RUBEL. It really isn't comparable to Advent, but it resembles Advent to the extent that it is in a synchronous orbit. That is about where the resemblance ends, right there.

Mr. RYAN. How much money did the Defense Department put into Advent?

Mr. RUBEL. We estimated we expended about $170 million on the Advent project.

Mr. RYAN. Do you consider all of that money wasted?

Mr. RUBEL. No, we don't consider it all wasted. I testified to this last year at considerable length. We have somewhere on the order of $50 to $60 million worth of ground facilities, for example, which were developed under the Advent plan and are in use today on Syncom, and will be in use on this program if this program goes forward. That represents a substantive investment that you can identify.

In addition to that, I think many other useful results were obtained from the Advent project in the development of components, the evolution of reliability techniques, things of that character.

So by no means was all this $170 million wasted.

Mr. HECHLER. I would be interested in Secretary Rubel's answer to Mr. Boone's question.

Mr. BOONE. Mr. Chairman, may I elaborate on that? Certain members of the committee have expressed considerable concern as to why you don't buy Relay or Telstar and put that in orbit. I think if you would address your remarks to that, it would be helpful.

Mr. RUBEL. I think the easiest answer to that is that if one analyzes the requirements for an operational system, what it takes in terms of the reliability of boosters, what it takes in the reliability of the satellites themselves, you distinguish a very great difference between the requirements for a successful experiment of the Telstar type, for example, and the requirements for a successful medium altitude system on the other hand. Take Telstar as an example. In order for a Telstar system to be successful, you would have to have a very substantial number of Telstar satellites in a comparatively high orbit, high by comparison to the actual Telstar orbit that was used for the experiment.

You have to have, I would imagine, based on what I have read about Telstar, somewhere in the neighborhood of between 25 and 40 satellites at an orbital altitude of between 5,000 and 10,000 miles. The exact altitude and the exact number of satellites are dependent

variables and what you choose by way of a system configuration has something of a designer's choice about it.

In any event, you would have to have a substantial number of these satellites in an orbit that we have been calling a medium altitude orbit.

The actual Telstar was launched in an orbit that had a minimum altitude of several hundred miles and a maximum altitude of several thousand miles. It couldn't be put into a medium altitude orbit using a booster that was used to put it in an experimental orbit. It would take an Atlas-Agena, and now you are talking about a much more expensive launch vehicle.

Point No. 2, the Telstar was a very dramatic experiment, a very successful experiment, but it was an experiment. It stopped functioning after several weeks had passed. If you visualize a system of Telestar satellites in a medium altitude orbit, where every time one fails it has to be replaced, you come to the conclusion that Telstar is too heavy and too expensive for use in an economically viable system.

That is the fundamental distinction to be made between a single successful experiment, on the one hand, and the requirements for a successful system on the other hand.

As I emphasized in my prepared statement, we are putting emphasis on simplicity of design, on reliability of design, because without that simplicity you can't get that reliability, and without that reliability you can't get the conditions that are necessary for a successful operational system. The economics are against you. We have made many calculations as to what the tradeoffs are among reliability of boosters, reliability of satellites themselves and the economics of creating and maintaining that system. We are convinced, therefore, as I said in my testimony, that the simple system that we have described here is the system which has a chance of being the earliest successful operational system.

Anything more complicated than that, anything with more capacity than that, anything which will require more capacity, will not be economically viable.

Mr. RYAN. What is the altitude proposed for this system?

Mr. RUBEL. I mentioned 5,000 miles.

Mr. RYAN. That is more than the Telstar?

Mr. RUBEL. No, when we first talked about Telstar, I think the Bell System was talking about 7,000 miles. There is nothing fixed but somewhere in the order of 5,000 to 10,000 miles.

There are trade-offs between a lower altitude with more satellites, a higher altitude with fewer satellites. All we are saying is, it is a medium altitude system somewhere in the order of 5,000 miles. There could be more, depending on the designs, and the evaluation of those designs.

Mr. RYAN. How do you know that the satellite has a chance to live longer than the Telstar satellite, that you won't have to continuously shoot up satellites every month?

Mr. RUBEL. I think the way we will approach that will have to be based upon calculations that begin with an assessment of the number of components and their character in the satellite itself. If you had a satellite of the sort that we are envisioning here with a very small number of parts, parts which for the most part are solid-state devices—transistors, semiconductors, things of this sort, that can be made to

have a very high degree of reliability—you can make calculations of the reliability that you will get from the operation of the aggregate of those parts. If you have here a simple satellite with a small number of parts, and you have here a much more complex satellite, but with more capability and with a larger number of parts, you can make calculations in order to estimate what the probable lives of each will be. Probable lifetime decreases markedly with increased complexity.

We have considerable data now on the reliability of devices of that sort and reliability of particular parts. Those calculations are pretty good. They are not perfect, but they are pretty good. So our estimate of whether or not it makes sense to go forward with the development of a satellite system of the sort I have described in my testimony here will be based upon that kind of calculation.

If we can't estimate with confidence based upon the other experiments that were conducted both in space and in the laboratory that these satellites will have the necessary reliability, then we won't go ahead.

Mr. RYAN. Who is going to make the decision of whether or not to go ahead?

Mr. RUBEL. Mr. McNamara.

Mr. RYAN. Is this going to be a Defense Department decision or is it going to be made in consultation with NASA or any other agency?

Mr. RUBEL. It will be strictly a Defense Department decision, but it will be made in consultation with other agencies, especially NASA.

Mr. RYAN. What funds are you budgeting in 1963? How much have you budgeted in fiscal year 1963 for communication satellites?

Mr. RUBEL. The total is $95 million in fiscal 1963.

Mr. RYAN. And 1964?

Mr. RUBEL. Our budget requests are before Congress at the present time, and we don't have any firm number.

Mr. RYAN. You must have submitted to Congress a dollar amount.

Mr. RUBEL. We submitted a number to the Congress.

Mr. RYAN. What is that?

Mr. RUBEL. I wonder if I could go off the record for a moment?

Mr. RYAN. This is a public hearing.

Mr. RUBEL. The problem is that our Defense Department submittals to the Congress on the budget are classified. I don't know if I can testify to this.

Mr. RYAN. Our committee is very interested in this. Suppose we get an answer to that question before we adjourn this morning.

Mr. BOONE. Suppose you submit it in writing.

Mr. RUBEL. I would be delighted to submit it in writing.

Mr. RYAN. My suggestion is that before we adjourn at 11 o'clock this morning one of your staff men check with the Department of Defense on whether or not you may state this.

Mr. RUBEL. I will be happy to do that either in an open hearing or a closed hearing.

Mr. WYDLER. I would like to say something about what Mr. Rubel said about the Telstar question. You stated one of the problems of trying to use Telstars would be you would have to put up a lot of Telstar satellites to provide the system that would be needed. Do you figure you would need more than 24 or 30 Telstars to do it?

Mr. RUBEL. For the same altitude the same calculations would apply, however Telestar has a short (10 percent) duty cycle. Therefore this number could not provide continuous coverage.

Mr. WYDLER. You are suggesting that under the present system you are programing to put 24 to 30 of these new satellites up, isn't that correct?

Mr. RUBEL. That is correct. The only difference that I can think of, and I am not sure whether it is a difference, is the difference between the completeness of coverage that you would need for commercial purposes as distinct from military purposes.

There is a possibility I believe, and I say this very tentatively because I am not sure, that the military can stand to have a somewhat lower level of that kind of reliability (by which I mean you can say to the fellow at the other end of the line: "We are going to have an outage for 3 minutes and I will be back to you 3 minutes from now") whereas for commercial service you can't afford to provide the public with that kind of service.

In order to get this complete reliability of coverage timewise (I am not talking about the reliability of the satellites any more; I am talking about the reliability with which you as the person who picks up the telephone, can count on getting a connection and keeping that connection;) I think that may have to be somewhat higher for commercial purposes than for military purposes, and for that reason you might decide that the commercial system required somewhat more satellites in orbit than a military system.

We might have a more austere system as a result, but I am not sure about that.

Mr. WYDLER. You want it at least as reliable as the commercial system, don't you?

Mr. RUBEL. That is my whole point. I am not sure.

Mr. WYDLER. I would like to clear up one other thing on this. You state that this will be the first communications satellite system in existence. When will it come into existence operationally?

Mr. RUBEL. We believe if we were to approve the program subsequent to the program definition phase and adhere to the schedules that we presently contemplate, that an initial operational capability, using the research and development devices themselves, would be attainable somewhere around the early part of 1965, calendar year 1965.

Mr. WYDLER. You mean 2 years from today?

Mr. RUBEL. Yes.

Mr. WYDLER. You would have an operational system?

Mr. RUBEL. It would be operational in this sense. It is what we call IOC or initial operational capability.

If you succeeded in putting up 24 satellites as part of a research and development program leading to an operational capability, and they all worked, then there is no reason why you couldn't use it initially for operational purposes, even though it hasn't been turned over to the operational people, even though you are still doing some experiments with it, and even though you are still learning some things from it that may cause you to make some changes later on in the configuration of devices used in the initial system.

So I mean those operational features, those operational capacities that can be gained from the deployment of the R. & D. system.

A good example is TIROS. We are getting a lot of very useful information out of the TIROS satellites all the time.

It is not an operational system. It is still a research system. Yet we are putting these research-type satellites up and getting very good operational data.

Mr. RYAN. At what point would you be ready to transfer the burden of defense communications to a system so that you were dependent upon it?

Mr. RUBEL. I think if you accept the assumption that you just made; that is, we adhere to these schedules, we will get this initial operational capability somewhere around the calendar year 1965.

Mr. RYAN. In other words, you would be ready to swing away from radios and cables?

Mr. RUBEL. No, sir. You are not going to substitute a satellite communications system for some other kind of system just because the satellite communications system is new.

Mr. RYAN. It might be cheaper.

Mr. RUBEL. I made that point too. You are going to substitute only in those cases where it is a more economical way of doing the same job or in those cases where you can do a job that can't be done in any other way. That is where we get into the remote area consideration.

There is no presumption in advance that we are going to put this system up and then start closing down on our other communication capabilities. If, over a period of time in future years it turns out that the economic viability of satellite-based communication system becomes such as to make it a cheaper way, an easier way, a better way of doing the communications job than, say, using more radio communications, using more cables, then we will do it, obviously. But the presumption here is, as a starter, that we are mostly interested in supplementing and not replacing.

Mr. WYDLER. In other words, this is going to be by early 1965, if everything works out, a backup; is that what it amounts to?

Mr. RUBEL. Yes, sir; it is a backup.

Mr. WYDLER. If everything goes the best we can hope, it will be a backup system by 1965?

Mr. RUBEL. Yes, but I want to add to your statement. The answer is "yes", with a caveat. The caveat is: it will do more than just back up because you will get capabilities in areas and of a character which you don't get right now.

Mr. HECHLER. It may be sort of like an overdrive.

Mr. BOONE. I believe in the previous testimony the sense of the testimony has been that this would supplement your existing facilities to give you what you called a minimum essential communications system.

Now, I think the question of Mr. Ryan is, when will you have this completely operational minimum essential capability? You will have some capability obviously in 1965 if you meet your schedule as you have announced, but would you have then the complete minimum essential communications system?

Mr. RUBEL. I think you would have insofar as satellites are concerned, Mr. Boone, but not insofar as ground stations are concerned.

The next thing you would do would be to expand the framework of your ground station deployments when you went operational.

That would be the next stage or step. So that probably the main distinction between the IOC, the initial operational capability of this minimum altitude system with a comparatively small number of stations deployed worldwide, and the transition into an operational system deployed worldwide, would be that you would have a lot more ground stations worldwide once you had gotten to the point where it warranted the deployment of operational ground stations.

Mr. RYAN. You are not defining then a "minimum essential system" as approximately 24 satellites with 10 ground stations? I think that is the sense of your previous testimony, and I believe that is——

Mr. RUBEL. I believe you have got a point there, but I don't think we should get hung up on it. I think the point is, once you have got the satellite capability and some number of ground stations, further expansions from an operational point of view are obviously easily obtained by adding some ground stations up to some level.

Just exactly what that level is, I don't know, because that depends, too, on what you find out. We are talking about something we have never done and which even our best calculations are going to show to be somewhat different than what we presently envision.

That is the nature of these very advanced and rapidly advancing technologies. So what we now call the minimum essential system we may find out is not the minimum essential system after we have gone through this work. If we knew the answers to all these things——

Mr. RYAN. What do you anticipate this is going to cost DOD by the time we reach an operational capacity?

Mr. RUBEL. Well, that is another item that is going to stem from this program definition phase. Before we embark on the R. & D. program full scale, we are going to have that estimate firmly in hand. We don't have it firmly in hand now.

Mr. RYAN. Can you make a rough calculation?

Mr. RUBEL. We are thinkng of another $200 to $250 million. I might emphasize the point here——

Mr. RYAN. That is in addition to the $95 million in 1963? And in addition to 1964?

Mr. RUBEL. No, it includes a substantial amount of that $95 million of 1963 funds.

Mr. RYAN. And it includes 1964?

Mr. RUBEL. Yes, sir, and 1965. An awful lot of the expense in all of these space undertakings is the amount of money it costs you to boost things, to put them in orbit in the first place. It really isn't R. & D. It is buying the boosters.

Mr. RYAN. Where are you going to buy the boosters?

Mr. RUBEL. We have the Atlas-Agena coming along and coming off of production lines, and we will buy them off those production lines.

Mr. HECHLER. How far away are you from multiple launching of six satellites?

Mr. RUBEL. That is one of the items that is subject to development. That is one of the features that is essential to the economic viability of this kind of system, absolutely essential to the economic viability of this kind of system, which has not been developed and has not been demonstrated and is part of the development program.

Mr. HECHLER. Of course, it is difficult to make guesses on these things, but it appears to be fairly casual the way you have mentioned

this; we are going to send up six satellites per booster, and this is part of your whole plan.

I wonder if you had any feeling as to whether or not this is really coming along fast enough so you will have time to tie it in with the rest of your proposed future schedule?

Mr. RUBEL. Our answer to that is, if we don't, we won't do it. We are not going to embark on developing major elements for a system where other major elements are not in the proper time phase. That is one of the principal objectives of this program definition phase, to assure ourselves that we have looked forward to every one of those kinds of technical questions, laid out a program for their accomplishment, funded them in a realistic manner, gained a thorough understanding between the Defense Department on the one hand and the contractors who are given the job on the other, so we can proceed with much greater confidence.

Mr. RYAN. After you have achieved an operational capability and have this medium-altitude system in operation using it for communications and have achieved the first operational communication satellite system, do you anticipate that this private corporation which is designed to pay dividends to stockholders will want to take advantage of your technology and your research and development?

Mr. RUBEL. Mr. Chairman, all I can say in response to that question is based upon the reading that I have done of the record of testimony by the incorporators of the Communications Satellite Corp. before various congressional committees.

Mr. RYAN. You mean to say you have had no conversation with any incorporator or officer of the Communications Satellite Corp.?

Mr. RUBEL. We have had informal discussions with Dr. Charyk.

Mr. RYAN. In his capacity as president of the Communications Satellite Corp?

Mr. RUBEL. Since he resigned from the Defense Department and since he was announced as the president of the Communications Satellite Corp., yes, sir.

Mr. RYAN. Do you expect to establish any kind of exchange of information between this corporation and the Department of Defense?

Mr. RUBEL. That, I think, depends on the manner in which the Satellite Communications Corp. organizes itself, the kind of research and development undertakings which they undertake on their own, and the kind of relationships that are established between that corporation and other Government agencies.

There is nothing in the statute establishing the Communications Satellite Corp. which calls for direct liaison between that corporation and the Defense Department.

Mr. RYAN. By the same token, theoretically the purpose of that corporation is to develop a communications satellite system which is operational, and based upon your testimony this morning the most immediate and feasible system is the medium-altitude system which you are going to develop; is that right?

Mr. RUBEL. Yes, sir.

Mr. RYAN. And the most economical?

Mr. RUBEL. Yes, sir. But the distinction here now must be made between requirements the Communications Satellite Corp. will perceive for a commercial system on the one hand and the characteristics of the defense communications satellite system on the other.

The extent to which they will match is an item about which we simply can do no more than conjecture at this time because they are not organized to address that problem in its entirety at this point in time.

Mr. RYAN. Have you given any thought to establishing a formula by which the Department of Defense would be reimbursed for any information or research and development advantages or benefits which it would transfer to the Communications Satellite Corp.?

Mr. RUBEL. I would say the answer to that best can be divided into two categories. There are the developments which are undertaken by the Defense Department in a variety of fields which over a period of time become part of the public domain. Examples are the capabilities of the Defense Department involved in the field of boosters.

I mentioned earlier the Atlas-Agena, which is undoubtedly going to be of considerable interest to anybody who is concerned with communication satellite experiments. It might even turn out to be of interest to any concern, such as the Communications Satellite Corp., responsible for the deployment of a commercial communications satellite system. The reimbursement would be——

Mr. RYAN. Are you saying you would give to this Communications Satellite Corp. something that you wouldn't make available free to all of industry?

Mr. RUBEL. We would obviously not give boosters to anybody but under proper circumstances we could arrange to sell them. In fact an arrangement was made to sell the booster for the Telstar to the A.T. & T. Corp. for launching that experiment. That was a booster developed for and by the Defense Department. This is the kind of arrangement that I think would carry over to this domain.

Mr. WYDLER. Mr. Chairman?

Mr. RYAN. Yes.

Mr. WYDLER. I read an editorial, Mr. Rubel, in the New York Times last Sunday which stated in regard to the space program, particularly what we are talking about today, the following: It says that the Air Force, in a memorandum, has suggested that some $7,671,000 of projected NASA construction costs represent unnecessary duplication of existing facilities. Is that true?

Mr. RUBEL. Mr. Wydler, I don't know if that is true or not.

Mr. WYDLER. You have never seen such a memorandum?

Mr. RUBEL. No, sir. Yesterday after the hearing, or Monday after a hearing that we had before another subcommittee of the Space Committee, I was asked that same question by one of the representatives of the New York Times, and there were several people with me who had been in the hearing, and none of us knew about the existence of that memorandum.

I just don't know what they are talking about, frankly. I haven't been able to find out.

Mr. WYDLER. But you have never heard anything such as a discussion of duplication of existing facilities? This has never come to your attention in any form, whether it is in a memorandum or not?

Mr. RUBEL. I wouldn't want to say "No" to that question. Perhaps it would be best and most responsive to your question if I described how we try to approach that problem, if you would care to have me do that.

Mr. WYDLER. Yes; as long as it is directed to the fact whether there is or there is not duplication.

Mr. RUBEL. We have between NASA and the Defense Department a coordinating mechanism known as the Aeronautics and Astronautics Coordinating Board. We have testified on this before this group many times before, as I am sure you know. Every year the AACB, as we call it, has appointed a representative from the Defense Department and a representative from the NASA to get together and review all facility requests of the Defense Department and all the facility requests of the NASA with this express objective in mind: To see if there are any areas of duplication and to work those out before the NASA or the Defense Department comes before the Congress for authorization and appropriation hearings.

That procedure has been underway now for the last several years. Our representative this year, and also last, was General Cooper, who is the head of one of our offices in the Department of Defense, and the NASA representative was Mr. William A. Fleming, Director of Technical Programs at NASA.

These gentlemen have put together a comprehensive review of every facility request that was envisioned by NASA and every facility request that was envisioned by the Department Defense. I am not aware of the $77 million duplication that is alleged.

Mr. WYDLER. I am sure this wasn't an outgrowth of that particular committee. That committee has supposedly, after it has operated, determined there is no duplication, but does the term $77,671,000 mean anything to you?

Mr. RUBEL. Absolutely nothing.

Mr. WYDLER. They gave as an example the projected construction by NASA to build at Moffett Field, Calif., a live sciences research facility at a cost of about $5 million, though they give the exact figure, and say the Air Force has long maintained a superb laboratory of the same type. What do you have to say about that?

Mr. RYAN. Might I suggest that that is in the purview of another subcommittee?

Mr. WYDLER. I realize that, but I think it might help me to understand this prior question I asked. I am trying to ascertain where the Times got that information. Has that matter come to your attention at all?

Mr. RUBEL. No, sir; it hasn't.

Mr. WYDLER. In connection with the satellite that the military is projecting to put into orbit around the Earth, are they developing solar cells to put up the Sun for use as energy in these?

Mr. RUBEL. Yes.

Mr. WYDLER. You know, of course, that NASA is doing exactly the same thing?

Mr. RUBEL. Right.

Mr. WYDLER. Why can't one or the other of you do that? Why do you have to have two separate R. & D. projects like that?

Mr. RUBEL. I think you will find in fields like that—solar cells is an example, batteries, telemetry, stabilization devices are others—all of these technologies that are common to a variety of space applications are very well coordinated between NASA and the Defense Department.

The people who are working in this field, who are primarily in industry, of course, and not in the Government anyway, have access to all of these technologies. So there is not——

Mr. WYDLER. What I want to ask you is, why we have to have two contracts to develop that?

Mr. RUBEL. Maybe my answer to your question suggested that we do, and I shouldn't have answered it that way because I am not sure that we actually do.

Frankly, I don't know what the status of contractual coverage is for the development of solar cells by the Defense Department or the NASA at the present time.

What I do know is that everybody in the United States who is looking for a solar-cell application for a space mission is aware of all the developments that are underway.

Here is another example of a rapidly advancing technology where we are learning something every day.

Mr. WYDLER. I don't think you understand my point. I don't object to doing research and development on solar cells, but if NASA lets contracts to two different people to do the same thing, I would object to it. Just because NASA would let one contract to do it and the Department of Defense lets one—I still object to it. I think it is the same thing, the purpose is exactly the same. So the question is, are you letting contracts to develop solar cells, and, if so, I think a fair question is, should NASA do it or should the Department of Defense do it, because I don't think both of you should do it.

Mr. RUBEL. I agree with you a hundred percent.

Mr. WYDLER. Could you supply for the committee the information of the fact whether you are letting contracts for solar cells?

Mr. RUBEL. We will give you the information as to whether we are letting contracts for solar cells and what agencies are furnishing these and some indication of how these developments are coordinated among the agencies.

Mr. RYAN. Since the House will reconvene in 15 minutes, may I come back for a moment to this question of the relationship between DOD and the Communications Satellite Corp.?

Have you discussed this relationship with NASA? Have you had any meeting with NASA personnel?

Mr. RUBEL. Mr. Chairman, the meeting which I mentioned which we had with Dr. Charyk—well, we have had more than one meeting—but the first meeting that we had with Dr. Charyk after he resigned his post in the Defense Department and was nominated as president of the new corporation, was a meeting between Dr. Charyk, Dr. Seamans from NASA, and Dr. Brown and Dr. Fubini and myself, so in that sense, yes; we did have the NASA involved. Dr. Charyk has been talking to some others. He has talked on other occasions besides that first meeting with Dr. Fubini. I am sure he has talked with people in the NASA, but there is no formal program yet of setting up an on-going relationship because the corporation is not organized for that.

Mr. RYAN. Could you give us briefly a step by step description of the operational system? In other words, you say by September we will have let contracts for this element and by October for this. Can you give us a step-by-step development as you see it with the time-table?

Mr. RUBEL. The last schedule I looked at, and I am not sure—let me see, I think I might have it in here. Yes; I do.

We have a schedule for the Air Force and a schedule for the Army. The Air Force is responsible for the satellite and space portions and the Army is responsible for the ground portions. This is the latest schedule that we have. I will just read off a few of the milestones.

The Department of Air Force would initiate its phase 1 contacts during the month of May and in early June they would begin their program definition phase efforts. These will continue during the months of June, July, and August. Reports will be received and the final evaluation would be accomplished in August and September.

They would negotiate the follow-on contracts, if the program were approved for full-scale development, beginning in the month of September and during the months of September, October, and November, and the initiation of the Air Force developments for the satellite and the other developments related thereto would commence in about November of calendar year 1963.

The schedule for the Army is slightly different from that. I don't think it will pay to read it to you. It is only different by a matter of a week or two here and there. They are going along very much in parallel.

Mr. RYAN. What are you budgeting for the Syncom satellite, if anything?

Mr. RUBEL. The budgeting for Syncom in fiscal year 1963 was in the order of $20 million. I think I can probably give you an exact number; $18 million is the number for Army support of the Syncom in fiscal year 1963.

Mr. RYAN. Army support for ground stations?

Mr. RUBEL. That is right.

Mr. RYAN. Are you doing anything with the spacecraft?

Mr. RUBEL. No, sir; that is entirely NASA on Syncom I.

Mr. BOONE. What about the ship?

Mr. RUBEL. The ship, I believe, Mr. Boone, is included in that number. It is counted as a ground station for that purpose.

Mr. RYAN. Do you intend to leave the complete development of the Syncom space facilities, the spacecraft and all that goes along with it, to NASA?

Mr. RUBEL. Yes, sir.

Mr. RYAN. But have you reached the division of labor on this program?

Mr. RUBEL. Absolutely. In fact, we have a written agreement on that with the NASA which we concluded with them in the fall of 1961. My memory tells me it was in August of 1961 that we actually had our written agreement with NASA for this precise division of responsibilities.

Mr. BOONE. Do you have an organization that effects liaison between the Department of Defense and NASA, a group that meets to discuss common problems and to arrive at solutions?

Mr. RUBEL. Yes, we do. We have had under the AACB the Unmanned Spacecraft Panel, and that established a communication satellite subpanel quite some time ago, I would estimate 2 years ago.

We, in the Defense Department, supported a number of studies in this field by the Institute of Defense Analysis and others, and I invited NASA to participate in these studies with us.

We now have under that panel a joint Defense Department effort which is aimed at further studies of precisely the matter I mentioned earlier, namely the economic viability and corresponding trade-offs among reliability of boosters, reliability of spacecraft, altitude of satellites, capacity of the system and that sort of thing, and we are working with NASA through that mechanism.

Mr. BOONE. Would this serve as the body for transfer of information that might be given to the Communications Satellite Corp. if they wanted data from you?

Mr. RUBEL. It is hard to say how that is going to work out because it is so difficult to predict how the Communications Satellite Corp. is going to function in this field, how much R. & D. they are going to do, where they are going to go to get information, how they are going to relate themselves to various Government agencies.

I just don't think I can answer that question at this time and until they get organized and we have an opportunity to sit down with our counterparts in the NASA and in the Communications Satellite Corp. and see what makes the best sense.

Mr. BOONE. Do you feel that you have other projects that contribute to the type of R. & D. they would like to participate in or at least get information from?

Mr. RUBEL. Of course, you can say that generally everything that is done in the field of space has a bearing on any kind of an operational capability in space; everything that makes devices more reliable in space, everything that tells you more about the space environment.

For instance, radiation levels in space are very important. Everything that develops boosters and that makes boosters more reliable, all of these things are part of the ground work, the technical base on which any kind of a system has got to be constructed.

So, to that extent, the answer is, yes, we have lots of things that are going to be of value not only to the Communications Satellite Corp., but to the NASA. We have things that will be of benefit too, to the Nation as a whole.

Mr. BOONE. Directly you don't have any funds in R. & D. that would apply to them except this program, the communications program?

Mr. RUBEL. We have no funds—we have nothing in our program in the Defense Department in the field of communication satelites or anything else that we are doing because there is a Communications Satellite Corp.

Mr. RYAN. On page 2 you say "The developments we contemplate with this satellite system will not in any way alter the historic policy of the Department of Defense in leasing channels from commerical carriers."

My question is why not; if this is an evolutionary system which is going to develop communications more economically and more feasibly, why should not the Defense Department use its medium altitude and its synchronous system and avoid the cost of renting lines from commercial organizations?

Mr. RUBEL. We don't think it will reduce cost. The last thing in the world that the Defense Department intends to do or will do is to set up a system which competes, arbitrarily competes with a commercially available capability. We don't lay ocean cables, we rent circuits on ocean cables. The only time that we——

Mr. RYAN. But if this provides a substitute, why wouldn't you use this system?

Mr. RUBEL. The only time that we would use this system is when it provides a capability that is unavailable commercially or is uniquely required for military purposes.

For the same kind of reasons, we are going to use a Defense Department satellite communications system, if one is developed, for those things which are uniquely military.

Mr. RYAN. But if the time arrives when you have a synchronous system with multiple channels such as you predicted with Advent, it would seem to me it would be an uneconomical method to then turn around and abandon that possibility and use a commercial communications satellite system.

Mr. RUBEL. Well, Mr. Chairman, I think that is looking awfully far ahead into a rather cloudy crystal ball. Right now we see no point, just because you can develop communications satellite systems very useful from a military standpoint, we see no basis for the modification of our policies.

Mr. RYAN. Do I infer from your statement that if the Communications Satellite Corp. could develop a system that is equal to the defense system that you would lease from the commercial system?

Mr. RUBEL. I can almost guarantee that the Communications Satellite Corp. is not going to deploy a system like the one I have described here. It doesn't have the capacity. It wouldn't have the economic capability from a commercial standpoint. We are not talking about a system like this in the hands of the Communications Satellite Corp. and the same kind in the hands of the Defense Department. We are talking about a system that the Communications Satellite Corp. would create and deploy and operate which would have much more capacity and much more economic viability from a commercial standpoint than the system I have described here for the Defense Department.

Mr. RYAN. I am concerned here not from a commercial standpoint, but of use and value to the Defense Department. Would you expect to get commercial rates from the Communications Satellite Corp. or preferential rates?

Mr. RUBEL. There has been no negotiation.

Mr. RYAN. Have you given any thought to that?

Mr. RUBEL. Only those general kinds of thoughts. If the day comes, as I have said, when a communication link can be established from here to Europe by a cable under the ocean or by a "cable in space" which is the communications satellite system, and we in the Defense Department and other governmental agencies can rent lines or channels on that communications system, when that day comes, we will rent lines on that communications system on the same basis we have been renting capabilities from the commercial companies all the time.

Mr. RYAN. You ignore the difference in the way the two have been developed, one private and one by taxpayers' expense.

Mr. RUMSFELD. You made a statement earlier in answer to Mr. Wydler which amazed me. I would just want the record to be absolutely correct. We have had various witnesses in from Defense as well as NASA, and it seems to me that one of the most serious problems we have with the billions of dollars being spent on science and research and development is this process of communicating these ideas, and

yet you made the statement that every individual in this country working on a certain given thing knows what everyone else is doing. There has just been page after page of testimony to the contrary. Do you really feel this problem is solved?

Mr. RUBEL. No; I don't want to suggest that, and if I did suggest by my testimony in response to Mr. Wydler's question that everybody knows what everybody else is doing, then I retract that right here and now.

Mr. RUMSFELD. You used the absolutes, the "every" and "any," and it just amazed me.

Mr. RUBEL. I believe I can say this, though, with confidence; that anybody in an industrial concern in the United States today who has got a job of developing a satellite that is going to have solar cells to convert solar energy into electrical power, any engineer in any company who has that kind of a job from the Government has access to all the information that there is about solar cells, whether the development information has been paid for by the NASA or whether it has been paid for by the Defense Department. That is the burden of what I was trying to say in answering Mr. Wydler's question. That is my belief. I hope it is true. I could be wrong. I don't think I am.

Mr. DAVIS. In other words, what you are saying is, if a man engaged on research on solar cells isn't abreast of the forefront of knowledge, it is his own fault?

Mr. RUBEL. I believe that is right, Mr. Davis.

Mr. WYDLER. I just want to make it clear, Mr. Rubel, that still doesn't have anything to do with what I am asking you.

The fact that they know what each one is doing doesn't justify having two different contracts to develop this.

Mr. RUBEL. I agree with you.

Mr. RYAN. Can you give us any estimate of the date at which you expect to launch that first multiple series?

Mr. RUBEL. Yes. By the way, I am authorized to tell you that our fiscal year 1964 budget request for communication satellites is $76 million and, of course, these funds are divided among all three services, primarily the Air Force and the Army, with some going to the Defense Communications Agency.

Mr. RYAN. That includes all aspects of communication satellites, including ground stations?

Mr RUBEL. Yes, sir.

Mr. RYAN. Syncom I and the medium altitude system?

Mr. RUBEL. That is right.

Your question was, when would we launch; and I think I can tell you that.

The first multiple launch—the first R. & D. launch is scheduled for January 1965. So that would be the first multiple launch. When I say——

Mr. RYAN. You said that would be the first operational date.

Mr. RUBEL. I said early 1965 for that.

Let me qualify what I said about early 1965. It is awfully hard to predict exactly when you get these operational capabilities because you can't predict ahead of time which of these launches are going to be successful and which are not going to be successful.

If the launches that we have scheduled here were successful, we would have about half the system deployed by the middle of calendar

year 1965. That was the basis for my answer to your question, Mr. Wydler. But we wouldn't have the entire system deployed until the end of calendar year 1965.

You know that not all of these launches are going to be successful. You also know that they are going to succeed in a somewhat random way. You are going to have a success, success, maybe, failure, failure, and then success and so forth. So it is almost impossible to sit here now ahead of the event and look at this schedule and say when we are going to have this capability or when that capability will be a useful operational capability.

So my guess on the first half of 1965 is that a substantial number of these launchings will have taken place by that time and about half the system will be deployed by that time, and that is going to give you a substantial capability.

Mr. BOONE. Mr. Rubel, do you have an agreement with NASA in their going ahead with synchronous satellites and your going ahead with medium altitude?

Do you feel that the communications satellite program is a complete one now with NASA and the Defense Department?

Mr. RUBEL. I think I would answer that yes, right now, Mr. Boone, but both of us, both you and I have seen how these programs have evolved during the last several years. A lot of our ideas have changed, including my own, so that while that seems to be the answer now to the very best of our ability, naturally in a dynamic and fast-moving situation like this changes are to be, if not expected, at least anticipated as a possibility. That certainly seems to be the case now.

Mr. BOONE. Would you say that your current program will tend to phase out the military in communications satellite R. & D., that is, you would have nothing in the communication satellite field after this program?

Mr. RUBEL. I wouldn't prejudge that point at this juncture. This happens to be now the thing on which we are concentrating all our efforts.

We feel we are doing what seems to be a reasonable set of experiments and development undertakings at the present time. These are matters of judgment. This is the best judgment we have been able to bring to bear on it.

Mr. RYAN. On the last page you speak about Westford. That was the injection into orbit of needles that took place before?

Mr. RUBEL. Yes, sir.

Mr. RYAN. And you are planning that for 1963?

Mr. RUBEL. Yes, sir.

Mr. RYAN. Let me ask this question: Has there not been considerable controversy about the merits of this proposal, and to what extent have you cleared this or discussed this with the President's science adviser and what has been his view?

Mr. RUBEL. There hasn't been much controversy about the potential value, but there has been a lot of controversy about the potential harm. A lot of people in the scientific community worldwide have been deeply concerned about what happens if we put a very large number—you know, we are talking here about something on the order of several hundred million of these dipoles into orbit and they stay there for a long, long time—what happens to radio astronomy, what happens to optical astronomy, what other deleterious effects

might stem from an experiment of that sort from the point of view of the scientific community interested in making observations from the surface of the Earth?

The President's science adviser has convened a special panel to review this matter, which included leaders in radio astronomy and optical astronomy and various fields that are germane to these considerations.

They reviewed the plan for the Westford experiment. I wish to emphasize that Westford is not a project, but it is an experiment. They reviewed these plans in great detail and they came up with the following conclusions.

Incidentally, this meeting, this review, was made about 18 months ago, before the first Westford launch was made, and at a time when there was the considerable controversy that you referred to. Their principal conclusions at that time were as follows, as I recollect them:

No. 1: That the experiment as it was contemplated would not interfere with radio or optical astronomy as radio and optical astronomy exist today. There are no receivers sensitive enough to be interfered with by this belt and there will not be any interference at all to optical astronomy.

Secondly, it is conceivable that if this belt were to stay in orbit for, say, 20 years, advances in some of these fields might be such that it would comprise or might comprise some kind of interference, although the extent of that is very difficult to assess and predict with any accuracy.

The conclusion was that the experiment should be made in a way which would insure that the belt would not last too long.

Now it turns out there are two ways that people have thought about, two principal ways that people have thought about for putting that belt up there so that it wouldn't last too long.

One of these ways is to put it at the proper altitude, and it turns out if you put this up in a certain orbit, at a certain altitude, that there are a combination of effects which have to do with the radiation pressure of the sun working in combination with certain gravitational anomalies that the earth reflects to this belt which, over a period of time, cause this belt to gradually shrink in toward the earth and finally get sucked up by the atmosphere and disappear.

If you get it to exactly the right altitude, the belt will only last a couple of years. On the other hand, if you put it into too high an orbit, then those effects don't work any more, it can last for a long, long time—many, many decades. It is very important to select an altitude where the life of the belt will be shorter.

A second way is to use these sublimable tin dipoles—that is, to make the dipoles themselves out of a material which over a period of time simply evaporates in space. That is the second procedure which people are contemplating.

So I believe it is fair to say that the scientific community and our policymakers, including ourselves, concerned with the particular experiments, as well as national policymakers, have been satisfied that the conduct of the Westford experiments in their present form are not going to be inconsistent with our objectives of refraining from creating disturbances in space or interference from a scientific standpoint in the use of space.

Mr. RYAN. Is this budgeted under your communications satellite program?

Mr. RUBEL. No, it is budgeted by the Air Force under Lincoln Laboratory.

Mr. BOONE. To utilize this, you would still have to have these things up there all the time, would you not?

Mr. RUBEL. That is right.

Mr. BOONE. What does the experiment tell you except that it works or doesn't work?

Mr. RUBEL. That is an important objective. That is the first bridge that you have to cross. That was the objective. It is the objective of these experiments to find out whether it works or not and also how it works.

Now, if the experiment is successful and if it turns out that some of the effects that are untestable except by conducting the experiment turn out to not be serious—for example, there are questions of how much band width can you get out of it, how much interference are you going to get from the fact that the dipoles have a different aspect in their tumbling and that short of thing—if it turns out that these defects are not too serious and would be useful for operational purposes, now you have to ask yourself where do we go from here.

Do we put up a belt of higher density which would be more practical from an operational standpoint and do we put up belts that would last a long time or not?

Actually, you are not constrained on that score, because you could put up a belt for a couple of years and then put up another one to replace it.

Mr. RYAN. Is NASA participating in this experiment?

Mr. RUBEL. No, sir, they are not. They are aware of it, but they are not participating in it.

Mr. BOONE. Last week the committee had a very interesting discussion from Dr. Seamans and Dr. Simpson of NASA regarding what they called a technology utilization program and this was their method of taking fallouts, if you will, from the developmental program that they are doing and disseminating the information to industries.

Does the military have such a program?

Mr. RUBEL. Not of the sort that NASA has.

Mr. BOONE. You wouldn't say it is worth while?

Mr. RUBEL. I wouldn't say it isn't worth while. It is unique to NASA, and it is something that they have only started recently.

Mr. BOONE. Have you considered establishing such a program?

Mr. RUBEL. We have not considered it in my office, in Dr. Brown's office, and I am not sure where else in the Defense Department it is under consideration at this time.

Mr. RYAN. Thank you very much. I urge upon the Department of Defense right now at the conception of the Communications Satellite Corp. that you come to some clear understanding if you intend, as you seem to, to use the channels which that system will have, and insist that the Department of Defense have at least a preferential Government rate.

I think it would be quite contrary to the public interest for the Government to pay commercial rates to this corporation which has been financed and developed at vast taxpayers' expense.

I also hope you will work out now a formula for the measure of costs of any research and development technology which you turn over to this corporation so that adequate reimbursement can be made to the Government.

There are very serious questions here, and I hope we will all be aware of them at the start so that later on it won't be said we are reversing a historical policy if we change.

I certainly hope that the Defense Department doesn't mean that it is bound by historical policy to lease lines if communications channels become available through other and more economical means.

Thank you very much.

(Whereupon, at 11:10 a.m., the subcommittee was adjourned.)

1964 NASA AUTHORIZATION

TUESDAY, APRIL 30, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON APPLICATIONS AND
TRACKING AND DATA ACQUISITIONS,
Washington, D.C.

The subcommittee met at 10 a.m., in room 214–B, Longworth Building, Hon. William Fitts Ryan presiding.

Mr. RYAN. Will the committee come to order, please.

Today the subcommittee continues hearings on that part of the NASA budget request related to the NASA communications satellite program.

For fiscal year 1963, NASA has programed some $43 million for researchment and development of communications satellites. NASA is requesting some $51 million for the same purpose in fiscal 1964.

In order to evaluate NASA's budget request, the subcommittee should review the total national effort in communications satellites. We have already questioned NASA about the policy implications of turning over to a private profitmaking corporation the benefits of publically financed research and development.

We have looked into the communications satellite program of the Department of Defense. The Department of Defense budgeted for communications satellites $95 million in fiscal 1963 and is asking for $76 million in fiscal 1964.

Today the subcommittee will hear testimony from Leo D. Welch, chairman of the board of the Communications Satellite Corp., and Joseph V. Charyk, president of the corporation.

Last year Congress created this private corporation in the expectation that it would lead to the expeditious development of a commercial communications satellite system.

The decision to rely on private investment for the financing of the system was made, as one congressional supporter explained, because—

> private enterprise would have more flexibility, greater speed, more initiative, greater risk taking than the Government would.

As another congressional advocate of the act explained:

> In the case of satellite communications, free enterprise will be paying its own way. The rockets and other equipment necessary to make such a communications system operational will be paid for by the satellite corporation and the people who invest in it.
>
> And, equally important is the fact that the satellite communications corporation, proposed under this bill, would be a profitmaking organization and would pay Federal and local taxes just like any other business enterprise.
>
> Rather than spending Government money to run such a communications system we would be getting the benefit of these tax moneys * * *. No Government subsidy is proposed under this bill—nor is it needed.

And the distinguished chairman of the Committee on Interstate and Foreign Commerce said on May 3, 1962—

> * * * But not only do we want to keep ahead of the Communists and get this development in operation, but we want to keep ahead of anybody else and any other nation. We want to be the leader in the world in this. I would say to the gentleman, if we do not set up a vehicle, as I indicated yesterday, to get this in operation, then there is no way it can be developed. So far as the research is concerned, that has been completed. We know that the research and development has by this time reached the stage that it can become operational.

The NASA budget for research and development of communications satellites is $7½ million greater for fiscal 1964 than for fiscal 1963. Now that the corporation is established, should the taxpayers continue this expenditure?

About 90 percent of the $51 million proposed for fiscal 1964 would be placed on contract with industry.

Cannot the corporation place the same contracts and fund the work? If NASA continues to support research and development which benefits the corporation, should arrangements be made to reimburse the Government?

If there is a justification for continued public expenditures on communications satellites, what line of demarcation should there be between the responsibilities of NASA and those of the Communications Satellite Corp?

These are some of the questions we will want to explore.

The subcommittee is concerned with the progress of the corporation since the passage of the act in August of 1962. What discussions have taken place with NASA and the Department of Defense? What negotiations have been started with foreign countries?

I am sure other questions are in the minds of subcommittee members and the American people. Primarily we want to know how the public interest will be protected, and we hope you gentlemen can throw some light on these questions.

It is a pleasure to welcome you to the subcommittee, Mr. Welch and Dr. Charyk, to our hearings this morning.

Before we proceed, I believe it would be appropriate to have some words from the chairman of the Subcommittee on Applications and Tracking and Data Acquisition, Mr. Hechler, of West Virginia.

Mr. HECHLER. I wish to join in welcoming the two distinguished gentlemen who are appearing before our committee this morning—Mr. Welch, who has had such outstanding experience in the banking and industrial world and Dr. Charyk, who has had a brilliant career as a teacher, research scientist, and administrator as Under Secretary of the Air Force.

The Communications Satellite Corp. is indeed fortunate to have men of your caliber as leaders in this pioneering effort.

I think it is also appropriate that you should be appearing on the same day as the announcement that Telstar II will be launched next week from Cape Canaveral and of course this will mean additional progress in the area in which you are most closely concerned.

We are concerned in this committee with getting answers to the questions of why we and Congress should authorize some $55 million to the National Aeronautics and Space Administration in the communications satellite field. Perhaps one way we could approach this would be to try to get the answer to what would happen to the Com-

munications Satellite Corp. if we did not authorize or appropriate these funds to NASA.

This is largely a matter of financing. Could we lend you the money and go ahead and do the job just as well, or what is so peculiarly necessary about having NASA expend these funds in the communications satellite field.

If, as has been suggested, NASA is merely going to contract this out to private concerns why can't the Communications Satellite Corp. itself contract out these funds?

I am perhaps putting a little exaggeration on these questions to sharpen them. These are questions which have arisen in the minds of many people both in Congress and throughout the country, this being a private corporation affected with the public interest. We are concerned with what kinds of return would come from Government subsidy and Government investment and this is an area that we would like to inquire into before we go ahead in Congress to authorize these funds to NASA.

With that general background I want to again welcome you gentlemen to this committee and wish you well in your work.

Mr. RYAN. Thank you, Congressman Hechler.

I believe that both witnesses have statements and I assume that Mr. Welch would prefer to proceed.

STATEMENT OF LEO D. WELCH, CHAIRMAN, COMMUNICATIONS SATELLITE CORP.

Mr. WELCH. Thank you, Mr. Chairman.

Now that the corporation is in being you may be interested in our thinking about the questions that people ask us, as they ask the management of any new enterprise—questions such as "What's the corporation going to do?", "What are the hardest problems it must solve?", "When will it start operating a satellite system?", "When will it start making money?", and so forth.

Before we accepted our posts, we studied the history of the corporation's creation, its objectives, and its intended scope.

We were immediately struck by the pioneer character of the corporation's mission, an adventure very much akin to the organization of the first railroad, the first airline, or the first commercial telegraph, but enormously more complex and more challenging than any of these.

New companies face substantial business risks even when they start out in well-known fields. This corporation will venture into new areas full of great promise but also full of great unknowns, so that both our risks and our opportunities are, of course, correspondingly larger.

At this stage, there are still many unknown factors important to our operations that can be defined only after further research and development. However, if we assume that these unknowns can be accurately defined and that the problems they present can be effectively solved—and the scientist and businessmen experienced in this technology believe that they can be—we believe this corporation will attain the objectives for which it was formed.

Before the global communications instrument will become operational many decisions must be made by the corporation, such as:

(1) What type of satellite is technically and economically best for the first operational system—medium altitude or synchronous?

(2) What is the most probable satellite lifetime?
(3) What kind of boosters can place them in the proper orbit?
(4) How much research and development remains to be done to permit the design of the components and subsystems of the operational satellite to be initiated with confidence?
(5) What kinds of organizational and financial arrangements can we devise and negotiate with our foreign counterparts to establish an efficient and viable international system?
(6) What will be the initial capital requirements of the corporation, and how should these needs by financed?

We have been in constant touch with the various people in Government and industry who have been studying these problems and we are confident that great progress has already been made toward their solution.

We are now instituting studies of our own to supplement and build on those previously conducted. If our present estimates as to the course of these studies and of the required developmental research are maintained, a satellite communications system that could commence functioning by 1967 is possible. We say "commence" because at the outset its coverage would probably not be global but would rather be limited to the more populous areas such as Europe, Japan, and possibly Latin America where traffic is expected to be sufficient to justify the construction of ground stations. Of course, it would be expanded to other areas gradually as demand grows and traffic is forthcoming.

It is as yet too early to compute the cost of the system in concrete figures. Others who have studied this question have made estimates that vary over a wide range between $100 million and $1 billion, but the assumptions on which these estimates are based include so many unknowns that we would not care to put forth any figure of our own as yet, even as a "guesstimate."

We have also examined data on the probable rate of growth of the international traffic to see if such a system can be economically justified. Again, the existing estimates vary.

However, the rate at which the traffic curve now rises and promises to continue to rise indicates that if a system can be established within a reasonable cost range, and if the satellites have the lifetimes predicted, a modest profit position can be attained sometime between 1969 and 1971 with the corporation at the same time fully discharging its large responsibilities to the Government and the public.

This conclusion rests on many assumptions that are still highly preliminary. The initial phase of our work must be to examine each of these assumptions in detail, and satisfy ourselves that they are well founded.

Dr. Charyk will now outline in a little more detail the immediate task ahead.

STATEMENT OF DR. JOSEPH V. CHARYK, PRESIDENT, COMMUNICATIONS SATELLITE CORP.

Dr. CHARYK. Thank you, Mr. Welch.

I would just like to say at the outset how pleased I am to be able to testify again before a subcommittee of the House Science and Astronautics Committee.

In retrospect, looking back to the first time I testified before the committee, it is amazing to see the giant strides that have been made in the space field. It would have been hard to visualize 3 or 4 years ago that we would be sitting here today discussing a commercial satellite system for worldwide communications. I think this perhaps bears out something that is frequently stated; namely, that we tend to be very conservative about our long-range predictions and very optimistic about our short-range predictions; in other words we tend to underestimate what will be accomplished over a period of years but we are very optimistic about what is going to happen in the next year or so. I think we see some of that in this area. It is a pleasure to be here and to outline some of our thinking as to the corporation's activities in the coming months.

The initial phase of the corporation's activities may be considered in several categories. First, rather detailed studies will have to be made of the various technical approaches to a worldwide commercial communications satellite system.

In addition to evaluating the time schedules, technical risks, and costs of various approaches, related economic analyses will have to be conducted to determine the specific course which will be most attractive from a combined technical and economic point of view.

During this phase there will also have to be detailed discussions with other countries who may become participants in the ownership, operation, and use of the total system.

During the initial phase of the corporation's activities, understandings with such countries will at least have to be developed to the point where the extent of foreign financial participation is reasonably well defined, in order that the financial requirements of our own corporation can be developed in an adequate fashion.

As focus is brought on the best course of action, the specific research which must be done to provide the technical basis for the operational system will become clear.

Thus, over the coming months it will become possible to spell out the scope of the research program that we will undertake, the course we propose to follow toward an operational system, financial requirements incident thereto, and a more precise estimate of the time in which we hope to have an initial capability.

During recent weeks, we have held discussions with NASA and with the Department of Defense in order to obtain the benefits of their thinking, to learn something of their present and planned programs, and to establish working relationships with them.

In addition, we have initiated and are continuing discussions with the various private corporations active in the communications satellite and related fields.

We have met with complete and enthusiastic cooperation on all fronts. The data provided to us and the discussions we have held will be of great value in the development of our program.

Initially, of course, if we expect to move toward an early capability, judgments will have to be made on the basis of technical data either already in hand or potentially available in the near future.

But as we go down the road and as the initial capability is established, we expect to move more and more into the exploration of new areas where technology may yield further the hope of enhanced and more efficient communications capabilities.

It is perhaps worthy of note that this research and development effort is still largely in a comparatively early stage. Much has been learned from the two experimental satellites, Telstar, and Relay. Valuable information has even been gleaned from the unsuccessful Syncom I experiment but a great deal of work remains to be done to provide the best basis for a design which can yield the first global communications satellite system, and to develop components possessing the necessary reliability.

This does not mean that it was unnecessary to form the corporation at this early stage, when considerable developmental work required for an operational system still remains to be done. On the contrary, the corporation will be an indispensable mechanism for focusing the best technical, economic, and management skills on the present development phase of the problem, and for financing a substantial part of the work that now lies ahead.

A wide variety of opinions exists as to the best technical course to follow. Many thorough and competent studies have been made of various approaches with, in some cases, widely differing conclusions.

This simply attests to the fact that our task is not an easy one and that detailed and extensive technical analyses and experiments are required to come up with the answers that are needed. This repretents the first and most important task of the corporation. We plan to activate work in this direction in the very near future, utilizing the talents and capabilities of the industry as well as the in-house capabilities which we are in the process of establishing.

It should be recognized that the development of a master plan for our activities, with all of its technical, economic, financial, and international implications, is a necessary preliminary before we can go to the public with the initial stock offering. It is not possible at this time to make a precise estimate as to how long this initial planning phase will take. But we feel that when we go to the public we have an obligation to do so with the most thorough and objective picture that can be developed.

It is also clear that the portion of our research and development work devoted to the perfection of reliable hardware cannot properly be initiated until this planning phase is completed.

The plan will, of course, not be perfect, and it will undoubtedly have to be revised as we go along. But at the very least, we intend to have a plan that identifies all the present knowns and unknowns, and proposes orderly, feasible, and economic methods of arriving at an operational system at the earliest practicable date.

As our program takes shape in the coming months, it is our intent to keep this committee and the other appropriate committees of the Congress briefed on our plans and activities.

Thank you, Mr. Chairman.

Mr. RYAN. Thank you very much, Dr. Charyk and Mr. Welch.

I know that there are many questions in the minds of the subcommittee members, and I think that it is important during the course of this discussion that we become as specific as we possibly can in terms of gaining an understanding of exactly what discussions have taken place between the corporation and NASA and the Department of Defense, what plans have been made in terms of putting the corporation together and getting it moving and as accurate a prediction as we can obtain as to the date when you predict you will have an operational system.

Suppose we start by letting me ask whether or not there have been discussions between the corporation and NASA regarding the technical characteristics of a system.

Dr. CHARYK. Mr. Chairman, we have had discussions both with the Department of Defense and with NASA. We have discussed the status of the research program up to the present time.

We have discussed at least in a preliminary fashion the problems which still remain to be solved, both in the case of the synchronous satellite approach and in the case of the medium-altitude approach and I think that we have generally arrived at uniform thinking as to the major problems which have to be overcome, the major considerations which remain insofar as an operational system using one or the other of these approaches is concerned.

Mr. RYAN. Did you meet with NASA pursuant to the letter of March 27, I believe?

Dr. CHARYK. We had an initial meeting with Mr. Webb, Dr. Dryden, Dr. Seamans, Mr. Jaffe, and other representatives of NASA.

I have had subsequent meeting with Dr. Seamans and with Mr. Jaffe.

Mr. RYAN. Who participated in that initial meeting?

Dr. CHARYK. Mr. Welch and I.

Mr. RYAN. Who represented NASA?

Dr. CHARYK. The people that I have indicated: Mr. Webb, Dr. Dryden, Dr. Seamans, and Mr. Jaffe.

Mr. RYAN. Can you tell us when that took place?

Dr. CHARYK. It was on Friday, April 5.

Mr. RYAN. That was one meeting. Have there been any others?

Dr. CHARYK. I had a meeting the subsequent week with Mr. Jaffe and I have talked with Dr. Seamans on a couple of occasions.

Mr. RYAN. That amounts then to two meeting with NASA and two conversations between you and Dr. Seamans?

Dr. CHARYK. That is approximately correct.

Mr. RYAN. Have there been any meetings with DOD?

Dr. CHARYK. Yes, we had a meeting with the Secretary, the Director of Defense, Research and Engineering, and Dr. Fubini of the staff of the Director of Defense Research and Engineering, I have had a series of meeting with Dr. Fubini and Dr. Brown since that time, perhaps half a dozen or so.

Mr. RYAN. In the course of the meetings with NASA, did you discuss the NASA budget and the items which are the subject of the NASA request to the Congress?

Dr. CHARYK. We discussed the general makeup of their budget. They indicated that they had made a determination to focus the bulk of their research in the direction of the synchronous system and they pointed out, for example, that something of the order of four and a half million dollars in their 1964 budget request was in connection with the continuation of the work on Syncom I and something better than $41 million of their budget request was for initiation of work on Syncom II.

We have subsequently had discussions with representatives of the Hughes Aircraft Co. who have briefed us on the status of their present program on Syncom I and their thinking relative to Syncom II.

We have also dicussed with NASA the planning as far as further Syncom I experiments are concerned and with the Department of Defense we have discussed their participation in the Syncom I program.

I believe that something of the order of $22 million of the DOD funds are being used in support of the Syncom I effect.

Mr. HECHLER. Dr. Charyk, I wonder if you could tell us what your philosophy is as to how these expenditures should be divided.

We talked about your discussion of the R. & D. on Syncom I and II; now what in your mind should NASA undertake in the field of advancing the state of the art and what should the Communications Satellite Corp. undertake?

Dr. CHARYK. Well, Mr. Hechler, I would say that it is very difficult to draw a firm line. As you well know, the total research and development spectrum involved here is very broad. At one extremum we would have a determination of the environmental conditions which such satellites would have to experience, for example, the measurement of radiation and so on. This would be considered I think by everyone to be fundamental research of interest to the complete space program.

On the other end of the spectrum you would have the development of a specific design for the commercial system. This is clearly directed toward the goals which this corporation was set up to achieve and as such we would certainly expect to fund that type of work. Somewhere in between these extremes our efforts blend and here will be an area where we will be conducting research work and where NASA will be conducting research work, where there will be close parallels I would say and it is very important therefore that we have a close liaison with them.

Starting as we are from scratch I think that our initial efforts are in conformance with the intent of the act; namely, to proceed on an expeditious basis to the development of a design for a commercial system, a design that will make both technical and economic sense.

That means that we are going to have to answer certain development questions which still remain and to proceed as quickly as we can to a specific design.

I would think that as we achieve an initial operational capability we will be thinking of what improvements can be made, what are the next steps that should be taken and that we will at that stage of the game be moving into greater depth into the total research field. So, in a sense, the scope of our activities will begin to move toward the left or the fundamental end of the spectrum.

We are starting pretty much at the right end.

I think our main job is perfectly clear. As we begin to get in business, as we begin to develop a capability, we are going to be looking more and more into newer areas.

Obviously we have got to focus our attention initially and I think that has to be in the direction of producing a commercial system as expeditiously as possible.

Mr. BOONE. Dr. Charyk, do you feel that you could start a design today of an operational system based on what background you have?

Dr. CHARYK. I don't think we can.

I think there are still questions that need to be answered before we can proceed with full confidence to a design. This has to do not only with the technical aspects but with considerations of producing a satellite with a sufficient communications capacity so that when we establish the system, we have a system that makes economic sense.

Economic sense of course is closely tied to the communications capacity that the satellite will have. It is also very intimately tied

to the lifetime of the satellites and I think it might be significant to say at this point that most people agree that lifetimes of several years must be achievable before a commercially attractive system is possible. There have been up to the present time no systems of this complexity that have actually been designed and flown that have approached anything like a lifetime of several years.

That does not mean it cannot be done. A great deal of work has been going on and there is a great deal of confidence in the industry that such designs can be perfected.

But there are these questions and they will have to be resolved through further analysis and test before one can say I can design with high confidence, and I am sure I have all the unknowns eliminated.

Mr. PELLY. Will you yield for a question, Mr. Boone?

Don't you anticipate that you will sign a contract with the Government and operate in accordance with preagreed arrangements as to sharing costs.

Dr. CHARYK. Well, we certainly do, Mr. Pelly.

In other words, we are going to outline the specific things that we need to have done in order to establish a system. On some of these items we will clearly go to the Government and request their support and make arrangements for reimbursing the Government for such work.

In other cases we will go directly to the industry and ask them to carry out certain work for us on a contract basis.

Mr. PELLY. It would seem to me that there should be a basic contract under which the General Accounting Office could make regular audits and protect the public. I would certainly have in mind that NASA itself has unlimited power as it is now to reprogram money and I don't believe there would be any protection to the public unless there was some such contract to audit.

Dr. CHARYK. As far as specific requests we make to NASA are concerned, I think these will be worked out on a case by case basis, that is, we will work out the details of the reimbursement.

That will be clearly spelled out.

Mr. RYAN. Your last statement was in reference, you said, to specific requests you make of NASA?

Dr. CHARYK. That is correct, Mr. Chairman.

Mr. RYAN. You spoke of answers being necessary to many unknown questions earlier.

Who is going to find those answers, is NASA going to find those answers or is the Communications Satellite Corp. going to find them or is the corporation going to sit back and let NASA find the answer and then take advantage of them?

I think you have to give some thought as to what reimbursement you will make on matters that will be turned over to the corporation that the corporation does not specifically request.

You should not limit your answer to those matters you specifically request. You could sit back and take advantage of the whole development. You have not told us when you are going to issue stock. You have not told us when you will be in operation. This may take years. We may spend $51 million this year and $51 million the next year.

If we take a look at the NASA budget for this year and the supporting research and technology involved, for instance, there is an item

in the budget for $2 million for 1964 for intermediate altitude satellite studies.

Why can't the corporation fund that $2 million?

Dr. CHARYK. Well, on that specific item, I am not sure exactly what they have planned. I would envision that NASA would formulate their program on the basis of what they consider to be in the national interest, taking a look at what the requirements of their own programs are, what the requirements of the Department of Defense and other agencies of the Government are, and that our job is to take a look at the total effort that is going on and determine the specific things we need to do to produce a commercial system. This we propose to do.

Mr. RYAN. When?

Dr. CHARYK. As expeditiously as possible.

Mr. RYAN. Can you give us a possible date?

Dr. CHARYK. This clearly depends upon the specific route that we choose. This is going to require this definition phase that I spoke about in my statement. I think Mr. Welch indicated that the earliest date that we can speculate about at the present time on the basis of inputs that we get from people both in the Government and in the industry is a date something like 1967 or perhaps 1968.

Mr. HECHLER. What kind of a system would that be, using the 1967 date?

Dr. CHARYK. I think the earliest date estimates generally favor the medium altitude system. This is not unanimous by any means. Some of the proponents of the synchronous system have high confidence that they can achieve the necessary goals in an equally short time or perhaps even sooner.

Mr. HECHLER. But you are proceeding on the assumption that this 1967 date would be a medium altitude system, is that correct?

Dr. CHARYK. No; I wouldn't reach that conclusion.

I indicated the majority of the people who talk in terms of an early date think in terms of a medium altitude system but that is not unanimous.

Some of the proponents of the synchronous system feel that they can perhaps meet or beat the earliest dates that have been mentioned, such as the 1967 date.

Mr. RUMSFELD. You consider 1967 an earlier date?

We are not starting from any place, so it is difficult for me to understand what you mean by "earlier" or "later."

Dr. CHARYK. I think we are talking about a date made up along the following lines. This program definition phase, if you want to call it that, which I referred to in my statement, is something that is going to take at least the better part of the year, in other words, this is the period before you would actually move into an active hardware development program. The hardware development effort will be something of the order of a 3-year program so if we add 3 and 1 we get 4 and 1963 plus 4 years is 1967.

Mr. WYDLER. Dr. Charyk, would it be fair to say that what you are saying is that this corporation would be willing to pay for what it wants, but it is not willing to pay for the entire satellite communications program of NASA or the Air Force or what have you?

In other words, when you know what you want you will be willing to pay for that, is that what it comes down to?

Dr. CHARYK. Well, I would not quite phrase it that way. I would say that clearly it is important that NASA carry on a wide range research and development program for the support not only of its own efforts, but to accomplish the research that is going to be necessary, for example; in the metrorological area for the Weather Bureau, and for the Department of Defense. They are going to have to work in other areas. For example, the development of long lifetime components is equally important to the entire program as it is to us. So we will both be conducting work in this field.

It is vitally important to both of us that we have adequate power supplies for space applications, so again there is a common interest and I would think that they would be amiss if they were not carrying on a vigorous program with respect to power supplies, also with respect to stabilization schemes for satellite systems.

Stabilization is also important to us so it is fair to say that we, together with a lot of corporations throughout the country, will be beneficiaries of the broad-gage programs that NASA is carrying out. I think this is reasonable and in the national interest. I think there are certain specific things which are closer to our immediate objectives that we must do and do alone and these we certainly propose to do.

Mr. WYDLER. I thought that is what I was saying.

What I am trying to point out, if I understand the point that you are making, is this: That you say until such time as you have defined what you need to build a communications satellite and determine what the most economic and practical systems is, until that time, and you know what you want, that will be the time when you will start to pay to develop it whether it is done by NASA in-house or what have you, and until that time you consider this program whether it is being done by NASA or the Department of Defense or whoever is spending money for research, the funds will honestly and fairly be picked up by the Government—it seems to me that is what this comes down to.

Mr. RYAN. You said that you expect in a year——

Mr. WYDLER. Excuse me.

I meant that as a question even if it did not end up that way. I would like to see if that is not what we are getting at.

Dr. CHARYK. Substantively it is correct. NASA and the Department of Defense have to make a determination of those research programs that it is necessary for them to conduct in the interests of furthering the state of the art and in the interests of furthering their own particular programs, that over the coming months the specific things that we are going to need to do in order to proceed with a commercial communications satellite system will become clear and these we will propose to initiate as they become clear.

Mr. HECHLER. I think I would like to ask this question of Mr. Welch.

As a student of American business history, wouldn't you say that there have been a number of contributions to the state of the art or the development of the Nation which have been made by American business operating in its private capacity over the years?

Mr. WELCH. Very decidedly, Mr. Hechler.

Mr. HECHLER. I don't see why it should bring any embarrassment to the Communications Satellite Corp. if it should make some contributions to the general space program beyond its central mission.

This seems to me to be in the main stream of American thought and I would hope that the profitmaking corporation would also produce some things that would be for the national interest, the national benefit, not only in the space program but commercially, industrially, and in other respects.

Mr. WELCH. I believe that that is not only possible; I think that is quite probable. I am not technical in my way; I am looking at this largely from the private corporation angle, which is conscious of its duty to the public as well as its shareholders, but it seems to me that there is an area of research that we are discussing here that goes way beyond what the Communications Satellite Corp. is going to require.

As Dr. Charyk pointed out, my conception of the NASA program is one that takes in a number of factors that will interest the Communications Satellite Corp. but over and above that, a very wide range of other things.

As I look at this thing fresh out of business and just coming into it with halting steps, all the money that NASA is considering spending here and all the money that the corporation can spend within its means is not going to be too much if we are going to maintain a lead and get on with this thing.

It seems to me that we are liable to lose ourselves in taking a too-narrow view on this.

We have in addition to the matter of the prestige that we want to maintain before the rest of the world in getting this corporation launched and getting this global sommunications system to be viable. it seems to me, a great factor of urgency and I just wonder how wise we are in trying to pinpoint who spends what money here.

Let us get on with this thing. Let us get going. Let us get it established. What the Government spends in this thing, if we get the benefit of it, I think that is all to the public good.

If it hastens the day we are in operation, that is fine. If it enables the corporation to make a profit sooner, we will pay taxes on it. We will be such a heavily regulated entity anyway that we are not going to make any great profits as I see it.

If we get into a heavy profit position, the FCC is certainly going to take a step on our rates; if we spend more money than we should in getting there; that is, to a profit position, all that will have to go in our rate base which can affect our charges, so what we are stressing here while interesting, it is not as great as the conception that has been made in the creation of this company and the objectives for which it was formed.

Mr. HECHLER. I am 100 percent in agreement with you as to the necessity of pressing forward on this program from the standpoint of American prestige. I think this is vital and I am glad you put your finger on that. You will pardon our extreme interest, however, in this $55 million expenditure by the Government.

I want to make absolutely sure, as I am sure my fellow Members of Congress want to make sure, that this is a sound and justifiable investment.

Mr. RYAN. I take it, Dr. Welch, you disagree with those congressional supporters of the Communications Satellite Corp. who urged the passage of the act by Congress by saying this was a matter for private enterprise which could do it more efficiently and do it first and there would be no need for further Government subsidy.

Mr. WELCH. I think private enterprise will do some of the things you are talking about very well. I think it will get there with the maximum speed and the tightest run organization and possibly move negotiations more rapidly than you would in a different kind of an entity, but I think there are many facets of the area of investigation about which we know so little that will have to be carried out by the Government, and should be carried out by the Government.

You have got a lot of precedents in this. The Government has spent great amounts of money in many areas——

Mr. RYAN. Is there any area where Congress created a monopoly to carry on a further program and then subsidized that monopoly?

Mr. WELCH. Is this a monopoly?

Mr. RYAN. Who, under the law, can compete with the Communications Satellite Corp.?

Mr. WELCH. All the communications companies.

Mr. RYAN. How? They are going to launch satellites and compete with you?

Mr. WELCH. They will have cable and radio.

Mr. RYAN. Don't you have a monopoly of the communications satellite business?

Wasn't this designed for that purpose?

Mr. WELCH. Yes.

Mr. RYAN. Don't you have a primary responsibility to your stockholders?

Mr. WELCH. Yes.

Mr. RYAN. Didn't you say the same thing in an article published in the New York Post?

You said:

> But we are still a private corporation with principal responsibility to our stockholders.

Mr. WELCH. I haven't seen this article.

Mr. RYAN. I will show it to you.

I don't think what I quoted disagrees with what you said a moment ago that you do have a primary responsibility to your stockholders.

Mr. WELCH. Well, we have a primary responsibility to the public.

Mr. RYAN. To which? Your stockholders or the public?

Mr. WELCH. We have a responsibility to both, Mr. Ryan. As a private company you have got to run a solvent show. You have got limitations as to the amount of moneys you can go to the market for, and you have to exercise a great deal of selectivity in how you dedicate that money.

You can afford a reasonable amount for research. You are going to dedicate that part to research that you will need in the corporation's communication efforts.

You cannot expect to raise enough money, I don't think, to move into the general area of research and development in space that may cover a lot of things beyond what you need.

I think you have some limitations there that you have to observe.

Mr. HECHLER. Looking over Mr. Ryan's shoulder, I see Mr. Welch, that in this article you are labeled as a "tycoon," for which I congratulate you.

Mr. WELCH. I am highly complimented.

Mr. HECHLER. May we come back to your statement that it will be a year before you propose to place any contracts for hardware?

In the interim what are you going to be contracting for?

In other words, if it is going to take a year to put a contract out for hardware are you going to be spending any money on research and development, on any preliminary designs?

What are you going to be doing?

Dr. CHARYK. Yes, we are entering what we are describing as a program definition phase.

This is a phase in which we will discuss studies as to the best technical approach to follow. In the latter phases of this stage of the program, we would develop the general technical specifications of the system which we propose to develop.

We may well find it necessary or desirable to seek to obtain the answers either through sponsored studies or experimental work on basic questions which may be inherent to the design of the system which we feel can best serve the purpose.

Mr. RYAN. I don't believe you have answered the question, however.

What specific contracts do you intend to let prior to the first hardware contract based on a decision which you have formulated based on the research development and advice and counsel of NASA?

In other words, are you going to undertake any research and development at the corporation's expense or are you going to take advantage of the research and development done by NASA and arrive 1 year from now at a point where you say:

Taking into consideration the work done by NASA and NASA's advice, we have decided we will let a contract with X Corp. for a particular spacecraft.

Dr. CHARYK. We plan to do both.

Mr. RYAN. Be specific.

Dr. CHARYK. We plan to contract for a study to assist us in arriving at the final design specifications.

We obviously plan to take full advantage of the work NASA has been doing to help us determine the route to follow.

Mr. RYAN. Suppose Congress did not appropriate $51 million to NASA, what would you do?

Dr. CHARYK. Given that situation we would have to make our own determination as to the best system design and the necessary work remaining to be done.

Mr. RYAN. How would you go ahead?

What is your salary?

Dr. CHARYK. $80,000.

Mr. RYAN. What is your salary, Mr. Welch?

Mr. WELCH. $125,000.

Mr. RYAN. What is the total payroll of the corporation?

Mr. WELCH. I think it is about—somewhere between $25,000 and $30,000 a month so far but we are not underway.

Mr. RYAN. That is for how many employees?

Mr. WELCH. Twelve.

Mr. RYAN. Suppose Congress says: "You have got the corporation; you have got a president at $80,000 a year, and a chairman of the board at $125,000. You have gone out and found the best talent available. You paid whatever was necessary to bring the people in. Let the corporation do it. We created this act for the purpose of letting private enterprise put us ahead of everyone else in this field."

What would you do?

Dr. CHARYK. We would have to proceed on the basis of the information that is available at this point together with the additional information that would result from the programs that we will sponsor over the coming months.

Getting a little more specific, I think that the net impact, if these funds were not appropriated, would be to make an approach toward a synchronous satellite system not feasible.

Remember that we have not as yet placed a single satellite into a synchronous orbit.

If no work were to proceed to develop a booster capable of doing that job, of developing the ability to station keep which is an important function for a synchronous system and—I might say parenthetically these things are important to a large range of space applications other than communication satellites. But if the Government should make the determination that it did not want to proceed to solve these problems, then I think from the standpoint of a commercial communication satellite system that we would not be in a position to seriously consider an approach along the synchronous line.

Mr. RYAN. It is my understanding that there are other parts of the NASA budget which relate to synchronous satellite capability. I was talking about the failure to appropriate money for communications satellites.

What would you do?

Dr. CHARYK. Well, my impression is that the bulk of the effort toward the establishment of synchronous satellites is included in this portion of the NASA budget.

Mr. HECHLER. Didn't the American Telegraph & Telephone Co. do a great deal of pioneering work on the research and development on Telstar?

Dr. CHARYK. They proceeded to build a spacecraft and proceeded to make arrangements with the Space Administration for the launching of this spacecraft and for the reimbursement to the Government for the booster and launch services and we propose to do exactly the same thing.

Mr. HECHLER. I was simply making the point that private industry has been extremely successful in this particular case and in the case of RCA with Relay. What would be wrong with your developing that kind of know-how through your corporation, for a synchronous system?

Dr. CHARYK. Well, I think that we would have no hesitancy about the problems of the design of the communications elements of a synchronous system, but we don't think it would be reasonable to look to the corporation for the development of the booster technology, station-keeping technology, stabilization technology, and development of the command and control technology that would be important to a synchronous satellite system.

We think that these are things which need to be done in the interest of the total space program and we think that our job is to focus our attention on getting a communications system into being and not sponsoring a complete range of space technology research.

Mr. HECHLER. Thank you.

Mr. BOONE. Dr. Charyk, are there items in the NASA 1964 budget that are vital to your getting a system in operation by the 1967 date that you mentioned?

Dr. CHARYK. I think that all of the items are helpful in this sense, that the more work that goes on—and by this I mean the work that the Department of Defense will conduct, the work that NASA will conduct, and the work that we will conduct—the more work that is done, the greater confidence we will have in proceeding toward a design that will operate at an early date and that will have the lifetime that is necessary to have an attractive commercial system. So the importance of developing the underlying technology cannot be overemphasized.

There are a good many unknowns still left and it is going to take a lot of resources in order to provide the answers to these unknowns.

The benefits will accrue not only to this particular activity, they will accrue to the entire industry that is working in the space technology field.

Now, I might just add in this connection that, after all, we are going to be looking to the industry ourselves to develop subsystems, components, and so on.

The industry is going to be the beneficiary of the work that is going to be conducted by the Government so it is not a situation where this corporation would be the sole beneficiary of certain work. The entire industry and the country is going to benefit from that work.

Mr. RYAN. Have you given any thought to the placing of restrictions on the letting of contracts to stockholders in your corporation, when you talk about industry benefiting, what about contracts let by this monopoly to shareholders?

Mr. WELCH. I don't think we have come that far yet, Mr. Ryan, and I think it will be some time before we will get to a point where we will be ready to consider techniques for letting contracts. You see we have got to get our staff of scientific people in there. They have got to make their studies. They have got to come to conclusions. This is going to consume a period of several months but in any case we have the FCC technique laid down for us in the law and I think they plan to exercise a rather careful surveillance over the process of letting contracts.

Mr. RYAN. Do you feel the public interest is protected by the bylaws and the articles of incorporation of this company?

Mr. WELCH. I do, very much.

Mr. RYAN. Was that the feeling of each one of the incorporators?

Mr. WELCH. Yes.

Mr. RYAN. At the time when these articles were drawn up, wasn't there disagreement as to whether or not the public interest was in fact being protected?

Mr. WELCH. I was not a participant then, Mr. Ryan.

Mr. RYAN. Maybe Dr. Charyk can answer.

Dr. CHARYK. I was not a participant.

Mr. RYAN. Maybe the lawyer can answer.

Mr. CUTLER. My name is Lloyd Cutler. I am serving as counsel to the incorporators and to the corporation. During the consideration of the articles of incorporation, there were of course differences of opinion among the incorporators in shaping them, but all the differences of opinions were resolved and the articles and bylaws were unanimously approved by all the incorporators.

Mr. RYAN. Prior to the final decision, was there circulated a memorandum by one of the incorporators, a memorandum in which he dis-

agreed quite strongly with the concept of the bylaws and articles of incorporation?

Mr. CUTLER. There were a number of memos distributed.

Mr. RYAN. Specifically, did Mr. Woodcock distribute a memorandum?

Mr. CUTLER. Yes.

Mr. RYAN. May we have that for the record?

Mr. CUTLER. There were a number of memorandums on that subject.

Mr. RYAN. I am talking specifically about Mr. Woodcock's memorandum.

Mr. CUTLER. Yes.

Mr. RYAN. Would you supply it?

Mr. CUTLER. I think it should be referred to the incorporators.

Mr. RYAN. Dr. Charyk, have you a copy?

Mr. CUTLER. You have a serious policy question whether on having appointed incorporators, whether you want all the records of their proceedings made available.

Mr. RYAN. I am not asking for all the minutes.

I am asking for a memorandum which you admit exists which raises serious questions concerning whether or not the public interest was protected by the bylaws and articles.

Mr. WELCH. Is that something we could take a little time to discuss both with our counsel and with the incorporators who were there?

Dr. Charyk and I were not present. We came late to the party, after it all had been finished.

Mr. RYAN. Wasn't Dr. Charyk there?

Dr. CHARYK. I was not. I have never seen such a memorandum.

Mr. WELCH. Nor have I.

Mr. CUTLER. We, of course, are going to provide to the committee anything the committee decides it should have and make public after due deliberation.

Mr. Woodcock voted for these articles. He was dealing with proposals which were under consideration and were amended to take account of his views and apparently to his satisfaction.

Mr. RYAN. Are you saying that all the points suggested and recommendations suggested in his memorandum were incorporated into the articles and bylaws?

Mr. CUTLER. Everyone was considered and I believe he was satisfied.

Mr. RYAN. Were they incorporated?

Mr. CUTLER. Not in the precise words he proposed. Each one was taken note of and the solution he proposed was adopted.

Mr. RYAN. I think it would be helpful to see the memorandum.

Mr. HECHLER. I don't think we ought to do anything that would inhibit the freedom of discussion of this group. We ought to consider this in that context.

Perhaps we should go ahead with the rest of the hearing. I would be hesitant to try to put a freeze on all freedom of expression by means of disclosing internal memorandums that pass back and forth.

Mr. RYAN. I am only suggesting that apparently from the testimony of Mr. Cutler there was a serious question of whether or not the public interest was being protected. Under the constitution, the bylaws and articles as now drawn, is it not a fact that the carriers

have six directors, the public has six directors, and there is no requirement that the carriers own or purchase 50 percent of the stock?

Mr. CUTLER. This is a fact under the statute. It was not one of the points which Mr. Woodcock alluded to.

Mr. RYAN. What did he allude to?

Mr. CUTLER. Do you want it on the public record——

Mr. RYAN. You said he did not allude to something, so I assume you have opened the door.

Mr. RUMSFELD. I would like to make an observation, Mr. Chairman, if I might.

Mr. RYAN. Yes.

Mr. RUMSFELD. In view of what the witness has said, would it not be appropriate in pursuing this line of questioning, to ask Mr. Woodcock, the author of the memo, to come in rather than discuss it with people who are not familiar with it.

Mr. CUTLER. Mr. Chairman, anything that the committee wants of the corporation's records which you feel is pertinent you will of course have. We ask you only whether you consider it wise to expose the record of the deliberations on preliminary drafts when the incorporators unanimously arrived at the conclusion that the final drafts were satisfactory and they discharged their responsibility and those drafts were approved by the Attorney General and the President.

Mr. HECHLER. Maybe we can ask Charley Bartlett what went on. [Laughter.]

Mr. CUTLER. We will be happy to tell you what you want to know.

There is an important policy point as to how much you should get into the deliberation of drafting the articles.

Mr. RYAN. The point, Mr. Cutler, is not any simple discussion over the draftsmanship or the language of the articles. The point is a broad point, that is whether or not the public interest has been really protected.

I think that is the point.

Mr. CUTLER. Yes, sir. And every effort was made by the incorporators and counsel to seek to do that. There was open and frank discussion among the members. They finally arrived, remarkably perhaps for so many people, at a unanimous conclusion. These drafts of articles were shown to the chairman and members of various committees of this Congress for information. We did everything we felt we could do to protect the public interest in these articles.

We believe we have and apparently the President and the Attorney General have agreed with us.

I would like to come back, sir, to the point you raised about the carriers being able to elect six directors even if they buy less than half of the stock. It is a fact that as now written this is the way the articles read. We felt and the administration attorneys felt we were compelled to this conclusion by the language of the statute.

We also felt that in the event the carriers do not buy their half of the stock, something which none of us had any reason to anticipate will happen, that we would recommend to the Congress that the statute be amended so as to provide for some proportional reduction of the number of directors that the carriers would have.

This issue was raised, discussed, and it was decided at the time, that there was no way that we, in the articles, could change what had been done in the statute.

This was point which you, among others I think, raised on the floor, the statute required this result, but we all felt that in the event the carriers do not buy their 50 percent—and as I said, we have no reason to thing they won't—the statute should be amended to allow for the correct situation.

Mr. RYAN. Do you think, when you have 15 directors, all of whom are on an equal footing, that there really is any protection provided by the fact that 3 are designated by the President?

Mr. CUTLER. Yes, sir. I think there is a very considerable protection in there.

Mr. RYAN. Do you intend to give them any extra weight in the deliberations of the committee?

Mr. CUTLER. No, sir. They are directors just like any other directors as the Attorney General has stated in an opinion he prepared for the President on this subject, but there are——

Mr. HECHLER. Let us get back to the authorization.

Mr. RYAN. We have gotten a little bit away from the issue of research and development. I raised this because the question of public interest came up in questioning Dr. Welch and I think it would be helpful to see whatever memorandum Mr. Woodcock circulated so we can see whether we feel his points were sufficiently satisfied.

Mr. HECHLER. I think we ought to reserve decision on the Woodcock memorandum for the time being.

Mr. RYAN. All right. I would like to come back now to this question of R. & D. and contracting; at what point do you expect to have issued stock so you are in a position to let contracts?

When are you going to be organized as a going concern?

Mr. WELCH. Mr. Chairman, we are working on that rather diligently right now. We have interviewed quite a number of candidates who have both applied and others who have not applied that we have gone out to seek.

This is not a rapid process. We are trying to get a very high type of talent and to lure it away from where it is is not an easy or rapid job.

I would hope that we would have our main pillars of the organization chart in-house in the course of a couple of months more.

After that, then these men will have to institute studies, contacts. work of various kinds and I would not like to say when enough of those studies will be finished and appraised and decisions taken so that we will feel that we have enough to go to the public and sell them stock.

If I were to shoot from the hip, I would say we better be thinking in terms of 15 to 18 months.

Mr. RYAN. Fifteen or eighteen months from now?

Mr. WELCH. Yes.

Dr. CHARYK. I would like to add in further response to your question, that we will likely contract for various kinds of programs prior to an initial stock offer.

Mr. RYAN. Mr. Rumsfeld?

Mr. RUMSFELD. I would like to ask two or three questions.

We talked about prestige and the need for moving ahead rapidly, generally; I would like to know what date the first member of the corporation went on the payroll.

Mr. WELCH. The executives of the corporation?

Mr. RUMSFELD. The first employee or executive of the corporation who went on the payroll, what date was this?

When were you in business as such?

Dr. CHARYK. Actually there were people working with the corporation in the final stages of the incorporation proceedings.

Mr. RUMSFELD. Prior to February 1?

Mr. WELCH. Yes.

Mr. RUMSFELD. So roughly you started——

Dr. CHARYK. There were 2 or 3 months before, one or two people who were associated with the incorporators in carrying on certain work.

Mr. RUMSFELD. There are 12 today?

Mr. WELCH. Yes.

Mr. RUMSFELD. You say your payroll is $25,000 or $30,000 a month?

Mr. WELCH. Yes.

Mr. RUMSFELD. What do you anticipate will be the number of employees in 3 or 4 months?

Mr. WELCH. About 30.

Mr. RUMSFELD. Do you have an organizational chart of the corporation?

Mr. WELCH. Not with me but we have one which provides for the main structure.

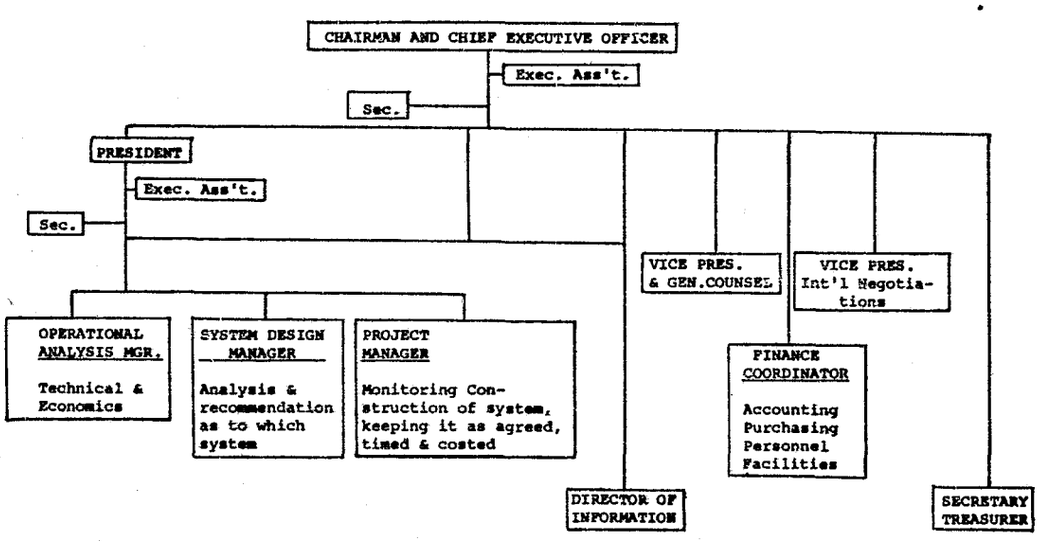
Mr. RUMSFELD. It would be helpful for the committee to have this for the record so we can see what your organization is going to be.

This will hopefully give us some clue as to the direction in which you are going.

(The information requested is as follows.)

COMMUNICATIONS SATELLITE CORPORATION

Table of Staff Organization for Initial Phase



Mr. RUMSFELD. Would this give us some idea as to the level of priorities you have established for some of these hundreds of problems whlh you as a corporation are facing?

Mr. WELCH. Yes.

Mr. RUMSFELD. Do you have additional information on that which might be enlightening to us as to the priorities?

Mr. WELCH. Yes, I think we have.

I am going to ask Dr. Charyk if he would like to discuss, in answer to your question, the communications side of this thing, that is what he envisions as the structure which he will create and bring about for the operating and implementation of the actual communications part of the entity. Over and above that, there will be the financial, the legal, the public relations, the administrative and such things as that.

I think Dr. Charyk might like to fill you in on that.

Mr. RUMSFELD. If that could be submitted for the record, it would be helpful.

I know time is short and the committee has other questions.

How are you currently financing your operations?

Mr. WELCH. We are working under a $5 million bank loan that is arranged with 10 banks.

Mr. RUMSFELD. When do you anticipate this will be used up?

Mr. WELCH. I am shooting from the hip now, Mr. Rumsfeld, because I am not certain but I would think that $5 million would probably go us for about the first 12 months.

Mr. RUMSFELD. You anticipate that the first stock offering might be in 15 or 18 months?

Mr. WELCH. Yes.

Mr. RUMSFELD. So you are going to have to do something in the middle?

Mr. WELCH. If we run out of money we will probably have to get another bank loan.

Mr. PELLY. I would like to return to the matter of the corporation having some sort of contract with NASA covering the relationship and the various adjustments that will be made in the future.

As I see it now, it is wide open.

Mr. WELCH. Could I refer that to you, Dr. Charyk?

Dr. CHARYK. I am not sure what I can add to what has already been said.

We will be contracting during the coming months for various studies and perhaps experiments. We will make a determination as to whether we will let such contracts directly with the industry or whether we will ask the Space Administration to use their good offices to assist in the work, and we will, of course, in each case work out the arrangements for reimbursement.

Mr. PELLY. Isn't there now a general understanding as to which areas the Government will take and which the corporation will undertake to pay for?

Dr. CHARYK. Our problem is to outline as I indicated the specific work that needs to be done from the development point of view, the specific studies that need to be conducted to make a determination as to the best approach and then work toward the actual design specifications of the system. These will be the areas in which we will initiate work in the coming months.

Mr. RUMSFELD. I understand that, Mr. Sundlun mentioned before the Senate that there is a possibility that the corporation would perform work for other corporations.

It strikes me that Mr. Pelly's question when related to Mr. Sundlun's statement poses an area of some concern.

Dr. CHARYK. I think we are going to have our hands full for the immediate future without worrying about doing work for someone else. I think Mr. Sundlun was referring to the fact that down the road, after we are solidly in business, he did not want to exclude the possibility that we would do work upon request. That is not contemplated in the immediate future.

Mr. RUMSFELD. I would say that the lack of a well-defined relationship with NASA coupled with this possibility of doing work for others poses an area that certainly the Congress would be concerned with as to a possible transfer of this information from NASA to you, then to be contracted out to other private concerns.

In other words, before you get down the road as you say, I would think you would have to have very clear relationships with NASA.

Dr. CHARYK. Actually the work that is being undertaken by NASA or rather, the results of their experiments, are available pretty much to the industry at large.

We would anticipate that we would have the benefits of the results of the work in the same fashion as other corporations have these benefits.

Mr. RYAN. I think Mr. Rumsfeld has raised a very good point because it is true that Mr. Sundlun testified before the Senate committee that he believed it was possible, before there was a profitable communications system, for this corporation to engage in outside work and receive revenue from outside sources such as technical research.

Do you consider that the act contemplated that the Communications Satellite Corp. would be engaging in other work besides the development and operation of the communications satellite system?

If so, I think we ought to have that very clear right now.

Dr. CHARYK. I think the situation is that the act did not exclude the possibility. From a realistic point of view, I would repeat what I said a few minutes ago. We are going to have our hands full with the job in hand without worrying about taking on additional work.

I think the point that Mr. Sundlun was making was that the act did not or should not exclude the possibility that down the road we could receive contracts for work.

Mr. RYAN. I think this is a far cry from what Congress was thinking about when it enacted this law, but I also believe Mr. Sundlun was not just speculating when he made this statement or why did he make it?

He was talking about a source of revenue in the interim between now and the time the system becomes profitable in operation.

It would be helpful to have an affirmance or a denial of that possibility.

Mr. WELCH. Mr. Chairman, I talked to Mr. Sundlun about that and what Dr. Charyk said I think is the case.

I don't think he had in mind an interim case of the corporation doing research or any other type of work for outside interests for income. It is not going to be equipped to do that.

I think what he had in mind was maybe the day will come when we will get into that position. As of now, that day is so far off that we don't think we are looking at it so if I were to try to straighten it out, I would just discard that.

Mr. RYAN. Before you have a public issue, what are you going to use for funds and how much do you anticipate funding in terms of contracts for research and development or for studies?

Mr. WELCH. We can't tell you that right now. We have got to be a little older in our shoes before we do. We have got to have these men aboard that I have been telling you about that we are looking for who will have instituted the studies upon which to base these outlays, but we can already see the possibility in the fairly near future of instituting some research contracts of somewhere between half a million and a million dollars.

Mr. RYAN. In what field? Contracts on what? Research on what?

Mr. WELCH. Research leading toward the choice of satellite system, some of the initial clearing away of the brush.

Mr. RYAN. You mean low altitude versus medium altitude versus synchronous?

Mr. WELCH. That is right.

Mr. RYAN. There is no possibility that you would have your first system a synchronous system?

Mr. WELCH. I would doubt it but I would not be so bold as to sit here and say there was no possibility of it. If you listen to the people who oppose it, they will tell you there is no use wasting your time on anything like that.

You can't lightly come to a decision like that.

You have got to study it and thread it through.

Mr. RYAN. The Department of Defense is going to construct and operate, they maintain, by early 1965, a medium altitude system.

Dr. Charyk, when you were in the Department of Defense, were you concerned with the research and development of that system or any satellite work?

Dr. CHARYK. In my official capacity as Under Secretary of the Air Force, I, of course, had responsibility across the board as far as the Air Force is concerned. In the case of the defense communications system, the Air Force is responsible for the satellite portion of the program, the Army is responsible for the ground portion, and the overall responsibility is vested in the Defense Communications Agency.

Mr. RYAN. Do you believe that the Department of Defense will have an operational capability, as Mr. Rubel put it, by early 1965?

Dr. CHARYK. I would estimate that the best dates today would be the latter part of 1965.

As I understand the situation, the Department of Defense is planning to initiate in the very near future, system definition or program definition studies with one or two contractors and the final decision then would be made at the end of the program definition phase which would probably be this fall.

I think they estimate something like a 2-year development time after this point as a minimum.

Mr. RYAN. Cannot a great deal of the research and development and the studies that have gone into the Defense Department system be useful to the Communications Satellite Corp.?

Dr. CHARYK. Actually, the characteristics of the defense system are really quite different from those of the commercial system. The main interest in the case of the defense system is in passing information critical to the national security; hence secure communication is important. The capacity requirements are very low; they are talking about something like only two duplex voice channels. Also, one of the essential system characteristics is the ability to rapidly install terminal facilities anywhere in the world, so they are talking in terms of mobile facilities and this puts a rather strong input into the systems design.

We anticipate that we will certainly be talking large, high capacity permanent terminal facilities as contrasted to very low capacity mobile facilities.

We are not interested in security so there is quite a wide difference in our respective interests and this in turn reflects very strongly on the type of system that makes the most sense.

Mr. RYAN. As you sit here now, what type of system makes the most sense to you?

Dr. CHARYK. Well, I don't think that we are in a position to make a final determination. I think it could be summarized by saying that obviously more information is available on the medium altitude system, the synchronous system offers certain unique advantages, but the real question there is whether the development problems which still remain can be adequately solved in a short enough period to permit one to proceed with high confidence on a design of that type.

Another factor that still needs to be better defined in the case of the synchronous system is the effect of the time delay in the transmission of the signal on the quality of the communications.

With the synchronous system at 22,000 miles, you have something like 0.6 second time delay involved. I think a series of experiments needs to be conducted to determine whether a delay of that type will be tolerated by the general public.

Mr. RYAN. Who do you think should conduct those experiments?

Dr. CHARYK. I think that the Federal Communications Commission is charged with finally approving the technical characteristics of the system which we recommend.

I would imagine that one of the factors that they would consider in making their determination would be whether the quality of service that would be rendered by the system in question would be adequate and one of the factors there that they would have to consider would be whether the lag was going to be a serious obstacle or not, so I would imagine that they would have an interest in the conduct of such experiments.

Mr. RYAN. It is your suggestion that the FCC should pay for the conduct of those experiments?

Dr. CHARYK. No. I don't think that there would be a significant price tag involved in conducting such experiments, but I do say that it is one of the factors involved in a synchronous system.

In order for the test to be realistic, it would have to use real subscribers, real telephone subscribers.

Mr. RYAN. It would have to use real synchronous satellites, too?

Dr. CHARYK. No; you could introduce the delay artificially.

Mr. RYAN. Hasn't it been tried?

Dr. CHARYK. Under controlled conditions, but I think it does not necessarily follow that the controlled experiments are typical of how the public at large might respond.

This is a very complicated question and I am not sure that a hard answer is possible without having exposed a large cross section of the using public to the type of delays that would be involved in the synchronous system.

Mr. RYAN. I think, Mr. Welch and Dr. Charyk, we still have not come to grips with the question which Mr. Pelly raised and which I raised earlier in my opening statement and that is the extent to which NASA should be reimbursed, if at all, for the research and development and for the benefits which will inevitably flow to this corporation.

Mr. Pelly spoke of a possible contract spelling this out. I think the committee should be satisfied.

Speaking for myself; I don't think you satisfied me that you have any firm plans to set up the framework for reimbursing NASA for the work it is doing.

We have a budget here of $51 million. Included in that budget is a lot of work, a lot of study on intermediate altitude satellites, $2 million for that.

There are many other study areas. It seems to me that all of this is going to flow to the benefit of your corporation and that it is incumbent upon you to explain to the Congress whether or not you expect to receive this research and development as a subsidy or whether you expect to reimburse the Government for it.

Did you give any thought or has any thought been given to giving NASA shares of stock in exchange for this research and development technology?

Dr. CHARYK. As far as the NASA program is concerned, I am assuming that the program which they are recommending to the Congress is the program that they feel it is necessary to conduct in the public interest.

It is up to the Congress to decide whether those funds will be appropriated or not. Our mission is clear; namely, we have the job of establishing a commercial communications system as expeditiously as possible and we will proceed toward that goal as vigorously as we can.

The determination which the Congress will ultimately make as to whether funds are made available to NASA or not will certainly have an effect upon the specific program that we will have to conduct in order to achieve our goals.

It might have an influence on the type of system that we ultimately select. I assume that the NASA program has been put together on the basis of what they feel to be in the national interest and I believe it is up to the Congress to make a determination as to whether those funds should be appropriated or not.

Mr. PELLY. Mr. Chairman, could I ask Dr. Charyk if he feels that his corporation is subject—as a creation of the Congress—is subject to audit by the General Accounting Office?

Dr. CHARYK. I would not think so.

Mr. CUTLER. We are subject to the most complete kind of accounting supervision and audit by the Federal Communications Commission.

Mr. PELLY. But you don't feel that the General Accounting Office has any responsibility to enter into and see whether the act is being carried out?

Mr. CUTLER. They will do anything Congress asks them to do, and I suppose they also have supervisory power over the FCC but we are under the most complete kind of control in our accounting, the expenditure of our funds, and even the raising of our funds and purchasing.

Mr. RYAN. Mr. Wydler?

Mr. WYDLER. I don't know what is really bothering the members of this committee, but we all seem to have a feeling and I think we are unanimous, that somehow and for some good reason this Communications Satellite Corp. should start to really get into the act.

I want to tell you why I feel that way. I was not here when this was voted on last year. I do believe free enterprise will do a better and more economical job in this field as in any field, but I don't think we are going to have any free enterprise operating in this area until we get some money from free enterprise.

Until that happens, I would be afraid that what is taking place is this: A hard business decision has been made and a sensible one to let the Government go ahead with a full-scale research program in every area of communications satellites and get the answers to all the problems.

If that is what is going to happen and that is what is happening because NASA's program wasn't changed one iota by the passage of the communications satellite bill nor do I think it will be changed, until such time as this corporation asserts its responsibility in this area.

The question I would like to see answered and I would like the question Mr. Ryan asked answered. What would this corporation with private money really be willing to pay for in the NASA budget?

What would they really think was worthwhile?

What is so far out that it is not economically sound to invest in?

I would like the answer to that question as a Member of Congress. That is why I am interested in the questions that have been put today. I want to get the benefit of this free enterprise system, but I am afraid we are never going to get it until we get the free enterprise money into this program.

Then I am willing to take a look at the NASA program in the light of that. This is what I have in mind. This is why as a member of this subcommittee I am urging you quite frankly with all my heart to please get going and get the free enterprise system working in this communications field as fast as possible for the benefit of the people of this country. That is how I feel about it.

Mr. WELCH. Mr. Wydler, I certainly agree with that. I think you are pointing up a question here—the thread of which has run all the way through the whole discussion and that is what the chairman referred to in the beginning.

We believe that it was Congress' idea and it has been reflected in the various discussions, that NASA would continue to do a certain amount of research in the communications field anyway, because the Government has great interest in communications over and above the presence of the Satellite Corp. If it came or it did not come about, they would have still had this interest and we believe NASA would have undertaken a great many of these studies whether the corporation existed or not.

It is not the intention of the corporation to try to cadge a free ride. They, NASA, will continue on a wide band of investigation.

We hope to come to them and say we want help in some particular section.

We shall talk about how it is going to be done, how much it is going to cost and we will negotiate out the terms of paying for it. We are not looking for a free ride. We expect to pay our way. I don't know if that clears up any of the area we have been discussing. That is our feeling. We will not be in a position to undertake great expenditures until we are solvent, until we have our money, until we get going; once we get into a revenue making condition, profit condition, we can embark out on further scope.

In the meantime we have to cut our cloth to fit such resources as we have.

Mr. RYAN. In the interim period, while you are relying on NASA to do the work and spend the public funds, why not issue stock certificates to NASA?

Mr. WELCH. I think probably by the time we come to close contracts with NASA, Mr. Chairman, we hope to be able to pay them for what we ask them to do.

Mr. RYAN. But you have constantly said you are willing to pay NASA for what you ask them to do. The question is what are you going to gain from NASA research that is going to flow automatically to you, this year $51 million; last year $43 million?

Much of these funds from NASA and DOD have gone into research.

Mr. WELCH. I don't think all of that $51 million is primarily going to flow from NASA to the corporation. I think there are certain good areas that will come to us as benefits, but I don't believe that that is primarily being done all to be turned over to the corporation.

Now I defer to my distinguished colleague who views this technical side of it much more clearly than I do.

Mr. RYAN. The real question is can we arrive at a formula now for sharing the costs of this program, perhaps between NASA, Communications Satellite Corp., and the Department of Defense?

The Department of Defense has a lot of money in this.

Dr. CHARYK. I would not view the NASA program as being a program for the benefit of the Communications Satellite Corp. at all. I think their program is a broad gage program put together in the public interest and put together on the basis of doing the broad gage work that they deem to be necessary for their programs and for the programs of other Government agencies.

The benefits from this work will flow not only to the Government but to the entire industry and as part of that industry, we will, of course, be partial beneficiaries.

Mr. RYAN. But you are the only part of the industry that has a monopoly on the operation of commercial communication satellites for profit.

Mr. WYDLER. I think what we may be doing is asking these gentlemen to answer a question that is really a question we have to answer as Congressmen and we are asking them to say in effect that the entire $51 million program that NASA is asking us to authorize for this communications satellite field is going to the corporation's benefit.

The only way to get to the truth of that, is to ask how much would they spend of their own money for this program if they were faced with this decision. That is the question we have to ask ourselves. How much of this expenditure is sound and justified and reasonable

and this is why I don't think we are getting the answer to the question that you are asking because you are asking them in effect to review NASA's program and I don't think they are willing to do that.

Dr. CHARYK. I don't think we are in a position to define specifically the things that we are going to do as of today. We certainly anticipate, as I said earlier, in the coming months to actually sponsor various kinds of activity directed at the definition of the type of system toward which we are going to proceed, and at the definition of the specific research areas that are going to have to be explored in order to provide the answers for that design.

I think at the time that we define that program, we can address ourselves in a much better fashion to the type of question that was raised.

Mr. PELLY. Mr. Chairman?

Mr. RYAN. Yes, Mr. Pelly.

Mr. PELLY. I wonder if the corporation is not under the jurisdiction of another committee.

Our interest is this $51 million. The thing that concerns me if there were an appropriation for the Defense Department, if there were any additional funds deemed necessary by the Secretary of Defense, it would be submitted to the appropriate committee of Congress and it would be approved.

Here we are with $51 million which we don't understand very well I don't think, speaking for myself anyway; I know if Mr. Webb suddenly decides he wants additional millions he can reprogram without ever coming first to the committee. I feel that my responsibility is to find out how much money is necessary in the interest of science and not to give anybody an opening so that they can completely change the figures with only giving me word of it but not asking me to exercise my responsibility.

I don't like this flexibility to reprogram funds and I will say so.

Mr. RYAN. I think you have raised a valid point, Mr. Pelly.

I think that also in your efforts this morning to have the representatives of the corporation come to grips with the question you have served a very important purpose because I do think that it would appear that the corporation is relying and will rely in the future on the continued public expenditure of funds by NASA to do the research and development.

If Congress is going to continue to subsidize the research and development on communications satellites, then we have an obligation to see that the public interest is protected and that is why I question whether we can view this corporation as essentially a private corporation with responsibility solely to its stockholders or whether there is an element of public interest which must be protected, whether this means that the Presidential directors should have a greater voice than is presently contemplated in the affairs of the corporation, whether it means that the communication carriers should have proportional representation to their stockholdings—these questions are legitimate questions.

These are the questions which I was trying to raise alluding to the fact that there was a disagreement among the incorporators at the beginning as to whether or not the public interest was truly protected under the proposed bylaws and articles of incorporation.

I think there are other questions.

What about the ownership of the ground stations? Is it your contemplation that the Communications Satellite Corp. will control and own the ground stations?

Mr. WELCH. We have not come to grips with that, Mr. Chairman. We are studying that now in a preliminary way, but I don't think I can give an answer to that until we have gone quite a lot further into the economics of this situation.

I think it would be very useful for the corporation to own the ground stations but——

Mr. RYAN. I would go further than that and say that I would think that it would be essential, if you want my opinion.

Mr. WELCH. I want to be sure that we have studied the economics of that and are aware of the advantages and disadvantages of that before trying to answer that.

Mr. RYAN. Let me raise another question which I think is an important policy question.

If the Government is going to continue to subsidize the Communications Satellite Corp., and I don't think it is not, has any thought been given to providing preferential Government rates for Government users?

The Voice of America is talking about needing a means to communicate with underdeveloped areas. The Defense Department is talking about using commercial systems except for its special communications needs.

Have you given any thought as to preferential rates to the Government?

Mr. WELCH. Again, I say we have not come to grips with that. I only got my chair, Mr. Chairman, on the 1st of April and I have learned from many years of experience in business that when you rashly announce decisions without having studied the subject back of them, they often come back to plague you and I would not like to make any rash statements here that I would find coming back to plague the corporation.

I think we can beg for a little more time before we try to answer some of the issues you are raising.

Mr. HECHLER. I would only suggest that we in Congress have to make some rash decisions about the authorization.

In asking these questions we are only asking questions to enable us to make the decisions which we will have to make perhaps before you do.

Mr. RYAN. If we may, and I know it is almost 12 o'clock, I would like to explore another area briefly.

Mr. Welch said he thought it would take 15 to 18 months before the corporation would issue public stock.

In the meantime, what negotiations, if any, have been started or do you expect to initiate with foreign nations concerning foreign investment and do you view the timing of the issuance of stock as dependent upon the conclusion of agreements with foreign countries?

If so, why? That is a broad question.

Mr. WELCH. We certainly have the intention of moving right in on the discussions with the foreign governments as soon as we feel we are prepared to. This is an area that we have got to do a lot of homework on our own before we talk with foreign governments, before we try to match cards with them.

This is an extremely involved area as we are going to be talking to these people as prospective partners.

As such they are going to want to know an awful lot about what we are going to do, how we are going to do it, and they are going to take a very hard look at the invitation to put up their share of the money, so, as far as we can get ourselves in a position to go over to talk with the foreign governments, we are going to do it, but we are certainly not there yet.

Mr. RYAN. It is 12 o'clock and time to adjourn, unless there are any further questions.

Mr. HECHLER. I think we ought to end on a high and happy note.

What does the corporation expect to get out of Telstar II?

Dr. CHARYK. I believe the committee probably has been fully briefed on the difficulties which Telstar I encountered.

There have been incorporated in Telstar II certain fixes aimed at curing the difficulties encountered in Telstar I.

Whether the diagnoses were correct or not will certainly be of importance and interest to us in looking at the problem of designing a satellite of our own.

Mr. PELLY. Mr. Hechler, you might find that there is a problem that Telstar I did not have and that is that there are going to be pickets down on Cape Canaveral starting May 2 and it may never get off the ground.

The International Machinists Union are going to start covering the country on their Boeing contract, so it may start with a new problem we never had before.

Mr. HECHLER. Thank heavens we don't have to solve that, at least not this morning.

I want to renew my personal appreciation to Mr. Welch and Dr. Charyk for their appearance this morning. Your testimony has been helpful. I hope we can proceed a little bit more specifically toward defining the lines of demarcation between NASA and the Communications Satellite Corp.

If we can go in that direction, it would be helpful.

Mr. RYAN. I want to thank you gentlemen for the time you have taken to be with us. There were some questions which Mr. Boone prepared. Could we submit them to you and ask you to provide written answers for the record?

Dr. CHARYK. Yes.

Mr. RYAN. I am referring to questions which we were not able to cover in our testimony this morning. The questions are as follows:

1. When initially operational, what services; i.e., voice, data, transmission, and television does the corporation plan to provide?

2. At what point in time do you expect that the corporation will be economically competitive with existing oversea communications services? What are the revenue prospects for the next 10 years? What is the expected income by years and when will the profit level be commensurate with existing oversea carriers?

3. The committee is interested in knowing when the corporation will have funds available to finance their own research and development program. What factors will determine the amount of the first stock offering and what is a reasonable amount for this offering?

4. Have any carriers been authorized by FCC to purchase stock and if so, what percentage and dollar amounts have or will be authorized?

5. Would you favor changing Public Law 87-624 in any way? If so, how?

6. In reply to Mr. Ryan's question, "Do you consider that the act contemplated that the Communications Satellite Corp. would be engaging in other work besides the development and operation of the communications satellite system?",

Dr. Charyk said, "I think the situation is that the act did not exclude the possibility from a realistic point of view." The committee would like opinion of counsel to the corporation of whether or not the corporation has the power under the act to engage in R. & D. for outside firms in any field. If so, what authority does counsel cite?

7. Dr. Charyk testified that there were meetings with the Director of Defense, Research and Engineering, and with Dr. Fubini of his staff and that he has had perhaps a half dozen such meetings. In any meetings or discussions with any representative of the DOD has there been any discussion of the possibility of the corporation contracting to do R. & D. for DOD? If so, with whom were the discussions held, where were they held, and when did they take place? Was any understanding reached? Please furnish complete details.

8. Were any such discussions held with NASA? If so, give details.

COMMUNICATIONS SATELLITE CORP.,
Washington, D.C., May 20, 1963.

Mr. W. H. BOONE,
Technical Consultant, Committee on Science and Astronautics,
House of Representatives, Washington, D.C.

DEAR MR. BOONE: Enclosed are the answers to the eight questions which you forwarded with your letter to me of May 8 for inclusion in the record of the hearings held by the Subcommittee on Applications and Tracking and Data Acquisition on April 30.

Sincerely,

JOSEPH V. CHARYK, *President.*

ANSWER TO QUESTION NO. 1

It is envisoned that the initial system will have a capability for data, voice' and television transmission. The total capacity of the system and the flexibility of service between these various forms, remains a matter for further study.

ANSWER TO QUESTION NO. 2

An adequate answer to this question is unavailable at this time. The planned studies over the coming months will provide bases for considerations of this type. Key questions relate to the anticipated growth rate in international traffic, the stimulus on such growth that a commercial communications satellite system will produce, the development and implementation of communications capacity by other means, and, of course, adequate estimates of the cost of establishing and maintaining a communications satellite system. These factors are key elements in the studies now being undertaken. An adequate assessment of the financial picture will not be possible until after the completion of these studies.

ANSWER TO QUESTION NO. 3

The commitment of major financial resources can only be justified after extensive studies of the type noted in the response to the previous question are available. As has been noted, a key element in the initial phase of our activities will be the selection of the optimal approach, the determination of the research and development questions that need to be answered, and the development of the schedules for achieving the technical milestones and the capital requirements therefor, together with a determination of the nature and extent of foreign participation in the system. It is envisioned that the amount of the initial stock offer will be based on judgments as to (*a*) the estimated capital requirements necessary to achieve an initial operating capability, (*b*) the portion of these requirements that should be raised by sale of common stock and the portion that should be raised by other means of financing, and (*c*) the desirability of raising the required funds through a single financing operation or a series of operations over a period of time as funds are needed to establish the operational system.

ANSWER TO QUESTION NO. 4

It is our understanding that more than 80 carriers have applied to the FCC for permission to qualify as purchasers of stock. Actual subscription amounts will, of course, not be known until the time of the initial stock offering.

ANSWER TO QUESTION NO. 5

There are no specific suggested changes in Public Law 87–624 at this time. With respect to questions raised in the confirmation hearings before the Committee on Aeronautical and Space Sciences in connection with representation on the board of directors, the incorporators who now constitute the initial board of directors have indicated that in the event the communications carriers do not subscribe to 50 percent of the common stock offered by the corporation—an event which the board has no reason to believe will occur—that the board will recommend to the Congress an amendment of the act to require carrier representation on the board to be proportionate to the amount of stock subscribed.

ANSWER TO QUESTION NO. 6

See attached letter to Mr. Welch from the law firm of Wilmer, Cutler & Pickering, dated May 17, 1963.

ANSWER TO QUESTIONS NOS. 7 AND 8

There has been no discussion of the possibility of the corporation contracting to do research and development for either the Department of Defense or NASA.

WILMER, CUTLER & PICKERING,
Washington, D.C., May 17, 1963.

MR. LEO D. WELCH,
Chairman, Communications Satellite Corp.,
Washington, D.C.

DEAR MR. WELCH: We have been asked for our opinion as to whether or not the Communications Satellite Corp. has the power to engage in research and development work for other firms in any field.

The corporation's powers are governed by the Communications Satellite Act of 1962 and by the articles of incorporation filed pursuant to that act, with the approval of the President of the United States, on February 1, 1963.

Section 305(b)(1) of the act provides that "included in the activities authorized" to the corporation is the power "to conduct or contract for research and development related to its mission."

This same language is included in section 3.02(b)(4) of the articles of incorporation.

The word "mission" is not a defined term in the act. From section 102 (a) and (c), however, the corporation's mission appears to be very broad. It is to serve as the U.S. participant in "a commercial communications satellite system, as part of an improved global communications network, which will be responsive to public needs and national objectives, which will serve the communications needs of the United States and other countries, and which will contribute to world peace and understanding" (sec. 102(a)).

The statute and articles authorize the corporation to "conduct or contract for" research and development work. In our opinion this language means that such work may be done either by the corporation itself, by third persons for the corporation, or by the corporation for third persons.

There are many types of research and development work which relate to the establishment and operation of a commercial communications satellite system, including the development of satellites and components, ground stations, related electronic equipment, positioning in orbit, effects of space environment, and many other subjects. It is conceivable that, after the corporation has established its own research and development capability, various entities, including the U.S. Government, foreign governments, communications companies, and others, might desire to take advantage of the corporation's special capability and might contract with it to perform research and development work related to communication by satellites. In our opinion, both the Communications Satellite Act and the articles of incorporation filed pursuant to that act clearly authorize the corporation to engage in such activity.

It does not seem feasible to attempt at this time to define the precise boundaries of research and development work related to the corporation's mission. This can best be done on a case-by-case basis as the corporation proceeds.

Sincerely,

Lloyd N. Cutler

An inquiry was addressed to the National Aeronautics and Space Administration and to the Communications Satellite Corp. requesting their views on a proposal in the National Aeronautics and Space Administration Authorization Act, language which would require the Communications Satellite Corp. to pay, compensate or reimburse NASA for expenditures in research and development for the benefit of the Communications Satellite Corp. The Administrator would transmit reports on this determination to the appropriate committees of Congress.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION,
OFFICE OF THE ADMINISTRATOR,
Washington, D.C., June 14, 1963.

Hon. KEN HECHLER,
Chairman, Subcommittee on Applications and Tracking and Data Acquisition, Committee on Science and Astronautics, House of Representatives, Washington, D.C.

DEAR MR. CHAIRMAN: Your letter dated June 12, 1963, requested our views on a proposal which your subcommittee is considering to include language in the National Aeronautics and Space Administration Authorization Act for fiscal year 1964 "which would require the Communications Satellite Corp. to pay, compensate or reimburse NASA for expenditures in research and development for the benefit of the Communications Satellite Corp."

The Congress carefully considered this matter during the hearings on H.R. 11040, which was signed into law on August 31, 1962, as Public Law 87-624, "Communications Satellite Act of 1962," and, in section 201(b), provided that "the National Aeronautics and Space Administration shall—

* * * * * * *

"(3) assist the corporation in the conduct of its research and development program by furnishing to the corporation, when requested, on a reimbursable basis, such satellite launching and associated services as the Administration deems necessary for the most expeditious and economical development of the communications satellite system;

* * * * * * *

"(5) furnish to the corporation, on request and on a reimbursable basis, satellite launching and associated services required for the establishment, operation, and maintenance of the communications satellite system approved by the Commission; and

"(6) to the extent feasible, furnish other services, on a reimbursable basis, to the corporation in connection with the establishment and operation of the system."

The Congress carefully defined, in section 201 of the act, the categories of services for which the Communications Satellite Corp. was to reimburse the National Aeronautics and Space Administration. We, in NASA, agree with the statutory language of the Communications Satellite Act of 1962 and believe that no further legislation to broaden these categories is desired.

Sincerely yours,

HUGH L. DRYDEN.

COMMUNICATIONS SATELLITE CORP.,
Washington, D.C., June 17, 1963.

Hon. KEN HECHLER,
Chairman, Subcommittee on Applications and Tracking and Data Acquisition, Committee on Science and Astronautics, House of Representatives, Washington, D.C.

DEAR MR. HECHLER: I am in receipt of your letter of June 12 to the effect that the Subcommittee on Applications and Tracking and Data Acquisition of the Committee on Science and Astronautics of the House of Representatives has under consideration a proposal to include in the National Aeronautics and Space Administration Authorization Act language which would require this corporation to pay, compensate or reimburse NASA for expenditures in research and development conducted for the benefit of this corporation.

I am attaching herewith for your information and use a detailed statement of the corporation's attitude in this matter, including a legal assessment of the question. I am also enclosing for your use, if you should so desire, a short summary paper which highlights our major reasons for feeling that such an amendment would be unwise and would seriously handicap the achievement of the major purposes of the Communications Satellite Act.

I appreciate the subcommittee's courtesy in inviting us to express our ideas in this matter.

Sincerely,

LEO D. WELCH,
Chairman of the Board.

Enclosures.

SUMMARY OF ATTACHED STATEMENT IN BEHALF OF COMMUNICATIONS SATELLITE CORP.[1]

The proposal has been made to include language in the NASA Authorization Act which would require the Communications Satellite Corp. to pay, compensate, or reimburse NASA for expenditures in research and development conducted for the benefit of the Communications Satellite Corp.

This proposal, we believe, is contrary to the provisions of the Communications Satellite Act and would, in effect, constitute an amendment of the Communications Satellite Act inconsistent with the clear intent of the Congress in enacting the act and inconsistent with the national policy declared by Congress in the act.

The proposal ignores the fact that NASA research and development in the communications satellite field and in related areas is essential if NASA is to carry out its own responsibiltities under the Communications Satellite Act, as well as under the National Aeronautics and Space Act, and that such continued research by NASA, without reimbursement from other sources, was clearly envisioned at the time of the passage of the act.

A practical point in the consideration of such an amendment is the fact that it would be exceedingly difficult, if not impossible, to administer as between NASA and the Communications Satellite Corp. NASA has a national responsibility to provide a balanced research and development effort in many fields. Within this total effort it is unreasonable to expect NASA to define at the outset the portions of their research and development efforts which may be beneficial to the Communications Satellite Corp. and to specify the degree of benefit. A fundamental aspect of research and development is that it is impossible to define its ultimate application or degree of application. It may not be possible to determine such benefits for many years after the project has been initiated. It is obvious that the coproration and NASA would find extreme difficulty in arriving at an equitable monetary settlement for such undefined efforts.

In addition, the Communications Satellite Corp. would be in the untenable position of being asked to accept charges for NASA research and development programs which have broad application but in which the corportion had no voice in program determination or direction and no part of which it had requested.

Finally, such an amendment to the NASA authorization bill would be inequitable unless directed not only to the Communications Satellite Corp. but to all communications and aerospace companies who will in the future, as they have in the past, derive benefits from NASA research and development programs as well as from all Government research and development programs. It is obvious that the corporation will have no monopoly on such benefits in any meaningful sense. Its system must compete with all forms of telecommunications. Other carriers may be authorized under the law to engage in the development and operation of satellite terminal facilities. In addition, other private companies will directly benefit from contracts for the development and manufacture of hardware for the entire system. NASA research and development efforts will assist directly in providing a basis for such a capability.

STATEMENT IN BEHALF OF COMMUNICATIONS SATELLITE CORP.

This statement is submitted by Communications Satellite Corp. (the corporation) for the purpose of expressing the views of the corporation with respect to a proposal that there be included in the National Aeronautics and Space Administration Authorization Act language which would require the corporation to pay, compensate, or reimburse NASA for research and development conducted for the benefit of the corporation.

We recognize, of course, that under the provisions of the Communications Satellite Act (the Satellite Act) it was contemplated by the Congress, as stated

[1] Page references are references to a more detailed statement of the subject in the attached statement.

in subparagraphs (3), (5), and (6) of section 201(b) of the act, that the corporation would reimburse NASA for satellite launching and associated services requested by the corporation and for other services in connection with the establishment and operation of the satellite system.[1]

The appropriateness of reimbursement by the corporation of NASA for such services was recognized by Leo D. Welch, chairman of the board, and Dr. Joseph V. Charyk, president, in testimony given by them before the Subcommittee on Applications and Tracking and Data Acquisition of the Committee on Science and Aeronautics of the House of Representatives on April 30.

Insofar as services of the nature referred to above are concerned, we point out that the Satellite Act itself contemplates reimbursement by the corporation of NASA for such services, but we believe that it is clearly intended that the measure of such compensation would be the cost incurred by NASA in the furnishing of such services, and would not be determined by an evaluaton of the benefit to the corporation resulting from such services. For reasons mentioned below, we believe that any measure of reimbursement of NASA based upon benefit to the corporation rather than upon cost to NASA would be unfeasible and was not intended by the Congress, and we assume that the language which it has been suggested be included in the NASA Authorization Act would not affect the basis of reimbursement by the corporation of NASA for the above-mentioned services in accordance with subparagraphs (3), (5), and (6) of section 201(b) of the Satellite Act.

We respectfully submit, however, that, for the following reasons, theNASA Authorization Act should not include language which would require the corporation to pay, compensate, or reimburse NASA for research and development from which benefit is derived by the corporation:

(i) NASA research and development in the satellite communications field and in related areas is essential if NASA is to carry out its own responsibilities under the Satellite Act, as well as under the National Aeronautics and Space Act;

(ii) NASA's communications satellite program is and will continue to be of great value to other phases of the national space program unrelated to communications satellites;

(iii) Requiring the corporation to compensate or reimburse NASA for expenditures in research and development from which the corporation "benefits" would discriminate against the corporation and would be impracticable in application; and

(iv) Requiring the corporation to compensate or reimburse NASA for expenditures in NASA's own research and development program would also be contrary to the provisions of the Satellite Act and would in effect constitute an amendment of the Satellite Act inconsistent with the clear intent of the Congress in enacting the act and inconsistent with the national policy declared by Congress in the act less than a year ago.

A more detailed statement of these reasons appears below.

(i)

Research by NASA in the field of satellite communications and related areas is essential if NASA is to discharge its responsibilities under the Satellite Act, as well as under the National Aeronautics and Space Act of 1958. These responsibilities are to insure the continued preeminence of the United States in peaceful applications of space technology (sec. 102(c)(5), National Aeronautics and Space Act of 1958); to advise the Federal Communications Commission on the technical characteristics of the communications satellite system (sec. 201(b)(1) of the Satellite Act); to consult with the corporation on technical characteristics of the communications satellite system (sec. 201(b)(4) of the Satellite Act); to advise the Secretary of State on technical feasibility of particular routes (sec. 201(a)(3) of the Satellite Act); and to cooperate with the corporation in research and development to the extent deemed appropriate by the administration in the national interest (sec. 201(b)(2) of the Satellite Act).

The provisions of the Satellite Act referred to above are statements of some of the ways in which, by the terms of the act, the U.S. Government is to further the national policy stated in the act—the policy that the United States, in cooperation with other countries, shall establish as expeditiously as practicable a commercial communications satellite system (secs. 102(a), 201(a)(1) of the Satellite Act). The responsibilities of the Government in furthering this national policy were

[1] The test of sec. 201(b) of the Satellite Act is set out in the appendix to this attachment.

emphasized by President Kennedy in his report to the Congress on activities and accomplishments under the Communications Satellite Act. The President stated:

"Under the Communications Satellite Act, the U.S. Government has basic responsibilities in meeting the goal of an operational satellite system. The act calls for the planning, development, and execution of a national program to establish a commercial communications satellite system. Such a national program involves significant activities on the part of a number of Government agencies, and a vigorous effort has been made to coordinate the activities of the agencies interested in space communications to promote a full and effective program. The main areas of Government action are related to regulatory, technical, and international responsibilities." [1]

The concept that the corporation ought to pay NASA for the benefits of NASA research wholly ignores the fact that such research has been and is being conducted in furtherance of a national policy declared by the Congress and in carrying out particular responsibilities assigned to NASA by the Satellite Act.

(ii)

The NASA program for communications satellite research is and will continue to be of benefit to aspects of the national space program not involving communications satellites. The bulk of the NASA request for the fiscal year 1964, for example, is designed to help further develop the capability to launch and operate a synchronous satellite—that is, a satellite in a highly precise orbit, 22,300 miles in the sky, which appears to be stationary over a fixed place on Earth at all times. Development of such a capability involves difficult and complex technical problems, the solution of which would be very useful to many NASA and Department of Defense programs. As pointed out by Mr. Leonard Jaffe, Acting Director of NASA's Office of Applications, in his testimony before the Senate Aeronautical and Space Sciences Committee on April 26, 1963:

"* * * many of the items or technologies being pursued as a part of the communications satellite program are of very general and urgent interest in many other areas of space flight, exploration, and application. They are being developed under the communications satellite program because of the early promise of application in this area."

Apart from any other consideration, there is a basic unfairness in the concept that NASA research activity of "general and urgent interest" in many areas of the national space program should be paid for as though the research activity had interest and application to only one aspect of the national space program—the early establishment of a commercial communications satellite system.

(iii)

Requiring the corporation to pay for the benefits of NASA research would place an inequitable burden on the corporation, not only because the corporation would be required to pay for research which will be of great value to the national space program even if there were no corporation and no congressional policy for the establishment of a communications satellite system, but also because the proposed provision is directed at the corporation only and does not require anything of any other private American company, however much it may benefit from NASA's research program in the communications satellite field. In this connection, it is important to note that the results of NASA research programs are not classified but are freely available to all U.S. industry. The corporation fully supports that policy because the free availability of the results of research is in the national interest. But it has been recognized that the corporation will not be the only private American company to benefit from that policy. In his report to the Congress on activities and accomplishments under the Satellite Act, referred to above, President Kennedy referred to NASA's communications satellite research program and pointed out one of the ways in which private American companies other than the corporation would benefit from the program. The President stated:

"NASA will continue the development and improvement of components and techniques for use in future communications satellites and will continue flight programs to test spacecraft feasibility and reliability. Such research and development programs will be beneficial, not only to the corporation, but also to others

[1] Report of the President of the United States on "Activities and Accomplishments Under the Communications Satellite Act," transmitted Jan. 31, 1963.

in private industry who supply components and services for the communications satellite systems."

The fact that, under the Satellite Act, the corporation will be the only direct U.S. participant in the international communications satellite system, does not justify the inequity involved in requiring the corporation to pay for benefits of NASA research while permitting other private American companies to benefit from such research without paying for it. For the corporation will not be a monopoly in any meaningful sense: the satellite system, when established, will compete with other means of telecommunications for the business of international communications. Moreover, under the provisions of the Satellite Act, it is possible that the corporation will not have a monopoly in any sense with respect to satellite terminal stations in the United States—essential elements in the satellite system. Section 201(c)(7) of the Satellite Act provides that it is for the Federal Communications Commission to determine, in terms of the public interest, convenience and necessity, whether satellite terminal stations are to be constructed and operated by the corporation or by one or more authorized communications common carriers or by the corporation and one or more such carriers jointly. The act further provides that the Commission shall authorize the construction and operation of satellite terminal stations by the corporation or communications common carriers, "without preference to either." It is entirely possible under these provisions of the Satellite Act that, not only may the corporation not have a monopoly on the construction and operation of satellite terminal stations, but that some or even all such stations will be constructed and operated by private American companies other than the corporation. Private companies would also benefit from the development and manufacture of hardware for the entire system, and the NASA communications satellite research program will assist in providing a basis for such a capability. Thus, the benefits of the NASA program will be widely dispersed, and the inequity of requiring that the corporation alone pay for such benefits is clear.

The carrying out of a requirement that the corporation pay for the benefits, as determined by the NASA Administrator, of NASA research programs, would also be subject to a number of serious practical difficulties. First, precisely because many of the technologies being pursued in the NASA communications satellite research program "are of general and urgent interest in many other areas of space flight, exploration and application," the benefits will flow in many directions and as a practical matter it would not be possible for the NASA Administrator, or anyone else, to determine in monetary terms the benefits of the program which are benefits to the corporation, or to distinguish benefits to the corporation from benefits to other private American companies, or to distinguish benefits to all private American companies from benefits to other phases of the national space program. Second, by the very nature of research, the benefits derived from a particular research program may not be ascertainable for an indefinite period, and determination of each year's benefits at the end of the year, as though the benefits were a kind of inventory of shoes, is an approach which ignores the nature of research and the nature of the benefits of research. Third, the proposed requirement that the corporation pay for the benefits of NASA research is not accompanied by a suggestion that the corporation have a voice in deciding the research which NASA will carry out. We think it would not be in the national interest (or in the interest of the corporation) for the corporation to decide the nature of NASA's research programs. In this regard, the provisions of section 201(b) of the Satellite Act, providing for consultation and cooperation between the corporation and NASA with respect to research, reflect the approach which we think is the right one. But without an effective voice in the determination of the research work that NASA will do, the corporation would be in the untenable position of being obligated to pay for research which it did not request, over the nature and costs of which it will have no control and which the corporation may consider is of no benefit to it. For apparently it is the intention that the NASA Administrator will determine, not only the value of the benefits received by the corporation, but will also determine, without reference to any standards, the question whether the corporation has received any benefit from a particular NASA research activity.

The inclusion of the proposed language in the NASA Authorization Act would also contravene the clear intent of the Congress as evidenced by the provisions of the Satellite Act and the legislative history of that act.

Section 201(b) of the Satellite Act directs NASA to carry out certain activities "in order to achieve the objectives and carry out the purposes" of the act. An examination of the specific provisions relating to the activities required to be

carried out by NASA makes it clear that it was anticipated that the corporation would reimburse NASA for certain of those activities (those described in subparagraphs (3), (5), and (6) of sec. 201(b)). These activities, specifically stated to be reimbursable, are those relating to the furnishing of satellite-launching services or the furnishing of other services "in connection with the establishment and operation of the system." [1] The NASA activities specified in section 201(b) of the Satellite Act as reimbursable by the corporation do not include research and development activities. The provisions of section 201(b) which contemplate that NASA will carry out research and development activities (i.e., subparagraphs (1), (2), and (4)) do not make any mention of reimbursement by the corporation. They contemplate that NASA will carry out such activities, period. The words of section 201(b), defining NASA's responsibilities under the Satellite Act, make it clear that, when the Congress intended that the corporation should reimburse NASA for certain activities, it said so specifically. The introduction of the concept that NASA research activities should be paid for other than by NASA would in effect be an amendment of the Satellite Act through the mechanism of NASA authorization legislation.

The conclusion that under the act, NASA's research and development activities are to be paid for by NASA is supported not only by the specific language of section 201(b) of the act, but also by the nature of certain of the research activities which it was contemplated NASA would undertake. It makes perfectly good sense for the Satellite Act to say, as it does, that the corporation shall reimburse NASA for satellite-launching services and for other services requested by the corporation in connection with the establishment and operation of the system. These are activities which are specifically oriented toward the corporation and which do not contribute to any national space program except the program for a communications satellite system. It was clearly contemplated, however, that the research and development activities to be conducted by NASA would be activities of many possible applications and of benefit to many different phases of the national space program. For example, in testifying, on April 11, 1962, before the Subcommittee on Antitrust and Monopoly of the Senate Judiciary Committee, Dr. Dryden, Deputy Administrator of NASA, referred to the contemplated NASA research and development program as follows:

"There will be continuing research and development in the communications satellite field by the Government. The Government is interested in it because of applications within the Government itself as well as because of the commercial applications of satellites."

"SEC. 201. In order to achieve the objectives and to carry out the purposes of this Act—

* * * * * * *

"(b) the National Aeronautics and Space Administration shall—

"(1) advise the Commission on technical characteristics of the communications satellite system;

"(2) cooperate with the corporation in research and development to the extent deemed appropriate by the Administration in the public interest;

"(3) assist the corporation in the conduct of its research and development program by furnishing to the corporation, when requested, *on a reimbursable basis*, such satellite launching and associated services as the Administration deems necessary for the most expeditious and economical development of the communications satellite system;

"(4) consult with the corporation with respect to the technical characteristics of the communications satellite system;

"(5) furnish to the corporation, on request and *on a reimbursable basis*, satellite launching and associated services required for the establishment, operation, and maintenance of the communications satellite system approved by the Commission; and

[1] The Satellite Act, of course, does not treat the phrases "establishment and operation" of the system and "research and development" as meaning the same thing. There is a specific definition of "research and development" (sec. 103(5)) which clearly shows the understanding and intention that "research and development" refer to activity preliminary to the establishment and operation of the system.

"(6) to the extent feasible, furnish other services, *on a reimbursable basis*, to the corporation in connection with the establishment and operation of the system." [Emphasis supplied.]

We appreciate your interest and your willingness to spend the time with us today.

Thank you.

Dr. CHARYK. Thank you.

Mr. WELCH. Thank you.

(Whereupon, at 12 noon, the subcommittee was adjourned.)

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1964 NASA AUTHORIZATION

THURSDAY, MAY 2, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON APPLICATIONS AND
TRACKING AND DATA ACQUISITION,
Washington, D.C.

The subcommittee met at 10 a.m., in room 214–B, Longworth Building, Hon. Ken Hechler presiding.

Mr. HECHLER. The committee will be in order.

This morning, in continuing our hearing on the NASA authorizations, we discuss the important areas of procurement methods and policies. This committee is interested in insuring that the policies and procedures are in the public interest, that small business is properly protected, and that NASA pursue an effective and efficient course in obligating the authorized funds.

This committee is also interested in obtaining information on the distribution of contract dollars with nonprofit organizations, in contracts through other Government agencies, and some of the results of the incentive contract methods.

We are very pleased to have with us this morning, Mr. Ernest W. Brackett, Director, Procurement and Supply Division, NASA; we are pleased to welcome you here, Mr. Brackett, and you may proceed with your prepared statement.

Mr. BRACKETT. Thank you, sir.

STATEMENT OF ERNEST W. BRACKETT, DIRECTOR, PROCUREMENT AND SUPPLY DIVISION, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. BRACKETT. Mr. Chairman and members of the subcommittee: Since NASA became an operating agency, its procurement functions have become increasingly important. During fiscal year 1962, approximately 90 percent of funds appropriated by the Congress were spent by contracts as compared to 64 percent in fiscal year 1960. In fiscal year 1964, the percentage of funds going to contractors may increase further. NASA appreciates its responsibility to see that this money is spent prudently, economically, and in accordance with the intent and policies laid down by the Congress and the President.

DECENTRALIZATION OF NASA'S PROCUREMENT OPERATIONS

Each of NASA's Centers place contracts in support of the projects assigned to their cognizance. Four other NASA offices also do contracting for the agency. The Jet Propulsion Laboratory is operated

by the California Institute of Technology under a cost type contract. About 60 percent of the amount of money obligated on the Jet Propulsion Laboratory contract in fiscal year 1962 was spent by it in subcontracting work to business concerns.

Procurement policies and procedures are issued by NASA headquarters. These follow quite closely those promulgated by the Armed Service Procurement Regulations. We are facing many of the same procurement problems faced by the military departments, our basic statutory authority is the same as theirs (the Armed Service Procurement Act of 1947), and we are dealing with much of the same segments of industry. This uniformity is advantageous to industry as it simplifies contract systems and ccntractual provisions.

Major contracts are reviewed and approved by NASA headquarters. This includes a review by the Office of General Counsel for legal sufficiency. Authority is delegated to eight offices and centers to issue contracts up to $1 million without headquarters approval. The other procurement offices have lower maximum contracting authority without headquarters approval. The reasons for review and approval by headquarters is to assure compliance with NASA's procurement policies, contractual provisions, and sound business principles. The reason for the different limitation amounts is to assure a review of a representative number of contracts from each procurement office.

METHODS OF COMPETITION

The most difficult part of procurement is the selection of contractors. It is our policy to advertise formally for items we procure whenever this is possible. This is where there are adequate detailed technical or performance specifications available so that all bidders will understand and bid on the same thing.

However, NASA is predominantly procuring research and development items, things which have never been made before, such as the Apollo spacecraft, where there are no specifications and various engineering designs should be considered. For this reason most of our contract dollars go into contracts which must be negotiated. In fiscal year 1962, 64 percent of our contracts were negotiated under the authority of 10 United States Code 2304(a)(11) which authorizes procurement by negotiation for research and development.

Mr. HECHLER. Mr. Brackett, if I may interrupt you at this point, do you mean 64 percent of the number of contracts, or 64 percent of the dollars?

Mr. BRACKETT. Of the dollars.

Mr. HECHLER. Of the dollar volume?

Mr. BRACKETT. Yes, sir.

Mr. HECHLER. The way it reads, it might seem to indicate the number of contracts, so I just wanted to clarify that.

Mr. BRACKETT. No, sir; it is dollars.

Mr. HECHLER. Thank you.

Mr. BRACKETT. Fourteen percent of our contracts were negotiated with educational institutions under the authority of 10 United States Code 2304(a)(5). This includes the contract for operation of the Jet Propulsion Laboratory.

Mr. HECHLER. Again, to interrupt you, Mr. Brackett, I would like to clarify the other 22 percent——

Mr. BRACKETT. Well, there are 17 exceptions, as you will recall.

I think I can give you the details of the 11 exceptions under this authority that NASA has used.

Mr. HECHLER. Yes, I would like to have the breakdown on that.

Mr. BRACKETT. Well, I think we do have these exceptions here with us.

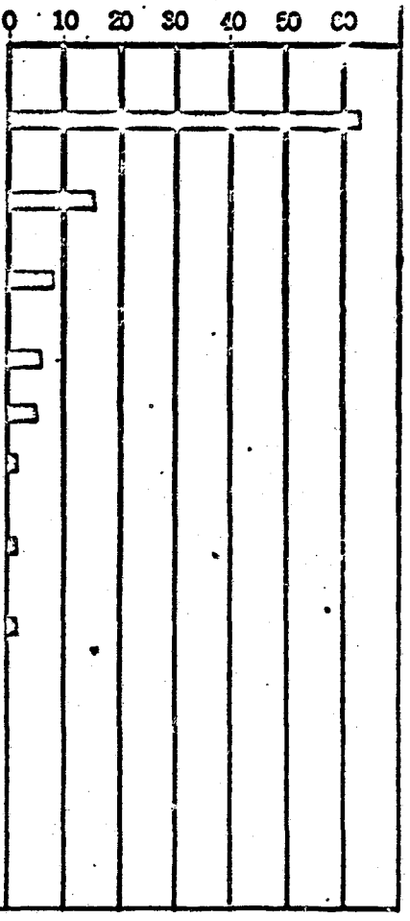
Mr. HECHLER. I think we should have those exceptions for the record, at least.

Mr. BRACKETT. Yes; shall I finish and then put them in the record, sir?

Mr. HECHLER. Yes.

(The information requested is as follows:)

Authority 10 USC 2304 (a)		Thousands of Dollars	Percent of Total
	Total	$1,141,482	100
(11)	Research and Development	732,370	64
(5)	Educational Institutions	164,507	14
(10)	Advertising Impracticable	85,730	8
(1)	National Emergency	65,642	6
(3)	$2,500 or Less	61,444	5
(17)	Otherwise Authorized by Law	11,767	1
(4)	Personal or Professional Services	8,373	1
(14)	Substantial Initial Investment Required	8,021	1
(6)	Outside the United States	4,895	*
(2)	Public Exigency	2,729	*
(15)	Negotiation After Advertising	4	*



*Less than one-half of one percent.

Mr. BRACKETT. When a contract is negotiated it does not mean that competition is waived; usually it is just as possible to get competition by negotiation as it is by formal advertising. Our policy is to obtain competition whenever it is feasible and possible under a negotiated procurement. There are instances when clearly one company should be chosen, and it would be a disservice to other companies to invite competition.

An example is a new contract for Scout vehicles with some differences in configuration from the original. Any company except the original contractor would have to duplicate certain engineering work, the successful experience obtained by the contractor would be lost and the ultimate cost to the Government would be increased. This contractor was awarded the original contract after a competition with 12 other companies.

NASA procurements for research and development of over $100,000 start with a procurement plan which sets up the method, steps to be taken, type of contract which will be used, and other details. In instances where the estimated cost is over $5 million the plan is submitted to the NASA Associate Administrator for approval; if under that amount, the Center Director approves the plan.

SOURCE EVALUATION PROCEDURES

In nearly all of the competitive research and development procurements, a Source Evaluation Board is appointed to evaluate the proposals submitted. The Board is made up predominantly of technical members with representatives from business management offices. This Board determined the criteria which will be used in the evaluation, and these points are then set forth in the requests for proposals. Usually a technical and a business committee is appointed by the Board who do much of the detailed examination of proposals. The Board makes its report to the Director of the Center if the estimated cost is under $5 million, who selects the company with which a contract will be negotiated if satisfactory terms can be arranged. If the estimated cost is over $5 million, NASA's general management at headquarters, makes the choice.

Companies which are considered to have the capability to perform the work are invited to submit proposals; however, any company may submit a proposal which will be evaluated on the same basis as those invited. During evaluation, companies which submit proposals are checked to determine their performance on work done for other Government agencies and in some instances for commercial customers. The results of this system are competition, which gives all interested companies an equal opportunity, impartial evaluations, and selection by high level responsible officials within NASA of contractors who are considered to have the best chance of successfully accomplishing the work at a reasonable cost.

TYPES OF CONTRACTS

NASA uses the fixed price form of contract whenever it is possible to fairly determine what the cost should be. This can be done where standard items are purchased or there is a basis for determining price. However, in most research and development projects, this is not the

case and cost-plus-fixed-fee contracts are usually made. The fee for the work is fixed in advance, but the contractor's actual costs necessary to perform the work are paid as they accrue. The fees on our contracts in fiscal year 1962 ranged from 1.85 percent to 9.65 percent with the average being 6.33 percent which is slightly less than the year before when fees averaged 6.65 percent. Forty percent of the fees are between 6 and 7 percent.

The cost-type contract does not give a contractor a real incentive to hold down costs, and NASA is trying to find other ways of contracting which will encourage economy. One way is to enter into a design contract, and when the design is completed and detailed specifications are known, to enter into a fixed-price contract for production of the end item. A second way is to place provisions in research and development contracts which give contractors a financial incentive to reduce costs, and to produce articles which will perform in a superior manner. The conventional incentive-type contracts have a formula by which the fee or profit is computed. This formula sets the fixed cost or performance targets with a premium fee or profit paid for completion of work below the target cost, or for performance of the article better than the target specification, and with a deduction of fee or profit if costs exceed the target, or performance is less than the target.

Mr. HECHLER. May I interrupt to ask if speed enters into this at all?

Mr. BRACKETT. We have a penalty fee and a penalty deduction if the contractor doesn't deliver on time, but, if we set a time, and there is no rush, and we don't need the article before that time, we don't feel that there is any need for paying an additional fee to get it before we need it.

However, if it goes beyond the time then there is a penalty.

Mr. HECHLER. I see. Thank you.

Mr. BRACKETT. The difficulty NASA is experiencing with this type of incentive contract is that our projects are so new that there is no history of cost or performance on which to base a fair target. A study is now being made of the possibility of converting to a fixed price incentive form some cost-plus-fixed-fee contracts under which the development and design work is far enough along to arrive at a fair price.

NASA is also trying a new contract system which we hope will accomplish the incentive objectives. The base fee in the contract will be lower than the usual fee. Criteria will be set up in the contract for evaluation of the contractor's performance. These criteria may include reduction and control of costs, excellence of performance, delivery on schedule, and other points. Periodically, a NASA board, also specified in the contract, will evaluate the contractor's performance and may award some higher fee, up to a set maximum, if the facts justify an increase.

CONTRACT ADMINISTRATION

After a contract is placed, it must be managed and monitored during its performance. There must be close technical checks maintained to assure quality control and to obtain the best possible performance. Much of this is done by NASA engineers assigned to the contractor's plant. Also, such things as audit of vouchers, keep-

ing accountability of Government property in the hands of the contractor, approval of overtime, and other contract administration work must be performed. NASA has an agreement with each of the military departments to do a major part of this work for us. These agreements save the Government the cost of setting up duplicate organizations, and efficiency is obtained by having the contractor transacting this type of day-to-day business with one Government agent. In plants where NASA has all or substantially all of the contract work it administers its own contracts.

CONTRACTS MADE BY OTHER AGENCIES FOR NASA

Other Government agencies, largely the military, contract for some of NASA's requirements where they are contracting for the same items or services for their own requirements. For instance, the Air Force bought the Atlas boosters used in Project Mercury. In the last fiscal year approximately 21 percent of NASA's contract dollars were expended through other Government agencies. These contracts are the contracts of the procuring agency, including such details as selection of source, pricing, and contract provisions.

DOLLAR DISTRIBUTION OF NASA CONTRACTS AND SUBCONTRACTS

NASA appreciates the increasing impact of its contracts on the national economy and is attempting to see that consideration is given in placing its contracts so that they will aid the economy, while at the same time, bearing in mind its duty to carry out the civil space program in a timely, efficient, and economical manner. It is the judgment of management throughout NASA that the ultimate success of the program depends to a large extent on placing contracts with companies which are found best qualified to perform the work. It should be recognized that certain companies have successfully performed similar work and have acquired unique technical experience, facilities, and equipment, which would cost hundreds of millions of dollars to duplicate. It is technically and economically advisable to utilize the services of such companies wherever they are located or whatever their size.

However, the fact that one of these companies receives a prime contract does not mean that the money obligated on the contract is spent in that company's plants. We estimate that nearly half, on the average, is spent in subcontracts. We requested nine of the largest NASA prime contractors to report on the volume and place of their first-tier subcontracts. They reported they had approximately 10,000 first-tier subcontractors in 46 States.

By permission of the Bureau of the Budget, we have recently initiated a simple report by postal card of the placement of the larger first- and second-tier subcontracts placed by 12 of our larger prime contractors. The reports are starting to come in and the early returns already show 2,172 subcontracts totaling $427,196,444 placed in 37 States. It is interesting to note that during the last fiscal year, 40 percent of NASA prime contracts, by dollars, were placed in labor surplus areas.

In order to assist companies, both large and small business concerns, in knowing where to solicit subcontract work, NASA synopsizes in

the Department of Commerce Business Daily all pending procurements for research and development where the estimated cost is $100,000 or more, listing the names and addresses of the companies which are being invited to submit proposals.

SMALL BUSINESS PARTICIPATION

Small business concerns also have participated substantially in NASA's prime contracts. They received 16 percent in dollars of new contracts placed in fiscal year 1962. Of a total of approximately 118,000 contractual transactions, large and small, small business companies received 66 percent. In procurements where small business companies bid for prime contracts they were successful in obtaining contracts for 57 percent of the dollars. Of the 100 companies which received the largest dollar amount of NASA contracts in fiscal year 1962, 24 were small business concerns. The above facts apply only to prime contracts and it is probable the participation of small business concerns in NASA subcontracts is somewhat larger.

IMPROVEMENTS IN CONTRACT SYSTEM

We are constantly trying to further improve our procurement practices and procedures. The Administrator has appointed a committee to study NASA's source-selection procedure, means of using incentive-type contracts, and a system of evaluating contractor performance. It is anticipated that constructive innovations will be made as a result of its efforts. NASA recognizes its responsibility in the expenditure of the money appropriated by the Congress and will continue to exert its best efforts to see this trust is properly carried out.

Mr. HECHLER. Thank you, Mr. Brackett.

I was fascinated by the figure that you give here on page 8, when you say that 40 percent of NASA's prime contracts, by dollars, were placed in labor-surplus areas.

The reason I was fascinated, was my reaction in glancing through the most recent report which I saw, which came across my desk on NASA's prime contracts for fiscal 1962. I just happened to skip through it and, naturally, as a Member of Congress is always interested in his own State, I looked for West Virginia, and was concerned to see that West Virginia had zero.

This is why I raised the question about this 40-percent figure which you have given.

Mr. BRACKETT. I think that Mr. Boone has a copy of the report there that shows a list of where the areas are. I think it is page 43.

Mr. HECHLER. Yes, page 43, and this confirms my conclusion that not a single one of the awards over $25,000 went to the State of West Virginia.

I am not raising any issue about that, of course, but it is simply a matter of interest that it does happen to be a labor-surplus area which received absolutely zero, under this formula.

I think it would be very helpful, Mr. Brackett, to include for the record, a State-by-State breakdown of the items which you mention here on page 7; namely, the 10,000 first-tier subcontractors for the 46 States.

Would it be possible for you to give us a dollar total figure for the record, on those?

Mr. BRACKETT. I don't think we have it here.

Mr. HECHLER. Well, if you do have that, I would be very interested to see it, and I think it would be very useful to have it for the record.

(The information requested is as follows:)

Geographical distribution of NASA first-tier subcontracts awarded by 9 major prime contractors, calendar year 1961

State	Total (thousands)	State	Total (thousands)
California	$40,852	Nevada	(1)
Missouri	1,2[illegible]	North Carolina	$89
Alabama	59[illegible]	New Hampshire	24
New York	22,627	Hawaii	56
Florida	11,398	Oregon	24
Texas	1,143	Washington	390
Maryland	16,390	South Dakota	-------
Pennsylvania	11,010	Rhode Island	200
New Jersey	5,744	Utah	18
Ohio	4,261	Alaska	-------
Massachusetts	1,992	Arkansas	173
Virginia	124	Delaware	28
Michigan	3,262	Kentucky	294
Illinois	3,808	Idaho	-------
Connecticut	4,864	Kansas	12
Colorado	45	Maine	78
Georgia	683	Mississippi	(1)
Minnesota	3,353	Montana	(1)
Tennessee	224	Nebraska	10
Wisconsin	671	North Dakota	-------
Louisiana	5	South Carolina	3
Indiana	1,547	Vermont	6
Arizona	374	West Virginia	128
New Mexico	19	Wyoming	1
Oklahoma	14		
District of Columbia	788	Total	140,625
Iowa	2,038		

[1] Less than $500.

Then also, you mentioned this postal card return, on page No. 7, and if you could give us a State-by-State breakdown of the subcontracts and dollar amounts there, I think that would be very helpful too.

Mr. BRACKETT. Mr. Chairman, I find I do have the figures here, and I can give them to you, if you wish.

Mr. HECHLER. Yes; that would be helpful, for the 37 States that you mentioned, if you would submit for the record, a State-by-State breakdown.

Mr. BRACKETT. I would be glad to.

(The information requested is as follows:)

Distribution of NASA 1st- and 2d-tier subcontracts, Jan. 1, 1962, to Feb. 28, 1963,[1] based on reports from 12 of NASA's major prime contractors

State [2]	Amount	Percent of grand total	State [2]	Amount	Percent of grand total
Alabama	$435,820	0.1	New Hampshire	$19,332	(3)
Arizona	4,022,237	.9	New Jersey	7,647,172	1.8
Arkansas	171,558	(3)	New Mexico	15,576	(3)
California	207,085,316	48.9	New York	36,331,477	8.6
Colorado	1,846,275	.4	North Carolina	509,000	.1
Connecticut	12,717,188	3.0	Ohio	5,099,555	1.2
Florida	34,424,710	8.1	Oklahoma	452,113	.1
Georgia	82,219	(3)	Oregon	573,250	.1
Illinois	6,707,030	1.6	Pennsylvania	17,309,909	4.1
Indiana	1,017,368	.2	Rhode Island	68,503	(3)
Iowa	12,885,548	3.0	Tennessee	78,393	(3)
Kansas	524,209	.1	Texas	2,080,601	.5
Louisiana	4,774,395	1.1	Utah	256,801	.1
Maryland	12,344,894	2.9	Vermont	41,589	(3)
Massachusetts	19,003,767	4.5	Virginia	114,397	(3)
Michigan	3,650,177	.9	Washington	73,689	(3)
Minnesota	26,237,834	6.2	West Virginia	724,699	.2
Mississippi	28,415	(3)	Wisconsin	1,404,374	.3
Missouri	2,005,239	.5			
Nevada	1,099,452	.3	Total	423,864,081	100.0

[1] Reporting program was established August 1962. Retroactive reporting to Jan. 1, 1962, was voluntary basis and such reporting is not necessarily complete. This is particularly true with respect to reports on 2d-tier subcontracts.
[2] Principal place of performance of subcontracts.
[3] Less than 0.05 percent.

Mr. HECHLER. That will be very helpful, for the 37 States that you mentioned in your statement.

Then, do you have any other State-by-State breakdowns, of the contracts in the areas that you have covered in your testimony, to supply additionally for the record?

For example, for small business, or any other categories that you have covered in your testimony?

Mr. BRACKETT. I don't think we have got them here, sir, but we could get them for you, I believe, if you would like.

You wish a breakdown by States?

Mr. HECHLER. Yes.

Mr. BRACKETT. Of small business?

Mr. HECHLER. Yes.

Mr. BRACKETT. I think we could get that.

I don't have a breakdown by States here, but I do have a breakdown by States, under the 10,000 subcontractors, and I would be glad to put that in the record, too.

Mr. HECHLER. Thank you very much.

(The information requested is as follows:)

Distribution of NASA 1st- and 2d-tier subcontracts, Jan. 1, 1962, to Feb. 28, 1963 [1]

SUMMARY TABLE

	Distribution of subcontracts based on principal place of performance of prime contracts		Net distribution of 1st- and 2d-tier subcontracts									
			State total		Small business		Large business		Labor surplus areas		Nonlabor surplus	
	Amount [2]	Percent of grand total	Amount [3]	Percent of grand total	Amount	Percent of State total	Amount	Percent of State total	Amount	Percent of State total	Amount	Percent of State total
Alabama	$1,512,599	0.4	$435,820	0.1	$270,576	62.1	$165,244	37.9	$216,937	49.8	$218,883	50.2
Arizona			4,022,237	.9	73,304	1.8	3,948,933	98.2			4,022,237	100.0
Arkansas			171,558	(4)	26,500	15.4	145,058	84.6			171,558	100.0
California	254,373,138	60.0	207,085,316	48.9	33,027,301	15.9	174,058,015	84.1	1,400,232	.7	205,685,084	99.3
Colorado			1,846,275	.4	69,683	3.8	1,776,592	96.2			1,846,275	100.0
Connecticut			12,717,188	3.0	1,197,380	9.4	11,519,808	90.6	686,388	5.4	12,030,800	94.6
Florida	2,672,706	.6	34,424,710	8.1	499,959	1.5	33,924,751	98.5	95,665	.3	34,329,045	99.7
Georgia			82,219	(4)	58,993	71.8	23,226	28.2			82,219	100.0
Illinois			6,707,030	1.6	1,700,139	25.3	5,006,891	74.7			6,707,030	100.0
Indiana			1,017,368	.2	91,809	9.0	925,559	91.0			1,017,368	100.0
Iowa			12,885,548	3.0			12,885,548	100.0			12,885,548	100.0
Kansas			524,209	.1	135,929	25.9	388,280	74.1			524,209	100.0
Louisiana	8,809,537	2.1	4,774,395	1.1	2,697,833	56.5	2,076,562	43.5	4,704,366	98.5	70,029	1.5
Maryland			12,344,894	2.9	279,084	2.3	12,065,810	97.7			12,344,894	100.0
Massachusetts			19,003,767	4.5	1,956,761	10.3	17,047,006	89.7	248,879	1.3	18,754,888	98.7
Michigan			3,650,177	.9	1,103,053	30.2	2,547,124	69.8	2,963,754	81.2	686,423	18.8
Minnesota			26,237,834	6.2	701,466	2.7	25,536,368	97.3			26,237,834	100.0
Mississippi			28,415	(4)	13,095	46.1	15,320	53.9			28,415	100.0
Missouri	134,095,285	31.6	2,005,239	.5	1,138,224	56.8	867,015	43.2			2,005,239	100.0
Nevada			1,099,452	.3	1,099,452	100.0					1,099,452	100.0
New Hampshire			19,332	(4)	19,332	100.0					19,332	100.0
New Jersey			7,647,172	1.8	1,713,790	22.4	5,933,382	77.6	2,070,429	27.1	5,576,743	72.9
New Mexico			15,576	(4)			15,576	100.0			15,576	100.0
New York	17,846,953	4.2	36,331,477	8.6	2,419,980	6.7	33,911,497	93.3	786,671	2.2	35,544,806	97.8
North Carolina			509,000	.1			509,000	100.0			509,000	100.0
Ohio			5,099,555	1.2	544,772	10.7	4,554,783	89.3	1,596,296	31.3	3,503,259	68.7
Oklahoma			452,113	.1	273,050	60.4	179,063	39.6			452,113	100.0
Oregon			573,250	.1	560,000	97.7	13,250	2.3			573,250	100.0
Pennsylvania			17,309,909	4.1	991,521	5.7	16,318,388	94.3	16,405,247	94.8	904,662	5.2
Rhode Island			68,503	(4)	33,465	48.9	35,038	51.1	68,503	100.0		
Tennessee			78,393	(4)			78,393	100.0	22,812	29.1	55,581	70.9
Texas	4,553,863	1.1	2,080,601	.5	164,966	7.9	1,915,635	92.1			2,080,601	100.0
Utah			256,801	.1	10,000	3.9	246,801	96.1			256,801	100.0

Vermont			41,589	(4)			41,589	100.0			41,589	100.0
Virginia			114,397	(4)	24,192	21.1	90,205	78.9			114,397	100.0
Washington			73,689	(4)	28,160	38.2	45,529	61.8	22,816	31.0	50,873	69.0
West Virginia			724,699	.2	80,048	11.0	644,651	89.0	161,067	22.2	563,632	77.8
West Virginia			724,699	.2	80,048	11.0	644,651	89.0	161,067	22.2	563,632	77.8
Wisconsin			1,404,374	.3	52,967	3.8	1,351,407	96.2			1,404,374	100.0
Total	423,864,081	100.0	423,864,081	100.0	53,056,784	12.5	370,807,297	87.5	31,450,062	7.4	392,414,019	92.6

[1] Reporting program was established August 1962. Retroactive reporting to Jan. 1, 1962, was on a voluntary basis and such reporting is not necessarily complete. This is particularly true with respect to reports on 2d-tier subcontracts.

[2] This column shows the dollar value of the reported 1st-tier subcontracts distributed according to the principal place of performance of the applicable prime contracts.

[3] This column shows the net distribution of the 1st- and 2d-tier subcontracts according to the principal place of performance of the subcontracts. The total dollars are the same as in the 1st column since the 2d-tier subcontracts represent only further distribution of the 1st-tier subcontracts.

[4] Less than 0.05 percent.

Are there any questions at this point, from any of the committee?

Mr. BOONE. If I may, Mr. Chairman, I would like to ask Mr. Brackett if he has a plan to make a determination of where the second tier might go?

It seems to me that this would be an extremely interesting statistic.

Mr. BRACKETT. Yes, sir, we do.

As you know, the Bureau of the Budget has authority, by statute, to determine what type of reports may be requested, and we asked for authority to obtain such reports, and wanted to make this as simple as possible, so we designed a self-addressed postal card.

Mr. HECHLER. May we see it?

Mr. BRACKETT. Certainly.

(The information requested appears on following pages.)

This just has a few questions which we ask the prime to fill in when it places its first-tier subcontracts, and to mail into us. The prime keeps no records, makes no reports, and then the first-tier contractors are asked to do the same.

The Bureau of the Budget has limited this report for use in 12 of our larger companies, and it is only to be used in connection with prime contracts of $500,000 or more, and only to report on first-tier subcontracts of $10,000 or more.

Mr. HECHLER. May I ask, for the record, the names of the 12 largest companies?

Mr. BRACKETT. Yes.

Mr. HECHLER. Would you read them at this time, for the record?

Mr. BRACKETT. Yes, sir.

Aerojet-General Corp., Boeing Co., Chrysler Corp., Douglas Aircraft Co., Inc., Grumman Aircraft Engineering Corp., Ling-Temco-Vought, Inc., Lockheed Aircraft Corp., McDonnell Aircraft Corp., North American Aviation, Inc., Space Technology Labs., Inc., United Aircraft Corp., California Institute of Technology.

Mr. HECHLER. Without objection, and in view of the brevity of this form, I think it would be useful to have this also placed in the record.

Mr. BRACKETT. Would you like a copy of our circular for the record?

Mr. HECHLER. Yes, I think so.

Mr. BRACKETT. I will see to this, also, sir.

Mr. HECHLER. Thank you.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON 25, D. C.

OFFICIAL BUSINESS

POSTAGE AND FEES PAID
NATIONAL AERONAUTICS
AND SPACE ADMINISTRATION

National Aeronautics and Space Administration
Procurement & Supply Division (Code BRP)
Washington 25, D. C.

1964 NASA AUTHORIZATION

3347

SECTION I.	1. PRIME CONTRACT NO.			Form Approved Budget Bureau No. 104-R012	For NASA Use Only
	2. PRIME CONTRACTOR				A.
	3. ADDRESS				B.
II. FIRST-TIER SUBCONTRACT	4. SUBCONTRACTOR				C.
	5. ADDRESS				D.
	6. SMALL BUSINESS ☐ YES ☐ NO	7. SUBCONTRACT NO.	8. SUBCONTRACT AMT. $	9. ☐ NEW CONTRACT 10. ☐ MODIFICATION	
	11. PRINCIPAL PLACE OF PERFORMANCE *(If known)*				E.
	12. DESCRIPTION OF WORK				F.
III. SECOND-TIER SUBCONTRACT	13. SUBCONTRACTOR				G.
	14. ADDRESS				H.
	15. SMALL BUSINESS ☐ YES ☐ NO	16. SUBCONTRACT NO.	17. SUBCONTRACT AMT. $	18. ☐ NEW CONTRACT 19. ☐ MODIFICATION	
	20. PRINCIPAL PLACE OF PERFORMANCE *(If known)*				I.
	21. DESCRIPTION OF WORK				J.
	22. COMPANY SUBMITTING REPORT		23. SIGNATURE	24. DATE	

NASA FORM 667 AUG 62 GPO 938893

REPORT ON NASA SUBCONTRACTS

INSTRUCTIONS

GENERAL

A. This report form is for use by NASA prime contractors and first-tier subcontractors participating in the NASA subcontracting reporting program. Parts I and II of the form are for use by the prime contractors; Parts I, II and III are for use by the first-tier subcontractors.

B. NASA prime contractors will complete and submit Parts I and II of the form for each subcontract *(as defined in paragraph D below)* placed by them which is estimated will exceed $10,000 and for each action *(modification)* in excess of $10,000 on such subcontract. Modifications to be reported include actions which result in the decommitment of funds as well as commitments.

C. First-tier subcontractors having any subcontracts which are estimated will exceed $10,000 will complete and submit the form in entirety for each subcontract *(as defined in paragraph D below)* placed by them which is estimated will exceed $10,000 and for each action *(modification)* in excess of $10,000 on such subcontract. Modifications to be reported include actions which result in the decommitment of funds as well as commitments.

D. The term "*subcontract*" as used herein means procurement in excess of $10,000 by the prime contractor or first-tier subcontractor of articles, materials, or services entering into the performance of a specific NASA prime contract. It does not include purchases, regardless of amount, of stock items, materials, or services which cannot be identified with a specific NASA prime contract.

E. NASA prime contractors will provide the number of the NASA prime contract to their first-tier subcontractors for entry on the reports.

F. The report is to be submitted as soon as possible after placement of the subcontract to the National Aeronautics and Space Administration, Procurement and Supply Division, Code BRP, Washington 25, D. C.

G. Prime contractors will obtain a supply of the forms from their NASA Contracting Officer. Subcontractors will obtain the forms from the prime contractor.

SPECIFIC

Item 1. Enter the NASA prime contract number.

Item 2. Enter name, and division if applicable, of the prime contractor.

Item 3. Enter address *(City and State only)* of the prime contractor.

Item 4. Enter name, and division if applicable, of the subcontractor.

Item 5. Enter address *(City and State only)* of the subcontractor.

Item 6. Enter a check in the applicable box.

Item 7. Enter subcontract or purchase order number specified by the contractor initiating the action.

Item 8. Enter in terms of commitments, to the nearest dollar, the amount of the subcontract, or amount of modification to the subcontract. Modifications resulting in decommitments are to be enclosed in parentheses.

Item 9. Enter a check if this report is the first report submitted on the subcontract.

Item 10. Enter a check if this report is for a modification of a previously reported subcontract.

Item 11. Enter the location *(City and State only)* of the principal plant or place of business, where the items will be produced or supplied from stock or where the work will be performed, if known. For construction subcontracts enter the site of construction.

Item 12. Enter a brief description of the item to be furnished or the work to be performed under the subcontract. *(For example: Environmental control system for Apollo Spacecraft, Fuel Pumps, etc.)*

Items 13 thru 21. See Items 4 thru 12.

Item 22. Enter the name of the company submitting the report. This should be the name of the prime contractor for reports on first-tier subcontracts; it should be the name of the first-tier subcontractor for reports on second-tier subcontracts.

Item 23. To be signed by the company individual submitting the report.

Item 24. Enter the date of signature.

(The information requested is as follows:)

[Date: August 16, 1962. Circular No. 243]

NASA MANAGEMENT MANUAL

MATERIAL TRANSMITTED

1. NASA Circular 243, "Geographic Distribution of NASA Subcontracts."
2. The attached circular covers procedures and reporting requirements for the furnishing of certain information by a selected list of major NASA contractors and their subcontractors on the geographic distribution of NASA subcontracts in excess of $10,000 on a post card form. NASA Form 667. In addition to providing a statistical measurement of the geographic dispersion of subcontracting by major NASA contractors, the report is intended to provide NASA headquarters with information on the identity and location of first- and second-tier subcontractors and a description of the items being furnished or work being performed by them under the major NASA contracts.
3. The Bureau of the Budget has approved the use of NASA Form 667 on a selective test basis for a limited period. The expiration date of Budget Bureau approval is December 31, 1963.
4. Attachment A lists existing contracts in excess of $500,000 with the selected contractors which will require amendments to include the subcontract reporting requirement. The list should be reviewed by field procurement officers to determine if existing contracts with the selected firms over $500,000 which will involve significant subcontracting have been omitted by NASA headquarters, in which case, such contract(s) will also be amended to include the requirement.
5. A supply of NASA Form 667 is being furnished to each procurement office under separate cover. In this connection, see paragraph 4 of the attached circular.

[No. 243. Reference: 18-50.4. Effective date: Aug. 16, 1962]

NASA CIRCULAR

SUBJECT: GEOGRAPHIC DISTRIBUTION OF NASA SUBCONTRACTS

1. PURPOSE

This circular prescribes procedures for the furnishing by certain major NASA prime contractors and their first-tier subcontractors of information relating to the geographic distribution of subcontracts awarded under NASA contracts.

2. APPLICABILITY

This circular is applicable only to the following NASA prime contractors and their first-tier subcontractors:

Aerojet-General Corp.
Boeing Co.
Chrysler Corp.
Douglas Aircraft Co., Inc.
Grumman Aircraft Engineering Corp.
Ling-Temco-Vought, Inc.
Lockheed Aircraft Corp.
McDonnell Aircraft Corp.
North American Aviation, Inc.
Space Technology Laboratories, Inc.
United Aircraft Corp.
California Institute of Technology.

3. PROCEDURES

(*a*) In connection with each NASA contract with the contractors listed in paragraph 2 which is estimated will exceed $500,000, the prime contractor will furnish to the Procurement and Supply Division (code BRP), NASA Headquarters, on NASA form 667, information with respect to the geographic distribution of each first-tier subcontract exceeding $10,000.
(*b*) Each first-tier subcontractor awarded a subcontract in excess of $50,000 will furnish to the Procurement and Supply Division (code BRP), NASA Headquarters, similar information on NASA form 667 on each second-tier subcontract exceeding $10,000.
(*c*) The Report on NASA Subcontracts clause set forth in subparagraph *d* will be included by NASA contracting officers in each prime contract which it is estimated will exceed $500,000 entered into with the firms specified in paragraph 2 after the effective date of this circular. Also certain existing contracts (including

letter contracts) with the firms listed in paragraph 2 will be amended to include the "Report on NASA Subcontracts" clause set forth in subparagraph *d*. The list of such contracts is set forth in Attachment A.

(*d*) Clause:

"REPORT ON NASA SUBCONTRACTS (SEPTEMBER 1962)

"(a) The contractor agrees to submit information on NASA Form 667 to the National Aeronautics and Space Administration (attention: code BRP), Washington 25, D.C., substantially as follows with respect to each subcontract or modification thereof exceeding $10,000 as soon as possible after execution thereof:

(i) The name and address of the prime contractor and the NASA prime contract number.

(ii) The name and address of the subcontractor.

(iii) Whether the subcontractor is a large or small business concern.

(iv) A brief description of the subcontract work.

(v) The amount of the subcontract.

(vi) The principal location where the subcontract work is to be performed, if known.

"(b) The term 'subcontract' as used herein means procurement in excess of $10,000 by the contractor or first-tier subcontractor of articles, materials, or services entering into the performance of this contract, except purchases, regardless of amount, of stock items, materials, or services which cannot be specifically identified with this contract.

"(c) The contractor further agrees to insert the provisions of paragraphs (a) and (b) of this clause in each subcontract in excess of $50,000. The contractor will instruct his subcontractors to submit their reports directly to the National Aeronautics and Space Administration (attention: code BRP), Washington 25, D.C., and will provide his subcontractors with the number of the NASA prime contract."

(*e*) The Procurement and Supply Division, NASA headquarters, will compile and analyze the data reported on NASA Form 667 and will distribute the analyses to all interested offices.

4. SUPPLY OF FORMS

(*a*) An initial supply of NASA Form 667 has been furnished to each installation procurement office. NASA Form 667 will be stocked centrally at NASA headquarters for requisitioning additional supplies.

(*b*) NASA contracting officers will furnish the necessary supply of NASA Form 667 to the prime contractor for his use and for his first-tier subcontractors.

5. EXPIRATION DATE

This circular is automatically canceled December 31, 1963.

ALBERT F. SIEPERT,
(For Director of Administration).

ATTACHMENT A

LIST OF EXISTING NASA CONTRACTS TO BE AMENDED

Aerojet-General Corp.:
NAS5-417: SNAP 8
NAS5-2252: AEROBEE
NAS8-4014: M-1 engine
NAS1-1330: SCOUT motors
Boeing Co.:
NAS8-2577: S-1C
Chrysler Corp.:
NAS8-1666: GSE for SATURN
NAS8-2576: S-1
Douglas Aircraft Co., Inc.:
NAS5-1681: DELTA
NAS7-1: S IV
NAS7-101: S IVB
Grumman Aircraft Engineering Corp.:
NAS5-814: OAO
Ling-Temco-Vought, Inc.:
NAS1-1295: SCOUT vehicle
NAS1-1970: Spare parts for SCOUT
NAS1-1928: SCOUT
NAS1-1946: Velocity package project fire
Lockheed Aircraft Corp.:
NAS8-5600: RIFT
McDonnell Aircraft Corp.:
NAS9-170: GEMINI
North American Aviation, Inc.:
NASw-16: F-1 engine
NASw-333: Liquid hydrogen cooled test nozzles
NASw-347: Phoebus feed system
NAS5-412: KIWI B
NAS8-19: J-2 engine
NAS8-5603: J-1 engine
NAS8-5604: F-1 engine
NAS7-3: H-1 engine
NAS7-4: H-1 engine
NAS7-80: SATURN II
NAS7-162: H-1 engine
NAS7-90: Facilities for S II
NAS9-150: APOLLO spacecraft
NAS9-167: APOLLO paraglide system
Space Technology Laboratories, Inc.:
NAS5-899: OGO
United Aircraft Corp.:
NAS8-2690: A-3 engine
NAS8-2691: A-3 engine
NAS3-1833: Space condenser facility
California Institute of Technology:
NAS7-100

Field procurement officers should review this list to determine if all existing contracts over $500,000 with these firms which will involve significant subcontracting have been listed. If any contract is omitted, such contract will also be amended to include these requirements and the information furnished to the Procurement and Supply Division (code BRP), NASA Headquarters.

Mr. BRACKETT. The Bureau of the Budget has further limited us as to the first-tier subcontractors, who will make reports on their second-tier subcontracts.

It can only be applicable to the first-tier subcontracts that are $50,000 or more.

And they report on second-tier subcontracts of $10,000, or more.

This will give us some picture of the subcontract structure, and where the subcontracts are going, but it is only going to hit the larger ones.

It is our feeling that it is the smaller subcontracts, in particular, the lower tier subcontracts, which will go to these small business concerns.

Of the postal cards that we have gotten in so far, we have made some analysis just to bear out this point, and we have found, that as the dollar amount, as the subcontracts go down in dollar amounts, small business gets a larger participation. In subcontracts of $25 million or under, those in the second tier only, as was shown here, small business gets 17.3 percent, but when it gets down to $10,000, or under, the percentage goes up to 22.1 percent, and when it is down to $5,000, or under, 32.2 percent; and $1,000, or under, 43.9 percent.

In other words, we are not getting the full picture of the help that has gone to small business by the subcontracts.

Mr. HECHLER. Mr. Brackett, getting back to geographical distribution, I must say that I am not impressed by the way you phrased your statement on page No. 7.

You indicate here, under dollar distributions of NASA contracts:

> NASA appreciates the increasing impact of its contracts on the national economy, and is attempting to see that consideration is given in placing its contracts, so that they will aid the economy * * *.

Immediately following this, you indicate that you are undercutting that phraseology completely in your statement, and you wind up by saying, well, it is more efficient and economical to put these contracts where there is demonstrated experience.

I think the net effect of your testimony, therefore, is to give a little glimpse of lipservice at the beginning, and then to cut away the entire structure by the time you complete your testimony.

Mr. BRACKETT. Well, I am sorry, sir, I didn't mean to do that.

Our policy is, top management policy is, that we feel in research and development, we must go to those companies that can do the best job, and have the best chance of successfully performing the work.

Where we are buying supplies and services that can be done by companies, regardless of the area in which they are located, or the size of the company, these are the places where we do go, particularly, to small business concerns.

This is where we are buying standard items or products. Unfortunately, Mr. Chairman, we do not buy supplies to the large extent that some of the other departments do. But when it comes to research and development, our management feels it must go to the best qualified company that they can find, regardless of where they are located.

I know, in the selection of contractors and companies by our management, the question of selection has come up between two or three companies, either located in surplus areas or not, but in research and development, as I say, technical capability has been the prime consideration.

However, if, say, a second or third rated company is pretty close technically, to the top, then Mr. Webb has said: "This will go to the company in the labor surplus area." Even though it is not rated the best.

Mr. HECHLER. I don't want to belabor this point too much, except that whenever NASA is pushed on this point NASA has usually said: "Well, if all other things—are equal, why, the contract will then go to the labor surplus area."

But I have found in so many cases, that NASA concludes that all other things are not equal. And therefore, to he that hath, shall be given.

Mr. WYDLER. Mr. Chairman, if I may make this comment, I would like to say for the record, that of course, these are very difficult problems for Mr. Brackett, as Administrator, to handle, and I would like to say to you how I feel as a member of this subcommittee, and of this committee.

Of course, I come from a State which is of very great concern to me. Just as in the case of every other Congressman, and we all have an interest in seeing that contracts do go to our States.

However, as a member of this committee, although I do feel the same way, I would like to make it clear that if I ever found that any judgment was used in awarding any of these contracts, except on the

basis of the standard of excellence, really meaning the standard of excellence, I personally would object to it, and would make it public, and do everything in my power to see that you immediately returned to that standard as a basis of selection, and placement of these contracts—whether or not that means the company might be in my area.

I would not care which way the chips happened to fall.

Mr. BRACKETT. No, sir.

Mr. WYDLER. And I think actually what you are really saying here is that in these very serious and important matters you are not going to take a chance on some company that you really don't know too much about, in giving to that company an important part of the space program, just because they have an economic problem in the area.

I am personally wholeheartedly in concurrence with this policy, if it is your policy, because I certainly don't think we should use the space program as a method of solving our unemployment problems, except to the extent that it is really decided that they are so close that there would be no other reason for doing it another way.

In that case, that may be a fair judgment, of course.

Mr. BRACKETT. Yes.

Mr. HECHLER. By my remarks, I certainly would not wish to leave any inference, that I disagreed with the gentleman from New York, Mr. Wydler, or that I am arguing that we sacrifice any standards of excellence.

I would simply underline that on those occasions when other things are equal, and where there is competition among bidders that are relatively equal in other respects, attention be given in such cases, to the labor surplus areas. If you can take advantage of the surplus labor supply and maintain your standard of excellence, there is absolutely no reason why more contracts cannot go to labor surplus areas.

Mr. BRACKETT. I think, Mr. Chairman, that is our policy.

Mr. HECHLER. That is good.

Mr. RUMSFELD. I think there is another aspect to this whole question, Mr. Chairman, if I may comment at this point, when one appreciates that we have a defense budget in excess of $50 billion, and here NASA is requesting in the neighborhood of $5.7 billlon, of which 90 percent, you indicate, Mr. Brackett, is spent by contract.

We can see that we have very serious and social, as well as economic implications in our society, therefore, and I think we do, very definitely, have to look toward the most economical suppliers.

On the other hand, we have to avoid the potential danger of creating a one-industry, or almost one-industry economy, in an area.

If the Federal Government can turn this money on, as it has done, then it can turn this money off, so I do think there is this additional factor which should be considered.

Believe me, I don't envy you your responsibilities, Mr. Brackett. I appreciate how difficult they are, but I think we should make every possible attempt to spend these moneys throughout the United States.

Of course, this money is raised from taxes throughout the United States, which is one reason why I say this. But, not only should we try to spend the money where it is raised, but also we should remember this question of the potential danger to a given area, by stopping such

expenditure, and thus creating a very serious unemployment problem where the money has previously been spent.

I think the history of California in the past, over a very brief period, indicates this.

Mr. BRACKETT. Yes, sir.

Mr. HECHLER. I think, Mr. Rumsfeld, you have added another dimension to this, and I appreciate your bringing up this matter. Because, I think you would agree, Mr. Brackett, that part of this economic problem is the very impact of which Mr. Rumsfeld has spoken. Measuring the economic impact may not be as much a matter of the immediate dollar figure in your immediate target as the overconcentration and the economic impact which might result—that is to say, overconcentration of contracts in one area.

Mr. BRACKETT. Yes, sir. Mr. Webb is very conscious of this and, as I have heard him say many times, he feels he must not only bring more companies into the program because it is a growing program and we do want to have competition, but we must have a broader base for this work—not just more companies. Because he appreciates the economic impact on the economy, he feels that we should, within our economic limits, and within our job, do everything we can to keep our standards, and come up with the best space program we can, spreading this business into all areas.

Mr. HECHLER. Well, good.

Now, you are going to give us a State-by-State breakdown so that we can make an effective analysis of what you have done, and what you propose to do on this point?

Mr. BRACKETT. Yes.

(The information requested is as follows:)

U.S. geographical distribution of NASA procurement direct awards of $25,000 and over [1] fiscal year 1962

State	Actions		Obligations	
	Number	Percent of total	Amount in thousands	Percent of total
Total	2,707	100	$939,143	100
Alabama	220	8.1	81,264	8.7
Alaska	11	.4	4,227	.5
Arizona	18	.7	5,583	.6
Arkansas	1	(2)	37	(2)
California	784	29.0	441,179	47.0
Colorado	27	1.0	3,622	.4
Connecticut	45	1.7	3,796	.4
Delaware	1	(2)	34	(2)
Florida	85	3.1	50,925	5.4
Georgia	24	.9	3,352	.4
Illinois	63	2.3	8,403	.9
Indiana	23	.8	1,646	.2
Iowa	14	.5	1,898	.2
Louisiana	19	.7	18,534	2.0
Maryland	154	5.7	26,773	2.9
Massachusetts	141	5.2	19,737	2.1
Michigan	64	2.4	5,644	.6
Minnesota	31	1.1	2,927	.3
Mississippi	1	(2)	93	(2)
Missouri	40	1.5	70,600	7.5
Nevada	3	.1	435	(2)
New Hampshire	7	.3	320	(2)
New Jersey	130	4.8	26,980	2.9
New Mexico	9	.3	1,696	.2
New York	200	7.4	55,301	5.9
North Carolina	10	.4	1,695	.2
Ohio	114	4.2	11,320	1.2
Oklahoma	11	.4	687	(2)
Oregon	1	(2)	33	(2)
Pennsylvania	105	3.9	25,291	2.7
Rhode Island	3	.1	243	(2)
South Dakota	1	(2)	98	(2)
Tennessee	19	.7	2,163	.2
Texas	146	5.4	32,755	3.5
Utah	1	(2)	37	(2)
Vermont	3	.1	112	(2)
Virginia	91	3.4	13,785	1.5
Washington	4	.1	325	(2)
Wisconsin	23	.8	4,618	.5
District of Columbia	60	2.2	10,975	1.1

[1] Excludes awards placed with or through other Government agencies, awards outside the United States and actions on the JPL contract.
[2] Less than 0.1 percent.

U.S. geographical distribution of NASA procurement direct awards of $25,000 and over[2] July 1–Dec. 31, 1962

State	Obligations		State	Obligations	
	Amount in thousands	Percent of total		Amount in thousands	Percent of total
Total	$776,797	100.0	Minnesota	3,215	0.4
			Mississippi	45	(1)
Alabama	35,288	4.5	Missouri	85,788	11.0
Alaska	1,907	.2	Nevada	314	(1)
Arizona	1,724	.2	New Hampshire	269	(1)
Arkansas	30	(1)	New Jersey	22,973	3.0
California	371,308	47.8	New Mexico	2,843	.4
Colorado	879	.1	New York	39,175	5.0
Connecticut	3,747	.5	North Carolina	273	(1)
Florida	30,907	4.0	Ohio	7,353	.9
Georgia	1,234	.2	Oklahoma	322	(1)
Hawaii	124	(1)	Oregon	109	(1)
Idaho	250	(1)	Pennsylvania	9,638	1.2
Illinois	5,669	.7	Rhode Island	38	(1)
Indiana	780	.1	Tennessee	889	.1
Iowa	805	.1	Texas	15,140	1.9
Kansas	276	(1)	Vermont	79	(1)
Louisiana	73,361	9.4	Virginia	8,477	1.1
Maine	61	(1)	Washington	219	(1)
Maryland	17,617	2.3	West Virginia	395	.1
Massachusetts	13,195	1.7	Wisconsin	5,717	.7
Michigan	1,804	.2	District of Columbia	12,560	1.6

[1] Less than 0.05 percent.
[2] Excludes awards placed with or through other Government agencies, awards outside the United States and actions on the JPL contract.

Mr. WYDLER. Do I understand, Mr. Chairman, from what you were saying previously, that NASA has awarded no contracts in the State of West Virginia whatsoever?

Mr. HECHLER. No prime contracts over $25,000. NASA's own figures so demonstrate.

Mr. WYDLER. No prime contracts; I understand—I thought it would be pretty hard to understand about any State in the Union, considering the size of this program today, why it would not be possible to do something along those lines.

Mr. HECHLER. Well, we West Virginians down through the years have found many things here that were hard to understand, without any large military installations, and with very few military prime contracts, at least until recently, Mr. Wydler.

Mr. WYDLER. Well, then I quite understand your questioning the point under those circumstances.

Mr. HECHLER. Thank you, Mr. Rumsfeld.

I think because of Mr. Wydler's look of surprise about West Virginia not getting any contract [laughter] I would ask that this total on page No. 29 of the NASA procurement report be placed in the record at the point where we had our discussions.

Mr. BRACKETT. Yes.

Mr. HECHLER. This shows the geographical distribution by States of where the prime contract awards of $25,000 and over were made.

Mr. BRACKETT. As I was telling you, Mr. Chairman, before we started, we have recently placed this $400,000 contract in West Virginia.

Mr. HECHLER. Would you be able to identify that?

Mr. BRACKETT. Yes, sir.

Mr. HECHLER. You could? Good; we might be able to break the news before noon for the afternoon papers. [Laughter.]

Mr. BRACKETT. Yes. This was to the East Coast Flying Service; and it is for $395,324.16.

This was obtained by formal advertising limited to small business concerns. It was a set-aside, as I understand it, and this company was low bidder, and received the contract.

Mr. BOONE. Mr. Chairman, if I may address this comment to Mr. Brackett: Do you have a published policy on this point that goes out to all these centers?

Mr. BRACKETT. On the labor surplus areas?

Mr. BOONE. Yes.

Mr. BRACKETT. Yes, we do.

Mr. BOONE. Would you like to have a copy of that, perhaps, Mr. Chairman?

Mr. BRACKETT. This is our policy.

Mr. HECHLER. Yes, I think it would be useful. Would you please supply us with a copy of that?

Mr. BRACKETT. Yes, I will be glad to. It is entitled: "Increased utilization of firms in labor surplus areas."

Mr. BOONE. I asked the question because it seems to me that you were talking about actions by NASA headquarters. When you get down to the small, $25,000 contract, this might be a locally handled problem by each center and therefore, the published policy would insure uniform procurement by all NASA centers.

Mr. BRACKETT. Yes. I will submit this for the record, then.

(The information requested is as follows:)

[No. 247. Reference: 18-1.7. Date: Sept. 4, 1962]

NASA CIRCULAR

SUBJECT: INCREASED UTILIZATION OF FIRMS IN LABOR SURPLUS AREAS

1. PURPOSE

This circular prescribes procedures for review by NASA headquarters of certain proposed procurements in order to insure that adequate consideration is given to qualified firms in labor-surplus areas and to improve the opportunities for such firms to participate in the NASA program at the prime or subcontract level.

2. APPLICABILITY

This circular is applicable to procurement offices at NASA headquarters and field installations.

3. BACKGROUND

(*a*) The Area Development Administration Act (42 U.S.C. 2501–2525) established the Area Redevelopment Administration in the Department of Commerce.

(*b*) Presidential memorandum to heads of departments and agencies, dated February 27, 1962, requested agencies to give assistance to redevelopment areas.

(*c*) A number of States have designated special representatives to work with the principal Government agencies in Washington in an effort to channel more Government contracts into labor-surplus areas.

4. PROCEDURES

(*a*) Procurement offices will forward to the Procurement and Supply Division, NASA Headquarters, Attention: Industry assistance officer (Code BR), the following information with respect to all proposed unclassified procurements in excess of $250,000, including sole source, at the earliest possible date or, in any event, not less than 10 days prior to issuance of the invitation for bids or request for proposals:

(1) A detailed description of the item or work and the quantity involved. (A copy of the purchase request may be forwarded in lieu of the detailed description.)
(2) Estimated value of the procurement.
(3) Names and locations of firms to be solicited.
(4) Estimated date of issuance of invitation for bids or request for proposals.
(5) Whether a small business or labor-surplus set-aside will be made.
(6) Any special requirements or unusual aspects to be included in the solicitation, e.g., those which will require special capabilities or facilities for development, manufacture, or test purposes.

(*b*) The industry assistance officer, Procurement and Supply Division, NASA Headquarters, will:

(1) Review such proposed procurements to determine if adequate consideration has been given to qualified firms in labor-surplus areas,
(2) Suggest additions of qualified firms, when considered feasible, to the proposed source list of firms in labor-surplus areas, and
(3) Serve as a central point of contact for representatives of the Area Redevelopment Administration, the Small Business Administration, and for special State representatives on proposed NASA procurements, and will afford such representatives an opportunity to suggest additions of qualified firms to the proposed list of sources.

Any additional sources suggested will be promptly communicated by the industry assistance officer to the procurement office concerned for appropriate consideration.

RALPH E. CUSHMAN
(For Director of Administration).

Mr. HECHLER. If there are no further questions on this point, then I would like to open up the hearing for any questions that the members might have.

Mr. RUMSFELD. This does not have to do with what you have said thus far, and I don't mean it as any criticism of you, really; I simply feel that the record should show that those in the administration, as well as the Members of Congress and the people of this country, should appreciate the fact that we are talking about the taxpayers' money. We are taking about tax dollars, and with the tremendous expenditures that are being made by NASA, by the Department of Defense, and so forth, we do have a potentially very serious problem.

I know this is a difficult area; you have listed four or five different types of contracts that you are using, and I feel it is important for all of us to be constantly aware of the public trust that we have here.

Mr. BRACKETT. Yes, sir.

Mr. RUMSFELD. I have been studying this question since coming to Congress, and I have a very deep concern about it. I have run across so many instances where we are working, not with black or white, but with a gray area, and this is what you are doing all day long.

Mr. BRACKETT. Yes.

Mr. RUMSFELD. You are working in this gray area, on these questions when people come in and ask for an amendment to the original contracts, changes in contracts, the addition of the liquidated-damages clause, for example, when you amend a contract, and I personally feel very strongly that our present procurement regulations are inadequate.

I say this because I believe the whole history of this country shows that, to the extent that we can put this type of sensitive activity in a goldfish bowl, and air it publicly, I feel we should do so.

I know that many of these contracts are of a confidential nature, some from a military standpoint, and some from a business standpoint, but I think that we in Government, have to work toward making more and more information of this type public, because this is the only

way that we can avoid the possibility, not only of errors in judgment but illegal irregularities.

Now, I have some specific questions on page 4.

You say in the second sentence, at the top of the page—

> The Board is made up predominantly of technical members with representatives from business management offices.

What is a business management office?

Mr. BRACKETT. Usually procurement or financial analysis.

Mr. RUMSFELD. This is a NASA office?

Mr. BRACKETT. This is a NASA office. Yes, sir.

Mr. RUMSFELD. All right. Then on page 5, you mention:

> The cost-type contract does not give the contractor a real incentive to hold down cost and NASA is trying to find other ways of contracting which will encourage economy.

Now, what specific programs or potential recommendations, do you have that you and NASA will be making to improve this?

Mr. BRACKETT. Well, I believe a year ago we did not have a single incentive-type contract.

Today we have, I think, 10, and we have several others that are in the process of negotiation.

For example, I can give you an instance of the contract for the Scout space vehicle. The first contract, I believe, was a cost-plus-fixed-fee contract; then we came up with the second contract, and we then switched, and are now negotiating a fixed-price, incentive-type contract.

We are now about ready to convert the contract for the establishment of the astronomical observatory with the Space Technology Lab, which is on a cost-type basis, and we are ready to negotiate what I believe will be a fixed-price incentive contract.

We are about to make a contract for what is called the Pioneer satellite. I am not an engineer, but it is my understanding that this will be a rather large surface satellite, to find out what meteorites do in space. We have had a competition on a cost-plus-fixed-fee basis for this contract, and two companies have been selected, again, by Mr. Webb, Dr. Dryden, and Dr. Seamans; and we are now going to negotiate with these two companies. We have asked them to come in, instead of with a cost-plus-fixed-fee contract proposal, with a fixed-price incentive contract proposal.

A year ago we had a contract for the operation of the Mercury network, which has five stations, and we went out on competition for renewal of this contract.

I am not quite sure whether there were 15 or 18 companies that competed, but here again, we came up with 2 companies, and we asked them to submit proposals for a contract on a cost basis, but with an incentive provision. This was our first so-called incentive award fee type, and the two companies were Bendix and RCA. We negotiated with both of them, and got their proposals, and Bendix was finally chosen.

Under the terms of this contract, it, in part, provides for a base fee, under which Bendix will receive approximately 3 percent, or slightly under 3 percent of the estimated cost. We have set up certain criteria, such as with respect to the time during which the station will be down, because of something like operating difficulties, the turnover of personnel, which means additional cost, or lack of efficiency. There

are several of these points, including logistics support, and a board is set up which will meet every 6 months and will examine the reports on what Bendix has done in the operation.

There will be reports made by NASA station people who are at the sites, by the procurement people, and so forth, as to whether Bendix can keep their costs under what they estimated them to be, and so forth, and based on these criteria, the Board may award Bendix an additional fee, if they feel that Bendix has done a superior job on all of these points, to warrant it. However, the top fee which they can get would be 7 percent, and this will be prospective only and they could get part, or all of it. This is the type of thing that we are trying to do to stimulate the effort of the companies concerned to hold down the costs and to do a better job, and it is just an example.

So far as I know, we are the only agency that is doing this. This is a brandnew thing with us.

Mr. RUMSFELD. I have not heard of it in connection with any other department.

Now, one last question: NASA is requesting $5.7 billion, and you say that approximately 90 percent of the 1962 fiscal year budget was let on contract.

So, from this, it is apparent that NASA is more than any other department or agency, to my knowledge at any rate, working in this gray area, this very difficult area.

Mr. BRACKETT. Yes, sir.

Mr. RUMSFELD. And the problem comes up, on page 7, where you say:

> It should be recognized that certain companies have successfully performed similar work, and have acquired unique technical experience, facilities, and equipment, which would cost hundreds of millions of dollars to duplicate.

Now, have they developed those facilities and equipment in many cases, with taxpayers' dollars?

Mr. BRACKETT. Yes.

Mr. RUMSFELD. Under the cost of the previous work, have those facilities and equipment, to some extent been purchased—I don't want to say "owned"—but I suppose, to some extent, they are owned by the Federal Government?

Mr. BRACKETT. That's right.

Mr. RUMSFELD. I have seen contracts where the justification for giving it to a specific company was the fact that they had this equipment, and I think we ought to be very careful here where the cost of that equipment was paid for by the taxpayers' dollars, that we do not create circumstances where we start to get into a vicious cycle, following ourselves down a path, whether or not it is the right path, because, simply, we have already started there.

Mr. BRACKETT. Yes.

Mr. RUMSFELD. Do you have any provisions where facilities or equipment are taken back, or partially taken back after initial performance by a company?

Mr. BRACKETT. Well, let me say this, I believe that most of the facilities that you are referring to——

Mr. RUMSFELD. Well, I am just quoting you.

It is what you are referring to that counts.

Mr. BRACKETT. Well, in that event, then, the facilities and equipment that I was referring to where not purchased by NASA. These

are facilities, just as an illustration, such as in the case of North American, where there are extensive test facilities, out in the mountainous area outside of Los Angeles, I believe. These are the types of facilities which are required for test firing, and which cannot be moved. They are stationary there.

Part of the facilities might be taken away, yes, but for the most part, these are sunk right in the ground—the base for them.

Mr. RUMSFELD. Well, of course, that is one example. I can appreciate that frequently, are we not talking about equipment?

Mr. BRACKETT. Well, if we are talking about machine tools, or that type of facility, those are movable, and can be taken away, and given from one company to another, but there are both types.

Mr. RUMSFELD. So your argument here that it should be recognized that certain companies have the facilities and equipment, really, in some cases, is no argument at all?

Mr. BRACKETT. That's with respect to the facilities that I am referring to here—those are the nonseverable facilities that cannot be moved. Machine tools can be moved from one plant to another, and they are. But what I am thinking about particularly, are those facilities, for example, where a new company might be set up as was set up in the case of the F–1 engine, which is a one-and-a-half-million-pound thrust engine, and there would have to be a duplication of these nonseverable facilities, to complete such a project. These would have to be paid for, and this is what we don't want to do.

We are, however, doing something, and I am not sure whether any other department is doing this or not, but it is very seldom that we put in any nonseverable facilities ourselves at any point. If we do, then it has to be on Government land, where it will be available for use by all contractors where the work is located. This is our policy.

Mr. RUMSFELD. Very good.

Mr. BRACKETT. In one instance that I know of, we are having to place nonseverable facilities on the contractor's own land, however, and in this event, we are obtaining the agreement by that company, or contractor, that not only will they have the authority to use the facilities, but also, any other of our contractors will have the authority to go in and use the facilities.

Mr. RUMSFELD. Well, I certainly think that that is proper, and I am delighted to hear it.

Mr. BRACKETT. We have a little trouble getting these agreements, but we say: "You don't get the facilities if you don't agree."

Mr. RUMSFELD. Fine.

In conclusion, I have seen situations where NASA has come before this committee and said: "We are placing a new electronic research center in a certain area, because they have the talent." And then NASA will go to other areas and draw off the manpower and in the future it is even more difficult for that area to get the NASA business, because they have even less ability to perform the job, than they had before the last NASA contract.

I see the same situation developing here, where it is possible, that we may contract for and build equipment, pay for equipment, and then turn around and say:

"We are going to let a contract there, because they have the facilities and the equipment."

I think that this is a dangerous theory, and I just want to throw this out as a word of caution.

Mr. BRACKETT. Yes.

Mr. RUMSFELD. I am personally quite concerned about this whole problem. From my discussions with Members of Congress, as well as residents of my district, and residents of other districts, this whole problem is a serious one, and it is going to become increasingly serious in the coming months. I would venture to say that had this hearing taken place 8 months from now, this hearing room would be filled, because I think there are going to be many investigations, not only by the Congress, but by other groups, because of the impact of this whole question of procurement on our society.

Mr. HECHLER. I believe that your points were very well taken, Mr. Rumsfeld, and I think we must exercise care where there is a huge investment by the taxpayers, in certain sections of the country, that we not simply use that as an excuse to keep piling higher and higher and higher, on the taxpayers' investment, simply because we have already made one big investment there.

I recognize the point about stationary facilities, but I do feel that where there is a possibility of moving them, that we should very carefully consider this.

Mr. WYDLER. If Mr. Brackett has completed his statement, Mr. Chairman, I have a question I would like to address to him.

Mr. HECHLER. Yes.

Mr. WYDLER. This is in connection with the proposed Electronics Research Center in Boston.

Is it proposed that they would also have the power to contract for electronics materials, and so forth, after it is established?

Mr. BRACKETT. Our present system, I would assume, would apply in that after the Center is established, they would also have authority to buy supplies for use at that point.

Each one of our centers does buy its own supplies and also makes contracts for the projects that are assigned to that Center.

Mr. WYDLER. In other words, it would more or less become electronics procurement center, would it not?

Mr. BRACKETT. For the projects that would be assigned there.

Mr. WYDLER. And has any thought been given to the limit. I think the general rule goes up to $1 million, does it not—they can do that without any clearance from Washington?

Mr. BRACKETT. I don't know what the level would be. We have different levels, of course, depending upon the capability, let's say, the procurement capability of the new Center.

This has to be taken into consideration, and perhaps they need a little closer surveillance than they would later on; but I do seriously question whether they would be able to make contracts up to a million dollars when they first started.

Mr. WYDLER. Thank you. I would like to ask some questions in a different field, but I will wait, if there are any further questions on this matter.

Mr. HECHLER. Proceed, Mr. Wydler.

Mr. WYDLER. Thank you, Mr. Chairman.

Have you come into contact with this question of proprietory rights in the awarding of these contracts?

A number of people have discussed with me this question, and truthfully, I would like to get a better idea of what the position of NASA is on this.

Mr. BRACKETT. I would prefer that you talk with our patent general counsel, who interprets the statute, and has drafted the clauses.

I can give you a general idea, but I am not an expert on this subject.

Mr. WYDLER. The point that I am talking about is that many of these suppliers for NASA feel that they are suddenly being put in a position where they have to make public all of their secrets in order to obtain a contract.

They say, in effect: "If we do that we will lose all of our patents in bidding on these contracts, and we don't want to do it."

This is a very serious question as to just what is the fair and proper procedure in these matters, and I truthfully have no answer to it—nor have I taken any type of position in my own mind.

I would just like to know if NASA has any provisions for such an instance in awarding contracts that might help me to understand it.

Mr. BRACKETT. Well, I will say this: That if a company has a patent, our patent provisions, under the Space Act, and under the regulations, and policies, in no sense expect the company to give us rights under such patents, unless we pay them a reasonable amount for such rights.

There are many processes and items that may not be patentable, however, and when a company feels they have a proprietary right to some knowledge which they don't want their competitors to find out, we try to take care of such a situation.

We send out requests for proposals, for instance, in something like this brandnew space vehicle and capsule area, and such things as that, and sometimes the companies come up with brandnew ideas which are not patentable, and they hesitate to submit those in a proposal feeling that, assuming they do not get the contract, these ideas may be purloined, and given to the successful bidder.

This is a very difficult thing to handle, because you can write regulations, and you can make rules, but you can't close the minds of engineers to new ideas when they read them somewhere.

Mr. WYDLER. No.

Mr. BRACKETT. Our policy is this: It is not to steal any company's proprietary rights and to give them to another company, and if a company wishes, in their proposals, to make the statement that the information which they have in a certain area is proprietary information, and that this should not be divulged, then this would be restricted.

Now, we do have some instances where we make a study contract, where we might make a contract with perhaps three or four people. For instance, before we made the contract for the Apollo capsule, we went out to, I believe, three different companies and paid them a certain amount of money for a feasibility study. Was it feasible to have three men in a capsule going to the Moon, and what were their suggestions for this? We paid them for it, we paid them a ceiling amount, and I believe all the companies put in some money themselves, in addition.

Now, none of these companies, which did the feasibility study, got the contract for the hardware, but they did make the study, and they did come up with new ideas.

Now, such a contract provides, where we are doing that, and where they come up with new ideas, that NASA pays for the ideas and we can use them in any way we want to. In fact, we took all three of these studies and made them known to the industry, released them, generally, with everything that they had found out, so that the companies coming in with proposals for the hardware on the Apollo capsule contract, would have the best thinking on it that had come up to date, for which we had paid, and which we owned.

Mr. HECHLER. I think that this is a very useful area, and there is a special subcommittee that Mr. Daddario chairs, which has gone into the patent rights matter.

You have also brought up some new points which may be under that jurisdiction, and I think they are very interesting.

Mr. BRACKETT. Mr. Chairman, one thing we are very careful about is where we have competition, and perhaps we have had some 7, 8, or 10 companies, all putting in a great deal of effort into their proposals, but only 1, of course, gets the contract, and the others say that they would like us to debrief them as to why they didn't get the contract.

There we will sit down and tell them where their proposal was defective, but we will not compare their proposal with the others, and we will not release any ideas that they may have come up with to the other companies.

Mr. WYDLER. Interestingly enough, the way this problem was presented to me, was that the subcontractor didn't object to making this information available to NASA but did object to making it available to the prime contractor. Which, under the system, he was forced to do, and I presume he did not trust the prime contractor, although he seemed to be willing to trust NASA.

There did seem to be a real problem and I didn't understand why NASA was making the subcontractor reveal this information to the prime contractor.

Mr. BRACKETT. We are not.

Mr. WYDLER. I can understand why NASA might be entitled to the information, and willing to work it out on that basis, but why they should make it available to the prime contractor, I couldn't understand.

Mr. BRACKETT. We are not making it available.

Mr. WYDLER. You don't?

Mr. BRACKETT. I think the prime is the one that makes them do it. [Laughter.]

It is pretty hard for us to control the prime where we are asking them to be responsible for this gadget working.

Mr. HECHLER. On page 5, Mr. Brackett, you say:

> The fees on our contracts in fiscal year 1962 ranged from 1.85 percent to 9.65 percent, with the average being 6.33 percent, which is slightly less than the year before when fees averaged 6.65 percent.

Now, why should the fees vary so much, and what are the circumstances which dictate the very wide variance here?

Can you not state clearly a standard for fees which you grant, and a more specific percentage figure?

Mr. BRACKETT. Well, Mr. Chairman, many things go into a consideration of what is reasonable as a fee for work.

Generally speaking, for an assembly job, if a company is buying most of these materials, the fee is considered to be less important,

especially if the work does not take a lot of engineering talent, and so forth. Therefore, the fee is usually lower.

However, where a company is devoting its very top engineering talent, and some of these people have almost rare engineering talents, this is considered the type of work which is deserving of a higher fee—the highest.

Then, there is a question of responsibility. If a company is producing an item which has very stringent requirements as to how it must work, and it is a very difficult thing to make, or great difficulty enters into it, then we feel the company deserves a higher fee. Again you may have a company which has a unique capability, and we have to go to them, and ask them their fee, and they say: "Well, this is our fee, and if you want our services, then you have to pay what we want for the work."

Mr. HECHLER. Yes.

Mr. BRACKETT. This is not the usual case, but there are companies that take that stand.

Mr. HECHLER. I want to recognize Mr. Boone, but I have just one or two other points:

You mentioned when I asked you about a figure of 64 percent of the contracts, that there were 17 exceptions, I believe?

Mr. BRACKETT. This is by statute.

Mr. HECHLER. I think it would be very useful, to preserve a little continuity, if you would simply put these 17 exceptions into the record.

Mr. BRACKETT. Yes, I think I do have them here, Mr. Chairman. Do you want me to read them in?

Mr. HECHLER. No, I would prefer to have them put into the record, unless there are any members of the subcommittee who would care to have them read at this point?

I think they would be very useful.

Mr. BRACKETT. We will put them into the record.

(See p. 3337.)

Mr. BOONE. Mr. Chairman, in line with this discussion, may I ask a question?

Mr. HECHLER. Yes, Mr. Boone.

Mr. BOONE. Do you strive for uniformity at all? For certain types of contracts, you would be better able to get a fixed fee, would you not?

Mr. BRACKETT. Those are fixed at the time the contract is made, yes.

Mr. BOONE. Yes, fixed at the time that the contract is made. But they are not fixed dollar amounts?

Mr. BRACKETT. They are fixed dollars, yes.

Mr. BOONE. They are, but these numbers here are fixed percentages.

Mr. BRACKETT. Right. These are percentages, but they are based on estimated cost at the time that the contract is made. Let us assume we have a $10 million contract, and the fee is at 6 percent. Your dollars of fee are fixed; the cost may go way higher than that, but the dollar amount of the fee that you paid, and the percentage of the original estimate of cost, which is actually paid, are fixed.

Mr. BOONE. Well, in view of Mr. Rumsfeld's questioning, how do you determine competition in such matters as continuing contracts?

You may recall the discussion last year which I believe was in executive session, on a continuing type of contract?

Mr. BRACKETT. Yes. Usually this depends upon the type of continuance. Are you talking about largely the service contracts?

Mr. BOONE. Service contracts, primarily, yes.

Mr. BRACKETT. Well, let us take an example—the operation of the minitrack station is one, and I believe this committee is aware that these stations are located at various places around the world, and the tracking is done by people out there who have been working on these matters, and are familiar with this work, and have been for some time.

Now, if we could go out and get competition, then we will take into consideration the cost to the Government in terms of transporting the present contractors' people back in case he does not get the continuing contract, and the cost of sending people out from the new contractor; also, the administrative cost of inventorying the materials on hand at the time the old contractor leaves, and the new contractor takes over, and the learning time which it takes for the new contractor to put his people in. These are the sorts of questions that we have to consider in rating the continuing contract. Our policy is not to continue a contractor indefinitely; but also, our policy is not to have an anual competition in that field. Perhaps we might have a competition every third year, or something like that.

There are certain types of contracts where the engineers have been working and are in the middle of working on some studies for us, and if we were to have competition on this type of contract, and another company came in, we might lose a great deal of the value of the work that has already been done by a certain company.

(At this point Mr. Hechler designated Congressman Fulton of Tennessee, to Chair the balance of the hearing.)

Mr. BRACKETT. There are other types of contracts where we do have contractors compete annually.

For instance, if we have a garbage disposal service, or a janitorial service, then we do have them compete annually.

It depends on whether it is going to cost the Government more if we do.

Mr. BOONE. Have you considered the placing of these continuing types of service contracts on an incentive basis?

Mr. BRACKETT. Yes, I would refer to the operation of the Mercury tracking range, for one, as an incentive-type contract, and then we did get competition, although we will probably continue with the contractor for an additional 2 years if his service is satisfactory.

This is on an incentive basis.

Mr. RUMSFELD. I would like to recognize Congressman Fulton of Tennessee, who is acting as chairman, and I would like to raise this question——

Mr. FULTON of Tennessee. Before you proceed, I do hope that it will be correctly noted that I am from Tennessee, because the other Fulton happens to be a Republican [Laughter].

Mr. RUMSFELD. I specifically mentioned that so that the record would be clear.

I think any discussion of procurement must mention the Government Accounting Office and the very fine work they are doing in this area.

Mr. BRACKETT. Yes, sir.

Mr. RUMSFELD. Despite the recent announcement that even GAO has been unable to figure out the TFX question. [Laughter.]

There have been proposals with which I am sure you are familiar, which would bring the GAO into the procurement picture prior to the actual signing of a contract, or at least at an early stage, rather than after the failure of a contract.

Mr. BRACKETT. Yes.

Mr. RUMSFELD. Do you, as an expert in this field, feel that this would unduly delay or hamper your administration of NASA's procurement policies? Would it be dependent upon the type of contract or the amount of money involved, and whether it was competitive or negotiated?

Mr. BRACKETT. I think it would impede our successful contracting if they did come into the picture at the contracting stage.

Now I would not have any objection to giving them any of the facts at any time. The fact is that we do just that, regularly.

However, to have them given any authority over our contracts and the placement of our contracts, the selection of companies, and the provisions that go into the contracts, I think would impede us.

After the contract is once placed, on the other hand, we have no objections whatever to giving them any information. As a matter of fact, just last night, on the new postal card system, GAO's auditor over in our building called me up and said: "We understand that you are getting some subcontractor reports in, and you are not ready to release them yet?" I said: "That's right." He said: "I would like to get your past experience right away if I could."

I said: "We will give that to you today," and he got that last night.

Mr. RUMSFELD. I think that this type of cooperation is important and I am confident that we are coming to a point where we must work out arrangements to bring GAO into it earlier and, hopefully, in a way that will not hamper your responsibilities.

Mr. BRACKETT. My feeling is this: If we are to have the responsibility of selection of contractors and the pricing and everything that goes into the contract, that it would dilute it if we had another Government agency entering inso this before we had done our job.

Mr. BOONE. Mr. Chairman, I wonder if I might ask something along this line?

Mr. FULTON of Tennessee. Certainly.

Mr. BOONE. What is your contract leadtime at the present moment? In other words, how long does it take to finalize contracts on the average now, and perhaps you could give us some explanation as to what the additional input by GAO would mean?

Mr. BRACKETT. Mr. Boone, this depends on the type of contract, and what we are doing in respect to it. I don't have any set figure on that.

Mr. BOONE. I see.

Mr. BRACKETT. We used to brag in the early days of how fast we placed a contract compared with some other agencies and I think we still can; but the use of formal advertising has a bearing on it, and other aspects, and the general span, I would say, between the time the contracting officer gets the request for proposals and the time he awards the contract—and I am going to guess now, sir—but I would say would be about 90 days. Perhaps less.

Mr. BOONE. Ninety days.

Mr. BRACKETT. Yes. If we are negotiating a contract, to give you an example, such as the lunar exploration module, which we did on the basis of source evaluation and competition—we issued no letter contract, but we got out a definitive contract—now that took, from the time the company was selected to the time we made the contract, around 90 days for negotiations, including analysis of costs, lining up of subcontractors and so forth.

Mr. RUMSFELD. Does NASA notify the Member of Congress involved when a contract is made?

Mr. BRACKETT. Now any contract that comes into my office for approval, as soon as it is approved our office phones the Congressional Relations Office—which I assume does in turn notify the Congressman—before it is released.

Mr. RUMSFELD. Then you have a rule that no publicity will be made on this contract for 24 hours.

Mr. BRACKETT. Yes.

Mr. RUMSFELD. Am I right?

Mr. BRACKETT. Yes.

Mr. RUMSFELD. And you do notify the Congressman of the district where the contract will be performed?

Mr. BRACKETT. Well, no——

Mr. RUMSFELD. Or you notify the NASA liaison man?

Mr. BRACKETT. Yes.

Mr. RUMSFELD. The day it is approved?

Mr. BRACKETT. That's right.

Mr. RUMSFELD. And it has this "not to be released" tag on it for 24 hours or whatever it is.

Mr. BRACKETT. Yes.

Mr. RUMSFELD. Do you know what happens to it after it reaches the NASA liaison office?

Mr. BRACKETT. I don't call the Congressman—but that is my understanding of what happens.

Mr. RUMSFELD. I see—I would like to say that I think there is a danger or implication when a Congressman is releasing such a contract or notification of such contract—there is a danger that the implication might be that he was instrumental in getting that contract, and I would like to suggest to you—and I am sure you would want to confirm this—that Members of Congress are for the most part not instrumental in determining the corporation that is going to get a contract?

Mr. BRACKETT. That is true; you are correct.

Mr. RUMSFELD. Because if they are, then you are not doing your job.

Mr. BRACKETT. You are correct; they are not.

Mr. RUMSFELD. Do you approve of this policy of giving notification to Members of Congress or giving them, so to speak, advance notification of these contracts?

Mr. BRACKETT. I think that Mr. Kresin would be in a better position to answer that than I am, being on the Congressional Relations Office, and he is here.

Mr. RUMSFELD. Don't you feel that, having so much responsibility in this area, there is an implication that you were pressured or were talked to, at least, about these things and possibly may have done something you should not have done?

Mr. BRACKETT. Well, sir, may I say this: We are not pressured.

Mr. RUMSFELD. The Members of Congress don't contact you and don't suggest——

Mr. BRACKETT. They may contact us and say "Our constituent is interested in this contract, in this procurement."

Mr. RUMSFELD. And you couldn't care less?

Mr. BRACKETT. They will possibly say: "We want you to be sure that they are given adequate consideration." And we do.

Mr. RUMSFELD. Would you not have given them adequate consideration if they didn't contact you?

Mr. BRACKETT. Yes, that is true.

Mr. RUMSFELD. Well, then, what is the total impact of the contact by the Member of Congress—zero?

Mr. BRACKETT. I think so far as the selection of the contractor is concerned, it does not affect our choice.

Mr. WYDLER. Well, if I may say, Mr. Rumsfeld, as you know, a Congressman is called on to contact many, many agencies.

Mr. RUMSFELD. Oh, yes—certainly.

Mr. WYDLER. And on all different types of matters—not only having to do with procurement.

We like to believe that people get more service if a Congressman does make a contact, on their behalf, or at least that we can get the answers quicker than they could—whether it has to do with procurement or any other matter concerning a Government department.

Mr. RUMSFELD. Yes. Absolutely true and every Congressman certainly has the responsibility of serving as a link between the constituent and this vast complex of agencies and departments and commissions, boards, and so on, of the bureaucracy that we have here in Washington.

That is a proper function of a Member of Congress.

Mr. BRACKETT. True.

Mr. RUMSFELD. The only thing I object to is the implication that there might be an improper function and I think that this is something that deserved some thought.

Mr. BRACKETT. Sir, I have yet to have any Member of Congress do, insofar as I am personally concerned, anything that I thought was improper.

Mr. RUMSFELD. I just thought this ought to be raised in relation to existing rules and regulations, so that on the face of it, there should be no implication that anything irregular is going on.

Mr. BRACKETT. We are always glad to give Members of Congress any relevant information; they are entitled to it.

Mr. RUMSFELD. Thank you.

Mr. BRACKETT. Sometimes, of course, we ask them not to reveal information perhaps, but this is all.

Mr. RYAN. Mr. Chairman, may I comment on a matter that concerns me?

On April 9, 1963, before this subcommittee we had a hearing which concerned, among other things, a contract which NASA had entered into with the General Electric Co.

Mr. BRACKETT. Yes.

Mr. RYAN. On the Apollo program. This is a contract for checkout, integration, and reliability which it was testified, would amount to approximately $100 million in fiscal year 1964 and $125 million in

fiscal 1965. The contract was originally made without competitive bidding.

Do you know what return or fee there will be to General Electric on that contract which was described at the April 9 hearing, Mr. Brackett?

Mr. BRACKETT. It has not been fixed as yet. It is being negotiated, Mr. Ryan.

Mr. RYAN. But that contract has been in effect for over a year.

Mr. BRACKETT. It is a letter contract; they are negotiating the definitive contract and no fee has been paid and no fee has been fixed at all.

Mr. RYAN. It has not?

Mr. BOONE. Is this attached to the existing contract?

Mr. BRACKETT. No, sir.

Mr. BOONE. It is a new contract?

Mr. BRACKETT. This is a new contract.

Mr. RYAN. I was talking about a contract entered into with General Electric for checkout reliability and integration?

Mr. BRACKETT. Yes, sir. That is right.

Mr. RYAN. This testimony was on the 9th day of April as I have mentioned, and since April 9, on or about April 16, NASA publicly announced that it was entering into a further contract with GE.

Mr. BRACKETT. That would be supplemental to the other, the first contract. It will all be in the one contract, but this would be additional work placed in that contract, Mr. Ryan.

Mr. RYAN. Was there an announcement on or about April 16 last?

Mr. BRACKETT. I believe there was, yes.

Mr. RYAN. And that announcement said that NASA was going to extend, am I correct——

Mr. BRACKETT. That's right.

Mr. RYAN (continuing). Extend the contract which was described here on April 9?

Mr. BRACKETT. I believe that is correct.

Mr. RYAN. How do you account for the fact, then, that on April 9 neither witness before the committee mentioned this extension?

Mr. BRACKETT. That I can't tell you, sir. I don't believe it had been decided at that time, but I may be wrong.

Mr. RYAN. So then NASA just put out a publicity release, and the whole matter was decided?

Mr. BRACKETT. This was not decided at our level, sir.

Mr. RYAN. All right.

Would you please describe for us what the extension of the contract involves?

Mr. BRACKETT. NASA is going to erect a test facility called the Mississippi Test Facility for testing the Saturn project down on the Pearl River, some distance up from New Orleans. Part of the original contract which General Electric was to fulfill was a checkout of this Apollo project and coordination of the Apollo project. Much of this work will be done at the Mississippi testing site, and the decision was made that not only would this work be done but the so-called housekeeping functions and other functions necessary to run this facility should be attached to the General Electric contract because they would be doing so much of the work down there anyway.

Mr. RYAN. Who made that decision?

Mr. BRACKETT. This decision was made by our top management, I believe.

Mr. RYAN. Who made it?

Mr. BRACKETT. I can't tell you, sir, the details, on who did make it.

Mr. RYAN. Well may I read a question that was asked (by myself acting as chairman) of Mr. Holmes and Dr. Seamans regarding this contract on April 9:

Question: "And there is no other anticipated expense to NASA under this contract with GE over and above the $100 millions?"

I was referring to the $100 millions for the integration checkout and reliability and development of the hardware that is involved.

Mr. HOLMES. For fiscal 1964.
Dr. SEAMANS. That is correct.

Mr. BRACKETT. I don't have the figures broken down, Mr. Ryan.

Mr. RYAN. That was, however, the statement to this committee—that there was no anticipation of any other expense to NASA on the GE contract. There was no implication, no statement, to this committee that there was any intention on April 9 of issuing a publicity release on April 16, stating that this contract was extended beyond or was to be extended beyond the "integration and reliability" function to include a service function.

I think that the committee—and I hope that the congressional liaison officer is here, and you will take this back to NASA as my personal feeling also—that the committee is owed a full explanation.

Furthermore, I would like to know why the contract for services is being entered into without competitive bidding and why it has fees for General Electric when they already have fees on the other contract.

What special ability has General Electric to perform fire protection services, and provide medical services and facilities, or photographic services?

Mr. BRACKETT. I believe that General Electric are doing this under contract at other places, sir.

Mr. RYAN. Where?

Mr. BRACKETT. One of them was—or both of them I think are under contracts with AEC.

Mr. RYAN. Where are they doing that under contract for NASA?

Mr. BRACKETT. None for NASA—none for NASA.

I believe that the rationale of having GE do this, however, was that it would be an administrative advantage, with perhaps a savings to the Government, to have General Electric do these things rather than have separate companies go in to do them.

Mr. RYAN. Was there any analysis made of what it would cost to let them do this? And what exactly is to be performed under this extension of the contract? Would you please describe that for the committee?

Mr. BRACKETT. Well they will do what is called the housekeeping functions down there.

Mr. RYAN. What does that involve?

Mr. BRACKETT. Probably guard services, running the cafeteria—things of that sort.

Mr. RYAN. Do the stockholders of General Electric realize that the company is running cafeterias?

Mr. BRACKETT. Of course, this is only an extension of what they are performing on the checkout and integration services.

Mr. RYAN. But that is a technical function—checkout and integration.

What effort was made for competitive bidding to let the contract. Were there competitive bids for the provision of cafeteria services and other services—guard services?

Mr. BRACKETT. I believe so—I believe GE will subcontract for this work.

Mr. RYAN. And make a profit on the subcontract?

Mr. BRACKETT. There will be competitive bidding on all this subcontract work.

Mr. RYAN. All right; for the record, the management of this test facility at Mississippi will include the cafeteria services, guard service, and fire protection service. What else is involved?

Mr. BRACKETT. Probably there will be a parking lot and transportation.

Mr. RYAN. Are they going to collect fees for the parking lot?

Mr. BRACKETT. They will probably get a small fee for the work that they do which will save NASA doing this work.

Mr. RYAN. It doesn't save NASA paying for it, does it.

Mr. BRACKETT. No.

Mr. RYAN. What else are they going to perform?

Mr. BRACKETT. These are the only functions I know of offhand, Mr. Ryan.

Mr. RYAN. Cafeteria service, guard services, parking lot, fire protection—what else?

Mr. BRACKETT. I don't have the details on this myself. I have not been in on this.

Mr. RYAN. Who let the work?

Mr. BRACKETT. The contract has not been let as yet. They have been selected.

Mr. RYAN. Who selected them?

Mr. BRACKETT. I believe our top management made this decision.

Mr. RYAN. Were you consulted?

Mr. BRACKETT. No.

Mr. RYAN. You are the procurement officer?

Is this not the very kind of thing where there should be competitive bidding, if NASA isn't going to do it itself?

Mr. BRACKETT. It could be.

Mr. RYAN. Have you any comparison as to what it would cost to have General Electric do it and what it would cost on the other hand to have it done by competitive bid?

Mr. BRACKETT. I don't but I believe that this is customary at certain places and that it has been done by other agencies.

Mr. RYAN. Where?

Mr. BRACKETT. I understand GE is doing this at least at two other places right now—or they have done it.

Mr. RYAN. For NASA?

Mr. BRACKETT. No—for other agencies that they work for—I am sure they do.

Mr. BOONE. Well, you have an additional contractor, do you not, that is performing these services for you—I believe it is called Mason & Rust—is that not right?

Mr. BRACKETT. That's right.

Mr. RYAN. You might make it clear as to whether or not there were competitive bids in that case.

Mr. BRACKETT. I think we had some 20 companies bid on it. This one is at Michoud. We had separate contractors in that case bidding and there was some consideration given to having one of the two companies working in the plant do the housekeeping functions, but the decision on that was that it would not be well to have the guard services and all things like that done by one company and that the other company might feel that it was not getting a fair shake, so we did decide to have a third contractor take care of the housekeeping.

Mr. RYAN. I think that this raises a very serious question. You take one of the giants of the aerospace industry that has a very peculiar relationship with NASA to begin with, and award to the giant a contract upon which it will make a profit to provide cafeteria services, to provide guard services, to provide parking lots. It seems to me that this is way beyond the purview of the General Electric Co. If anything should be let by competitive bid, these service type contracts should be. There is nothing peculiar here that requires them to be negotiated, is there?

You are not putting a parking lot on the Moon, yet, are you, Mr. Brackett?

Mr. BRACKETT. The subcontracts will be competitive.

Mr. FULTON of Tennessee. Pardon me; at whose discretion?

At whose discretion is this—the administration at NASA or General Electric?

Mr. BRACKETT. It has been decided that the subcontracts will be competitive.

Mr. FULTON of Tennessee. Yes, but who makes that decision? Did GE make that decision?

Mr. BRACKETT. No, I think NASA made that decision.

Mr. FULTON of Tennessee. I think it would be good if an explanation could be given from NASA as to why this decision was made from above, and not through the regular procedure. In other words, through you as procurement officer.

Is it within the discretion of this committee to ask for such explanation?

Mr. RYAN. Yes; I would like, Mr Brackett, to have a complete written statement as to the cost of this contract, what it is going to cost, in addition to the amount that was previously testified to.

Mr. BRACKETT. It may be, sir—I don't know this for sure, but quite probably it might be included in the cost that was quoted you.

Mr. RYAN. No. No mention was made of this to the committee—not about any such services.

Do you consider NASA already bound to this extension of the contract?

Mr. BRACKETT. I believe, sir, they are.

Mr. RYAN. In other words, you could not now——

Mr. BRACKETT. We can always terminate a contract, of course. We always have the right to terminate a contract.

Mr. RYAN. But you could not now ask for bids on this service?

Mr. BRACKETT. Well, we can always terminate a contract. We can always terminate any contract at any time.

Mr. RYAN. Does this not seem something that you should look into?

Mr. BRACKETT. I will be glad to take it up, sir.

Mr. RYAN. Doesn't it strike you as peculiar?

Mr. BRACKETT. I think there is a legitimate reason why it is well to have the company that is going to do the work there, do this, too.

The cafeteria, after all, will be for the benefit of the people, most of whom would be working for General Electric, and the guard services will be guarding things that they are using where the contract is taking place.

This could very possibly result in a savings to the Government by doing it this way, rather than having NASA try to put people down there to try and run these things themselves by means of several different contracts.

This has to be coordinated from the point of view of the different types of services that will be performed and the people have to work together, and as long as General Electric is going to do most of the work down there, or a great deal of the work down there, I think there is a legitimate and logical reason why General Electric, particularly since they have already had experience at other points in similar situations, and are doing this, should also do it in this case.

Mr. WYDLER. Let me ask you this just generally, Mr. Brackett. To get more general about this procedure, when you decide, or when NASA decides, to, let us say, have competitive bidding from two or three companies, to develop some particular item of space hardware, for example, who makes the decision as to what firm shall be asked to bid or submit proposals?

Mr. BRACKETT. Well any company may fill in a standard form No. 129 and get their name on the so-called NASA source list. This source list is sometimes apt to be pretty long and many companies that may like a contract but don't really have the capabilities will get on this list.

It all depends on what we are doing. For instance, if it is something like the lunar excursion module, something which would be very intricate in design and development—it will run, well, I think on the present contract it runs a little over $300 million—there are not many companies in this country that have the capability of doing this and it costs a company sometimes $300,000 or $400,000 to prepare its proposal alone.

Companies have to devote a great deal of their best engineering talent to prepare proposals on such a project and, of course, only one gets the contract.

Mr. WYDLER. Yes. I appreciate that.

Mr. BRACKETT. The point is this: We only invite those companies which we feel have a competitive chance of getting the contract and doing the work satisfactorily to submit proposals.

Mr. WYDLER. The question is really: Who is "we"?

Mr. BRACKETT. Our contracting officer at the field installation goes through the list of companies that have said they are interested in

doing this type of work. He confers with the engineers and between them they arrive at a decision that these are the companies that would be able to do this work.

With anything over $5 million, it starts with a procurement plan. The plan is submitted through our office to Dr. Seamans, the Associate Administrator, with details as to what we are going to buy and the names of the companies, which the center says they would like to have invited to bid, included in the plan.

We send a copy of this plan over to the program office—for instance, the lunar excursion module procurement plan went over to the Manned Space Office, to Brainerd Holmes. They may add some names, and we may add some names of companies, and when it gets up to Dr. Seamans, he may say: "I think so and so should be invited to bid," and these are the companies who are invited. We synopsize the requests for proposals in the Department of Commerce "Commerce Business Daily" and say, "This is what we are going to buy," and then we send out press releases and any other company that wants to submit a proposal can do so.

Mr. WYDLER. They may do so?

Mr. BRACKETT. They may do so.

And they will be evaluated.

Mr. WYDLER. Now as I understand it, say there is a contract for under a million dollars, this is something that Western Operations Office could award on a contract themselves, is that not right?

Mr. BRACKETT. Yes.

Mr. WYDLER. And somebody in the Western Operations Office will decide then who is going to be a bidder?

Mr. BRACKETT. And others also may be invited to bid.

Mr. WYDLER. Yes. Are there any other figures available that would show, for instance, as to the contracts awarded or the personnel or the persons in charge of Western Operations Office, where those contracts are awarded, geographically speaking?

Mr. BRACKETT. Whether that could be provided by our reporting system, I am not quite sure—although they do report to us, all the Centers, on what they do in the way of contracts, of course, that are awarded over $25,000. Every contract over $25,000 is reported to us and we put them all in one report.

Mr. WYDLER. Would I be asking a very onerous thing if I asked if you could explain why you do that for these various centers and what contracts were awarded—and on contracts within let us say half a million to a million dollar range, where they are, geographically, being awarded—for instance, as to the Marshall Space Flight Center and the Manned Space Center and Western Operations Office?

Mr. BRACKETT. I will have to see whether our reporting system can come up with that without going through each one of the individual contracts.

If we have to go through each contract, of course, it would be quite difficult.

Mr. WYDLER. Yes; well what I am saying is I want to eliminate the minor contracts in this and not consider them.

Mr. BRACKETT. Anything over half a million?

Mr. WYDLER. Well, let us say $250,000.

Mr. BRACKETT. Anything over $250,000—and you would like a regional breakdown?

Mr. WYDLER. By States or whatever you can do; yes.

Mr. BRACKETT. By States?

Mr. WYDLER. Yes.

Mr. BRACKETT. By each one of our Centers.

Mr. WYDLER. Yes; that is right.

Mr. BRACKETT. I will have to see what our system can produce.

Mr. WYDLER. I understand.

Mr. BRACKETT. We would be glad to give you anything we can, if we have it, certainly.

(The information requested is as follows:)

U.S. geographical distribution of NASA awards of $250,000 to $1,000,000, business and nonprofit institutions, fiscal year 1962

[Thousands of dollars]

	Total		Headquarters		Ames		Lewis		Langley		Goddard	
	Actions	Dollars	Actions	Dollars	Actions	Dollars	Actions	Dollars	Actions	Dollars	Actions	Dollars
Total	366	174,018	44	19,064	3	1,272	14	4,808	44	19,527	82	38,607
Alabama	46	24,192										
Alaska	2	738									2	738
Arizona	2	1,100									1	850
California	105	48,122	12	6,005	2	1,005	5	1,079	4	1,239	22	10,135
Colorado	4	2,206	1	250							3	1,956
Connecticut	1	267			1	267						
District of Columbia	7	2,888	4	1,514							2	900
Florida	16	8,957	1	784							6	2,501
Georgia	4	1,893	1	522								
Illinois	11	3,696	2	736								
Iowa	2	942	1	600								
Louisiana	5	3,378										
Maryland	15	7,144	2	723							9	3,977
Massachusetts	19	9,311	7	3,149					1	317	5	2,320
Michigan	5	2,266									1	275
Minnesota	3	1,076	1	260							2	816
Missouri	2	1,170										
New Jersey	20	8,790	4	1,459			3	1,300			11	5,061
New Mexico	2	1,221									2	1,221
New York	30	15,093	4	1,492			2	935	10	4,913	3	1,720
Ohio	3	1,137	1	250			2	887				
Pennsylvania	18	8,610					2	607	5	2,747	10	4,655
Tennessee	1	985										
Texas	26	11,058	2	620					15	6,904	1	300
Virginia	12	4,619							9	3,407		
Wisconsin	5	3,159	1	700							2	1,182

NOTE.—Flight Research Center had no awards in this category during fiscal year 1962.

	Wallops		Manned spacecraft		Marshall		Space nuclear		Launch operations		Western operations	
	Actions	Dollars	Actions	Dollars	Actions	Dollars	Actions	Dollars	Actions	Dollars	Actions	Dollars
Total	2	900	14	8,042	111	56,283	4	2,067	13	7,289	35	16,159
Alabama					41	21,468			5	2,724		
Alaska												
Arizona					1	250						
California			4	2,158	18	8,789	2	1,171	1	382	35	16,159
Colorado												
Connecticut												
District of Columbia					1	474						
Florida					4	2,710			5	2,962		
Georgia					3	1,371						
Illinois					9	2,960						
Iowa					1	342						
Louisiana					5	3,378						
Maryland					4	2,444						
Massachusetts			5	3,125	1	400						
Michigan					3	1,371			1	620		
Minnesota												
Missouri			2	1,170								
New Jersey					2	970						
New Mexico												
New York					9	5,137	2	896				
Ohio												
Pennsylvania									1	601		
Tennessee					1	985						
Texas					8	3,234						
Virginia	2	900	1	312								
Wisconsin			2	1,277								

Mr. WYDLER. Yes; certainly, I know.

Mr. BOONE. You do have this upper figure of $5 millions in the Centers, I think you have said?

Mr. BRACKETT. Yes.

Mr. BOONE. Could you give us some idea of how many contracts the Centers might let in excess of $5 million, is this something that runs into many per year?

Mr. BRACKETT. No.

Mr. BOONE. Or are most contracts in what category, dollarwise?

Mr. BRACKETT. I think we could give you this figure, Mr. Boone. This last year our office approved approximately a little less than 300 contracts, and we approve everything over a million dollars and some below.

Mr. BOONE. I see.

Mr. BRACKETT. So that is some idea.

Mr. BOONE. So that the $5 million contracts must be let in Washington, then, is that correct?

Mr. BRACKETT. Well, they are all approved here.

Mr. BOONE. All above a million dollars are approved here, are they?

Mr. BRACKETT. Yes. All above a million dollars are approved here; right.

Mr. RUMSFELD. On the matter that Mr. Ryan raised earlier, Mr. Brackett, do you in NASA utilize the services of any analysis groups to review the proposals to see if they are in line?

Mr. BRACKETT. Independent analysis outside of NASA? No, we don't.

Mr. RUMSFELD. Just the normal review within the NASA organization is used?

Mr. BRACKETT. Yes.

Mr. RUMSFELD. I am not familiar with this General Electric contract but in the event that you did determine that it was best for General Electric to proceed with these various services, such as maintenance, do you have a contract requirement that they have to have it on a competitive bid basis?

Mr. BRACKETT. Would you ask that once more, please?

Mr. RUMSFELD. In the event that NASA determines to leave in this case the responsibilities for such things as maintenance and janitorial services with the prime contractor, do you have a provision in your contract with the prime contractor which requires that they do it on a competitive bid basis?

Mr. BRACKETT. Well the only contract that I know of that we have similar to this is the housekeeping contract at the Michoud plant, and we do have such a provision in that contract.

Mr. RUMSFELD. In other words, if you are not going to have competitive bids on it and determine how it can be done most economically, you do on occasion require the prime contractor to do that very thing?

Mr. BRACKETT. Subcontracts of $25,000 and more under the contract at Michoud plant and also the one with General Electric are subject to approval, of course, by NASA—either by the contracting officer or someone he has designated—so that the obligation is on the contractor to obtain competition with respect to the subcontract since we do approve them.

Mr. RUMSFELD. I see.

Mr. BRACKETT. I would like to correct the record on one point that Mr. Ryan asked about.

He asked whether I was consulted and did I know of this. I did know of it and there was a so-called procurement plan which passed through our office on this extension of the General Electric contract, as I recall now.

Mr. FULTON of Tennessee. I am very glad you said that, Mr. Brackett, because I was going to ask you the question, if this had happened before—if you had been bypassed as Chief Procurement Officer, or your office?

Mr. BRACKETT. No, sir—I did know about it.

Mr. FULTON of Tennessee. Has there been any other occasion where you were not consulted as procurement officer on the procurement procedures, whether it be in connection with housekeeping or parking lots or whatever it might be?

Mr. BRACKETT. No, this is the only one.

Mr. RUMSFELD. A number of Members of Congress have described on the floor of the House what they considered to be in many cases—and what have in fact sometimes proven to be—a very serious situation in the letting of contracts. Some I recall were raised by Congressman Wilson of Indiana and by Senator Case of New Jersey. One was a situation where a bid was given to a company other than the low bidder on the basis of time of delivery and after a period of months the contract was amended to extend the time of delivery. There was then a complaint made by the higher bidder saying that they knew at the time the delivery could not be made in that shorter period, and the question I would like to ask is this: If such a complaint happens to come into your office, obviously there is a very serious problem and these people want to do business with you in the future——

Mr. BRACKETT. Yes.

Mr. RUMSFELD. They have to deal with human beings and they don't want to be a thorn in your side, and it occurs to me that in such a case they might be very careful about complaining.

What happens when they complain to you—who do they tell about that and how do you protect them?

Mr. BRACKETT. Well, I spent an hour with a man yesterday afternoon that had a complaint about one of our contracts out in the field. I frequently have these companies coming in with complaints and I find that there are two sides to the story, usually.

Mr. RUMSFELD. There generally is.

Mr. BRACKETT. And what we would do, before forming any opinions, is to get both sides of the story and then, if we find that our people have made a mistake and it can't be corrected, we take steps to see that it doesn't happen any more. If we feel that our people are right, we support them.

Quite frequently companies make a complaint to the General Accounting Office, right to the Comptroller General, which they have the right to do, and this is an instance where the Comptroller General does get into the procurement field before the contract is let. They will call our office and say: "Don't go any further on this until we send you over the protest," and then our office goes out to the field and gets the facts. Then we write back to the Comptroller General's Office with the facts as we have found them to be.

The Comptroller General then makes the decision—a written decision—in which he either sustains us or does not sustain us.

I don't like to brag, but since NASA came into being we have not been overrulled by the Comptroller General in a single instance on the selection of a contractor. There have been instances where protests have come through, and we have been into the matter and found that our field people have made a mistake and we have corrected it right there.

Mr. RUMSFELD. What about that man who made the mistake—he is a human being and he undoubtedly is not too happy about having made a mistake.

Mr. BRACKETT. Yes.

Mr. RUMSFELD. Let alone at being found making a mistake.

Mr. BRACKETT. That's right.

Mr. RUMSFELD. He is probably not too happy about the people who filed the complaint.

Mr. BRACKETT. Yes.

Mr. RUMSFELD. Now, what do you as Chief Procurement Officer, wrestling with this $5.7 million budget, do with regard to your man out in the field to see that this is not reflected in future business dealings?

Mr. BRACKETT. So far we have tried to issue regulations to avoid this sort of thing and to guide our people as to what should be done.

If something has come along that way maybe we have been partly to blame because we did not have a rule, but we do try to correct it by putting in a regulation on the subject. Of course, if he doesn't follow a regulation, probably, his chances of getting promoted are pretty slim. There may be extenuating circumstances, however.

Sometimes it could be an extension of time. Sometimes the technical people decide that after a contract has been placed—even though they say that they have to have a deadline date—they may come in and decide that they want to make some changes and so on in the specifications, and that will take the contractor more time.

Mr. RUMSFELD. I appreciate that.

Mr. BRACKETT. And this is brought out.

Mr. RUMSFELD. Generally these things will be aired and will always be brought out?

Mr. BRACKETT. Yes.

Mr. RUMSFELD. And any decision made, such as a decision in any Government department, will be aired and brought out?

Mr. BRACKETT. We bring out those things.

Mr. RUMSFELD. Well, I am very glad to hear that.

Thank you.

Mr. BRACKETT. People are human and they make mistakes. I sometimes make mistakes.

Mr. FULTON of Tennessee. Just along the lines Mr. Ryan brought out, with respect to General Electric again, you said that you were aware of this housekeeping contract?

Mr. BRACKETT. Yes, sir; I was.

Mr. FULTON of Tennessee. And were you consulted and asked for your opinion on that contract?

Mr. BRACKETT. No, sir. I believe I was not.

Mr. FULTON of Tennessee. You were not.

Mr. RUMSFELD. If a memo comes across your desk though, as chief procurement agent, that notice is tantamount to consultation, is it not?

Mr. BRACKETT. Yes, sir. To this extent I was consulted.

Mr. RUMSFELD. Yes.

Mr. FULTON of Tennessee. But you were not consulted as to your opinion on the so-called housekeeping contract?

Mr. BRACKETT. No.

Mr. FULTON of Tennessee. And does NASA not have any personnel at the Mississippi installation?

Mr. BRACKETT. Well, of course, this is just starting out, and we will have people down there.

Mr. FULTON of Tennessee. Management personnel?

Mr. BRACKETT. They will be management personnel, but we will have a skeleton staff. If we were going to gear up to a project to cover these several housekeeping activities with separate contracts down there it would be quite different. All have to work together and there has to be coordination, something that binds them together, and this would require a fairly sizable staff.

Mr. FULTON of Tennessee. I wonder if there is a record as to the small business contracts with new companies—how many of them are new companies that have been organized just for the sole purpose of bidding for related work in the space program—or incorporated for that purpose?

Mr. BRACKETT. I don't know the figures on it, sir, and I doubt that they would be available, but I do know that several New Orleans companies were formed—just how many I couldn't say—but I think we had 11 bids on this housekeeping contract at Michoud from companies in New Orleans and at least half of them I would say were formed just to put in a proposal although they had no experience. They just wanted to get into the business.

I might just say, and this is not in defense of General Electric, but I did check as to what they were doing for small business under this Apollo integration contract last week. They have organized a new department, and I think they call it the Apollo Support Department; but I checked to see what their experience was to date in helping small business concerns and subcontractors, and 90 some odd percent of the dollars that GE had spent in placing subcontracts had been placed with small business concerns by this department, under our contract.

Mr. FULTON of Tennessee. Well, one other question. On the Jet Propulsion Laboratory in the California Institute of Technology—What jurisdiction does your office have over the procurement policies of the JPL? At Cal Tech?

Mr. BRACKETT. At Cal Tech—well, this is a rather unique operation. It is a captive company, so to speak.

They have, however, a pattern of procurement regulations quite a bit like our standard procurement regulations, and, while it has not been written in the contract, it has been general policy that they will submit these regulations to us. We don't have the right to change them but it is a matter of cooperation, and we are working with JPL in coming up with their procurement regulations. This is largely done, or this particular thing is handled administratively by the Western Operations Office. They have a resident staff right at the Jet Propulsion Laboratory, administering this contract and, again, all

subcontracts which JPL make of $25,000 or over are subject to individual approval, of course, by NASA.

Mr. FULTON of Tennessee. And Cal Tech is on a cost plus basis?

Mr. BRACKETT. It is on a cost plus basis. Yes.

Mr. FULTON of Tennessee. And yet there is no written agreement; do you feel that there is a need for such a written agreement rather than this just general form of agreement between you?

Mr. BRACKETT. Well, of course, we have a contract with them. This is a cost plus contract with them, Mr. Fulton.

Mr. FULTON of Tennessee. I mean pertaining to these procurement procedures.

Mr. BRACKETT. I am quite sure that we do have adequate control of their subcontracting, sir.

Mr. FULTON of Tennessee. All right.

Mr. BOONE. You don't sit on the board of awards though, or anything of the sort?

Mr. BRACKETT. No.

Mr. BOONE. Nothing of that sort.

Do you have any say in the selection of the contractors or do you merely approve what they have already done?

Mr. BRACKETT. That's right. We do have one thing definitely, however, as part of the regulations with respect to any subcontract that they would make of over $5 million and that is that such subcontract has to be looked at by Mr. Webb, Dr. Dryden, and Dr. Seamans. They will have a board the same as we have a board, and they will be making their reports of the board to our top management, who in turn will select the major subcontractors under the JPL contract. They have done this in the two instances that I can think of right now.

Mr. BOONE. Their total amount of contract dollars is over a hundred million dollars; is it not?

Mr. BRACKETT. Yes, it is, definitely.

Mr. BOONE. Do you have any idea from your incentive awards idea—do you have any views about the results which are likely to be obtained as yet. Does it look promising, in other words?

Mr. BRACKETT. We are very hopeful about it. We are devoting a lot of time to it and we have a consultant who is spending almost full time in trying to work on these individual larger contracts, and seeing if we can't convert them to incentive-type contracts.

Mr. BOONE. Well do you know if you are making a saving in money or in time?

Mr. BRACKETT. This is difficult to say. I feel very certain myself that this is going to save money.

Mr. BOONE. But you don't want to convert until you are sure; do you?

Mr. BRACKETT. Well, we can't convert. We can't convert where the design is so nebulous, and when nobody has ever made any of these things before. There is no past cost history as a basis to rely on in making a contract, and it may be a long way off. It may be that the company can make a windfall if we do this. On the other hand, on some of these large ones, a company could be very, very bad off if costs were significantly underestimated.

Here is an example, with the military—the Air Force has a contract, which is an incentive-type contract, on the Titan III with Martin Marietta Co. They have made the Titan I, and the Titan II, and

they have made many other missile contracts so that they had a good basis of cost experience to fix the target. But many of these things that we are buying have never been made before.

Mr. BOONE. I realize it is very difficult and I am sure you are going to study it very carefully.

Mr. BRACKETT. Yes. This is why we have gone to this award fee where you don't have to have a target and your formula is such that you can correct a situation if necessary. If an individual contractor does a good job and saves money he will make more profit. We will save most of it, but he will make a profit, too.

Mr. FULTON of Tennessee. It is now 1 minute to 12 noon, and in accordance with the request of the chairman, Mr. Hechler, we would like to have the State-by-State breakdowns you have promised to provide, Mr. Brackett. Incidentally, I have noted that Tennessee is listed as 39th of the States in terms of contracts in the space program which is relatively low when you remember we are 17th in terms of population, so I would also, in general, urge you to look into our State also with a view to doing something with respect to subcontracts if possible.

Before we close I would like permission to submit written requests at a later date.

Mr. BRACKETT. Oh yes; certainly, Mr. Fulton.

Mr. FULTON of Tennessee. So if there is nothing further, we certainly appreciate your appearance here this morning Mr. Brackett, and we know you are doing a very good job in a very difficult situation.

Mr. BRACKETT. Thank you very much, sir.

(Whereupon, at 12:02 p.m. the subcommittee was adjourned.)

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1964 NASA AUTHORIZATION

THURSDAY, MAY 9, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON APPLICATIONS AND
TRACKING AND DATA ACQUISITION,
Washington, D.C.

The subcommittee met at 10 a.m., in room 214–B, Longworth House Office Building, Hon. J. Edward Roush presiding.

Mr. ROUSH. The committee will be in order.

We are pleased to have with us this morning the Honorable John H. Rubel, Assistant Secretary of Defense, and Gen. Paul T. Cooper.

The subcommittee has been concerned with possible duplication of the purchase of tracking ships for the use in the NASA Apollo program. Also it is concerned that appropriate coordination and cooperation may not have been established between NASA and the Department of Defense in satisfying their ship tracking requirements.

The purpose of the hearing this morning is to investigate the possibility of meeting the needs of NASA with their current DOD ship inventory. The subcommittee would like to have a presentation of what the current DOD inventory of ships is, what the workload factors are, and in what manner they feel they could satisfy the NASA Apollo requirements

We hope, Mr. Secretary, that you can throw some light on this question. It is a pleasure to welcome you and General Cooper before the committee, and you may proceed with your prepared statement.

STATEMENT OF HON. JOHN H. RUBEL, ASSISTANT SECRETARY OF DEFENSE FOR RESEARCH AND ENGINEERING; ACCOMPANIED BY BRIG. GEN. PAUL T. COOPER, ASSISTANT DIRECTOR, RANGE AND SPACE GROUND SUPPORT, DEPARTMENT OF DEFENSE

Mr. RUBEL. Thank you very much, Mr. Chairman. I am happy to to appear before this committee to present Department of Defense information concerning ships for the Apollo mission.

Representatives of the Department of Defense have been discussing NASA requirements for ships to be used with the Gemini and Apollo programs for over a year. Until recently, these requirements were stated in very general terms. Based upon our understanding of NASA needs, a DOD study conducted last June concluded that there would be enough tracking ships and telemetry ships in the combined instrumentation fleets of the Pacific Missile Range and the Atlantic Missile Range during the 1966–68 time period to fully accommodate NASA requirements.

Recently, NASA has definitized requirements in more detail. On April 2, 1963, NASA forwarded to DOD an 8-page description of the operational requirements for three Apollo tracking ships. They requested our assessment of the availability of these three ships from those already in or planned for addition to the Defense Department inventory.

Incidentally, Mr. Chairman, I believe that that request on the part of NASA was in response to a congressional inquiry that they ask the Defense Department in a formal way as to whether or not these three ships could be furnished out of either existing or planned additions to the Defense Department inventory.

Mr. ROUSH. This committee had asked NASA to submit in detail their requirements to the Defense Department with the view of determining whether or not you would meet those requirements.

Mr. RUBEL. Yes, sir.

We immediately formed a study group consisting of personnel of the Air Force Missile Test Center at the Atlantic Missile Range and representatives of the Pacific Missile Range to analyze in detail the new statement of NASA requirements. The results of this study were presented to NASA on April 23.

The study concluded that the instrumentation required by NASA for the Apollo program is similar to the instrumentation on board the general-purpose ships of the Atlantic Missile Range and the Pacific Missile Range, with certain exceptions. The principal exception is the lack of the so-called NASA unified S-band system; however, the study concluded that provisions could be made to accommodate this Apollo-peculiar equipment on the ships in question.

I might add here, too, that it is my impression from the data and information that I have seen that ships for the Apollo mission and general purpose ships have much more in common than they have dissimilarities.

There are nine ships in the combined fleets of the Atlantic Missile Range and the Pacific Missile Range, existing and planned, with a tracking capability as required and with hulls of sufficient size to accommodate this additional NASA equipment.

The study group analyzed the NASA and DOD programs which will require ship support in terms of the anticipated ship workload for the time period of the Apollo program. Using a computer technique, an operations analysis was conducted to determine the number of ships required, with proper allowance for launch schedule slippage, delays due to weather, cancelled launches, and so forth, and with the proper allowances for steaming time, reprovisioning, refueling, drydock and crew rest. This study assumed that every Apollo launch would require an arbitrary 30-day, onstation coverage and that Apollo requirements would be supported 100 percent as a matter of national priority. By using the computer technique, one can determine where the law of diminishing returns sets in as the size of the fleet increases. The study concluded that 11 ships are needed to achieve the desired level of support to the total NASA/DOD programs, again, assuming 100-percent support to Project Apollo.

I mentioned that DOD will have nine tracking ships of sufficient size to accommodate Apollo. We had planned to commence construction of a large satellite tracking ship, known as *Aris-3*, during this fiscal year, to be operated in the South Atlantic and Indian

Ocean areas for the purpose of monitoring satellite events taking place in those areas. The bid proposals submitted by industry indicated that the cost of this ship would greatly exceed our original estimates. A very careful review of the data requirements of the several satellite programs for which this ship was to be configured indicated that none of this data was absolutely essential to the success of any program. Whereas it would be extremely desirable to collect this data and, undoubtedly, such data would enhance the various satellite operations in question, it was our considered judgment that this data was not worth the price of *Aris-3*. It was decided that we must either forgo the data or be satisfied with a ship of a lower order capability in order to stay within reasonable costs. We are currently studying the feasibility of modifying (for this purpose) one of the several relatively small C-1 hulls now in the AMR telemetry fleet. Assuming this plan is pursued, this modification will provide the DOD with a 10th tracking ship although this ship is too small to accommodate the special Apollo requirements. It will serve, however, to satisfy some of the general-purpose ship workload and thus relieve the burden of the larger, more expensive ships.

I guess I should make it clear, if it isn't perhaps absolutely clear, that we dropped the *Aris-3* from our program. We are not going to include it in the Aris program. We are going to have a substitute of lesser but adequate capability. That is the thrust of this paragraph.

The Department of Defense study, and I am referring again now to the study that I set up with Air Force and Navy representatives, addressed specifically to the question of whether or not the Defense Department fleet could satisfy NASA's Apollo requirements, this study concluded that only one ship, the 11th, must be added to the tracking fleet for Apollo, if others are suitably modified to meet the special Apollo requirements. Although NASA proposed a total of three ships, our study concludes that this number is marginal, if indeed the Apollo requirements are "mandatory" requirements. I should differentiate between the term "mandatory" and the term "desired." A mandatory requirement is one which would cause cancellation of the mission if it could not be satisfied on the day of the mission. The desired requirement is one which would not cause a cancellation. Therefore, in order to meet the requirements as stated by NASA, we believe it is necessary to configure a minimum of five ships with Apollo equipment; one in the Atlantic between Bermuda and Antigua to monitor the insertion into Earth orbit, two in the South Atlantic or Indian Ocean to monitor the injection into the lunar trajectory, with two additional ships in the Pacific to monitor this same injection maneuver, when and if it occurs on that side of the world. Our estimate of costs to modify four ships is approximately $50 million. Adding the new ship, the 11th, raises this cost to the Apollo program to $80 million.

I should hasten to add that these costs are pure estimates, based on our experience in the DOD in the configuring of nine tracking ships. If our experience has proved anything, it is that the magnitude of costs are consistently underestimated. Additionally, as this study developed, we realized that the statement of operational requirements provided by NASA left many questions unanswered, some of which depend on Apollo program decisions of the future. Therefore, one must realize that there is no precise solution to the currently anticipated requirements.

There is room for a difference of approach and viewpoint with respect to the ship operations. I believe the DOD and NASA are in general agreement that general-purpose ships should be deployed wherever possible in order to achieve maximum utilization. We are also in agreement, I believe, that special-purpose ships are the proper solution in cases where the equipment on board is indeed unique to a particular project. The questions at hand are how much of the equipment on board these ships is unique to Apollo requirements and whether this equipment requires operators directly under the control of NASA, and whether these ships will be fully utilized in this special configuration. The answers to these questions will indicate whether the ships should be project peculiar or part of the general-purpose fleet. DOD cannot make this determination with the information at hand. It is necessary for NASA to arrive at these decisions which so vitally affect their programs.

We have submitted a plan to NASA which examines the various alternatives and suggests an arrangement whereby 100 percent of their Apollo requirements can be met by the modification of four DOD ships and the addition of one new ship as a part of the national fleet. We believe that it is up to NASA to answer the remaining questions as to the extent of the Apollo-peculiar equipment or whether there are deficiencies in this plan. We have provided them with our best estimates as to how we may assist them. However, the decision is theirs and it is not a simple one. NASA may determine that three new ships especially equipped for Apollo are necessary for the Apollo program. We shall, however, continue to take every opportunity to assist them in minimizing costs and to provide any tracking ship support that can be made available from DOD resources.

Mr. Chairman, that concludes my prepared statement, but since that statement was prepared I have received a letter from Dr. Seamans, the Associate Administrator of NASA. It came too late for incorporating its contents or the burden of its message in the prepared statement. I really haven't had time to study it in detail, either, but having read it now, it is my impression that what it says is that NASA has studied the Defense Department proposal, that NASA feels there are certain assumptions that were made in conducting the Defense Department study which were incorrect or would prove to be incorrect, that for these reasons NASA believes that it is necessary to add three new ships to the national inventory to satisfy the Apollo mission requirements without at the same time eroding support for other missions, and, finally, that it is NASA's conclusion that the solution and recommendation contained in the Defense Department report will not prove acceptable, and that the three-ship solution initially proposed by NASA is the one to be followed.

That concludes my opening remarks, Mr. Chairman. I would be very happy to answer any questions that I can. General Cooper, who is Assistant Director of Defense Research and Engineering for Ranges and Space Ground Support, is here at my right, and has much more detailed information on all of these subjects than I.

With your permission, I would like to feel free to call on him to answer questions, or for you to feel free to call on him directly at any time to give you whatever information you would find useful.

Mr. ROUSH. We would be very happy to have General Cooper participate in this discussion. We were aware, of course, that NASA

wanted its three ships. We felt, however, that we would be remiss if we did not investigate the possibility of using the ships which we have in our inventory at the present time, modifying these ships to meet these requirements if it would save the taxpayers money and still fulfill our national goal.

I also have a letter from NASA and they point out the same things you mentioned. However, there were a couple of details in this letter I wanted to inquire of.

One of the things they have stated is that it appears that some of the factors used by the Department of Defense in its computer analysis and in its conclusions are incorrect. First, they say that your proposal would cost $86 million, not $80 million; secondly, the DOD analysis assumed only 30 days of ship support for Apollo launch based on four launches a year, while NASA planning calls for six launches per year, and virtually full-time utilization of the supporting ships. Third, the Department of Defense study assumes that the total non-Apollo ship-support studies can be met by 10 ships and that only 1 additional ship will take up the additional Apollo workload.

This is considered to be a serious underestimation of the workload that Apollo will generate.

Fourth, the DOD analysis assumed a 50-percent reduction in non-Apollo missions between 1966 and 1968 which is not viewed as a realistic estimate of the national flight program over these years.

Do you care to comment, either of you, on that?

Mr. RUBEL. I would like to make a preliminary comment and then General Cooper may wish to add something.

In the first place, as I think I said in my opening statement, the estimates of the cost of undertaking any of these programs, whether it is the $90 million for three ships, or the $80 million for the Defense Department plan, are nothing more than estimates, and I tried to say in my opening statement that there is much room for possible changing as the program is actually undertaken. They are the best estimates we can make, and the NASA apparently differs with us, judging from this letter, by something less than 10 percent.

I doubt very much that our estimates or theirs are good to within 10 percent.

Secondly, with respect to the other substantive elements that are mentioned, how much support is really required? Whether the assumptions made in the Defense Department study were correct, or not, I would say that we ought to look at two possibilities. One is that they were not correct. The other is that they were, and we can discuss whether or not there is a misunderstanding in that regard in just a moment; but if they were not correct, and if in fact they should have used different assumptions in the computer analysis, that does not necessarily lead me to the conclusion that the approach we used in that analysis is wrong. It doesn't lead me to the conclusion that we should or should not acquire three ships separately or that we should or should not go for the solution as outlined in the Defense Department study.

As I emphasized, we made that study on a real crash basis. The people who did it did the best job they could in the time available. They used all of the information they had at their disposal at the time. If there is additional information available now or retrospectively, and it appears that we could do a better job of approaching that

analysis, we certainly would be willing to do so if called upon by the NASA.

In short, I don't conclude that because one might quarrel with the assumptions or quarrel with the numbers used, that the approach is wrong or one can decide any best final course of action at this time.

Mr. ROUSH. May I ask you, Mr. Secretary, when the requirements were submitted to you, did the requirements include six launches per year or four launches per year, and if it included six launches per year, why did you use four if their statement is correct?

General COOPER. Mr. Roush, the statement of operational requirements that was presented to the Department of Defense on the 2d of April, I believe, did not discuss the launch schedule, per se. I think NASA assumed that we had the schedule. The people that worked up the study did indeed have a schedule. The schedule called for four. When we met on the 23d of April, NASA said this figure of four should be six. Since that time the people that worked up the computer study reran their figures and they concluded that if you increased the Apollo flights by 50 percent from four to six that the level of support to the non-Apollo missions would be reduced from an 85-percent figure to an 83-percent figure. Furthermore, if they had Apollo flights bunched up so that you scheduled them on the basis of two per quarter for two consecutive quarters, this figure would be further reduced to 81 percent.

Now, I think it is important to understand what this percentage means. It means that after having satisfied Apollo requirements 100 percent, what is the percentage of the total estimated workload that can be satisfied with the time that is left over on the ships? We have found by experience that if you plot the number of ships needed versus the percentage of workload that you have to cover, you end up with a number that almost reaches infinity. In other words, the curve flattens out at some point. Using our computer routines where we used actual geographical locations and actual sailing times, and the assignment and selection of specific ships for tasks, this curve flattened out at the point of 10 ships for our current workload; at 11 ships, including the Apollo workload.

I might say that, however, this is based upon a long-range forecast and we have found that by experience, the availability of ships steaming to and from, the judicious scheduling of the lower priority missions, and, in some cases, the waiving of data allows us to handle 100 percent of the workload.

What I am saying is that this 15 percent the difference between 85 and a hundred, we must handle on this basis, a cut and fit on the day of launch. We do this. We have done it for years. It is part of our way of life in the scheduling business on the ranges.

Now, this 85 percent, when you change the Apollo flights from four to six, decreases to 83 percent, which we don't think is a significant workload reduction in our capability, and we don't think it warrants the procurement of a 12th ship.

Mr. ROUSH. Mr. Wydler.

Mr. WYDLER. To clarify something, they say they are going to have six Apollo launches; what year is that going to be in?

General COOPER. I can't answer that.

Mr. RUBEL. It is the 1966-to-1968 period.

Mr. WYDLER. There must be some projection; when do they say they are going to have six Apollo launches; what year would that be?

Mr. ROUSH. I believe we have been informed that the specific dates on this is classified information. The general time frame I think could be discussed.

Mr. WYDLER. Well, it would be some time; we presume by 1970; but, in other words, the requirements for these ships are not something which is very immediate as far as I can see, isn't that a fact?

Mr. RUBEL. The leadtime on the ships is pretty long.

Mr. HECHLER. What is the leadtime on the ships?

General COOPER. The *Aris-1* ship, a very expensive ship, was dedicated on the first of this month. I think it has been described to you by the NASA. It took 21 months from the time of contract to the time of delivery. The second ship was built on a more leisurely pace of 24 months. Certainly, if you have the time, it probably would reduce the cost to build it. So I think a figure of from 24 to 30 months is a very reasonable figure to use, from the date of contract.

Mr. RUBEL. Mr. Chairman, I would like to volunteer something, if I may.

I think there are two kinds of requirements that we are talking about, and I think it is important that we distinguish between these two kinds of requirements. One kind of requirement concerns the technical characteristics of any ship. It might be useful for us to speak of that as technical requirements. That concerns what kind of communications, what kind of radar, what kind of telemetry, what kind of control, what kind of display, things of this sort, that are on board a ship to accomplish the technical requirements.

A second kind of requirement is what we might call the operational requirement. This is what the ship has to do, how long it has to be on station, in fact whether you even need it or not in the context of the mission.

Now, we have addressed ourselves to both the technical requirements and the operational requirements in our study. The assumptions that we have made about the operational requirements are largely the ones that are addressed in this letter that you, Mr. Chairman, have just cited, but the technical requirements are the ones that are principally, although not exclusively, covered in the document which we received on the 2d of April, and which was the basis for our analysis.

I think it is very important that we distinguish between these. We are satisfied, I believe, that we are at the point where there is very little disagreement concerning technical requirements. I think we understand what needs to be on these ships, and whether or not there is room to put everything on a general-purpose tracking ship that is necessary to accomplish the Apollo mission. Things of this sort are not at issue. The kind of requirements we are really talking about now are in the operational category for the most part.

Mr. BOONE. Does this mean, Mr. Rubel, that you do not have a complete statement of requirements from NASA?

Mr. RUBEL. Well, it is hard to answer that question, Mr. Boone, because it goes back to this matter raised a few moments ago relative to whether four per year or six per year is the proper schedule to use. That is an example of an operational requirement. There are others which relate to whether or not you are going to need simultaneous

coverage in the Pacific and the Atlantic Oceans, what kind of planning factors are proper for turnaround times in ports, what the appropriate assumptions are with respect to time on station. These are examples of operational requirements. Whether we have them all or not is a little hard to say in view of this last letter. What the impact of any changes would be on the conclusions of the study is difficult to say because we haven't had time to assess those.

Mr. BOONE. From your past experience in this, say, with Mercury or other shots, when do you really firm up this type of requirements; in other words, 6 months ahead of time, 2 months ahead of time, or what can you expect in the Apollo program, when would you have to know, say?

General COOPER. First of all, with regard to the technical requirements, I think that the statement that NASA has given us is probably the best statement that could be written at this point in time, and I think it is adequate because we understand what they mean by a C-band radar, we understand what they mean by a stabilization system and a computer and communications. We have worked with this type of equipment for years.

Normally, however, in the case of range instrumentation support, we receive requirements not in terms of what instruments are required to satisfy them, but in terms of what data they want; in other words, metric data such as position and velocity to a certain accuracy. We don't have this type of requirement statement but I think in the case of ships the NASA requirement will be the best that we can get, and I think that NASA is proper in asking for it in this manner, but we don't have it in detail yet, and I doubt that NASA will be able to give it to us until they have looked into the Apollo program and gone much further down the road than they are now.

Now, so much for the technical requirements. The operational requirements are usually stated in terms of launch dates and ship location at a certain geographical area. If there is a launch window involved, they state the length and duration of the window, the type of the window, and then we determine the number of ships required. We don't have a clear statement of this type of operational requirements upon which to base a good judgment.

The April 2 statement of operational requirements states that NASA will accept a three-ship solution. Keep in mind that one ship is going to be off Bermuda and the island of Antigua at all times for a specific job, and there is a second job to be done, the monitoring of the injection maneuver that varies widely between the North Atlantic-South Atlantic and down into the Pacific. The job for these two ships is very nebulous indeed, at this point in time, but NASA's statement of requirements says that they will be satisfied with two ships. We don't understand this, and I think that we must have further discussions with NASA in order to fully understand it.

Mr. BOONE. Does this mean that you think they may need more than three ships?

General COOPER. Well, if indeed this ship is to play the very vital role that they say it is, and that it is to take some measurements so that, on the spot, on the ship, as a result of these measurements, almost instantaneous reaction can occur on the part of decisionmakers, so that abort decisions can be made, and command decisions transmitted to the spacecraft, if this is the role for this ship, then it is

absolutely vital to the Apollo mission and this means that it is a mandatory requirement in the strictest sense of the world.

Mr. BOONE. Did they tell you this is the kind of command they want?

General COOPER. This is what they said in their April 2 letter. I have it here. Perhaps I had best read it to you to make sure that these words are properly stated, but nonetheless they also stated that they have a launch window requirement. They are constrained by very practical reasons, some of them safety considerations, between a launch heading or launch azimuth from Cape Canaveral from 73° to 106°. They must pick a time each day that the Moon is in the proper position to launch on one of these azimuths so that inclination of the Earth orbit properly coincides with the point at which they want to inject into the lunar plane. This means that the launch azimuth varies. This takes time, while the launch azimuth is varying, a period of about 4 hours. To restrict this is a very severe restraint on the launch crew. Our calculations show that with only two ships down in the South Atlantic or in the Pacific monitoring this injection process, the 4-hour launch window is constrained to about 45 minutes to enable them to make the injection decision after launch and during the second or the third Earth orbit as they stated.

Now, if indeed the requirement is as vital as they say it is, they must cover the entire area during the 4-hour period over which the injection point might occur. To do this takes a minimum of four ships in that area. Yet they are planning on only two. So obviously, they are making some sort of trade off, some sort of compromises in either restricting the launch window or the job for the ship is not quite as vital as they have stated.

Now, there is another school of thought, that you can indeed do this job after the ascent maneuver and from land stations and over a long period of time as opposed to just a 1 minute of track from the ship. Our discussions with the NASA people have not clearly indicated exactly what the plan of action is. Therefore, these operational requirements we consider to be somewhat nebulous at this time. But this is a NASA determination. It is not for us to tell them what these operational decisions are to be.

Mr. WYDLER. Mr. Chairman, if I might, right on the testimony that we are receiving, just to see if I understand this, I remember when they explained the need for these ships to the subcommittee, the representatives of NASA, they were proposing that they use them in connection with certain land stations, some of which were located on the continent of Africa or to be located on the continent of Africa, as I remember the testimony, so that they stated that with a combination of these proposed stations on land and the ship they could cover the area or the window I believe as you are describing it that they needed to.

Have they explained that to you or am I talking about something else here?

General COOPER. No, I don't believe so. There is a limit to the number of land stations they have and if you draw the radius of coverage from each of these stations, there is a great deal of land area not covered.

Mr. WYDLER. Well, they are proposing—this is what I am asking you now—they are proposing, as I remember it, new stations to be

built in Africa that would cover part of this so-called area that has to be covered. So between those and the ships that they would have to station in the Indian Ocean, or wherever they were, they would be able to cover this particular area.

Now, am I not talking about the same thing here?

General COOPER. I think you are talking about the same thing, and this is the type of information that we need to arrive at common conclusions with NASA. We are not aware of any plans they have for land stations other than those that now exist. The area of coverage, incidentally, includes a great northeastern portion of the South American Continent.

One way to cover this is to put land stations along the coast. Another way to cover it is to put ships offshore along the coast, but nonetheless if it is an absolute mandatory requirement to cover this area, and it is a very broad area, indeed, almost 4,000 miles in width, you cannot do it with two ships.

Mr. ROUSH. Mr. Rumsfeld.

Mr. RUMSFELD. How long did this Department of Defense study take you, was it a rather extensive study?

Mr. RUBEL. Well, we started it as soon as we received NASA's communication dated I think the 3d of April, maybe it was April 2, within just a couple of days, and we submitted a report to them April 22——

General COOPER. It was ready on the 19th; however, Mr. Rubel had not seen it so NASA suggested that we wait until the 23d.

Mr. RUBEL. So it took us about 2½ weeks, actually about 2 weeks to do the work.

Mr. RUMSFELD. Were a number of people involved in this study?

Mr. RUBEL. Yes. I don't know exactly how many.

General COOPER. The people involved were the Air Force people at the Atlantic Missile Range, and the Navy people from the Pacific Missile Range.

Mr. RUMSFELD. It took time and it took effort and presumably it was based on specifications, because you talked specifications. Now we see this communication from NASA, both to you and to the chairman of the subcommittee, which indicates different specifications from those you used. Do you follow?

Mr. RUBEL. Yes.

Mr. RUMSFELD. I think that you have said, General, that there is a need for greater communications. I would certainly suggest that there is, but it seems to me that the NASA communications on a brief reading of what I have seen here is inadequate, and it would appear to me that there is at least on the surface a tendency for them to direct their letter toward justifying what they want, but not to clarifying the specifications.

Are there underlying factors here? In other words, are we talking about one thing in your communications with NASA while something else is actually bothering NASA or bothering the Department of Defense?

I have heard complaints in the past that NASA suggests that the use of military crews aboard these ships is not totally satisfactory. Are there factors like this which are bothering you which causes this difference of opinion on what presumably should have been the same set of facts?

General COOPER. Specifically with regard to the use of military crews you may be referring to some NASA testimony that I also read about a month ago with regard to a situation in Nigeria. This was not a problem of military versus civil service. This was a problem of whether or not the vessel was to be declared a public law vessel and given public law status, and this would occur regardless of which agency was operating the ship. Indeed, there are military communicators on board this ship and to my knowledge they have offered no trouble.

Mr. RUMSFELD. Are there any other problems like this?

Mr. RUBEL. I think there are. NASA has a tremendous program and a tremendous national responsibility in connection with the Apollo. They have a natural desire and a proper desire to insure that every step they take is in the direction of discharging that responsibility. The Defense Department, on the other hand, has no direct responsibility for that program—I am speaking specifically of Apollo—but the Defense Department does have a substantial fleet of ships for general purpose tracking and other functions in connection with both the Atlantic and the Pacific Missile Ranges. Our orientation tends to be primarily directed toward the optimum utilization of Government facilities in the Government interest regardless of whether it is a NASA program or a Defense Department program. We have approached this study in that way. We have said that it seems to us that there are obvious advantages of scale in trying to satisfy Apollo needs out of a pool. It is always easier to solve traffic problems if you can draw on a pool than if you cannot, and the larger the pool is the easier it is to do that. This pool is large enough and the factors sufficiently varied so that it has been profitable to use a computer, in order to find out on a probabilistic basis what kind of results you would get if you were to accomplish both the Apollo and the other missions in the manner suggested here. But from the standpoint of the people directing the Apollo program—and here I am surmising just as you surmised, Mr. Rumsfeld, I haven't discussed this directly, but I would suspect that my thoughts on this subject aren't too far afield—from the standpoint of people charged with a very important project responsibility, the emphasis is going to be much more on being sure that that responsibility is effectively discharged than on taking the viewpoint which we have taken in this report here of trying to see how you can operate from the standpoint of overall economics.

Now, I wouldn't suggest, by the remarks that I have just made, that considerations of this sort have intruded themselves into the judgment of NASA officials. I don't mean to suggest for one moment that anybody in the NASA, certainly not my friend Bob Seamans or Dr. Dryden, who signed the letter for him, are only giving pro forma attention to the submittals of the Department of Defense. I am sure they are perfectly sincere in the conclusions they have reached. I think there is a natural difference of emphasis on the part of the two agencies in a subject of this kind.

Mr. RUMSFELD. Well, if they can be so sure of what they need, then to have this assurance wouldn't they have to base this on specifics and, if so, why don't you in the Department of Defense have the same specifics and work from the same set of facts, and it is obvious you are not.

Mr. RUBEL. I think I made the point earlier that we worked from the best set of facts that we had at the time the study was initiated. We did the study as fast as we possibly could. Judging from this letter of May 7 which I haven't had time to study in adequate detail, it would appear that NASA has raised certain questions relative to the adequacy of those facts, or of assumptions based upon them which were used in this report.

Mr. RUMSFELD. And this is during a 2-week period, in other words, the 2-week period that it took you to do your study, the basic specific facts underlying this whole study changed, and they apparently were changed upon receiving your study?

Mr. RUBEL. How basic they are I really can't say, Mr. Rumsfeld. I am not sure what impact——

Mr. RUMSFELD. Well, four to six launches per year is a change, and from 30 days to virtually full-time utilization is certainly a change.

Mr. RUBEL. The 30 days per Apollo mission was one of the specifications that was spelled out in the original document. If that is a change it has been changed from the written information that was given to us on the 2d of April.

General COOPER. I don't think that is exactly correct.

Mr. RUBEL. General Cooper says he thinks I testified wrongly in regard to that. Would you clarify that?

General COOPER. The original document states that the operational requirements, the ship must be on prime assignment to Apollo, committed to Apollo as its top primary function, it must be under the control of NASA, it did not specifically state 30 days, I don't believe.

Mr. RUBEL. Yes, it did.

General COOPER. However, the assumption was made that 30 days was an adequate assumption.

Mr. RUMSFELD. Let me read here. In this letter to Congressman Roush, it says first the cost to NASA of the DOD proposal would be $86 million, not $80 million. Second, the DOD analysis assumed only 30 days of ship support per Apollo launch based on four launches per year, while NASA planning calls for six launches per year, and virtually full-time utilization of the supporting ships.

General COOPER. Under their paragraph "Port to Port Endurance Requirements," they say, stated it somewhat differently:

> The ship must have the capability of staying on station in any of the areas outlined in paragraph 2 above, and in reference 4 for a period of at least 30 days.

Mr. RUBEL. Let's read the sentence before. It says due to the Apollo mission complexity and high probability of technical delays of the launches—I am reading now from the original specification which we received on the 2d of April upon which the study was based—a port to port endurance time of at least 45 days is required.

Then it goes on to say what General Cooper just said, that 30 days of that has got to be on station.

Now, in this letter of May 7, which I haven't had an opportunity to study in detail, it says your study assumes an on-station time of 30 days per Apollo mission plus an allowance of travel time. Yes, it does, because that was in this original document as I said. We feel that the total requirements for Apollo support including on-station time, travel time, and so on, and so forth, all add up to a much heavier demand for ship assignment time than is being considered.

Mr. RUMSFELD. That is exactly my point.

Mr. RUBEL. Mr. Rumsfeld, my lack of understanding corresponds to yours in this particular regard. I haven't had time to fully assess what that really is.

Mr. RUMSFELD. You suggest we both have a lack of understanding. I think we have a lack of understanding of what NASA is talking about, but, as far as the specifics, it indicates to me in my humble mind that there was a change within the 2-week period.

General COOPER. I don't think that there was a change with regard to the four launches per year to the six launches per year. I think this was a misunderstanding, Mr. Rumsfeld.

Mr. ROUSH. I think it is fair to say that NASA has informed us that these requirements are not as firm as they will be, or could be, that this is a launch that is taking place at a far-distant date, and the requirements are not completely firm. I think we are in agreement, however, that it would appear that the Defense Department is using one set of requirements to determine the need for ships, the number of ships especially, and that NASA is using another requirement. Either that or else there is a mistake in judgment on the part of one or the other.

Mr. HECHLER. Mr. Chairman, it may be cheaper to invest in a communications ship between NASA and the Department of Defense.

Mr. RUMSFELD. Mr. Chairman, your point that these specifications are not firm is well taken. However, if they are not firm how can NASA be so dead sure of their requirements to meet these unsure specifications and suggest that the DOD study is that far off. This is what concerns me and this is the point of my question.

Mr. ROUSH. I think your point is well taken. I wanted to ask along this line, referring to the second paragraph of your statement, Mr. Rubel, you stated that a DOD study was conducted last June, and that the conclusion was that there would be enough tracking ships to meet the NASA requirements. What different requirements or different facts came to your attention as a result of NASA's presentation requesting your analysis of this matter, what different facts came to your attention that changed this conclusion?

Mr. RUBEL. Well, I think speaking generally, and General Cooper may wish to amplify this, we never had any written requirements for Apollo tracking ships from the NASA with the exception of perhaps a one- or two-paragraph statement in the most general terms, until we received this eight-page document of the 2d of April.

Now, I want to be sure that that statement of mine is not interpreted by anybody on the committee as suggesting that NASA was withholding information from the Defense Department. This is a very complicated problem that they are coping with there, and there are a lot of technical ramifications to it, and they are doing a tremendous job on this program, and the best they possibly can to develop this information, and, as soon as it was available I am sure they made it available to us, but the fact still remains that not until the 2d of April did we actually get this 8-page document specifying the technical and some of the operational—mostly the technical requirements for the tracking ships. It is for that reason that our studies earlier, the one referred to here in June, led to a different conclusion.

Mr. ROUSH. Mr. Rubel, could you furnish a copy of this 8-page document to the committee, and, if there is no objection we will

include it in the record at this time, and also if there is no objection on the part of the committee we would like also to include in the record at this place the communication to me which has been signed by Paul G. Dembling dated May 8, 1963, also the letter to Mr. Rubel dated May 7.

If there is no objection, those will be included as part of the record.

OPERATIONAL REQUIREMENTS AND EQUIPMENT PLANNING CONSIDERATIONS FOR INSTRUMENTATION SHIP SUPPORT FOR THE APOLLO PROGRAM

I. Nature of the Apollo mission.
II. Relationship of the Apollo mission to ship requirements.
III. Operational requirements.
IV. Technical requirements.
V. Additional technical crew requirements.
VI. Port-to-port endurance requirements.
VII. Miscellaneous requirements.
VIII. References.

I. NATURE OF THE APOLLO MISSION

(NOTE.—To prevent misunderstanding in Saturn vehicle nomenclatures, the following name-change designations are provided here for information:)

1. Saturn C–1 is now known as Saturn I.
2. Saturn C–1B is now known as Saturn IB.
3. Saturn C–5 is now known as Saturn V.

A. The Saturn I/Apollo manned missions consist of long-duration Earth orbital flights using the Mercury launch azimuth. One of the purposes is to permit qualification of the spacecraft subsystems.

B. The Saturn IB/Apollo manned missions consist of long-duration Earth orbital missions, also using the Mercury launch azimuth. Among the purposes is to permit qualification of ground and flight operational systems, development of operational techniques to insure Saturn V mission readiness, and orbital operations between the LEM and the command-service modules.

C. The Saturn V/Apollo (lunar flights) missions will culminate in the actual lunar orbit and lunar excursion module landing. These missions will be flown on a variable launch azimuth (73° to 106°).

II. RELATIONSHIP OF THE APOLLO MISSION TO SHIP REQUIREMENTS

A. In the Saturn I and Saturn IB Earth orbit missions, present indications are that the spacecraft will be inserted into orbit within range of the Bermuda tracking radar. However, additional tracking support from shipborne instrumentation may be necessary to meet requirements for S–IV performance evaluation on the early Saturn I flights, and for S–IVB performance evaluation on the early Saturn IB flights. (See reference 3, Saturn program requirements document, PRD 2400.)

(NOTE.—"Insertion point" is the subsatellite point of the spacecraft at the end of the S–IVB stage first burn. Tracking and telemetry coverage is required for the interval "insertion to insertion plus at least 3 minutes." "Injection point" is the subsatellite point of the spacecraft at the end of the S–IVB stage second burn. Tracking and telemetry coverage is required for the interval "injection to injection plus 1 minute.")

B. In the Saturn V/Apollo lunar missions, the launch azimuth may be varied from approximately 73° to approximately 106°, in order to afford an acceptable length of launch window. This variable launch azimuth, plus the longer powered flight of the three-stage Saturn V, places the insertion point beyond range of land-based radars. Following insertion into the parking orbit, at approximately 100-mile altitude, the S–IVB stage and the spacecraft continue in this orbit for a certain number of orbital revolutions (between one and four) until a desired crossing of the lunar transfer plane is reached. At this point, following a second burning of the S–IVB engines the Apollo spacecraft is injected into its lunar transfer trajectory.

For all Apollo/Saturn V launches, insertion of the spacecraft into earth orbit must be tracked to obtain trajectory, telemetry, and voice data for proper decisions for control and command of the spacecraft, particularly in case of an abort situation. One ship is required for this purpose, in the area generally between

Bermuda and Antigua. The ship will be checked out and operationally qualified using the Saturn IB flights.

In the Apollo lunar missions, injection of the spacecraft into its lunar trajectory must be monitored to obtain trajectory, telemetry, and voice data necessary for immediate decision and control. This injection point swings widely over broad ocean areas (both South Atlantic and mid-Pacific and North Pacific) as a function of the variable launch azimuth used to maintain an adequate launch "window." Further east-west motion of the injection point occurs due to the variable number of parking orbits. The injection points also vary day to day in a north-south direction due to the change in the Moon's declination. Attempting to restrict launch azimuths so that an injection point always would fall in sight of land-based stations would result in an intolerable restraint on launch opportunities. Therefore, to cover the likely span of these injection points for any one mission will require at least two ships. These ships should be available for checkout and operational qualification using the Saturn IB flights.

In summary, a total of at least three ships are required for coverage of insertion and injection phases of the lunar Apollo flights; the ships should be available for checkout and operational qualification on the Saturn IB missions.

Nothing firm has been decided yet as to specific requirements for ships during the reentry and recovery phases of the Apollo program. It is anticipated that two landing sites may be required, one in Australia and the other in the Southwest United States, in order to permit operation throughout the range of the Moon's declination. This is, however, dependent on the reentry maneuver capability of the final Apollo spacecraft design. This entire reentry problem is still under active consideration by the Office of Manned Space Flight.

Other information on NASA ship requirements, including those for Apollo support, is contained in reference 4, "A Study of Requirements of NASA Space Flight Programs for Instrumentation Ship Support for Tracking and Telemetry," dated March 1962. Copies were transmitted to DOD/D.D.R. & E./RSGS on 4 April 1962.

III. OPERATIONAL REQUIREMENTS

Each instrumentation ship will constitute a primary station of the manned space flight network for lunar missions, and as such must be planned, engineered, operated, maintained, and scheduled as an integral part of the network. It will use project-oriented equipment essentially identical to that at other stations of the net, and its operational procedures and the general performance of its primary function must be the same as the other stations in the net.

For these reasons, the following operational requirements apply:

A. Prime assignment

1. The ship must be on "prime assignment" to the Apollo program; that is, committed to Apollo support as its top-priority primary function. The modifications, positioning, and scheduling (initial and subsequent) of the ship for this program must be under the control of NASA.

2. On an "as available" basis, when permitted by breaks in the prime assignment function, the ship may be used for support of other missions. The scheduling of the ship for such support, and approval of any ship instrumentation modifications for such support, must be under the control of NASA.

3. Under the provisions of A–1 above, the ship will be required to participate in the manned space flight network tests, checkouts, and simulated missions, as well as actual missions, and must maintain its state of readiness during the inevitable delays attendant to such complex missions. For these reasons, the "as available" time for support of programs other than Apollo is expected to be very limited.

B. Ship instrumentation planning and implementation

1. NASA will specify the specialized equipment to be placed aboard the ship for Apollo support, perform the engineering involved in system modification to install such equipment, and supervise installation and checkout.

2. Specifications, requests for proposals, etc., for modification of the ship and/or its instrumentation, for installation of new equipment, and for system integration and checkout must be prepared under NASA cognizance. Contracts to accomplish the work will either be let by NASA or must provide for primary NASA participation in proposal evaluation and awards, contract technical monitoring, etc., to assure their compatibility with, and proper integration into, the overall manned space flight network.

C. Technical operation and maintenance

1. The technical operation and maintenance of the ship instrumentation systems must be responsive directly to NASA technical management and therefore must be performed by an organization under direct contract to NASA.

2. NASA standards of maintenance, engineering change methods, training procedures, and operational philosophies and techniques must be used.

IV. TECHNICAL REQUIREMENTS

A. General

1. Reference 1, the AFMTC PRD Handbook, cannot be totally complied with at this early stage of the Apollo program, since the majority of the detail required is still in the process of formulation. A preliminary PRD (No. 3200, dated December 11, 1962) has been submitted to AMR. Revisions containing details will be submitted as information becomes available.

B. Principal instrumentation systems required

1. *Tracking.*—A precision C-band monopulse tracking radar (of the FPS–16 class or better) appropriately modified for ship use, for tracking of C-band beacon aboard the space vehicle.

2. *Navigation and stabilization.*—A precision stellar inertial navigation system with peripheral equipment, including a ship motion data correction system to precisely and continuously correct radar data for ship position, orientation, and motion. An automatic star tracker must provide for up-dating as necessary. It is required to determine the ship's position to an accuracy in the order of 1,500 feet during tracking operations. The exact accuracy required is under study.

3. *Computation and data processing.*—The computer system must be capable of accomplishing the following tasks:

(*a*) It must accept high-speed inputs from the radar (pedestal readings) and data stabilization (inertial navigation) system and correct the data for pitch, roll, and azimuth of the vessel.

(*b*) It must be able to accept inputs from navigational aids to locate the ship's position to an accuracy in the order of 1,500 yards and continually update this position if the ship is underway.

(*c*) It must be capable of using predetermined acquisition data to acquire the target.

(*d*) If track is lost, the computer must be able to point the radar so as to reacquire the target.

(*e*) The computer must be able to format the corrected radar data and output it to the ground network data transmission system.

(*f*) The computer must be capable of processing flight data and computing orbital parameters, position and velocity parameters, and special parameters for quick-look monitoring of the basic trajectory. Details of this capability requirement are still under study.

(*g*) The computer must be capable of accepting the telemetry data. The computer would select and format the data for transmission to the IMCC as well as for driving various displays and plotboards on the ship.

Preliminary study indicates that a dual Univac 1206 computing system or equivalent may meet the requirements.

4. *Telemetry and acquisition aids.*—

(*a*) Antenna: Two automatic tracking telemetry antennas, providing capability similar to the AGAVE telemetry signal trackers used in the Mercury/Gemini net. Reception is required in the 220 to 260 megacycle band. A gain of approximately 18 decibel is required in this band.

(*b*) Electronics: (1) A complete PCM telemetry reception and recording system, including necessary demodulation and processing equipment, equivalent to that planned for the Gemini network (see reference 3, Gemini PRD 3600).

(2) Launch vehicle stage telemetry and specialized display equipment are required. Several types of telemetry receiving equipment are necessary (see "Saturn Radio Frequency Systems," MSFC).

5. *Ship-to-shore communication.*—A high-reliability communications system is required between the ship and the manned space flight communications network The communications system must be capable of operation on a 24-hour basis and must include standby equipment for high reliability.

Communications between the ship and ground network will consist of teletype, voice, and high-speed data links. One of the voice channels must be capable of relaying conversations between the ship and the spacecraft astronauts to the ground network.

A minimum of two automatic semi-receive sets, and two receive-only teletype terminal sets are required in the ship's receiving and terminal area. A high-speed data transmission capability is required to transmit corrected radar tracking data and selected PCM telemetry data to the ground network computing center.

The ship-to-shore communications system is required to operate simultaneously with the operation of sensitive space data acquisition receivers required on the ship for spacecraft mission operations.

6. *Control and display consoles (GSE).*—An instrumentation and mission control room is required to centrally locate flight control consoles and displays. It is expected that special alpha-numeric displays will be required for telemetry monitoring. Telemetry and command system display requirements will be similar to those being planned for Gemini ground stations. Specialized computer output displays for trajectory monitoring are required. Detailed display requirements will be defined at a later date. An intercommunications system will be required between flight control positions and instrumentation areas. Equipment will be furnished by NASA. Room space required: 1,000 square feet. Power consumption: Negligible.

7. *Timing.*—A timing system comparable to the present Mercury timing system is required. In addition, VLF receiving capability for real-time synchronization of the network will be required.

8. *Unified S-band station (GSE).*—The Apollo lunar missions will use a unified (single frequency) communication system, operating in the S-band, for telemetry, voice, tracking, and command functions. The spacecraft transponder will transmit in the 2,280- to 2,290-megacycle region and receive in the 2,100-megacycle region. The ground-based (and ship-based) S-band system, including antennas, to be used in the manned space flight net will be procured by NASA. Included in this is a parametric amplifier, two simultaneous lobing, three channel-phase-locked receivers, 10-kilowatt transmitter, data processor, pseudo-random-ranging modulator and demodulator, etc. The following estimates may be used in preliminary planning of installation of this system on an instrumentation ship: Room space: 2,000 square feet. Power consumption: 400 kilowatts. Antenna mount: To accommodate 30-foot antenna.

9. *Command.*—In addition to the unified system, command equipment similar to the 10-kilowatt, AN/FRW–2-type transmitters installed recently aboard the Mercury net ship, will be required aboard the three Apollo ships. Technical details concerning size, power, characteristics, etc., are available at the Atlantic Missile Range.

V. ADDITIONAL TECHNICAL CREW REQUIREMENTS

In addition to the normal ship's complement, and those technical personnel required aboard to operate the general-purpose instrumentation, it is anticipated that 20 technical people to handle the project-peculiar equipment must be supplied with living accommodations on a full-time basis. Moreover, during specified mission periods an additional mission operations team of six people must be accommodated.

VI. PORT-TO-PORT ENDURANCE REQUIREMENTS

Due to the Apollo mission complexity, and high probability of technical delays of the launches, a port-to-port endurance time of at least 45 days is required. Stated somewhat differently, the ship must have the capability of staying on station, in any of the areas outlined in paragraph II above and in reference 4, for a period of at least 30 days.

VII. MISCELLANEOUS REQUIREMENTS

To accommodate spares for GSE equipment and special test sets needed, it is anticipated that an additional 2,000 square feet of shop and storage space is required aboard each ship.

VIII. REFERENCES

1. AFMTC Pamphlet No. 57–2, Program Requirements Handbook.
2. Saturn Program Requirements Document, PRD 2400.
3. Gemini Program Requirements Document, PRD 3600.
4. "A Study of Requirements of NASA Space Flight Programs for Instrumentation Ship Support for Tracking and Telemetry," dated March 1962.
5. "Saturn Radio-Frequency Systems," issued by Marshall Space Flight Center.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION,
OFFICE OF THE ADMINISTRATOR,
Washington, D.C., May 8, 1963.

Hon. J. EDWARD ROUSH,
Member, Subcommittee on Applications and Tracking and Data Acquisition, Committee on Science and Astronautics, House of Representatives, Washington, D.C.

DEAR MR. ROUSH: On May 1, 1963, Mr. Edmond C. Buckley, the Director of the National Aeronautics and Space Administration's Office of Tracking and Data Acquisition, met with you and Mr. W. H. Boone of the committee staff to discuss further the NASA's fiscal year 1964 budget request for three instrumentation ships in support of Apollo. The discussion centered about three main points: the unit cost of the proposed NASA shipborne stations, the timing of the proposed procurement in relation to the flight schedule to be supported, and the relationship of NASA's instrumentation ship planning with that of the national ranges (AMR and PMR).

It is useful to restate here the recent history of the NASA–DOD discussions and views relative to the Apollo shipborne tracking stations. We believe this will also be useful as an expansion upon our April 5, 1963, responses for the record to the subcommittee's request of March 21, 1963.

In February 1963, an ad hoc committee of the Aeronautics and Astronautics Coordinating Board completed its review of the proposed fiscal year 1964 NASA and DOD construction programs with the finding that, upon detailed review, no unwarranted duplication existed between the plans of the two agencies. A specific comment on the NASA instrumentation ships was made as follows:

"A question was raised as to whether the three tracking ships requested by NASA should be considered as peculiar to the support of the Appollo missions or whether these ships should be included as a part of the total national range instrumentation ship capability. It was agreed that this matter of policy should be explored further in the immediate future, as a special case, between the Associate Administrator, NASA, and the Deputy Director of Defense Research and Engineering, DOD."

There was no question as to the requirement for such shipborne tracking stations, only as to their eventual management.

Early in April 1963, at the request of the House Committee on Science and Astronautics, the NASA forwarded to the DOD a statement of operational requirements and equipment-planning considerations for ship support of Apollo, together with a request as to whether or not the DOD could provide three full-time tracking ships for Apollo support from its present inventory. The preliminary response from DOD was that there were insufficient resources to permit a commitment of three such DOD ships to the exclusive support of Apollo, but that the DOD would examine the question further and present a position on its Apollo-support capabilities at a later date.

Later in April 1963, the DOD presented its views to NASA. In summary, their conclusion was that the Apollo support requirements could be met by modifying four ships of the existing inventory and by the addition of a single new ship. Only three of these five ships with Apollo capability would be available for any one mission. This plan was the result of a computer analysis that dealt with the total estimated requirements for tracking ship support through 1968, including Apollo. The cost to NASA of modifying four such ships and of instrumenting a single new ship was estimated by DOD at $80 million.

NASA has been examining the proposed DOD approach with great care; no decision to accept, reject, or recommend modifications to it has yet been made. However, it appears that some of the factors used by DOD in its computer analysis and in its conclusions are incorrect. First, the cost to NASA of the DOD proposal would be $86 million, not $80 million. Second, the DOD analysis assumed only 30 days of ship support per Apollo launch based on four launches per year, while NASA planning calls for six launches per year and virtually full-time utilization of the supporting ships. Third, the DOD study assumes that the total non-Apollo ship support requirement can be met by 10 ships and that only 1 additional ship will take up the additional Apollo workload. This is considered to be a serious underestimation of the workload that Apollo will generate. And fourth, the DOD analysis assumed a 50-percent reduction in non-Apollo missions between 1966 and 1968, which is not viewed as a realistic estimate of the national flight program over those years.

A copy of our letter to DOD, dated May 7, 1963, which comments in more detail on these aspects of the DOD proposal, is enclosed for your information.

Without in any way prejudging the question of DOD participation in Apollo shipborne tracking station support, the NASA feels at this time that its plan to increase the total national inventory of tracking ships by three for a cost of $90 million is more economical in the long run than to increase that inventory by only one ship under a program that would cost $86 million. Under either plan approximately $90 million is required to be included in the NASA budget for 1964 in order to meet the time schedule. There are no funds for ships included in the Department of Defense budget. The NASA is undertaking further discussions with the DOD to develop a mutually satisfactory approach to the operations aspect of shipborne tracking stations as well as to the future possible increase in ship support requirements.

It is hoped that this brief review of the status of NASA's planning is useful to you and to the committee. We will be glad to answer any further questions that may arise or to meet with you to discuss any other aspect of our program that you may wish.

Sincerely yours,

PAUL G. DEMBLING,
Director, Office of Legislative Affairs.

MAY 7, 1963.

Hon. JOHN H. RUBEL,
Assistant Secretary of Defense,
Washington, D.C.

DEAR JOHN: We have reviewed the DOD study of national instrumentation ship needs (fiscal years 1964–68), as forwarded by your letter of April 22 and as presented by your representatives at the conference at NASA headquarters on April 23. We regret that circumstances necessitated your conducting this study under such rushed conditions.

We agree in principle that the concept of integrated instrumentation ship operations does afford certain advantages, and we recognize that this is a matter which we must explore with you in more detail as our own planning firms up. However, there are certain other aspects of the study and its conclusions to which we would take exception. Some of these were touched on in discussions during the presentation, but will be repeated here for completeness.

Your study presents the conclusion that 10 general-purpose tracking ships in the national inventory will provide range support for all DOD and NASA programs other than Apollo, in the 1966–68 period. These proposed 10 ships will comprise the 2 existing general-purpose C-band ships, 3 now under construction or test, and 5 to be modified and augmented. Cost of this program is to be borne by DOD under annual range improvement programs.

The study concludes further that 1 additional ship in the national inventory (together with Apollo-required modifications of 4 of the above-proposed 10) will enable the ranges to handle the normal range support workload plus Apollo. This plan would provide 11 ships in the national inventory. We estimate the cost of this plan to be about $86 million. (Please note that the cost estimate of $60 million presented in your report did not include the GSE systems for Apollo; nor did it allow for the increased cost per ship resulting from a procurement of one ship, as compared to the cost per ship in a three-ship procurement as estimated in the NASA plan.)

Based on our studies, and on our estimates of the extent to which the Apollo program will tie up its support ships, we do not believe that an increase of only one ship in the national inventory will be adequate to absorb the great increase in ship-days loading which will result from Apollo requirements. We wish, therefore, to comment on certain factors and assumptions in your study which we think are subject to question.

1. *Projected total tests to be supported.*—Your study shows a 50 percent decrease from 1966 to 1968 in total tests to be supported. In our network loading studies in previous years we have observed that these projected sharp drops do not usually materialize; such projections, or runout charts, are based on a no-new-start assumption, whereas actually program schedules will usually remain on a more even level. We would expect this to be true in this case.

2. *Number of Apollo flights per year.*—As was noted in the conference of April 23, your study assumed a lower number of lunar Apollo launches per year than is shown in the latest NASA planning. This discrepancy apparently arose from a misunderstanding on the part of your people as to which documented material constituted our official proposed schedules. Although the difference in number

of tests is small, the total ship assignment time involved is significant, amounting to approximately 50 percent of the estimated time allocated to Apollo support.

3. *Number of ships per NASA tests.*—In addition to the lumar Apollo, some other NASA programs will also require more than one tracking ship for full support. For example, the injection patterns for Mariner, with its plan for two closely spaced consecutive launches, are such that as many as four or five ships may be needed to provide full support. Our estimated average for all NASA programs other than lunar Apollo is two ships per launch. Your study does not appear to have fully considered such multiple-ship requirements.

4. *Assignment time per Apollo mission.*—Your study assumes an on-station time of 30 days per Apollo mission, plus an allowance for travel time. We feel that the total requirements for Apollo support including on-station time, travel time to and from possibly remote operating areas, network drills when the ship is not on station, time for modifications and new equipment installations, lost time due to month-by-month postponement after having already spent some extended time on station, and other factors, all add up to a much heavier demand for ship assignment time than is being considered in your studies. Our experience with the Mercury telemetry ships, which, constitute a much less complicated operation then will prevail in Apollo, confirms this. If this turns out to be the case in Apollo, as we are confident it will, it can only result in a serious curtailment of ship support for other programs, both DOD and NASA, in the 1967–68 time period.

For these reasons we bel. ve that, in order to meet 1967–68 Apollo requirements. along with DOD requirements and the non-Apollo NASA program requirements (which have been and will continue to be given to the ranges for support), an increase of three new ships in the national inventory is essential, rather than only the one new ship proposed in your study. These new ships must be started now, under fiscal year 1964 budget authority, in order to assure their readiness in time for the Apollo program. In the meantime, as Apollo mission planning progresses, requirements for still more ships for Apollo support may become necessary, particularly in the area of reentry coverage. At that time, with a total of 13 ships planned for the national inventory, it would be likely that such additional requirements could be met by modifications of some of the ships of this augumented national inventory. With the benefit of the planning and experience gained on the first three ships, such additional modifications could be initiated at a later date, if necessary, and still be accomplished within the time available.

We hope you will reconsider these aspects of your study and can concur with us in our conclusions that the country must implement three new shipborne tracking stations with fiscal year 1964 funds.

Sincerely,

HUGH L. DRYDEN, *Deputy Administrator.*

Mr. RUMSFELD. I would like to make one comment on this topic. I don't think anyone is implying bad motives. Certainly I didn't mean to have anyone assume that. But confusion and lack of communication is equally disastrous from a financial standpoint for this country as well as for the success of this program, and this is what does concern me, and this is what I think we are finding.

Mr. ROUSH. Mr. Wydler.

Mr. WYDLER. Mr. Rubel, I understand you figure that modifying two of your existing ships, is that right, and building this third ship would cost $80 million?

Mr. RUBEL. We modify four ships, Mr. Wydler, and add an additional one for a total of five. So what you have when you are through with that action is five ships which can be used either on an Apollo mission or as general purpose tracking ships.

Mr. WYDLER. Right, but that would cost $80 million and NASA says you made a mistake, it is 86, but whether it is 80 or 86 they say they want to build three ships for $90 million. Is that possible, three brandnew ships?

Mr. RUBEL. Our estimates for the costs were made on the same basis as NASA's estimates. Thus we assume that it would cost $30 million to add one ship since $30 million per ship is the number that

NASA used to reach their $90 million figure. In fact, in this letter they say that is wrong, we have advantages of scale if we make three ships, so if you only make one it will cost more.

As to whether that is a realistic figure, or not, I find it a little hard to comment. Our experience in building instrumentation ships in the past has been very disappointing with respect to forward estimates of cost. We frequently found they cost a lot more when they were through than we ever imagined they would in the beginning. In fact, the reason for canceling the *Aris-3* is because the cost of building it simply grew to the point where it no longer was worth the expenditure in terms of the data which we would acquire from deploying it.

Mr. ROUSH. Pardon me, how much was the cost estimated for *Aris-3?*

General COOPER. The estimate we made was $38 million, and this is the amount of money that was set aside for that purpose. I cannot tell you the exact figure of the lowest bid because this has not been revealed, but it is greatly in excess of that.

Mr. WYDLER. Well, just to get back, and my point doesn't really go even to this, this is an additional point, but what I am trying to get is how can you build just one ship and put on some modifying equipment to perform this function at a cost under your figures of $80 million—and NASA says should be $86 million, and they want to build three brandnew ships for $90 million. I don't get the relationship between these figures at all to begin with.

Mr. RUBEL. Your question is, Why does it cost so little to build hulls or so much to modify them, as the case may be?

Mr. WYDLER. That is put exactly the way I wanted it to be put.

Mr. RUBEL. You can answer that better than I can.

General COOPER. I am not sure that there is an adequate answer to this, Mr. Wydler.

Mr. RUMSFELD. May I ask a question, Mr. Chairman?

Mr. ROUSH. Yes.

Mr. RUMSFELD. I see nothing in the communication about the difference in expense over a period of time, between one new ship and three new ships. You have crews and maintenance and upkeep that is going to go on for a period of years, and certainly the existence of one new ship would be roughly one-third of the continuing cost for three new ships.

Mr. ROUSH. Do we have an estimate as to the cost of operation of one of these ships for a year?

General COOPER. I can give you the cost of operations that we have experienced in the case of a C–2 hull, which I think is the hull that is being proposed here, and it totals $1,723,000 per year.

Mr. RUMSFELD. For what; could you be specific on that?

General COOPER. This is for the *Twin Falls Victory* on the Atlantic Missile Range. This takes care of the ship's crew of 60 people, plus a technical crew of instrumentation operators of 50 people, 110 altogether. The ship's crew cost, $600,000; technical crew cost, $520,000; other maintenance-of-operations costs, $603,000; a total of $1,723,000. Now, this is for a C–2 hull. We don't have experience yet in the operation of the C–4 hull similar to the *Aris-1* that was commissioned this month, but our estimate is that this will be larger and on the order of $2.19 million per year.

Mr. BOONE. In this respect are you talking about comparable equipment aboard? Now, Mr. Rubel mentioned this earlier, but just how much difference is there in meeting the NASA's technical requirement as you stated it, to put equipment aboard?

General COOPER. Are you talking about the cost difference?

Mr. BOONE. Not so much cost difference as the costs relate, are these ships comparable?

General COOPER. Well, NASA is specifying a C-band radar. There are only two C-band radars on the market. One is almost as good as the other.

Mr. BOONE. In this respect they have told us that you would have twice as many C-bands as they would need aboard your ships.

General COOPER. I am not sure I understand you, Mr. Boone.

Mr. BOONE. Well, you have a horizontal and vertical polarized radar, they would only need one of those.

General COOPER. Oh, you are referring to the *Aris-1* ship?

Mr. BOONE. Type of vessel.

General COOPER. This is true.

Mr. BOONE. So there would be considerable difference here if they were to go for only one radar.

General COOPER. This difference does not exist if you compare the Apollo ships with the *Aris-3* or the Apollo ships with the *Twin Falls Victory* or any other of the ships that we would intend to modify. The *Twin Falls Victory* has only one radar.

Mr. BOONE. Then what other equipments are aboard?

General COOPER. You need an inertial navigator, you need communications, you need a command transmitter, you need some computers and some telemetry, a large telemetry dish and the receivers and recorders, discriminators and display consoles.

Mr. BOONE. And this is essentially what you have on your vessel?

General COOPER. We have telemetry on all of the ships, we will have radar on all of the ships. The computer capacity may have to be augmented. We have adequate communications. We have to add the command transmitter. Generally speaking, the major deficiency of our ships is the unified S-band system which is unique to the Apollo program.

Mr. BOONE. And this is your $12½ million estimate?

General COOPER. There is also a requirement placed by NASA for 1,000 square feet of console and display space and 2,000 square feet of space for shop purposes and storage of parts.

Mr. RUMSFELD. Just to clarify this, the alternative as it stands now is between the DOD plan, modifying four existing ships and adding one new, or as NASA suggests not modifying any of the existing ships and adding three new?

General COOPER. Yes, sir.

Mr. RUMSFELD. So what you would be doing, you would be updating four existing ships to serve the Apollo mission, and adding one, which gives you a total of five ships, as opposed to three ships under the other program?

General COOPER. Yes, sir.

Mr. RUMSFELD. In taking all of your equipment overall would you say that when you were through with your $80 to $86 million DOD program would you have a greater capability than with the three new ships NASA $90 million program or would it be equal or less?

General COOPER. Only to the extent that two of the four upgraded ships that are to monitor the injection maneuver are planned to be a part of the Pacific Missile Range fleet and will be in the Pacific. Your greater flexibility comes from having two ships in each ocean, so that when you elect to inject in the Pacific as opposed to the Atlantic, you save the steaming time between oceans. You can reassign these ships if you find that as you go down the Apollo program the Atlantic injection is best way to do it all of the time, you can rotate and have four ships in the Atlantic and indeed the flexibility is increased.

Mr. ROUSH. Would the addition of the one ship meet the requirements of your *Aris-3*?

General COOPER. Sir, to answer this I think we would have to examine the specifications of the *Aris-3*, and I think that unless you would like me to supply this in detail on the record, I think the answer is that *Aris-3* had some requirements for wide-band telemetry that cannot be met by any of the other ships at this time, but by and large the answer is "Yes."

On the other hand, *Aris-3* would not have the unified S-band that is required for the Apollo program.

Mr. ROUSH. Would the cost of the operation of the modified ships increase materially?

General COOPER. Not materially, sir, because the crew is on board and ready whether you are sailing or not.

Your fuel consumption would go up, your spare parts consumption would go up, but this is not a significant part of the total.

Mr. ROUSH. Mr. Wydler.

Mr. WYDLER. This question is just for your opinion: Could there be any reason that we might want to build more of this type ship for possible other programs that we might be getting into in the next few years that we might be able to use all of these ships? In other words, is there a possible probability that there might be a need for all of these ships, in a few years might we need a large number of tracking-type ships to make use of—do you understand the question—from a scientific point of view, General, is what I am asking. I cannot see it, myself, but I am not a scientist.

General COOPER. Well, I can state an opinion on this Mr. Wydler.

Mr. WYDLER. That is all I am asking you for, if you will.

General COOPER. First of all, from a tracking standpoint, if you have any recourse as to satisfying your requirements by a land-based station you should always pick this alternative. Gathering data from a moving platform is a very difficult task and transmitting this to the land station computers where your decisions are made is an equally difficult task. So if you can avoid it, you should, in arranging your array of ground based instrumentation.

In a sense we programed *Aris-3* against the possible large requirement that would take place in the Indian Ocean. The Indian Ocean just happens to be the antipodal point of satellites launched from Cape Canaveral and also from Point Arguelo going down around the South Pole, so the insertion events from both ranges occur in about the same area and we thought this would be a very busy area to monitor this insertion, but when it comes to paying the bill for monitoring this insertion, we balked. We have consistently overestimated our short-term launch rates and underestimated our long-term launch rates and this is a point to which Dr. Dryden's recent letter is

addressed. They point out the fact that our schedule shows a 50-percent dropoff between the year 1966 to the year 1968. This is true. But this is the schedule. This is NASA's schedule and the DOD schedule—it is not filled out. I believe, like NASA does, that it will be filled up but I believe also that the peak that we are now talking about for 1965 and 1966 will not be reached in 1965 and 1966.

The computer routine used an average figure of 45 launches per quarter and if you average the peak which we now plan, which I don't think we are going to meet, this averages out arithmetically at 48, so there is not a gross difference here. I think that it is unwise at this point in time, knowing what we know about our programs, to increase the size of the fleet just for the sake of possibility that we can put them to use.

Mr. BOONE. Mr. Chairman.

Mr. ROUSH. Mr. Boone.

Mr. BOONE. General Cooper, you indicated that your study revealed that there is a need for more than three ships or there is a possibility that you would need five ships. Did you anticipate supplying five ships or did you anticipate supplying three ships in your response to NASA?

General COOPER. The NASA statement of requirements was three ships.

Mr. BOONE. So your answer was predicated only on a basis of three ships?

General COOPER. Yes.

Mr. BOONE. And did you inform them that you felt that it should be five?

General COOPER. Yes, we have done this informally and I don't think it was in the study nor was it in the letters that have been signed.

I would like to make this comment about my previous statements as to these operational requirements: We do not disagree with the statement of NASA requirements. We just don't fully understand them. To this extent I think we have to get with NASA again and again.

Mr. HECHLER. What was their response when you made the suggestion that they could profitably use five?

General COOPER. My discussion was with Admiral Boone, and Admiral Boone said we will have to talk with the experts on this and he would be glad to set up conferences in this regard.

Mr. BOONE. If I may continue, in Mr. Rubel's statement he made the remark that your study concluded that this number is marginal and you just said that you didn't quite see the necessity for buying additional ships unless you had a specific use for them. Do you think that it is marginal to the extent that maybe we should consider buying three additional ships?

General COOPER. Well, in the context of Mr. Wydler's question I thought that he had in mind buying ships for the sake of a long-term projection that the ship-tracking business was generally going to grow so therefore we should generally expand the ship inventory as a result.

With regard to more than two ships to monitor the injection maneuver for Apollo, this is a NASA determination. Either this is a mandatory requirement or it isn't and if it is a mandatory requirement

it is vital to the success of the mission and if they still insist upon a 4-hour launch window they can't do it with two ships. I think that the NASA judgment will be that they will try to do the important tasks from land-based instrumentation and they will try to position the ships they have, regardless of the number, in an optimum fashion, and they will make the best of the data, but this means, then, that this is not a mandatory requirement. But this is a NASA determination and it involves many, many inputs from many centers of NASA which are working on the Apollo program.

Mr. ROUSH. In this event, the same thing could be done with three ships, three modified ships which come from our present inventory as could be done with three new ships.

General COOPER. Yes, sir; the difference being that three new ships would be available to NASA, under direct NASA control, available to the Apollo program 100 percent of the time, whether they were in use or not, whereas in the other case these ships would be very busy ships indeed, serving both NASA and the DOD purposes. They would be tracking unmanned NASA satellites as well as the Apollo.

Mr. BOONE. In this respect NASA has made considerable discussion to the committee and report to the committee on the full-time utilization of these ships. Under a six-shot-a-year schedule would this be full-time utilization of these ships? This would average 2 months per shot, so you could have a scheduling problem which would utilize them completely for a year, could you not?

General COOPER. If you had a long-term requirement for six shots per year, and the shots were random so that the ship could not stay on station in between shots, this indeed would be a scheduling problem. This is a matter of judgment, and we have one judgment in the matter, and NASA is privileged to have another.

Mr. BOONE. Was your study predicated on a reduction in the military need for ships?

General COOPER. The need for ships is a very fluid situation. The ship schedule that we looked at back in June of last year is different from the schedule that we are looking at today, and I am sure that next year's schedule will be equally different.

Mr. BOONE. These schedules always show a tailing off several years in the future.

General COOPER. This is right, and we are forced to neglect this tailing off because it is unrealistic, but the trend that we see is a diminishing in the requirement for monitoring ballistic missiles and an increase in space, particularly in the Atlantic Range, and an increase in the space shots out in the Pacific for the DOD.

I would like to be more specific in this regard, but I think this would be classified information.

Mr. BOONE. I think one of the other things that is bothering NASA is the surety with which you can make these ships available to them. Would you like to comment on your responses to NASA requirements in the past?

General COOPER. Well, we feel that the response of the national missile ranges to the users has been superior in the past. Of course, I am a biased spokesman in this regard. In the case of ships for the Mercury program, there have been two examples: one is the two AMR telemetry ships which are small, which were modified by NASA and operated as general purpose ships in support of Mercury as well as

other flights. I think that the record of the performance of these ships has been exemplary. By NASA's own statement there are fewer discrepancy reports on the status of instrumentation on these ships than there are on the NASA land stations. The ships never fail to be on station at the proper time and ready and track and give good data.

I think NASA is as proud of this data as we are. In the case of the tracking ships, however, this is a somewhat different picture, and I think first I should add, however, that the use of tracking ships for Mercury is a fairly recent requirement. The original Mercury missions planned for three orbits involved a deorbit maneuver over the United States and into waters of the Caribbean. Here we did most of the tracking by means of land stations. However, for MA–8, Schirra's flight, this required that the deorbit maneuver was tracked by ships in the Pacific. We knew about this perhaps 4 months ahead of the event. The only ship that we had available for this purpose—actually we only had two ships in our inventory that were properly equipped with good radars. One was in the Atlantic and it was fully used, and the steaming time to take it to the Pacific made this an impossible solution. The other one was in the Pacific, and it was involved as an integral part of the atomic test series without which the series would be delayed. So we didn't want to rip it apart. It was tied to the dock. It had cables going to computers and to rip it apart would require another proof test in our atomic test series, another flight of a missile to prove this instrumentation that was so vital to the atomic series. So really the ship that we planned on slipped along with the atomic tests into the summer months, and so alternative solutions had to be "cluged" up, if I can use the term, at the last moment.

We examined the S-band equipped ships which are marginal equipment at best, and NASA decided to use them. We used these ships. At the very last moment we decided to use another ship involved in the atomic test series, and we took it away from this series and used it on MA–8.

The results, in terms of good data, were unsatisfactory, and I think that by scheduling and planning on this short basis, you cannot expect satisfactory results. The NASA experience in getting these results has been unhappy and I am in sympathy with them. On the other hand, our 1962 inventory of good tracking ships consisted of two. Added to that are three of these marginal S-band ships and the *American Mariner* which is assigned to a special program, and it is operated by the Army, and to use it you must borrow it from the Army. Our 1964 inventory of good tracking ships will be 10. So that one cannot forecast the troubles of the future by recounting the troubles of the past, in view of these programs.

Mr. BOONE. They just continue, do they not?

Mr. WYDLER. If I might, it would appear to me that a decision like that which is a very difficult one, I understand, between continuing to use it for atomic tests or taking the ship out and using it in the flight, in the Mercury, it was really a decision in a case like that, which should be made by an authority higher than either the Department of Defense or NASA, somebody that could decide which of these had the greater priority. That would seem fairly logical to me, in other words, somebody at a higher level.

General COOPER. There was no disagreement on the desire on the part of the Department of Defense to satisfy NASA. The decision was made in favor of NASA.

Mr. WYDLER. You did take the ship out?

General COOPER. Absolutely.

Mr. BOONE. Mr. Chairman, I would like to ask if they could submit for the record a list of the ships that would be available, say, in this time period, and their expected locations at that time so that they can be compared with the NASA request?

Mr. ROUSH. Without objection, that will be included.

Could you give a generic equipment list rather than specifics in too much detail of what is available, the various types of vessels?

(The information requested is as follows:)

SHIP CONFIGURATION CHART

The following Defense Department tracking instrumentation ships, in the general-purpose configuration shown above, are anticipated to be in the following operating areas during the 1966–68 period:

Ship type	Name	Operating location
C-2	Twin Falls Victory	Atlantic.
C-2	American Mariner (DAMP)	Do.
C-4	Aris-1	South Atlantic.
C-4	Aris-2	Do.
C-2	AGM-1 Range Tracker	Pacific.
C-2	AGM-4 Richfield	Do.
C-2	AGM-6 Watertown	Do.
C-2	AGM-7 Huntsville	Do.
C-2	AGM-8	Do.

Ship configuration

Instrumentation	Apollo ship	General purpose range ship
C-band radar	X	X
X, L/UHF band radar		[1] (X)
Unified SHF system		[1] (X)
Unified S-band system	[1] (X)	
Telemetry	X	X
Command control	X	X
Timing	X	X
Communications HF, VHF, UHF	X	X
Navigation/stabilization	X	X
Data handling/computation	X	X
Meteorological	X	X
Recovery	X	X
Range user control consoles	[2] X	[2] X
Display and plotting boards	X	X

[1] Parentheses ( ) indicates program-peculiar equipment.
[2] Varies.

Mr. RUBEL. It is just a one-page listing. We will be happy to furnish that.

Mr. BOONE. One other question I would like to ask, Mr. Chairman, has to do with costs. I recall Mr. Rubel's comment previously, but it seems to me that the Defense Department has had more experience with cost of vessels than certainly I believe NASA has at this time. You should be able to give a better estimate of cost than the comments that Mr. Rubel made which were—maybe he would like to make them again, I don't know if I can recall exactly, but we think it not good but

reasonable enough for this kind of submission at the moment. I hope I didn't misinterpret your remarks.

Mr. RUBEL. Would you excuse us for just one second? I am trying to look something up here.

Mr. ROUSH. Surely.

Mr. RUBEL. We are trying to give you the best answer we can, Mr. Boone, which is consistent with our understanding of the facts as we have them. We have them in front of us here, an internal document, for example, signed by some of our own people which says that they concur with the NASA estimate of $30 million apiece for these three ships totaling $90 million, and including all of the costs for the Apollo-peculiar equipment.

General Cooper and I have talked about this since we have looked at this, and we have looked at some of our past experiences, and I think our personal feeling is that that might be an optimistic estimate. We are awfully hesitant in making very positive statements about that before this committtee. The NASA people have studied this a lot more than we have. It is their submittal, not our submittal, and we don't want to be putting ourselves in the position of just thinking that something which they have studied in a lot of detail isn't right or even raising doubts in the mind of the committee, just based upon our statements that their considered submittal isn't the best possible submittal that could be made, so you can understand, I think, our reluctance to cast that doubt, or to make statements that suggest that.

The fact is, though, just the same, that we have gone through the *Aris–1*, *Aris–2*, and *Aris–3* experience, and we have found at least in our case that the costs of these ships have gone up, and in some cases they have gone up a great deal. Our natural fear is if you were to actually engage in the program that experience might be repeated. It might not.

Returning, then, to the other aspect of that same subject that Mr. Wydler raised earlier, which is the question of reconciling the cost of modification with the cost of acquiring ships that are instrumented, I think here we can say that our confidence in the instrumentation cost is relatively high. The reason for that is that we have got quite a few ships that are already instrumented, and the cost for that instrumentation is already pretty well known based upon lots of experience, and it covers probably 90 percent of the instrumentation that would go on these ships, so that when we put that estimate down we are pretty sure that it is a good one.

Furthermore, a very large fraction of the cost of these ships is in the instrumentation. I have been trying to find what the precise division of cost is as between hulls and instrumentation. My memory doesn't serve me. I don't know if you have the figures there, yourself, Paul.

General COOPER. Well, the ship design and ship reactivation, ship work including the installation of the instrumentation, amounts to about one-third. The peripheral instrumentation not including the radar is another third. In the case of *Aris–1* and *Aris–2* the radars are peculiar to the special job for which designed, and they are very expensive.

Mr. BOONE. In this respect you would expect this one ship under your plan to be a general-purpose vessel not merely to meet the NASA requirements?

Mr. RUBEL. Well, that is right, but the difference isn't really very great. The amount of Apollo peculiar equipment that is on board the ship really doesn't represent a very substantial addition to it relative to all of the other equipment that is already there to make it a general-purpose ship. I think what we ought to do is supply you for the record, because while General Cooper has been talking I have been trying to find the number, and I can't find it, and I can't remember it, we ought to give you for your record how much the hulls cost. I think that would go to your question, Mr. Wydler, and I think to yours, too, Mr. Boone, and we will furnish that for you as soon as we possibly can, That will show you what the division is as between hulls and modification.

I don't think the numbers are necessarily as inconsistent as they appear, because under the Defense Department plan that was submitted here we were really modifying four and building one, so that is a total of five sets of complete instrumentation.

Mr. WYDLER. Wait a minute, now, that is inconsistent with what the general said just a short time ago. I understood that your program was based on the three ships that NASA said they needed, not on the five. Which is it?

Mr. RUBEL. That testimony was relevant to the question of whether an addition of three ships by NASA would serve the NASA needs as stated. However, under the Defense Department plan you would take four general-purpose ships and add the Apollo peculiar equipment to them, and then you would build one more ship completely.

Mr. WYDLER. So the $80 million figure is five ships; is that right?

Mr. RUBEL. Yes.

General COOPER. I can break this down further. In the Atlantic the two ships we would modify would cost $28 million. The two ships in the Pacific would cost an additional $22 million. This includes an estimate of $5 million per ship for the special NASA equipment. Now, the difference between the Atlantic and the Pacific is that we would take advantage of the Pacific ships being out for overhaul and for the modification of special equipment for Dyna-Soar at that period of time, and there would be a savings.

Mr. WYDLER. Just giving us the price of the hulls isn't going to help too much, either, because there is a lot of instrumentation on these ships to begin with.

Mr. RUBEL. We will give you an analysis which shows that if you take these four ships that are in the Defense Department inventory already, and add the Apollo peculiar equipment to those, and add the consoles and displays, and what not, that will give you a line item for those things. Then you take a hull and add that and then you add all of the instrumentation for general-purpose functions to that hull plus now the Apollo peculiar equipment to it, and that breakdown will enable you then to see, I think, how you can compare the 90 million for the three completely configured ships to the 80 or 86 or whatever the number turns out to be for a total of five ships of which four were modifications and one was a new addition. I think that analysis would be directly responsive to your question. We will try to furnish that for you as soon as we can.

The information requested is as follows:

The following is a breakdown of the estimated costs to modify four existing Defense Department instrumentation ships to include the required Apollo ship support equipment:

Modification costs for Apollo

[In thousands of dollars]

Item	*American Mariner* (DAMP)	*Aris-1*	AGM-6 *Watertown*	AGM-7 *Huntsville*
Tracking radar modification	473	15	2,150	2,150
Stabilization/navigation			1,000	1,000
Computation/data handling	1,640	1,043		
Telemetry/acquisition aids	1,406	2,169	100	100
Controls and displays	1,000	1,000	1,000	1,000
Communications	156		140	140
Timing	1		10	10
Unified S-band	4,000	4,000	4,000	4,000
Command control	555	555	800	800
Ship modification	6,117	3,719	1,740	1,740
Total	15,348	12,501	10,940	10,940
Total for all 4 ship modifications		49,729		

NASA estimates were used to price the modification and equipping of an existing C–2 ship which is currently in the Reserve fleet in a cargo/transport configuration. (Original costs for a C–2 hull (World War II prices) were approximately $5 million when built, depending on configuration. New hull construction has not been proposed by either NASA or DOD.)

The breakdown of the $30 million cost for this ship is as follows:

Item	*Estimated cost (millions)*
1. Ship activation, installation of equipment, repair and modification (VC–2)	$9.50
2. Navigation/stabilization	2.50
3. C-band radar	5.00
4. Unified S-band	4.25
5. Dual PCM telemetry	.50
6. 10-kilowatt command transmitter	1.30
7. Dual acquisition aid/telemetry	.20
8. Computer	2.50
9. Control consoles, displays, intercom, recorders	1.10
10. Spacecraft-to-ship voice communications	.15
11. Ship-to-shore data, voice, teletype communications	1.00
12. Systems integration, documentation, and test	2.00
Total	30.00

Mr. BOONE. In any event, NASA would be expected to pay all of these costs; is that right?

Mr. RUBEL. Well, yes, sir.

General COOPER. We have no money.

Mr. RUBEL. There is no money in our budget for any of this. My assumption has been that if NASA after analyzing it found that this was—that this or some modification of this plan was the best way to solve their problems for Apollo as well as other tracking problems, too, then they would direct the Defense Department to execute that plan or a modification of it, and they would furnish the funds to the Defense Department for carrying it out.

Mr. ROUSH. Pardon me, Mr. Rubel, the decision might not entirely be NASA's. They might receive some guidance from the committee as to authorization of funds and the Congress.

Mr. BOONE. I have one last question, Mr. Chairman.

NASA has made considerable discussion about MSTS operation which they consider as a possibility for operation of their ships. Would you tell us the difference in MSTS operation and the way in which you operate your vessel?

General COOPER. At the present time we use the MSTS to operate the instrumentation ships of the Pacific Missile Range. The instrumentation is operated by direct contract from the Pacific Missile Range to several instrumentation contractors so that there are two sets of crews and the manager of the ship, not the captain, but the manager, is a representative of Admiral Clark who commands the Pacific Missile Range.

We do it differently in the Atlantic and this raises the immediate question as to which way is best. In the Atlantic the down-range bases as well as the launch site at Cape Canaveral are operated and maintained by a range contractor, Pan American Airways. They, in turn, subcontract the technical work to RCA.

In the case of the ship operations, we consider a ship to be the same as a land station and Pan American has a ship operations manager on board who receives instructions from the scheduling officer as to where to go and what to do, just like the officer at PMR does this in the Pacific. In this case it is a ship operations manager of Pan American. His instrumentation crew is RCA and here we have the advantage of being able to take a radar operator from Cape Canaveral or Antigua and put him on ship for a tour of duty and then put him back on the island for a tour of duty. We have great rotational opportunity at both AMR and PMR.

The instrumentation is operated on subcontract by RCA. The ship's crew is also a subcontract, a contract by Pan American to a shipping company. Until recently it was the Suwanee Steamship Co., and then more recently the Marine Transport Line. So it is a contract operation and dissimilar to MSTS only in that the crews are civilians. In MSTS they are civil service.

In one case we have a contract with small business, we have a union agreement between the small business and the appropriate union and in the case of MSTS they use the same union, I think it is the National Maritime Union, as their bargaining agent. The wages are the same. We have forced the Air Force and the MSTS to sit down and compare cost data over a period of almost a year and this has produced no significant difference in cost data for MSTS versus the contractor operation. There are advantages and disadvantages to both systems. There are no significant advantages or disadvantages that the Office of Secretary of Defense could see to warrant a change from one modus operandi to another, either in the Atlantic or the Pacific, so indeed we have two dissimilar operations. They are both very effective.

Mr. ROUSH. Mr. Hechler.

Mr. HECHLER. Well, I think it should scarcely be necessary to mention that the purpose of these hearings is not to bring out any differences between the involved agencies but rather to arrive at how we can accomplish this program most effectively and economically.

Mr. Secretary, I was glad that you made perhaps an unconscious editorializing of the last sentence of your statement when you said, "we shall however continue to take every opportunity to assist them in minimizing costs." You left out the word "their" costs, and I am glad you did that because we are trying to minimize the Nation's costs. We are investing too much in the space program in the way of manpower and economic resources to afford to have a waste in money or breakdown of communication between the agencies. I

recognize the very valid statement which you made about the respective missions of NASA and the Department of Defense. Yet it has struck me in these hearings that there is certainly room for closer cooperation and closer communication. When we bring up this subject generally usually the answer is well, we have an Astronautics and Aeronautics Coordinating Board that always gets them together. Yet there is an ingredient here that seems to be missing as revealed by our testimony this morning and I am hopeful that this will provide a good inspirational lesson for both agencies as to the necessity in the national interest to have a unified effort in this program.

Mr. WYDLER. Mr. Chairman.

Mr. ROUSH. Mr. Rumsfeld.

Mr. RUMSFELD. Just to satisfy my curiosity, you received this letter on May 7, directed to you and I understand signed by Dr. Dryden, which points up some of the problems which Mr. Hechler has just mentioned. The concluding paragraph says, "We hope you will reconsider those aspects of your study and can concur with us on the conclusions."

What happens now?

Mr. RUBEL. I am not sure what happens now, Mr. Rumsfeld but I am going to have to discuss this with Dr. Seamans or Dr. Dryden. What I would like to see happen now is to see if the NASA folks would like us to do just what is suggested in that last paragraph, that is to reconsider this study in the sense of putting the new inputs into it and redoing it and submitting the additional data to them. That last paragraph is somewhat ambiguous in that regard. It suggests that they would like us to reconsider the study but NASA has really made the decision. I am not really sure because of that ambiguity what it means and I think the way to clarify it is to talk to Bob on the telephone. That is what I haven't been able to do in the last 24 hours but that certainly is the next step that we are going to take.

Mr. HECHLER. Well, he is out of town today, I understand.

Mr. RUBEL. Right.

Mr. HECHLER. This committee would love to serve as a catalytic agent wherever possible, but we don't want to be put in the position of God in the old New England poem about the Lodges and the Cabots.

Mr. RUMSFELD. Just to conclude, in the first paragraph he stated that they regret that you conducted your study under such rushed conditions.

Mr. RUBEL. He is simply giving recognition to what I testified to earlier, Mr. Rumsfeld, that they asked us to make this study as quickly as we possibly could. They gave us data for the first time in complete form on the 2d of April. They would have liked to have had the study within just a few days and I told them that we couldn't do it in just a few days. We did it in 2 weeks, and he is simply saying I realize—I believe this is his intent—I realize you have done everything you possibly could to expeditiously fulfill our request. Thank you for doing it.

Mr. RUMSFELD. Well, what I regret is that the data that they supposedly furnished you on April 2 for the first time in complete form was not what they furnished you at the completion of your study.

Mr. RUBEL. Well, this is a dynamic and fast-moving situation, Mr. Rumsfeld, and I think that personally that isn't or shouldn't be a source of criticism of either NASA or the Defense Department. I

think they generated those requirements and gave them to us as fast as they could. We did the study as fast as we could. They have been looking at the problem intensively in the last 2 or 3 weeks, since their communication of the 2d of April. They have got some additional thoughts. They are communicating those additional thoughts. We are working with them to try as best we can to serve their needs and the national interest. I think we are merely witnessing here the fact that it is an extremely complex problem and one that takes a great deal of effort by both agencies to arrive at the right solution.

Mr. WYDLER. Mr. Chairman, I wanted to second Congressman Hechler's statements here today, but I just can't put it quite as mildly as he manages to do. I personally find this situation to my mind a very disappointing one. I think NASA should stop and think about what they are going to do in their future programs. I can't possibly justify in my mind the fact that only in April of this year did they go to the Department of Defense to ask them to make a study as to what ships the Department of Defense had and what those ships could do, a meaningful study anyway, and that was only after they had come before our committee. It seems to me that that should have been an almost automatic action at the time that they considered building these ships in the first instance. By that I mean automatic. In other words, the Department of Defense has this experience and we should utilize it. They are all part of the same team and it should have been done then and when they came before our committee they should have had the answers then as to why the Department of Defense could not meet these requirements and they needed these ships in spite of the fact that the Department of Defense had ships, and that fact to me makes whatever they say from now on sort of suspect. In other words, they didn't do that and I don't understand why they didn't do that and when they now say that it couldn't be done in the first instance, I have to, for some reason, doubt their sincerity in what they say from now on. I hope personally that in the future all of our departments, concerned with our national space effort particularly, can work as one team, and that we don't have to some day set up a superdepartment again, like we did with the Department of Defense, to make agencies of our Government work together as one team. In this field I think they should be able to do that and I personally won't be satisfied with anything less.

Mr. HECHLER. Mr. Chairman, in this connection I appreciate Mr. Wydler's remarks, I recall a remark made by a man whose birthday we celebrated yesterday. He was once President of the United States. His name is Harry S. Truman. Once he said:

> I spend 50 percent of my time trying to persuade other people to do things that they ought to do without being persuaded.

I am putting this perhaps a little more gently than Mr. Wydler did, but I believe that I would subscribe to most of your remarks.

Mr. DAVIS. Mr. Chairman.

Mr. ROUSH. Mr. Davis.

Mr. DAVIS. Mr. Rubel, I would like to ask a few questions I suppose you could say with regard to the salvage value of these ships.

In the first place, suppose four vessels were modified and one was built at a cost of $80 or $86 million and then they were used and then the equipment was dismantled but you still had the equipment and

you still had the hulls, what would the value of those ships be; and the equipment? It wouldn't be useless, would it?

Mr. RUBEL. I think that depends a great deal first on when you did dismantle them. These equipment have a finite life like any other complex gear. Eventually it wears out. If these ships are used for a great many years, the salvage value would probably be very little. As far as the hulls are concerned, of course, they have a much longer life. Many ship hulls are useful for 20 years, even more. These ships could probably be converted to other use, if the dismantling operation——

Mr. DAVIS. Isn't that true of the electronics equipment, also?

Mr. RUBEL. Not all of it, it depends on how much you have had it in use.

Mr. DAVIS. Thinking hypothetically, as soon as we fired the Apollo shot, immediately after, whenever that would be, either you would have further use for the ships, you have a capital investment there, or if you didn't have any further use for them, I am saying they would have a salvage value, would they not?

Mr. RUBEL. They probably would during the next 5 or 10 years.

Mr. DAVIS. Now, you referred a while ago to the fact that certain of the equipment would be Apollo peculiar. Could you supply for the record how much dollarwise of the value would be Apollo peculiar?

General COOPER. It is approximately $5 million per ship.

Mr. DAVIS. Does that mean that that is equipment that is useless except for the Apollo shot?

General COOPER. It would be useless unless some other program decided to use the same type transponder. If this were the case then this equipment would be very useful.

Mr. DAVIS. I would like to have that figure supplied both with respect to the possible five ships, four modified ships and one new one, or—well, probably you would not be able to do that with respect to the three ships and the $90 million that NASA prescribed.

General COOPER. It is essentially the same.

Mr. DAVIS. It is?

General COOPER. Yes.

Mr. HECHLER. Following your observation about the same type of transponder, could this be utilized for other deep-space missions?

General COOPER. Yes, sir.

Mr. DAVIS. Is there a military use for these ships aside from the Gemini or Apollo programs?

General COOPER. Certainly not in the combatant sense. There is a military use as far as the tracking of ballistic missiles and space vehicles. If you want to rip out the electronics gear and convert them back to dry-cargo ships or troop transports, yes, indeed, there is this military use.

Mr. DAVIS. And, then, of course, if some military significance were to be suddenly discovered with respect to the environment of outer space, they might be very useful, is that not true?

Mr. RUBEL. I think if you said you were going to have any operations in near space, for military purposes, these ships configured as

they are, to fulfill the general-purpose range-tracking function, could be useful, whether they would be needed is another question; but they could be useful.

Mr. DAVIS. That is all, Mr. Chairman.

Mr. ROUSH. Mr. Secretary, and General Cooper, we have been happy to have both of you with us this morning. I think all of us on the committee appreciate the frankness and the fairness of the statement you have presented to us, and in answering questions which have been propounded by members of the committee. Our task is not always an easy task. I believe none of us would pretend to impose upon NASA or the Department of Defense technical or scientific knowledge which we don't have, but our responsibility is to gather as many facts as possible so that we might help guide the policies of the Department of Defense and NASA and we do this, of course, through the authorization of projects and through the appropriation of funds. We feel this responsibility greatly. It isn't our intention to cause contention between the Department of Defense and NASA but, rather, if possible, to bring the operations together for the benefit of our Government and the people of this Nation.

We are very happy that you were here with us this morning, and we wish you well in your future endeavors. I might say that I believe I can speak for the committee in this: We are going to encourage the NASA officials to sit down with you on this problem in order that there might be a greater meeting of the minds.

Mr. RUBEL. Mr. Chairman, could I add one last statement, if I may?

Mr. ROUSH. Yes, sir.

Mr. RUBEL. I want to emphasize just once more what I have said partially during the course of this testimony. NASA has a tremendous job to do as we all know in connection with this Apollo and other programs. They have a fine organization and have dedicated and competent people addressing themselves to that task. It is their responsibility, not our responsibility. Our job is to support them in every possible way. It is our policy in the Defense Department to support them in every possible way. We have tried to be as responsive as we know how to the requests imposed upon us by the NASA.

I am sure they have tried as hard as they know how to furnish us with the information on which we can base that kind of assistance. It is a rapidly moving, rapidly changing, technically complex situation with which we are dealing here, and I hope that nothing that I have said here or that General Cooper has said here today will suggest to anybody on the committee, Mr. Chairman, that we are in any way criticizing or even questioning NASA's approach to the accomplishment of this mission for which they have national responsibility. We will continue to stand by, ready to serve in every possible way, and hopefully do the best possible job on every occasion when called on.

Mr. ROUSH. We appreciate this attitude.

Before we adjourn, I would like to say that the committee is going into executive session, and we would like respectfully to ask you to leave the room as quickly as possible.

(The additional information submitted for the record is as follows:)

APRIL 22, 1963.

Dr. ROBERT C. SEAMANS, Jr.,
Associate Administrator, National Aeronautics and Space Administration,
Washington, D.C.

DEAR BOB: In response to your letter of April 2, 1963, the Air Force and the Navy have studied the NASA statement of operational requirements for instrumentation coverage of Apollo insertion and injection. In the limited time since receipt of this information on April 2, the Air Force/Navy study group examined the combined requirements of the DOD and NASA for large size instrumentation ships and arrived at the conclusion that the Apollo requirements could be satisfied by augmenting the existing or planned DOD ship capabilities with the special NASA unified S-band equipment on four ships and the procurement of one additional ship. Such a solution is feasible at a lower investment cost and at lower follow-on operational costs than one whereby NASA would procure three new ships specifically for Apollo. It presents numerous additional advantages, including economies of scale.

The study group recommends that the Apollo tracking requirements be added to the other DOD/NASA requirements being supported by the national range fleet under DOD management and operation. I believe this approach is consistent with the views expressed by Mr. Webb and Mr. McNamara as to the interagency cooperation and mutual support that is so necessary in the execution of our national space program. I sincerely hope that NASA will find this report and its conclusions and recommendations to be of assistance to the Apollo program.

The attached summary of the study group's findings is forwarded for your information. This matter will be presented to NASA tomorrow in considerably greater detail at a meeting being arranged with Admiral Boone.

The services of the DOD are available to assist NASA in meeting the Apollo requirements as stated on April 2, 1963, in the manner outlined in this report. I concur with the findings and recommendations of the study group. If they are adopted by NASA, I believe the overall operation of the ranges and of the total national space program, including Apollo, will be conducted with greater efficiency and at less cost. I will be pleased to discuss this matter further or to furnish any information you may need.

Sincerely,

(S) John,
JOHN H. RUBEL.

Enclosure.

DOD STUDY OF NATIONAL INSTRUMENTATION SHIP NEEDS (FISCAL YEAR 1964–68)

APRIL 22, 1963

INTRODUCTION

This study was prepared by the Department of Defense to determine the extent to which the DOD range ships can meet the NASA support needs for Project Apollo.

It is evident that this determination can be made only by evaluation of the total U.S. missile and space program instrumentation ship support needs, by judicious and economic application of instrumentation ship resources, and subsequent identification of any instrumentation ship deficiencies.

SUMMARY

The Department of Defense has performed an analysis, including computer techniques, of all missile and space programs to determine if the needed ship support can be provided using the DOD instrumentation ships.

This study concludes that—

1. The DOD can provide full support for the Apollo program and adequate support for the remaining DOD and NASA programs with the addition of one general-purpose ship capable of Apollo support and modification of four existing ships at a total cost of $60 million.
2. Alternatively, if NASA will select one ocean area for injection, the DOD can provide all needed support with the addition of one general-

purpose ship and modification of two existing ships at a cost of $48 million for AMR injection and $42 million if injection is on PMR.

3. The DOD can most effectively manage and operate the national fleet of instrumentation ships.

Specific Objectives

A. To determine the total number and type of instrumentation ships needed to support the overall U.S. missile and space programs from fiscal year 1964 through fiscal year 1968.

B. To determine the extent to which the existing DOD instrumentation ships using present, programed, or technically feasible equipment could meet the total U.S. requirements.

C. To develop and compare alternative solutions to meet any deficiencies which may exist.

D. To recommend the most efficient and economical solution for meeting both DOD and NASA instrumentation ship needs.

DOD/NASA Programs Needing Ship Support

DOD FIRM PROGRAMS

AMR:
- ABRES
- Polaris
- Polaris Training and Improvement
- MMRBM
- 624A
- 823
- X–20
- Titan II
- Advanced Minuteman

PMR:
- 626
- 162
- 461
- 369
- Typhon
- X–20
- 279
- 435/I

NASA FIRM PROGRAMS

- Centaur
- NASA Centaur Missions
- Apollo I, 1B and V
- Gemini
- NASA Agena Missions
- Communications Satellite
- Apollo 1B and V
- DM–21

A list of firm DOD/NASA programs needing instrumented ship support during CY 1964–1968 on the Atlantic and Pacific Missile Ranges was established.

The DOD programs needing ship support were approved by DOD, Headquarters, USAF, Headquarters AFSC and BuWeapons. NASA programs were approved, through a liaison representative, by NASA Headquarters and all were classified as a firm workload.

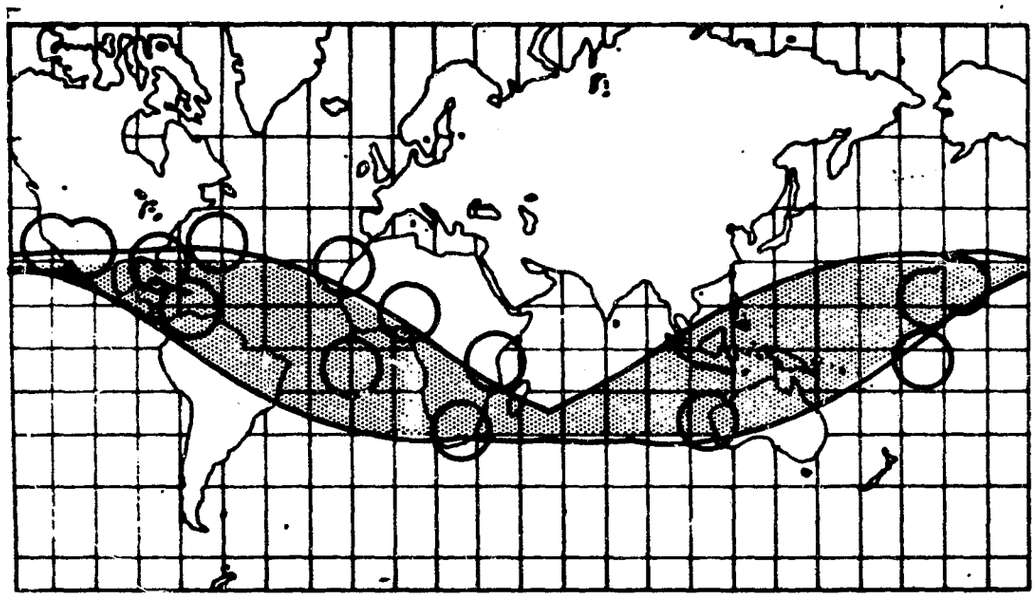
Projected tests by quarter—DOD/NASA programs

Firm tests	CY-64				CY-65				CY-66				CY-67				CY-68			
	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
DOD	30	28	37	40	31	30	37	45	36	33	46	49	46	38	40	38	20	18	24	22
NASA	8	7	7	7	9	8	10	12	12	10	6	9	4	7	3	4	4	4	4	5
Total	38	35	44	47	40	38	47	57	48	43	52	58	50	45	43	42	24	22	28	27

The projected tests are based on the schedule of DOD/NASA programs previously mentioned. They represent an average of 41 tests per quarter which is the workload input used in this study to determine the number of DOD ships needed to support the combined DOD/NASA workload during CY 1964–1968.

The average test workload has been used since the exact number of tests per quarter cannot be predicted reliably over a five-year period.

APOLLO TRAJECTORY ENVELOPE
LAUNCH AZIMUTH 73° TO 106° ORBITS 2 AND 3



The Apollo needs considered in this study are those contained in the NASA requirements of 1 April 1963 as modified by direct liaison with the NASA representative. The most significant of these are summarized briefly.

One ship will be stationed between Bermuda and Antigua to provide overlapping coverage with land stations during insertion into the 100-nm parking orbit. Tracking and telemetry coverage is needed from insertion to insertion plus 3 minutes.

The parking orbit will be maintained until injection into lunar transfer ellipse is made during the second or third revolution about the earth. The shaded portion of the map shows the envelope of all possible injection points between 73° to 106° launch azimuths and second or third orbit injection. Injection can occur in either the Atlantic or Pacific oceans with preselection prior to each mission.

Tracking and telemetry coverage is needed from injection into lunar transfer ellipse to injection plus 1 minute. NASA states that two tracking ships will be used for this purpose.

The data accuracies are equal to or less than those for Gemini.

Land stations, as shown by circles, provide only limited metric and telemetry coverage within the injection window. Also, on any particular launch day, the injection point may be beyond line-of-sight of any land stations.

The three ships will be instrumented to meet all Apollo needs for radar, telemetry, command control, communications, data processing, display consoles, and navigation and stabilization.

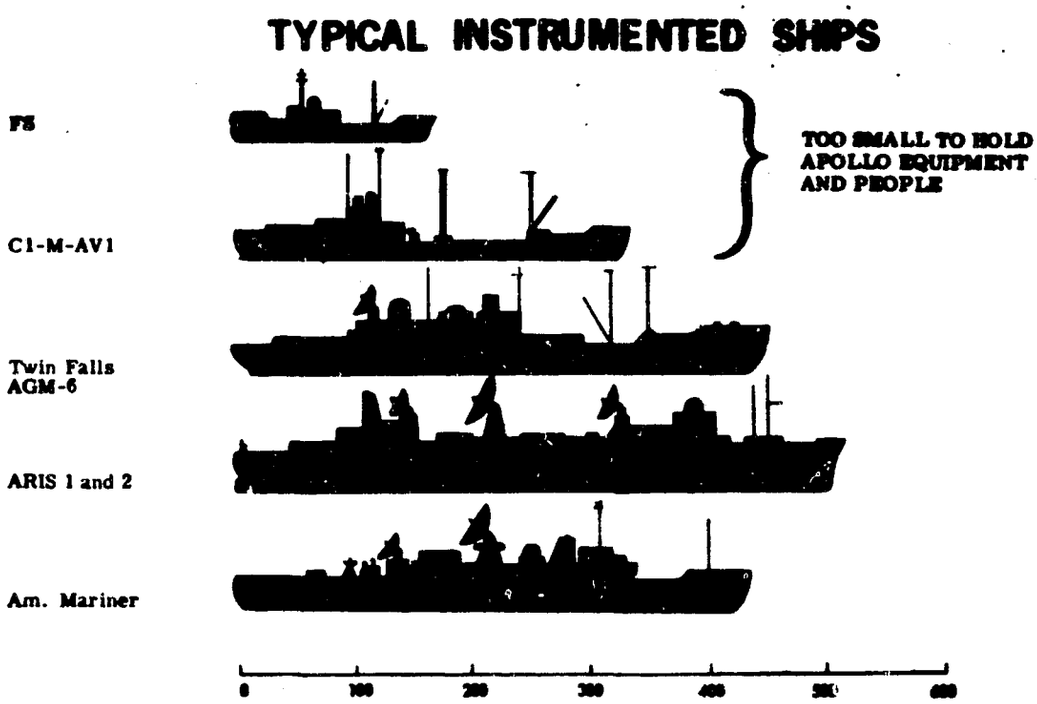
The ships will be on-station 30 days per test, one test per quarter.

No reentry or recovery requirements are included.

The existing or planned instrumented ships of the National Ranges were examined to determine those with potential ability to support the Apollo program; i.e., are large enough to hold the necessary equipment and people, have existing or planned equipment which can be made compatible with the Apollo needs, and which will be operated in the general ocean areas of Apollo support ships.

Because of the number and size of antennas, the amount of below deck equipment and the number of people needed, ships smaller than *Victory* class are not suitable.

The *Twin Falls Victory*, the AGM–6, ARIS 1, ARIS 2 and *American Mariner* (Damp ship) are typical of those ships with Apollo potential. Nine general purpose instrumentation ships with much existing or planned equipment have Apollo support potential. These are listed on the following page.



DOD General Purpose Range Ships With Apollo Potential

USNS *Range Tracker* (T–AGM–1)
USNS *Richfield* (T–AGM–4)
USNS *Watertown* (T–AGM–6)
USNS *Huntsville* (T–AGM–7)
Under conversion (AGM–8)
USAFS *Twin Falls Victory*
USAFS *General H. H. Arnold* (ARIS 1)
USAFS *General Vandenberg* (ARIS 2)
USAS *American Mariner*

These are the nine DOD general-purpose instrumentation ships with Apollo support potential. The first four are VC–2 hulls now in the Pacific Missile Range inventory. The T–AGM–8, a VC–2 now under conversion, should be operational by July 1964. In addition to being a general-purpose ship, it will be equipped for support of the X–20 program along with the T–AGM–4 and –6.

The USAFS *Twin Falls Victory* is a VC–2 hull. The USAFS *General H. H. Arnold* will be operational by June 1963, the *General Vandenberg* by July 1963. Both are C–4's.

The USAS *American Mariner*, a Liberty hull, will be assigned as an AFMTC resource in July 1963 and will be a general-purpose ship by fiscal year 1965.

In addition to instrumented ships for support of Apollo, the ranges are studying the use of JC–130A, JC–135, and WV–2 aircraft to provide telemetry, communications relay, search and recovery, data pickup and retransmission, and high-altitude photography for support of the program.

Ship comparison

Instrumentation	Apollo ship	General-purpose range ship	Instrumentation	Apollo ship	General-purpose range ship
C-band radar	X	X	Navigation/stabilization	X	X
X, L/UHF band radar		(X)	Data handling/computation	X	X
Unified SHF system		(X)	Meteorological	X	X
Unified S-band system	(X)		Recovery	X	X
Telemetry	X	X	Range user control consoles	X [1]	X [1]
Command control	X	X	Display and plotting boards	X	X
Timing	X	X			
Communications HF, VHF, UHF	X	X			

[1] Varies.

The Apollo ship configuration was compared to that of a DOD general-purpose ship. The main difference between them is due to program-peculiar instrumentation such as the unified S-band system and the need for more display equipment aboard the Apollo ship.

Some DOD ships are also instrumented with program-peculiar systems such as the unified SHF for X–20 and X, L/UHF-band radars for the ABRES program.

Most of the equipment aboard the ships is common usage. Program-peculiar equipment represents a relatively insignificant amount of the total ship configuration, as shown by (X) equipment on the chart. DOD proposes to add Apollo-peculiar instrumentation to existing general purpose ships, as for the X–20 and ABRES program, as the most efficient and economical means of doing the job.

OPERATIONS ANALYSIS COMPUTER MODEL

Workload factors

Random launch schedule.
Launch schedule slippage.
Launch delays for weather.
Launch to scrub ratio.
Reschedule time factor.
Average workload periods selected.

Ship support factors

One home port and one alternate per ship.
Actual sailing distances and speeds.
Optimum division of range by area.
Optimum selection of ships.
Special ships selected for certain tests.
Actual on-station times and positions.
Reprovisioning, refueling and drydock time.
30 days on-station for Apollo.
100 percent support for Apollo.

An operations analysis using a computer model has been performed to determine the ability to support the DOD/NASA ship workload. Using factors shown on the opposite page, the model is able to realistically account for all the significant variables in ship support for missile and space tests. First, workloads for typical periods are constructed using factors based on past experience extrapolated as necessary to future conditions. The ships are then selected and moved by the computer in a realistic manner to determine those tests which can be supported. By repeating this process many times and averaging the results the randomness is removed from the answer. Repeat runs permit the variability of ship support to be determined.

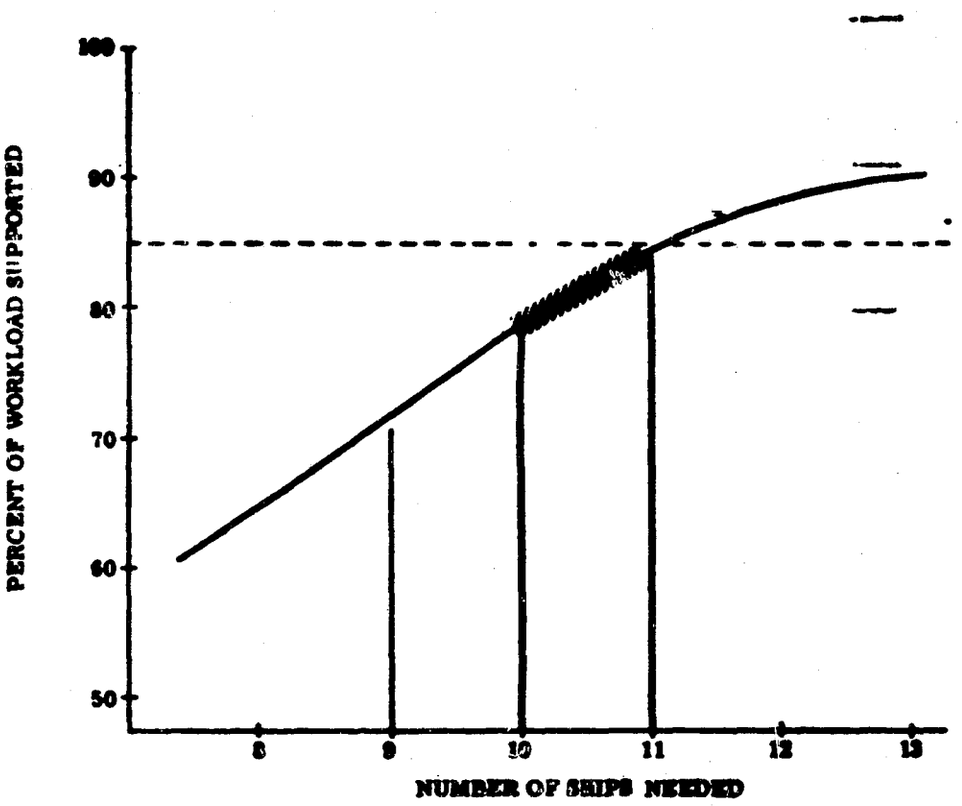
The analysis gives the percentage of the test workload which can be supported by any given number of ships.

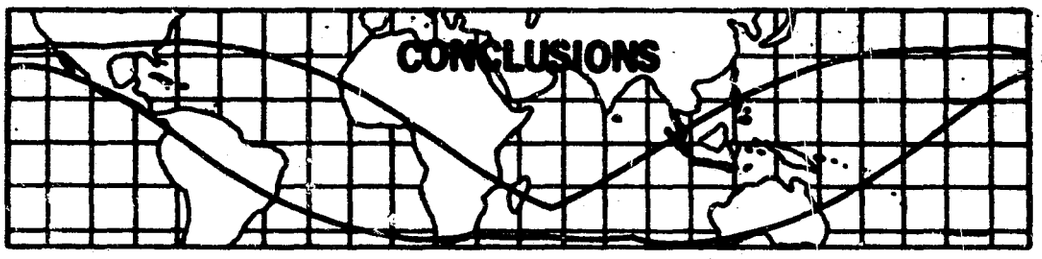
The result of the operations analysis of ship support for the total DOD/NASA workload, including 100 percent support for Apollo, is shown here.

Note that the curve flattens out toward the right side. A very large number of ships would be required to provide 100 percent support for firm programs. For this reason, plus the large cost of each additional ship and in light of range experience in rescheduling lower priority launches, a management decision was made to limit planned range support (except Apollo) to the 85-percent level.

Ten ships are needed to achieve the desired level of workload support without Apollo. The effect of guaranteeing 100 percent Apollo support with a 10-ship fleet is to reduce the capability of supporting the balance of the workload below the acceptable level of 85 percent. To once more reach this level, 1 additional ship is needed for a total of 11 ships.

In summary, the operations analysis has shown that one additional general purpose ship is needed to provide 100 percent support for Apollo and achieve the desired level of support for the balance of the workload.





1. To meet need for Apollo injection over either Atlantic or Pacific Oceans:

	Million
Modify 4 existing AMR/PMR ships	$30
Add 1 new C–2 general purpose ship	30
Total	60

2. To meet need for Apollo injection over Pacific Ocean only:

Modify 2 existing PMR ships	12
Add 1 new C–2 general purpose ship	30
Total	42

3. To meet need for Apollo injection over Atlantic Ocean only:

Modify 2 existing AMR ships	18
Add 1 new C–2 general purpose ship	30
Total	48

To support Apollo at the 100-percent level and the balance of the DOD/NASA workload at the acceptable level, one new C–2 general purpose ship capable of Apollo support is needed and four existing DOD general purpose ships must be modified with program-peculiar Apollo equipment.

The costs have been reached by using the NASA estimate of $30 million per ship and the NASA GSE of the unified S-band station and control and command consoles as specified in the 1 April 63 Apollo requirements.

The modification costs of existing AMR and PMR ships have been reached using established costing procedures.

COMPARISON OF DOD AND NASA SOLUTIONS

	Millions
NASA separately supports Apollo with 3 new ships	$90
DOD ships support complete DOD/NASA workload with Apollo	60

The DOD solution provides five ships configured to support Apollo. One of these will support the insertion into parking orbit between Bermuda and Antigua. Two will cover the Atlantic Ocean injection area and two will cover the Pacific Ocean injection area. (Injection area to be selected by NASA prior to each test.)

The DOD five general purpose ship solution offers the following advantages over the Apollo sole-use three-ship solution:

a. A comparison of the proposed DOD and NASA support concepts shows that the DOD solution is more economical and yet provides 100 percent, top-priority support for Apollo and maximum support of all other high priority U.S. missile and space missions.

b. No loss of ship time between tests by moving injection coverage ships from one ocean to the other (30 days per trip).

c. Provides NASA the option of two injection points per orbit.

d. Additional reliability by insuring that the bare minimum of ships will always be available.

e. Although not a part of this study, the ships would have possible use in future reentry and recovery requirements.

M. and O. costs represent several additional millions of dollars yearly if three new ships are used rather than modifying existing ships and adding only one more.

RECOMMENDATIONS

DOD can and should:

1. Support all NASA/DOD tests including Apollo using the National Range fleet.

2. Implement solution 1 shown in the conclusions.

3. Manage and operate the combined national fleet of range instrumentation ships.

(Whereupon, at 11:46 a.m., the subcommittee adjourned.)

1964 NASA AUTHORIZATION

THURSDAY, JUNE 6, 1963

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON APPLICATIONS AND
TRACKING AND DATA ACQUISITION,
Washington, D.C.

The subcommittee met at 10:30 a.m., in room 214–B, Longworth House Office Building, Hon. J. Edward Roush presiding.

Mr. ROUSH. The committee will be in order.

We are very pleased to have with us Dr. George L. Simpson, Jr., Assistant Administrator for Technology Utilization and Policy Planning of the National Aeronautics and Space Administration, this morning.

Dr. Simpson, in the course of discussion questions have arisen which we felt could best be answered if we called you back.

Dr. SIMPSON. Yes, sir.

Mr. ROUSH. I do hope we did not disturb your program too much, but we did feel that it was quite important that these questions be resolved.

Dr. SIMPSON. Yes, sir.

Mr. ROUSH. And that we be given as much information as possible, before we made our decision.

I observe that you have a statement which is not too long. Are you prepared to give this statement, or would you want this to be included in the record and then comment generally on it?

Dr. SIMPSON. Well, I think, since this is a general statement, and not too radically different from the earlier statement, that I would like to submit it for the record, and answer any questions.

Mr. ROUSH. All right.

If there is no objection on the part of the members of the committee, the statement, together with the attachments, will be included and made part of the record.

Is there any objection?

Would you care to make any general comments before the committee begins to question you?

Dr. SIMPSON. I believe I would like to make this comment:

This business of——

Mr. RUMSFELD. I have not had a chance to read this, and since it is not very long, I wonder if I could have an opportunity to do so.

Could we, perhaps, take a recess for about 5 minutes, so that we all have a chance to read it?

Mr. ROUSH. Well, yes, certainly.

Mr. DAVIS. I think that would be a good idea.

Mr. HECHLER. It might be just as expeditious for Dr. Simpson to read it, if that is agreeable.

Mr. ROUSH. Yes. All right. I had assumed that you had all read it.

Mr. DAVIS. I didn't have an opportunity to read it, either.

Dr. SIMPSON. I will be happy to read it.

Mr. ROUSH. You can go ahead, then, Dr. Simpson, and read it.

STATEMENT OF DR. GEORGE L. SIMPSON, JR., ASSISTANT ADMINISTRATOR FOR TECHNOLOGY UTILIZATION AND POLICY PLANNING, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Dr. SIMPSON. Mr. Chairman and members of the subcommittee, the functions of the National Aeronautics and Space Administration as contained in the Space Act, section 203(a)(3) "shall provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof."

Accomplishment of our national goals in space exploration will require and will result in accelerated progress in science and technology, will produce important innovations and inventions which can be widely used in nonspace applications and constitute a valuable national resource. The NASA regards, with a sense of deep responsibility, the importance of realizing the full industrial potential of the technological advances which are developed in terms of new products, processes and services as a contribution toward continuing national economic growth.

The technology utilization program has been established to accomplish this objective of insuring the fullest utilization of NASA sponsored scientific research and development for long-term national benefit. This program includes a team of technical specialists within headquarters who work in close cooperation with other groups having related interests both in headquarters and in all of our field centers. The technology utilization program, broadly speaking, covers the major program elements, identification and reporting of innovations, cataloging, evaluation, and dissemination and transfer of information.

The sources of information include: NASA in-house research and development projects, NASA-Contract Research and Development projects, and the invention disclosures of NASA employees and contractors.

A Technology Utilization Office has been established at each of our field installations to work with the installation technical project personnel and patent counsels. Organized activities to systematically search out and identify useful technological innovations have been established and this office is being assigned the responsibility for monitoring research contract requirements for reporting new technology.

The task of innovation, evaluation and appraisal for industrial potential is a difficult one, requiring a combination of talents of strong technical capability and knowledge of current industrial needs and requirements. This capability is difficult to find. One of the best sources, and I may say, not the only source since we are exploring others, but one of the best sources for this capability which has been enlisted is the industrial research institutes, such as A. O. Little, Inc.,

Southern Research Institute, Illinois Institute of Technology Research Institute, and Stanford Research Institute.

A number of this country's leading institutes are participating in this program. These organizations with a wide spectrum of capabilities help to ferret out potential industrial applications from the space program. They cover the regional industrial areas also.

Within headquarters the Office of Technology Utilization coordinates closely with the NASA Patent Counsel who provides advice and assistance on all patent and data-right matters and with the Procurement Office which insures effective and consistent administration of appropriate contract clauses.

And, if I may interpolate here, Mr. Chairman, since my last appearance before the subcommittee, we have brought in a gentleman from industry to work jointly with technology utilization and procurement on this problem of encouraging and getting reports from industrial contractors. This is a very difficult situation, and he is now in the process of establishing more vigorous programs in this area.

Publication and distribution of the technological information from the technology utilization program is handled through the Office of Scientific and Technical Information (OSTI) by procedures basically similar to those now used for technical information dissemination. In addition, OSTI provides its computer cataloging and retrieval services for technology utilization.

The technological utilization program is new and techniques and processes for the systematic transfer of technological information from the laboratory to industry are being developed.

In order to determine more effective techniques for retrieval, packaging and transfer of this information, NASA is supporting several studies to obtain a better understanding of these processes. Likewise, we are attempting to develop techniques and methodologies for measuring the effectiveness of the program, all intended to lead to more effective utilization of this rapidly increasing national resource of new technology.

Mr. Chairman, appended here are the data in answer to Mr. Boone's questions, I believe. The first item has to do with the budget and with personnel.

The second item is a breakdown of our research and development funds requested for 1964—that is, $3.5 million, and what we would propose to do with these funds.

Mr. ROUSH. Thank you, Dr. Simpson. Mr. Hechler, you have the floor, sir.

Mr. HECHLER. I have no questions at this time, Mr. Chairman.

Mr. ROUSH. Mr. Pelly?

Mr. PELLY. Yes, Mr. Chairman, I am going to show my ignorance here of this word on page 4.

On the fourth line you say: "In order to determine more effective techniques for retrieval."

Now, what is retrieval?

Mr. HECHLER. Just to retrieve, to capture, to identify.

M. PELLY. There is a question I would like to ask with respect to this interpretation of the Space Act, which calls for the widest practical and appropriate dissemination of information, concerning

the activities and results of NASA's work, and I wonder if this is not being pretty broadly interpreted.

I am thinking in terms of the various contracts that are contemplated under this budget, and the size and proportion of the personnel and dollars involved. I wonder whether you would like to comment on that?

Dr. SIMPSON. Yes, sir. I must agree that this is an interpretation of the Space Act. And I may say that I feel it is also an interpretation of another section which, in fact, says that NASA should attempt to develop the Nation's scientific resources, as well as transfer information. I believe that: (1) we are on reasonable grounds in talking about the sharing of information and applying the scientific and research data that we are gathering to the scientific strength of the Nation, and that (2) this requires some steps beyond simple "publication" to make the industrial people and others, acquainted with the results of this program.

I would say this, sir, that part of our approach to this is based on the fact that the Federal Government does now support a very large proportion of the Nation's research effort and that, to a certain extent, we feel that somewhere a really conscious and driving attempt must be made to see just how feasible it is, and the best way the transfer process can be established.

I think you know that there has been a lot of transfer in the past. There has been a good deal of disagreement on just how much and what type—and I am not now referring to the NASA effort alone, but I am talking about Government research and development efforts in general—but I do think that the country requires that a really conscious direct effort be made to see just how this can be done, because we know the decisions will have to flow from whether we can do it or not, effectively.

Mr. PELLY. I am under the impression, generally, that industry looks to scientific journals and publications of one area or another, in order to get its information and keep itself abreast of what is going on.

Certainly they have a great interest in anything that develops in the way of new techniques or technological information.

Dr. SIMPSON. Yes.

Mr. PELLY. On the other hand, I understand that the Navy which has a big research program, and the Air Force which has a huge research program, larger even than NASA's, does not have any means of utilizing industrial application to any of the developments in their research program, or the dissemination of information.

I have in mind, that maybe there should be one overall program, perhaps in the Department of Commerce, for the dissemination of information of all kinds, to business, and not to call on each agency and maybe overlap and duplicate along the lines in which we seem to be headed right now.

Dr. SIMPSON. I certainly see your point, Mr. Pelly, and certainly, in theory, would agree with it.

I would say this, however: As we look at this problem and learn more about it, it is increasingly clear that the transfer, at least a transfer that would be quicker than is ordinarily the case, and more effective, really takes place only when the industrial people at the work level, in the laboratory, address themselves to this problem and to the

particular problem involved in terms of profit and loss to their companies.

This means that we cannot do this job by just publications. It really means that we have to get the working people of the industries into a working relationship with NASA, or into the working organization of NASA, as the case may be.

I think that there is general agreement on this point.

We have consulted with industry through the directors of research and others, and it is our experience also. So what I am saying is that I think NASA is developing an approach which, if it is effective and pays its way, will then become the model for other Government departments.

At the same time, I may say that just as a practical working matter, to put this in an agency that does not have an operating relationship with research itself, will raise serious problems of effectiveness. And, to put it bluntly, it is awfully hard for the Department of Commerce, or NASA, or for any other department, to bring the industrial people into direct working relationship and contact with the people who are working on defense work, for example.

You can turn this around any way you want, but it is an inherent problem in the practical situation.

Mr. DAVIS. May I interrupt right on that point, and interpolate that there is a Government agency at this time which I believe is known as ASTIA, which has, I am sure, been mentioned from time to time in this committee, and I believe that it performs exactly the function that you have outlined, that you have in mind, Mr. Pelly, and that is to serve as a central clearinghouse for all technological development, and so on. I am afaraid I do not remember what the ASTIA stands for.

Mr. HECHLER. I think it stands for Armed Services Technical Information Agency.

Mr. DAVIS. Oh, yes. And I wonder if NASA is supposed to put its developmental research output into ASTIA?

I know it is supposed to be very comprehensive—you know what they are doing in that regard?

Dr. SIMPSON. You mean do they disseminate information?

Mr. DAVIS. Well, they do disseminate it, but I am not sure how widely it is disseminated.

Dr. SIMPSON. They do catalog.

Mr. DAVIS. I know they furnished this list; I think it is more like a bibliography.

Dr. SIMPSON. Yes.

Mr. DAVIS. Would there be some duplication in that work, do you think?

Dr. SIMPSON. As between us?

Mr. DAVIS. Yes, in dissemination and in any other respects, too, if you know?

Dr. SIMPSON. Well, the Office of Scientific and Technological Information, which is not the Office of Technology Utilization, is certainly retrieving, abstracting, and indexing. In NASA we take the information from all sources, all over the world, index it and put it into bibliographical form, and record it. This is comparable to the ASTIA.

You are right, there are many other Government agencies with this kind of service, and this matter has been before the Federal Council on Science and Technology.

Frankly, there is now an effort for substantially removing the overlap in the Government, perhaps even looking toward a central agency.

I think Senator Humphrey is interested in this particular matter.

However, this is the situation on this particular matter, and we are making an effort to see that we do not lose out with respect to giving information on the benefits of this research as quickly as possibly to those who can use it.

There is a broad NASA research effort which covers all fields, and which is advancing the state of the art almost daily. We have to go beyond that, and that is really the thesis or the rationale for the Office of Technology Utilization.

How do we go beyond that? We have set up some people in headquarters, and we have people in the centers making a search, and we are attempting to have the contractors report more often and more vigorously.

Once we get these reports they have to be evaluated to see what use can be made of them and where these uses might be: that if there is no use in one place, whether they could be used somewhere else. This is a major part of the effort, which we are doing partly in-house but we will also contract out.

Then there is the whole question of how do you attract the business and industrial people to these things, and a large part of our research and development money, the $3.5 million, is spent on these two activities.

Mr. PELLY. I would like to ask if you would repeat No. 1. I didn't get that.

Mr. RUMSFELD. Would you repeat it, please?

Dr. SIMPSON. I say the larger part of this $3.5 million, these items listed here on the last page, basically goes to the operation of evaluation of potential items and potential uses, and secondly, to developing ways and means of attracting the attention of industrial people, business and so on, to look in a rather closer and more realistic way at these things.

I think what, if I may say, is bothering you is the thing that bothered me when I first came into this work, and that is the question: "Why do people who are in business to make money need to have their attention attracted to something that might improve their competitive situation?"

Well sir, I don't know what the reasons for this are, but it is true that basically, people tend to change very slowly. There are some areas of the country which change very slowly, as some of you gentlemen will know. Even in some of the major areas, one of the controlling factors in research, in places like Detroit, Pittsburgh, the Midwest part of the country, in general, is that these people who come into us from these regions—well, frankly, it is a state of mind, and that has caused us to lose out.

The other fact is that we are trying to serve small business. As you know 200 or 300 of the larger companies do virtually—well, perhaps 75 percent of the total research in this country.

We must, I believe, make available to small business, the results of the Government's research and development effort. The man with the

small business, with maybe an engineer or a scientist working for him, turning out a relatively small contract for part of a project, whether he be in Kansas, or West Virginia, or Washington, is simply not in a position to watch the literature. This literature is mounting. We know that because we have gone to computers. When you are dealing with a question of relatively new work, as we are, there are many complications.

We put out two volumes this thick each month, with small type, abstracting and indexing reports from all over the world, on the space area.

Now, there is no way in the world, frankly, that a small businessman, or a man with a small outfit, making a small electronic part, or something of that nature, really could keep up with the literature. It would cost him the time of a good technical man, full time, and that is $20,000 to $25,000 a year.

Mr. PELLY. I am curious about one thing, and I would like to ask you a question.

I attended an industrial applications congress at the University of Washington during the Easter recess of Congress, which brought businessmen and researchers together. I think, perhaps, you know about it.

Dr. SIMPSON. Yes, sir.

Mr. PELLY. Now, is that the type of endeavor that you have in mind, in this budget?

Dr. SIMPSON. Yes, sir.

I don't know exactly where all these funds for this come from. Some NASA funds will go to this kind of thing. But what we are trying to do is to get the university to become directly involved in these matters. We are trying to really encourage and strengthen business and industrial people, to go to the universities and work on these problems. If I may say what our hope will be, it is that in every major area, or region, there would be a continuing group, a continuing mechanism, not only in connection with the NASA effort, but all Government research and development efforts. That is why I say that you can't look at this from the point of view of a publication basis alone, in our opinion.

Mr. PELLY. Well, I would assume that that is the type of endeavor that you have in mind?

Dr. SIMPSON. Oh, yes.

Mr. PELLY. But certainly NASA personnel must go over the country, but I don't see anything in here that would cover that kind of expense, and I wondered where actually these funds are going to be provided, and whether this is the true cost, or whether it is not covered up by a lot of other items?

Dr. SIMPSON. Well, I can say this: I didn't go, but I think Colonel Young was there, and Mr. Rosenberg.

Mr. PELLY. Yes. It was quite well attended. And, from what I gathered, there was a lot of interest on the part of the representatives of industry who met with the scientists in finding out whether there was something that they could take advantage of.

Dr. SIMPSON. Yes, sir.

Mr. PELLY. I am afraid I have taken up too much of what is really a very short time, and I am sorry, Mr. Chairman. I yield.

Mr. DAVIS. Mr. Chairman, by coincidence, it happens that I received a letter yesterday from the chairman of the board of regents of the University Systems of Georgia, stating that they had been to see Mr. Webb, representing the University Systems of Georgia, and had discussed the possibility of having a conference with appropriate officials looking toward the industrial development of the area from which I come.

Now, I notice, as I look at this, and I may say that I saw it for the first time yesterday morning, and I had no idea that this particular item in the budget would be coming up at this same time, but I do have certain questions that I would like to ask you.

In that particular letter, I gather that the board of regents had invited some members of NASA to just come to Georgia to confer with them, and with others, but nowhere would there be any expense to the Government.

Dr. SIMPSON. Yes, sir——

Mr. DAVIS. The entire expense was to be borne by the State of Georgia.

Dr. SIMPSON. No, sir——

Mr. DAVIS. Therefore, I was wondering, are any of these funds set up for such things as going out and conferring with people, are all of these funds set up for such things as studies, or perhaps engaging in a contract leading to competitive bid surveys, or things of that kind?

Dr. SIMPSON. Yes, sir. All of the $3.5 million is spent out of house.

Mr. DAVIS. Out of house?

Dr. SIMPSON. Yes, sir.

Mr. DAVIS. None of that is for transportation of personnel, to confer with people, or anything like that?

Dr. SIMPSON. No, sir.

It would go out on contract, or grant. There would be certain travel in connection with the work being done by these people to whom we contract, or who are taking the grants but this would not be NASA travel funds. NASA travel funds are accounted for on another basis, and I am sure that these are kept separate in the agency, entirely—always. I think that these travel funds are in perhaps the operation of installations, but I would not want to commit myself on the record at this time.

Mr. DAVIS. I have noticed that there is one item on the second page, the middle of the page—the last item: "Innovation, identification, and dissemination activities," which is, among other things, for conferences, exhibits, and seminars?

Dr. SIMPSON. Yes.

Mr. DAVIS. Well, is that a travel expense?

Dr. SIMPSON. Yes—other than travel for NASA personnel. It might, on certain occasions, involve travel of participants outside of NASA, or something of this nature.

Mr. DAVIS. I see.

Dr. SIMPSON. But it may very well end up as a contract for someone to build an exhibit for us, and that would mean that they would charge the travel expenses against it. But this would not include any NASA personnel travel expenses.

Mr. DAVIS. I understood you to say, however, that all of this $3.5 million was to be spent out of house?

Dr. SIMPSON. Yes.

Mr. DAVIS. All of it?

Dr. SIMPSON. Yes.

Mr. DAVIS. And would all of it, you say, be spent by contract, or would some of it be set up for a certain study that you might want made?

Dr. SIMPSON. A grant, an unsolicited grant.

Mr. DAVIS. Well, I suppose that is what it would be.

Dr. SIMPSON. An unsolicited proposal for which you might make a grant.

Mr. DAVIS. That is what I had in mind, anyway.

How much of that would be for such things as unsolicited grants?

Dr. SIMPSON. Well, I would say the bulk of this, as it now stands, would go out on a contract basis—the larger part of it.

Mr. DAVIS. Something over 50 percent?

Dr. SIMPSON. Yes, sir. I would say certainly nearer 75 percent, or even more.

NASA, as you know, does make grants through other offices, and they have an office to take care of this called the Office of Grants and Research Contracts—but these are large grants which are made to universities, essentially.

Now, if we wanted to accomplish a particular job with a university, we could use some of those funds on a grant basis through the proper channels, and those funds would be contracted out in that connection.

Mr. DAVIS. Would you give us a word or two on your background, Dr. Simpson? Have you had any experience in fields such as this?

Dr. SIMPSON. Well, sir, I will leave that to you. I guess my background is as a sociologist, trained at the University of North Carolina, in regional studies and development. I spent 2 years in South Carolina studying the history of the Coker family—you may know of the Coker 100.

Mr. DAVIS. Yes, I have heard of it.

Dr. SIMPSON. Wherein I first learned of the overwhelming influence of science coming into an undeveloped place and the opportunities for science to work in a variety of ways. But I won't elaborate on that now.

I then went back to the university in Chapel Hill, in 1950, where I was teaching.

Then in the middle of the fifties, Governor Hodges, and the business and industrial people of the State, asked me to take leave to become executive director of what was then known as the Research Triangle undertaking. This was an effort to build around the university in Chapel Hill, Duke University, and the State college, a concentration of the outgrowth of science of all types, industrial and governmental and so on, and quite similar to what is now going on in Pittsburgh and in Oakland, Calif.

I expect that will happen in Georgia, too.

Well, we had some success with this. I spent about 2 years, full time, and another year or 2 years, part time. I think it was on this basis, because so much of this work seems to develop into this kind of pattern rather than from a purely technical point of view, that Mr. Webb asked me to take this program over.

Mr. HECHLER. Mr. Chairman, if the gentlemen of the subcommittee would allow me, I would like to comment on Dr. Simpson's remark—"We had some success"—I believe that is somewhat of an understatement, because the program under Governor Hodges in North Carolina, was tremendously successful.

I would just like to underline the role which Dr. Simpson played in developing the program of research in the Research Triangle under Governor Hodges.

Mr. DAVIS. Now, I would like to ask another question, or two on this philosophy of the particular program that you have.

Dr. SIMPSON. Yes, sir.

Mr. DAVIS. What is your view as to the mission of your program, with reference to the geographical areas of the United States?

Do you conceive that it is your function to, for example, prevent an exodus of personnel from one area to another, or to hold men where they are? What is your philosophy in that connection?

Dr. SIMPSON. Our philosophy is that we want to give the fullest opportunity to every region in the country, insofar as it is consistent with NASA's program and resources, to help itself and to gain the benefits of world science and technology.

We cannot, I think, properly say that we want to keep people in one place or take them to another, but I think we properly can, and we do, want to respond to the interests of local people and the requests of people from all regions.

I would have no hesitation in saying that I think it is proper that we do not go out and beat up trade in the regions that are "have not" in this area, but we do encourage people from the "have not" areas—technologically and scientifically. I may say that this today is not only in the South, or in parts of the West, but it is also in the industrial Midwest to a very considerable degree, and we are working as much there as we are anywhere else. We cannot discriminate as we do want to give every region its fullest possible cooperation.

Mr. DAVIS. Well then, I would like to ask if you regard it as being your function, not to take the initiative, but to respond with such help as you may be called upon to give.

Dr. SIMPSON. Yes.

Mr. DAVIS. In the way of information and techniques that may have been developed by NASA—is that correct?

Dr. SIMPSON. Yes, sir; that is true.

I think that I would want to be entirely candid with the subcommittee and say that while we do not take the initiative in the sense that we go out and pull people in, we do state the case as to why we think regions should interest themselves in these matters, positively, on every occasion.

Mr. DAVIS. Of course, you don't run up against any dearth of interest in any area in respect to self-improvement, I don't suppose.

Dr. SIMPSON. No, sir, our problem comes, quite frankly, back to what we were discussing previously. We are doing certain things around the country, such as with Indiana University and the Midwest Research Institute. We would hope to get started under appropriate circumstances and in seeing this down the road far enough to where the local interests can take this thing up on a substantial basis for the long run.

This is our real problem, frankly.

Mr. DAVIS. How much money was spent in this program, Doctor, or will be spent during the current fiscal year. I know that carries it a little further down the road than we are at this point.

Dr. SIMPSON. Well the total here sir, is $3,760,000 of which 2——

Mr DAVIS. I didn't follow. I thought there were three columns of figures there.

Dr. SIMPSON. Oh, I am sorry sir. They are the years 1962, 1963, and 1964.

Mr. DAVIS. 1962, 1963, and 1964?

Dr. SIMPSON. Yes.

In effect, what we are asking in terms of research and development funds is for a little more than a million dollars, additional, in 1964, and the other increases come with reference to personnel and operations.

Mr. DAVIS. In these previous 2 years were these budgeted items?

Dr. SIMPSON. I am sure they were, sir—I wasn't here, so I can't be entirely certain.

Mr. DAVIS. Have any of the gentlemen with you any idea as to that?

Dr. SIMPSON. I believe they were included under the program funds; yes, sir.

Mr. DAVIS. The reason I am asking you this is that NASA has the capability of reprograming funds and I just wondered if these were budgeted items.

Dr. SIMPSON. It may be, sir. In the last year these funds were in the Authorization of Office of Applications which included meteorological satellites and communications satellites. This function, just in the last 2 or 3 months, actually has been moved from that office.

Mr. DAVIS. Well, it is entirely possible for the record, then, that one could say that they were included in other programs—they were a category of other programs?

Dr. SIMPSON. Let me just confirm this, if I may.

Mr. DAVIS. Oh, yes: certainly.

I just wanted to know if you could indicate if this was a cost included as part of the other programs.

Mr. TEPLITZ. My name is Jerome E. Teplitz, Office of Technology Utilization, NASA, and I believe that these were identified separately.

Mr. DAVIS. It doesn't refer to a program you see—it doesn't show that.

Mr. TEPLITZ. Yes.

Mr. DAVIS. In 1962.

Mr. TEPLITZ. Yes.

Mr. DAVIS. Would you repeat that answer, please. You say it was——

Mr. TEPLITZ. Well, these funds were included within those applications. It covered the communication satellites and meteorological satellites programs which included "Industrial applications."

(The information requested is as follows:)

This subject was discussed in both Senate and House 1963 NASA authorization hearings.

Hearings before the Committtee on Aeronautical and Space Sciences, U.S. Senate, page 723.

Hearing before the Subcommittee on Applications and Tracking and Data Acquisition of the Committee on Science and Astronautics, U.S. House of Representatives, pages 2086, 2087.

Mr. DAVIS. Well, was that thought of as a program at that time?

Dr. SIMPSON. It was part of the Office of Applications. The program was part of an office called Office of Applications and it was a part of that Office.

Mr. TEPLITZ. It was organized as a separate part of the Office of Applications.

Mr. DAVIS. And you now think of it as a program in and of itself, do you not?

Dr. SIMPSON. I don't believe so; not in the sense of the manned space flight of space sciences program, no sir.

We think of it as a program but not of that order of size or anything of that nature.

I must say, however, we think of it as an increasingly important part of the general context of things.

Mr. DAVIS. Now, referring to this first paragraph, and all the figures that you have furnished to us, would you give us a brief summary of the meaning of the three categories, "Technology utilization, direct research, and development costs," to begin with?

Dr. SIMPSON. Yes, sir. Well those refer to work we have done out of house and this is illustrated and indicated pretty well on the last page, I believe.

These are contracts and in some cases grants which we will execute to help identify potential applications or to help attract the interest of those people who may use them. That is what I referred to earlier and that is the first item there.

Mr. DAVIS. And what personnel costs are covered?

Dr. SIMPSON. These are costs of personnel involved in the NASA in-house effort.

Mr. DAVIS. You mean that is NASA personnel?

Dr. SIMPSON. Yes.

Mr. DAVIS. Part of installations, is that what you mean?

Dr. SIMPSON. Well really that is an accounting figure of the cost of the overhead that has been allocated.

Mr. DAVIS. Chargeable?

Dr. SIMPSON. Chargeable to this operation. Yes, sir.

Mr. DAVIS. As a matter of bookkeeping, you mean?

Dr. SIMPSON. Yes, sir.

Mr. DAVIS. Would any of the funds in this program go to pay the salaries of professors or anything like that in any of the universities?

Dr. SIMPSON. It could, yes, sir. We do have work at the universities.

Mr. DAVIS. Under what mechanism would that take place?

Dr. SIMPSON. Well, that would normally go as a grant to the university to carry on a given piece of work for us, and that would be administered in the normal way, under our grants to the university's administrative procedure, but the reports would come to us for review. In other words, we would be the reviewing office in NASA, and the office that would pass on the results.

Mr. DAVIS. You are aware that the National Science Foundation awards a number of fellowships, are you not?

Dr. SIMPSON. Yes, sir.

Mr. DAVIS. And has quite a number of studies done. Have you checked to see if there is any redundancy in the work that you are doing, and the work that they are doing?

Dr. SIMPSON. No, sir; I have not.

Mr. DAVIS. Don't you agree that it might be well to do that?

Dr. SIMPSON. Yes, sir; it would be.

Mr. DAVIS. I believe that is all, Mr. Chairman.

Mr. RUMSFELD. Dr. Simpson, I must confess that I am still quite confused about your terminology in NASA.

This section has been called "Industrial applications," during previous hearings, and today it is called "Technology utilization." What is the difference between the two, and which is above and which is below, or within?

Dr. SIMPSON. There is no difference, sir.

This change came about because of the movement of this office, or this function.

Mr. RUMSFELD. Which office, now?

Dr. SIMPSON. The old Industrial Applications Office.

Mr. RUMSFELD. So that no longer exists?

Dr. SIMPSON. That no longer exists. It was moved from the Office of Applications, which included the Meteorological Applications, as well. It was moved so that it is under my responsibility, and this was done at the time my title was changed. At that time my title was Assistant Administrator for Public Affairs, and it was desired to change my title in order to emphasize my responsibility for this area of work, and to emphasize my additional responsibility in some policy planning work.

I understand your confusion. It is not a substantive change at all. It was a change in the name, frankly, because we thought it sounded better, and because it covered a broader spectrum for industrial application.

Mr. RUMSFELD. Is it correct, then, to say that if the Office of Technology Utilization is taken as it stands today, you are within that office, involved with the old functions of the Industrial Applications section?

Dr. SIMPSON. Yes, sir.

Mr. RUMSFELD. Plus additional functions?

Dr. SIMPSON. Yes, sir.

Mr. RUMSFELD. What are the additional functions?

Dr. SIMPSON. Well, we are expanding the industrial applications program, both in terms of the programs that have been carried on with the research institutes, and the universities and we are also out to work more with the industries.

Mr. RUMSFELD. Well, my second question was:

What, in addition to the old function of the Industrial Applications section, and the Applications office, does your office now do?

Dr. SIMPSON. I see—all right, I am sorry.

I have that function which was formally under Public Affairs. This includes the public information; educational programs with the secondary schools; the Office of Scientific and Technological Information, which is the data search and retrieval function; and some general responsibilities as to policy matters in NASA. These are nontechnical in nature, as, for instance, manpower, and again, the question Mr. Davis raised, as to what would be our posture with reference to the regional development in the United States, and that sort of thing.

Mr. RUMSFELD. Is the funding requested on this sheet and titled "Technology utilization," the funding that is requested for all of your functions?

Dr. SIMPSON. No, sir.

Mr. RUMSFELD. It is not?

Dr. SIMPSON. This was given as the funding for the old Office of Industrial Applications.

Mr. RUMSFELD. I see.

Dr. SIMPSON. That is what this is.

That is the 1962 figure, and the figure for 1963 and the figure for 1964—well, we developed the 1964 figure last fall, before any of these changes were thought of.

Mr. RUMSFELD. I see. Is this funding then no longer realistic with a view to those changes that were not even thought of?

Dr. SIMPSON. No, sir; I don't think so. The only way that it is unrealistic is that the program itself was taken just about a year ago. We are learning as to the capability of these six institutes right now. We may decide that two of them can't do the job, so that it is unrealistic only in the sense that it is a new program, and we are learning as we go.

Therefore, I do not think, to answer your question, that it is unrealistic.

Mr. RUMSFELD. Therefore, if you were preparing your budget request this year, this would be roughly the same figure?

Dr. SIMPSON. Yes, sir.

Mr. RUMSFELD. Dr. Simpson, I would like to ask you this question as to what the present situation is: Mr. Davis asked you as to what was actually spent out of the 1963 fiscal year figures, or what you anticipate will be spent about the end of this month. I don't believe that you answered the question. I would like to know if you could now give me that figure?

Dr. SIMPSON. I don't——

Mr. RUMSFELD. I would like to know what is obligated, in other words.

Dr. SIMPSON. Yes, sir.

Mr. RUMSFELD. Or contracted for, out of the $3.7 million.

Dr. SIMPSON. I believe it is—I will get that for you. I know that there is something left. I know that we haven't overspent, but I can't give you the figure right now.

Mr. RUMSFELD. You say it would be out of the $2,370,000?

Dr. SIMPSON. Yes, sir.

Mr. RUMSFELD. In other words, your personnel costs and operation of installation are right up to the level you anticipated?

Dr. SIMPSON. I can't honestly say.

Mr. RUMSFELD. Or will be at the end of the year.

Dr. SIMPSON. No, I don't know whether this is the way it is actually accounted out, or will account out. This is the figure that came to you in the budget as our best estimate at that time.

Now, I don't know, and I can't say that this is actually coming out of this particular dollar, but this is the way it came to you. I don't see any reason to think it is going over this, but I don't know that it is going to come to that exact figure.

Mr. RUMSFELD. I see.

Mr. RYAN. Will the gentleman yield?

Mr. RUMSFELD. Yes, sir.

Mr. RYAN. Would one of these gentlemen who are with you be able to find that information out on the telephone, Dr. Simpson?

Dr. SIMPSON. We certainly could find it out on the $2,730,000 figure. I don't know about the personnel and operations, but I will try.

Mr. RYAN. The $2.73 million?

Dr. SIMPSON. Yes, sir; I will certainly have him try.

Mr. RYAN. Thank you.

Mr. RUMSFELD. As I read this budget and personnel page, it is going to take 112 people, employees, of the Federal Government, to contract out $3.5 million worth of studies to the research institutions?

Dr. SIMPSON. No, sir.

Mr. RUMSFELD. This is support personnel already involved in the program which you are presenting to us for the industrial applications?

Dr. SIMPSON. No, sir.

Mr. RUMSFELD. Well, let us clarify that so I will be correct.

Dr. SIMPSON. Yes, sir. The people involved here do much more than contract our research programs. Actually, the center people do very little, if any, of this. Their job at the center is to stay with the research program; that is to say, to go into the laboratories and sit in on the project review meetings, and, in any way they can, identify potential applications to civilian use, so that these people have very little, or nothing, to do with contract work. It is only at headquarters—almost entirely handled at headquarters.

Mr. RUMSFELD. Can you tell me why it takes 112 employees distributed 11 employees at Goddard to perform a function there, whereas it takes 2 or 4 or 1 or 3, at most of the other centers, and 13 at Marshall. What are the unique differences in the regional programs?

Dr. SIMPSON. Well, there are no differences, really, it is just the different speed with which these centers have moved. It has something to do with the quantity and type of program. Some centers have moved faster, and have been able to expand themselves, and to work faster.

Mr. RUMSFELD. I don't follow you. Do you anticipate by that last statement that it will be up around 11 or 12 at each of these places when they get caught up?

Dr. SIMPSON. No, I don't think it will be that. Some of these have shown some growth over the previous year, in any event, because at both Goddard and Marshall—Marshall, as you know, has some very large programs, with Saturn and other projects that they administer over there. Goddard has a wide variety of programs too.

However, I would not say that the quantity and the nature of their work is the only cause for the difference.

The fact is that, again, beginning about a year ago, we have been able to move faster, to do more in some places, than in others. This is the simple truth of the matter.

Mr. RUMSFELD. Well, what is it about these 112 employees that you have hired that leads you, as an official in charge of this program, to believe that they are competent to identify industrial applications?

I have in mind with the variety and the literally thousands of different industries, this would take a real giant of a man, would it not?

Dr. SIMPSON. Yes, sir. But I do not feel, and this is why we are moving out in new directions where we can, and I must come back to my earlier statement that the only really basic and sure way to do this is to bring the industrial research men directly into the problem.

I do not feel that either these people individually, or in a group. can do this thing entirely. But many of these people have a technical background, and many of them are from within NASA itself, and these are people who are taking these first steps. We must have people who can go into these centers and pull these things out.

Now, I agree with you, sir, that they are missing many things, and I know by the very nature of the case that they are pulling out things which may not have any application, but these are the people we have at this time. They are doing a good job, but they cannot do the full job.

We are moving right now toward getting particular industries to send their top people to the centers, and to look at these things directly, themselves.

This is the basic way in which this process is going to take place, in my opinion, but we have got to provide this information. We have got to get at it, and this is where you start from. This is where we can get information for people to evaluate and begin development work on.

Mr. RUMSFELD. Mr. Chairman, I have about five pages of questions, and I do not think it is fair to dominate this discussion right here. Why don't we proceed with some of the other gentlemen right now?

Mr. HECHLER. Would the gentleman yield?

Mr. RUMSFELD. Yes, sir.

Mr. HECHLER. For just one question. I notice that the average salary for these 112 people will be over $10,000, if we authorize $1,180,000 for personnel costs. Does this tie in with our discussion of getting men with high technical competence to perform these tasks; is that why the average salary will exceed $10,000 for these 112 people?

Dr. SIMPSON. Yes, sir. I would think so. It is difficult, very difficult, to get men so highly competent to leave their work on their own research and get into this kind of thing. It takes a man of special interest and special perception. It takes a man with patience to sit down and talk with people doing the work themselves. This is where it has to come from.

We emphasize in our work in the centers the attempt to elicit the interest, on a voluntary basis, in the work because they are the ones who are in it deep enough to see the new potentials.

Mr. ROUSH. Mr. Rumsfeld, we will come back to you for some more questions, but I think some of the other gentlemen have some points they would like to cover which may include some of your own, and it will give them an opportunity to participate.

Mr. RUMSFELD. There are just two things that I would like to request and one would be a statement describing the type of program or study that is requested under this $3.5 million for each of the contracts that are indicated on this sheet here.

That is to say, what is your goal for each one and what are you requesting it for?

Dr. SIMPSON. Yes, sir.

(Additional data subsequently submitted follows:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION,
OFFICE OF THE ADMINISTRATOR,
Washington, D.C., June 11, 1963.

HON. J. EDWARD ROUSH,
Subcommittee on Applications and Tracking and Data Acquisition, Committee on Science and Astronautics, House of Representatives, Washington, D.C.

DEAR MR. ROUSH: On Thursday, June 6, I appeared before the Subcommittee on Applications and Tracking and Data Acquisition to discuss the NASA program in technology utilization. With your permission, I would like in this letter to mention several points.

1. I wish to emphasize again that the essential purpose of the NASA technology utilization program is twofold:

(a) To identify those results of the NASA research and development effort that might have application in nonspace fields; and

(b) To find ways to attract the attention of potential nonspace users in the most effective and economical ways.

2. Such a program is justified on two grounds. First, the transfer of technology is not an automatic process. It proceeds at an uneven pace. In terms of the national welfare, if we can speed up the across-the-board transfer of the results of the space program to private use by even a few years, then the effort is worthwhile. If, in addition, decisive technological breakthroughs are achieved, then the effort is valuable out of all proportion to the money spent. Second, scientific and technological information is growing at such a pace that new measures to aid private concerns to acquire and apply it more quickly and effectively are indicated. This is especially true with respect to firms of middle and small size.

3. The focus of our technology utilization program is directly upon the new technology developed in the NASA effort. Our interest is in having this technology converted to economic use. We do not undertake to find the solution to large problems areas, such as transportation, or health, or water pollution. Rather, in these as in other areas, we simply attempt to transfer whatever is applicable from the space program.

4. We look upon the present program as essentially a pilot program, whose purpose is to indicate the value of a hard attempt at transferring Government research and development to other uses. If the program is successful, then its proper structure in the total Government may be determined on the basis of facts and experience. The advantage of this effort being positioned initially in NASA rests primarily on the fact that a more complete access to research and research people is achieved than would otherwise be the case.

It is my opinion, also, that if this program is successful, then private interests will come forward in a more vigorous way and will relieve the Government of much of the effort involved. As you know, we are taking steps to encourage the interest and active participation of business and industry. Within the limits of the Space Act, we are seeking every possible way through which business and industry can be encouraged to convert the results of the space effort quickly into economic use.

5. Our work with regional groups is based upon the fact that, in the long run, a local structure for scientific and technological advance seems necessary. Our efforts here are pilot approaches, transferable elsewhere, and based upon the premise that local interests must carry the main load. For instance, the Midwest Research Institute, which has worked in the Midwest, has gone to other regions and made its knowledge and experience available.

6. In the year's experimental program that has been conducted to date, more than 600 potential applications have been reported to headquarters. While perhaps only a small proportion of these will have direct transfer value, all must be evaluated, to some extent, and made available to the public. The number of potential applications will increase as our organization improves. It is clear that here is a national resource; and that we must find effective means of using this resource.

A copy of this letter is being sent to Mr. Boone and to all members of the subcommittee.

Sincerely yours,

GEORGE L. SIMPSON, JR.,
Assistant Administrator for Technology Utilization and Policy Planning.

DESCRIPTION OF PROPOSED EXPENDITURES IN DIRECT R. & D. FOR TECHNOLOGY UTILIZATION—TOTAL, $3,500,000

INNOVATION EVALUATION AND INDUSTRIAL APPRAISAL

Research institutes, $750,000.

At present the institutes are under contract with fiscal year 1963 funds as follows:

Armour Research Foundation	$46,241
Arthur D. Little, Inc.	49,650
Battelle Memorial Institute	36,280
Southern Research Institute	39,000
Southwest Research Institute	40,645
Stanford Research Institute	49,600
Total	262,000

The research institutes will appraise the industry potential of the innovation, indicate the industry requirements that it can fulfill, describe modifications that will be needed, recommend the dissemination media. The research institutes will also provide a complete industrially oriented technical description of the innovation and its relation to the state-of-the-art.

PILOT PROJECTS—INNOVATION EVALUATION AND AREA DISSEMINATION

Midwest Research Institute, $200,000.—Under an existing contract for $216,657, Midwest Research Institute has established a pilot program in a six-State region of the Midwest. This program is a pilot study to test and evaluate methods of identification and retrieval of innovations from NASA centers; to translate them into potential industrial applications and to disseminate them directly to industry in the six-State area it normally serves.

Indiana University Foundation, $150,000.—Under an existing contract, Indiana University is conducting a pilot program in cooperation with industry for investigating the most effective techniques for the quick transference of space technology to industrial requirements. This has resulted in the establishment of the Aerospace Research Applications Center (ARAC).

INNOVATION IDENTIFICATION AND DISSEMINATION ACTIVITIES

Jet Propulsion Laboratory support, $100,000.—The JPL activity is a contractor-managed Government-owned facility and therefore the technology utilization activities at the Center have to be separately supported. These include the identification and reporting of the research effort at JPL.

Industrial/technical documentation, $125,000.—Many potential transfer items will be of value only to the larger industrialists who maintain their own R. & D. complexes. So that a new technology can be applied or adapted to existing needs, careful documentation and expert editing will be required to translate the highly technical raw material into understandable industrial language.

We plan to prepare and publish a series of state-of-the-art summaries on certain specific areas of technology in which NASA is making a definite contribution. One under preparation now is on the subject of arc-jet technology, a cooperative effort between Ames Research Center, Lewis Research Center, Langley Research Center, and Marshall Space Flight Center. Other subjects will include antibacterial sterilization, noncommunication uses of the laser, etc.

NASA technology searches and reports, $250,000.—The transfers effected to date have been the more obvious ones. It is clear that more sophisticated studies and specialists will be required to uncover other useful work. Highly trained research teams, with a knowledge of current industrial needs and requirements, will visit NASA field centers to search out these developments which show promise of such adaptability. Such an effort is proposed in the areas of biological sensors, automobile safety, etc.

Technological adaptation and experimental development, $250,000.—In order to test certain areas for practical use, further developmental work may be required to provide engineering test data, for instance, on this basic research and to determine methods to improve industrial reception of the ideas and innovations thus developed.

Audiovisual productions, $75,000.—Short films, averaging about 5 minutes in length, are one of the best means of dissemination. Those innovations with the broadest potential will be publicized by this method. Two films have already been produced by Langley Research Center and some 10 to 15 are planned for distribution to business and industry. These films are also being disseminated to all NASA Centers, and have become an excellent communication channel between the technical staffs at the various Centers.

Exhibits, seminars, conferences, $100,000.—To enable all segments of the economy to benefit from the technology utilization program, we plan to participate actively in exhibits, seminars, and conferences. One example is the International Trade Fair, to be held in Chicago from June 19 to July 7. Seminars will be held with specialized groups of industrialists in all sections of the country to determine their particular needs and interests.

DYNAMICS OF THE TECHNOLOGICAL TRANSFER PROCESS

Dissemination and technology diffusion studies, $250,000.—How good is our dissemination system and how must it be improved so that the information generated reaches all segments of the industrial community? The information distribution media and their effectiveness will be studied and complementary techniques investigated. Of equal importance is a knowledge of what particular industries are doing with this data, how they are using it, and the problems they are encountering in getting this technology to the people who can make a decision on its ultimate application.

Motivation and incentive studies, $150,000.—Industry and Government face the common problem of motivating scientists engaged in basic research to think in terms of translating laboratory findings into production line applications. Here we plan to study the techniques of increasing their cooperation without interfering with their primary work. Since 90 percent of the NASA dollar is spent with contractors, motivation plans must also be devised for encouraging this group to cooperate fully in identifying inventions under NASA's reporting of new technology policy.

REGIONAL SOCIOECONOMIC ACTIVITIES

Washington University of St. Louis, $150,000.—This grant is designed to support studies of the effect of research and development upon regional economic change, with particular reference to the Midwest.

University of Chicago, $100,000.—This grant is in support of work at the University of Chicago on the problems of the administration of research, including factors affecting the introduction and development of technological change in industrial organizations, and the effect of science and technology upon public affairs.

Midwest Research Institutes, $150,000.—The purpose of this grant is to develop and apply a methodology for measuring both the short- and long-term effects of increased participation in space technology on the economy of six States and to analyze the technical capabilities of these States in order to determine the direction of future economic effort.

George Washington University, $150,000.—The purpose of this grant is to study the relationship between Government research and development and invention; and to study special features of the Government procurement market and the contract provisions relating to price and profit arrangements.

OFFICE OF TECHNOLOGY UTILIZATION

Proposed by 1964 budget distribution of $3,500,000 in direct R. & D.

Innovation evaluation and industrial appraisal: Research institutes (present, 6 institutes 262)	$750,000
Pilot projects—Innovation evaluation and area dissemination:	
Midwest Research Institute (present, 200,000)	200,000
Indiana University Foundation (present, 150,000)	150,000
Other	300,000
Total	650,000
Innovation identification and dissemination activities:	
JPL support (present, 67,000)	100,000
Industrial/technical documentation (present, 20,000)	125,000
NASA technology searches and reports	250,000
Technological adaptation and experimental development	250,000
Audiovisual productions	75,000
Exhibits, seminars, conferences	100,000
Total	900,000
Dynamics of the technological transfer process:	
Dissemination and technology diffusion studies	250,000
Motivation and incentive studies	150,000
Regional socioeconomic activities:	
Washington University of St. Louis	150,000
University of Chicago	100,000
Midwest Research Institute	150,000
George Washington University	150,000
Other	250,000
Total	1,200,000
Grand total	3,500,000

INFORMATION HANDLING PROCEDURES

The Office of Technology Utilization is concerned with identifying those new technological advances which can be used by a wide range of civilian industrial activities. These advances must be found from within NASA's research and development programs and made available to industry in a form suitable for industrial use. This process, as originally conceived and developed, has evolved along the following lines described in terms of a typical example.

IDENTIFICATION OF INNOVATION

This is recognition that a process, material, or a device is new and potentially useful in other than its space application. The field center Technology Utilization Office working with the NASA engineer identifies the innovation potentially useful and records the highlights of the innovation on a "flash sheet" as an initial reporting and internal working document (see attached). The field center patent counsel reviews the report for patentability, and the flash sheet is transmitted to the headquarters Office of Technology Utilization.

REVIEW AND EVALUATION

At headquarters the flash sheet is categorized generally by the technical staff specialists, for example, life sciences, electronics, etc., and initially judged as to potential value and interest to industry. At the same time the Office of Scientific and Technical Information reproduces the flash sheet and distributes it to interested NASA offices in headquarters, and to all field centers for intercenter information and coordination, so that all NASA centers learn promptly of these new ideas.

All flash sheets which are cleared from a "proprietary data" standpoint and those which show significant promise are sent to the research institutes and to Indiana University for further evaluation. The results of these reviews are then compared by the headquarters technical staff, and those innovations which show greatest promise are assigned specifically to one or two research institutes for further evaluation, preparation of documentation which is necessary to transmit a clear understanding of the innovation to a nonspace industrial user, and to determine industry reaction to the innovation.

DISSEMINATION AND TRANSFER

A most promising innovation will be published as an "application report" from the material prepared by the research institute, working jointly with the innovator at the NASA field center and the technical staff of the Office of Technology Utilization. Mechanics of publication will be handled by the Office of Scientific and Technical Information.

An innovation showing lesser promise will be published and disseminated by any of a wide variety of techniques. A group of related innovations may be packaged together and published as an "applications note." An example of this is "Selected Welding Techniques" which is the first formal publication of the Office of Technology Utilization. The attached "flash sheet" describing a weld fixture alinement tool is described on page 15 of the booklet "Selected Welding Techniques."

All these innovation reports will be rewritten in the form of "fact sheets" which present clear concise technical descriptions for use by the trade press and the public.

As stated previously, many other techniques for dissemination and assimilation of information are being tried. The Midwest Research Institute and Indiana University pilot projects attempt to work directly with industry to effect a direct transfer of this new technology. Technology utilization information is being made available to other Federal and State agencies interested in industrial development.

Mr. RUMSFELD. And the second is a statement describing the transfer of the information we are talking about—the type of information you refer to. I have listened with great interest to your statements here and I see different types of information. Now what kind of information are we talking about to be included within your program—I would like to know whether it is application or survey or technological or some other type, or just an idea.

Dr. SIMPSON. Yes, sir.

Mr. RUMSFELD. The second aspect of that is the type of action your office would take. I would really like that spelled out.

You have mentioned all through this "identification," "dissemination," "cataloging," and I would like to know which are going to be done under your office. So the type of information and the type of action would be of interest to me, Dr. Simpson.

Mr. ROUSH. We will give Dr. Simpson a chance to digest the information he is now receiving.

Dr. SIMPSON. Thank you, sir.

Mr. ROUSH. Following on this same line, this is in your area, Mr. Ryan, and perhaps you would like to ask some questions. You have the floor.

Mr. RYAN. Thank you, Mr. Chairman.

Dr. SIMPSON. May I now divulge this information?

Mr. ROUSH. Yes.

Dr. SIMPSON. We have now made total commitments of $2,065,000.

Mr. RYAN. For fiscal year 1963?

Dr. SIMPSON. Yes, sir.

Yes, and that has been made against the total of $2,370,000.

Mr. RYAN. Could you describe for the benefit of the committee exactly what kind of a regional setup you have. Have you divided the country into regions?

In terms of these contracts has NASA considered every State in the Union as part of a region or what?

Dr. SIMPSON. No, sir; we do not have a formal delineation of regions. We have responded to regional interests, in different ways, but we have not regionalized the country; we have not established this on that basis.

Perhaps it is a step that we ought to take—I don't know—but we have not done that.

Mr. RYAN. When you say you have responded to regional interests, what do you mean? For instance has a particular university come to you and asked you for a contract that you grant or have you stimulated the interest of a particular university in a contract in certain regions that you have selected because you think that they are underdeveloped technologically? What has been your rationale, in other words, for singling out a particular region?

Dr. SIMPSON. We have responded to local interests. For instance, I started out with Oakland, Calif. and, as you know, the University of California at Berkeley does a great deal of work for NASA—project work and direct mission work.

On that basis we have made a facility grant to the University of California at Berkeley together with some general support in space-related work.

Now then, out of that situation grew the interests of the Oakland community in that Bay area, on how Oakland could come into this matter of the NASA research and development effort and how it could be applied to the problem of the urban situation, the urban problems of Oakland.

Also, they considered how the city of Berkeley could begin to work more with the university, and how the university could begin to work more with the business and industrial people in the area. So we joined with the Ford Foundation and with the university in conference there at Oakland.

This conference was held in the spring and this whole business of technology utilization and how to transfer this information in the best possible way was discussed. We found that a number of the interests of the area, university, business, and industrial, said they wanted to go forward. They wanted to have a continuing committee to work on these problems of the transfer of research and development to other matters. We said: "All right; we are sympathetic—let us see what you propose and perhaps we can help in this way properly because of our interest and aims and those of the university."

This is one example.

Mr. RYAN. Now, wait—you have told us that you have had a conference and that you found a lot of interest on the part of the industrial and university people in the current year.

Dr. SIMPSON. Yes, sir.

Mr. RYAN. What have you committed in the way of money in terms of research grants to that area?

Dr. SIMPSON. Well, we have committed very substantial grants to the University of California, of course.

Mr. RYAN. As part of this program?

Dr. SIMPSON. No, sir—that has come out of another fund.

Mr. RYAN. Well that is what I am talking about—your program, now.

Dr. SIMPSON. Well we have not ourselves committed at this point any funds to this particular area in the way of a grant or contract.

We have spent some of the operating money that has been set up by some of our people and we have put in some funds that went to the analysis of the results of this conference but that did not come from our funds—that came from another account, didn't it?

Mr. TEPLITZ. Yes.

Dr. SIMPSON. So we have not done that ourselves.

We have not put any direct funds into Oakland although, as I say, on this matter of the transfer of technology, it is really perhaps the main core around which these efforts to develop can continue and we can say that it is proper and reasonable that we are attempting to do this. What we have attempted to do is to get their interest going and get them working on it—always to get the local groups to pick it up and carry it forward.

Mr. RYAN. I think to the extent that you can stimulate more local interest and encourage local industry to coordinate and utilize information of this kind that is very sound. That is one thing, but what I am trying to determine, and what I think this subcommittee is interested in now, is how the $2.6 million was spent last year and how you intend the $3.5 million to be spent this year?

To what extent have you set up any kind of regional basis for the allocation of this money and what are you doing in the various regions?

Dr. SIMPSON. Yes, sir—well, I think probably the best way to approach this is simply to say that, first, we have not established a hidebound set of regions. We are aware of different regional interests and are trying to stimulate them.

Secondly, I will take the Midwest Research Institute activity as one good example of what we are doing in the regional field. Over a year ago now we made a grant or contract with the Midwest Research Institute to help us identify items for transfer, to evaluate them, and then travel about the Midwest and to hold meetings with the business and industrial people of the area.

Now, this is clearly a regional program and a pilot program—not something that would not apply to any other region of the country, but something that would have general application.

Here again, we are seeking ways of identifying and evaluating these matters in terms of their transfer and ways of attracting the attention of the people.

Mr. RYAN. So then it was not your intention to limit the transfer of that information to the Midwest region.

Dr. SIMPSON. No, sir; no.

Here again, it was entirely a matter that we had to start somewhere. We had to see if this was a feasible program. In every case virtually we are trying to set models or pilot programs; we are doing something at the University of Indiana now, but we do not intend to in any way limit the information there to those few firms which are working with the University of Indiana.

Mr. RYAN. In other words, these contracts could be let in any part of the country to any institute?

Dr. SIMPSON. Yes, sir.

Mr. RYAN. As part of NASA research and development.

Dr. SIMPSON. Yes, sir; and are.

Mr. DAVIS. Would the gentleman yield?

Mr. RYAN. Yes.

Mr. DAVIS. It seems to me that perhaps the $3 million according to Dr. Simpson's statement may be the least important of the items here.

In other words, the matter of confining it—it is not a matter of confining it to any area but from your point of view, Dr. Simpson, it is simply an exercise in methodology or maybe helping somebody to take advantage of their own resources?

Dr. SIMPSON. Yes.

Mr. DAVIS. And is it not your position, in your view, as stated, that maybe a study carried out at MIT could help New Mexico more than it helps Massachusetts?

Dr. SIMPSON. Oh absolutely.

There are two dimensions—two "cuts" at this. There is the national cut which is to identify, say, a process of plastics that has been developed at NASA which is available to the plastic industry.

It would look as if all you would have to do would be to publish a piece of paper on this national aspect and then the trade magazines and journals would pick it up and that would be it.

Well, it just doesn't work out that way.

We are going to follow this from this national approach but it appears that we must also work on some kind of local level; to establish local or regional frameworks.

This is not merely with reference to the NASA program but we hope that this whole matter of research and development eventually, which takes place in every region, will spread to all Federal agencies.

For instance, 10 years ago the "haves" were in the Midwest but this is no longer the case. That situation has passed and what we are trying to do is lead the way and to help people lead the way in their own communities. These problems change, and have changed over the last 5 or 10 years with relation to specific regions and we expect that they will change again.

So, this is what we are trying to do really—we cannot, of course, change the situation on the national level. We are going to have to help these regions.

There are limits to our initiative, of course, in these matters. But take a State like North Carolina, for example, or Georgia, or even a metropolitan area like Pittsburgh or Detroit—when they come in to us, we say: "All right; we will do what we think is proper to help you develop a system for handling this matter of science and technology within the limits of the Space Act," because one of the major issues of this Space Act is this matter of industrial transfer.

So we are seeking means of doing this and we can take a general area on certain conditions and help them under certain specifications, but we cannot carry the load. Everything we do must be on the basis that they will pick it up and carry it forward.

As a matter of fact, I know that I am going to get a proposal today or tomorrow morning from Detroit with regard to the unemployment

situation there—this is from Wayne State University and we have a proposal from the University of Washington, that grew out of this meeting that you attended, Mr. Pelly.

There are no firm, hidebound, set rules or guides here. We are trying to help create something in the way of possible methods of meeting these problems. We are trying to find the right way and the best way to do it, so it is not something that NASA does, but it is simply something that we have to establish in the local framework.

Now, I think if I may, and I didn't mean to make a speech, sir, but this is what we are talking about, really: These regional areas of local effort. We are going to take the matter of industry itself, and I would like to emphasize again, that my experience, not only before I came here to Washington, but in my contacts with national industry since I have been here, indicates again and again that the matter of research in private industrial firms is a state of mind to a very substantial extent.

New things are not picked up immediately and automatically and there is no reason why they should be. There is an area of work that must be undertaken if this country is going to maintain its competitive stance in the world and we have got to look at it in terms of getting more out of the Government's research and development and getting it more quickly into the civilian economy.

This is the major thing. You see, we have to consider how we do this. We cannot give a contract to a private company to come in and see what NASA has got that they could use. That might be the most effective and direct way to do it, but you just can't do it that way.

Now, how can we get them to come in and look at these things? We work through these institutes, we are using these regional frameworks, both in this program and in our university program—we are encouraging universities to carry out programs and to take the initiative and look for ways themselves.

There is the problem, as the chairman knows, with respect to Pittsburgh, and I went up there about this. We had the same thing in Oakland, but in Pittsburgh there is a question of the University of Pittsburgh efforts in this regard. This won't come out of these funds, but there may very well be some funds that will go to the University of Pittsburgh.

In this case they want to use the documentation center there and take an inventory of the potential industrial uses for western Pennsylvania and put it on tape. They want to match it then with the kinds of things that we are learning in our NASA research and development efforts with respect to potential applications.

Now, we may or may not support this. It is still in the talking stage, but what I am trying to make clear at this time is that if we feel this is justified, one, that this is something needs doing and it is relevant to a particularly heavy unemployment area, or two, that we should work through them—and this is something that we really should and can do—then we will not undertake it on a continuing basis, but simply on a pilot basis.

This is to help them where we can and this is the way I think we almost have to approach this problem.

Mr. RYAN. It occurs to me that what you are attempting to do is undoubtedly in the overall national economic interest, but also that the

program has a much broader scope than that of NASA itself. Now, to what extent are you attempting to coordinate with the Commerce Department, and with the Labor Department on some of these functions which seem to me might well be carried out under these Departments?

There is the whole question of research and development and its application which is much broader than yours.

Dr. SIMPSON. Yes, sir.

Mr. RYAN. I mean, the specific research and development effort of NASA.

Dr. SIMPSON. Yes, sir.

Mr. RYAN. To what extent is the DOD research and development effort transferable to industry? To what extent is the effort being made to transfer such information and to what extent are your efforts being coordinated?

Dr. SIMPSON. Yes, sir.

Mr. RYAN. And the Department of Agriculture.

Dr. SIMPSON. Yes, sir; we do.

We are probably not doing enough of this kind of thing—coordination—but we do a lot of it, I am sure, in the technical information field itself.

We have not coordinated formally, although there has been a good deal of information talk, in our program at Pittsburgh or any of these other places, with the Department of Commerce, for example. That has been subject to coordination and I think we should do more. If I may, I will be perhaps a little bit indiscreet here but as I said earlier, in this we are working with essentially new ground and there is the question of ability to do these things—to get for instance the universities in the big cities to be interested in the city, economically, socially, and otherwise.

Then there is the ability to attract the attention of the industrial people which is frankly related to the drive and energy and to a certain extent the resources of your program.

I know I am telling my grandmother how to suck eggs here [laughter] about what it takes. However, we in NASA will certainly cooperate. As a matter of fact I am having dinner with Dr. Hollman and a group from the Department of Commerce this week, I think—but the fact is that, again, we are trying to move in the NASA research program further afield because it covers a wide range and because it is unclassified.

I think it is very proper for us, therefore, to move ahead and do some things on a kind of pilot study basis.

It is, of course, very difficult to go out to one of these places, even though they may have great needs and want help of all kinds. It is extremely difficult to call a meeting and say: "Here is some literature" and this kind of thing. I am speaking very frankly here, and I think that NASA is in really a very good position because of Jim Webb's interest and leadership and background in these matters. I think too—not to override the rest of the Government or anything of that nature, but simply to try to find ways and means without great cost to the Government—which is of vital importance and where there is a possibility of very great return.

Frankly, these questions are going to have to be solved if we are going to continue the Government efforts on a high level—this country is going to have to find ways to mine this great fund of information and to do it quickly and efficiently. I am not saying necessarily that NASA is going to be the chosen instrument but we do happen to be the organization right now with the research program and with the ability and the interest of the top management to go to our technical people and get them to cooperate and get them to work with industry, and with these other people.

I would certainly hesitate to throw that away before we have really tested it out. That is the situation.

Mr. RYAN. What relationship, if any, do you have with the Small Business Administration, relating to the interests of small business, and in what respects?

Dr. SIMPSON. We have been working very closely with Small Business, with Mr. Horne, and his group.

Mr. RYAN. Could you give us a concrete example of that?

Dr. SIMPSON. Well, I don't know of any particular place where there has been a financial transaction, but I know that we stay in close touch with them. I have talked to Mr. Horne and our people have, all along, so that I know they know what we are doing and what the potentials are, over there.

We don't get into the financing or the start of new business or anything like that, but in that particular case we have maintained very close liaison—I know that.

Mr. RYAN. Do you disseminate the patents which NASA takes title to?

Dr. SIMPSON. Under this, do you mean?

Mr. RYAN. Under your program.

Dr. SIMPSON. Under this program.

Mr. RYAN. When NASA takes title to patents—unless there is a waiver.

Dr. SIMPSON. Yes, sir.

Mr. RYAN. Do you disseminate that to industry?

Dr. SIMPSON. Yes. That would not be under this technology utilization program but it is disseminated otherwise. It would be disseminated but it would not come under this.

Mr. RYAN. Why would it not come under this?

Dr. SIMPSON. I think, frankly, it probably is something that we are moving on but we haven't been doing this as yet.

Mr. RYAN. Can you tell us what steps are going to be taken?

Dr. SIMPSON. Yes, sir. As I said——

Mr. RYAN. To do that?

Dr. SIMPSON. Yes. We have hired this gentleman to work with the contractors and we are making some changes in some of our organizational relationships, particularly in the Centers, and I am going to talk to the General Counsel about this matter.

I feel we need to.

Mr. RYAN. Do you agree with me that this is something that you could really examine, and that you could really perform a service by taking those patents to which NASA takes title and disseminating them widely and immediately to industry?

Dr. SIMPSON. Yes, sir.

Mr. RYAN. I am struck by your reluctance to get into this field.

Dr. SIMPSON. Oh no, sir. There is no reluctance.

I don't think—I don't know if we have done any of it, but I was struck myself about this not long ago, and I believe as a matter of fact——

Mr. TEPLITZ. We have already taken steps along these lines, sir.

Mr. RYAN. What have you done?

Mr. TEPLITZ. We are working with the General Counsel's office and they are making studies.

Mr. RYAN. Your General Counsel is opposed to the NASA patent policy so how is he going to be cooperative in this matter?

Mr. TEPLITZ. Whatever they have—what he is talking about.

Mr. RYAN. The patents NASA have title to—I want to know why they are not going out to industry.

Mr. O'BRIEN. I am Patent Counsel for NASA and we have, Mr. Ryan, been making all of our patents available to industry and to the public. There are lists that are published and made available to the Small Business Administration and they publish them, also. We put out lists of patents available for licensing in the Official Gazette of the U.S. Patent Office and all of our information is made available to the Office of Technology Utilization and they are published in our abstracts—so there are steps going forward along those lines, sir.

Dr. SIMPSON. If I may interpret your concern there Mr. Ryan, which is, Why does not the Office of Technology Utilization do more of this?

Mr. RYAN. Right.

Dr. SIMPSON. This is a question that I asked, myself, about a month ago, and it is a good question and it should have been done before but we are moving to do it now.

That is the situation.

That is the long and the short of it.

Mr. RYAN. I hope you will develop an affirmative plan.

Mr. WYDLER. These 112 people that you are suggesting for 1964, Dr. Simpson—how many of those are scientists or engineers?

Dr. SIMPSON. I don't know, sir. I think we have a problem here that I would like to clear up.

Mr. WYDLER. All right.

Dr. SIMPSON. I gave you these figures because they were the figures that were originally supplied to you. This 62 at NASA headquarters actually is a misleading figure because it includes support and if I may just take a minute, here, I would like to correct this.

The figures for the centers are people actually at work—I am sorry that this came in originally, and if I may, I think it would be helpful to you if I asked for some information here.

Mr. WYDLER. Certainly.

Dr. SIMPSON. If I may just consult with my colleagues.

Mr. WYDLER. Yes.

Dr. SIMPSON. I asked, for another purpose, on May 24, for a count of the people at that time on Technology Utilization, and we had then 10 in headquarters.

Mr. WYDLER. That is NASA headquarters?

Dr. SIMPSON. Yes, sir.

Mr. WYDLER. So that means instead of 39 this would now be 10?

Dr. SIMPSON. Yes, sir; and the other figures we had a total of 33 in the centers so that the total would come out at 43 as at May 24 of the people actually at work.

Mr. WYDLER. So that what you are suggesting is that the salaries will go from 10 to this figure, 62 in the next year?

Dr. SIMPSON. No. No, sir. I am not suggesting that. It is a much smaller figure. It is going to 20.

Mr. TEPLITZ. Twenty has been requested.

Dr. SIMPSON. To 20.

Mr. WYDLER. Instead of 62?

Dr. SIMPSON. Yes, sir. That 62 is an allocated support figure that came out of the budget originally and that is why I gave it to you—I am sorry.

Mr. WYDLER. What would the total figure be, then?

Dr. SIMPSON. Well the total figure would be 70.

Mr. RUMSFELD. May I comment very, very briefly on the actual number of personnel as opposed to the figures listed? At some point NASA is going to have to account for all the extra people through each separate department. It isn't going to be enough to say "Well, these are our allocated or budget figures, but we don't really have them. We only have 10 instead of 39." And so on, down the line.

As some point each department is going to have to say, "All right. This is what NAS Ais charging for this program, and this is a fact." It is just begging the question to talk about 10 instead of 39.

Dr. SIMPSON. Yes. I understand that. I am sorry I submitted it this way.

Mr. WYDLER. I would like to pursue this.

So that figure for 1964, instead of being 112, would be 70—is that correct?

Dr. SIMPSON. Yes, sir.

Mr. RYAN. What is this?

Mr. WYDLER. On the next to last page, the figure 112 total personnel request for 1964 is now 70.

Does that mean that the figure for personnel costs is thereby reduced?

Dr. SIMPSON. No, sir. I think the figure for the personnel costs would relate to the 62—to the total, as I understand it.

Mr. WYDLER. Well, now wait a minute. If you are going to reduce the total to 70 we have to reduce the total cost don't we?

Dr. SIMPSON. Well yes, sir—the total personnel costs would be reduced.

Mr. WYDLER. Do you know then, what that figure should be?

Dr. SIMPSON. No; I don't know what it should be, because I don't know the basis, entirely, on which the 62 were calculated, but I will get that for you.

Mr. WYDLER. Well, that is actually your request for 1964, is it not?

It is not the figure that you are talking about on this sheet—it is the figure that you are talking about now.

Dr. SIMPSON. Well, sir—the figure 62 is the one which the accounting people have submitted to the Congress as the proper figure, taking all the things into account.

I don't know that I understand every basis upon which this allocation was made, or that——

Mr. WYDLER. I don't know that I follow that.

Dr. SIMPSON. I would agree with it, but I mean, that is the figure, and I think it is proper for you to accept that.

Mr. WYDLER. Just a minute. You are not expecting me to authorize the same amount of money for personnel costs for 112 people as for 70 people, are you?

Dr. SIMPSON. Well, no—no, sir; not on that statement of it. My cost would be——

Mr. WYDLER. Well—all right, go ahead. I am sorry.

Dr. SIMPSON. If I may, I would say that this calculation on the basis of the 62 was not made in terms of full allocation of each one of these 62 people.

I certainly would not expect you to make the same amount of appropriation for 70 as you would for 112, but when I tell you that there are 70 people actually who would work at this full time, I am talking about just that and I am taking out the overhead and support people, so that we could reduce the personnel figure all right, if you like, and I can bring that down to a figure relative to the 70 persons.

Mr. WYDLER. Are the 70 all scientists and engineers?

Dr. SIMPSON. Yes, sir. There may be a few exceptions but essentially this is what they are. I mean, there may be clerical help.

Mr. WYDLER. All right. Then you were talking about this conference in your testimony and I gathered that you discussed urban problems.

Dr. SIMPSON. Yes, sir.

Mr. WYDLER. What does this mean—what urban problems were discussed?

Dr. SIMPSON. They discussed problems of transportation and water pollution, atmospheric pollution and this kind of thing.

Mr. WYDLER. Well what does NASA have to do with that?

Dr. SIMPSON. Well we, the NASA effort, may very well aid in the solution of some or all of these problems—research—in medical research, and similar things.

We have already learned that a filter may very well be effective or very useful in taking detergents out of the water supply and things of this kind.

Mr. WYDLER. But we do have all these departments and agencies on this type of work today and I am asking what NASA's program for industrial application or technology utilization would have to do with water pollution?

Dr. SIMPSON. Well, this is one of the results of our research and development effort that may have application and if it did, it would be extremely important.

Mr. ROUSH. Would the gentleman yield?

Mr. WYDLER. Surely.

Mr. ROUSH. Is it not true that your research in this area is aimed at specific problems?

Dr. SIMPSON. Yes, sir.

Mr. ROUSH. For example, do you not consider for one thing the astronaut's situation in his flights?

Dr. SIMPSON. Yes.

Mr. ROUSH. And in considering the astronaut in his flights we have to arrange for the disposition of human wastes—it can't just be thrown out.

Dr. SIMPSON. Right.

Mr. ROUSH. It has to be converted. So, in the process of your research in this area you have discovered certain systems and certain techniques which in turn might be conveyed to a city or a municipality and such technique might fit on an appropriate basis in handling this very serious problem of water pollution.

Dr. SIMPSON. Yes, sir.

Mr. ROUSH. Am I right in this assumption?

Dr. SIMPSON. Yes, sir; and the question of atmospheric pollution.

Mr. WYDLER. Well tell me: how does NASA's program relate to the question of transportation?

Dr. SIMPSON. Well this is primarily in the application of systems, and here again, this may not pan out, but NASA's ability to use systems, to use machines correctly, the Mercury network and this kind of thing, may very well have some application to the solution of metropolitan transportation problems.

There may be others.

Mr. RYAN. Would the gentleman yield?

Mr. WYDLER. Yes.

Mr. RYAN. I think we should nominate Dr. Simpson for an administrative post in the Department of Urban Affairs which is very necessary and which I have urged the Congress to enact rapidly. [Laughter.]

Mr. ROUSH. It is not a matter of NASA conducting research in the matter of transportation, is it, or in the matter of stream pollution or water pollution—it is a matter of these other interests in these areas possibly finding something that you have discovered in your effort in the course of the space program work and applying it to their own particular problems.

Dr. SIMPSON. Yes, sir; absolutely. We don't have any contracts or any grants relative to urban transportation of anything of that nature.

Mr. WYDLER. I happen to disagree on that. I was just about to ask you whether you were the person who had charge recently on behalf of NASA to award a grant for a transportation study in the United States. I think it was something around $80,000 to the United Research Corp., of Boston, Mass., and I was trying to find out what NASA really had to do with transportation problems of the United States and why it was granting money for that purpose.

That didn't come out of your department, however, did it?

Dr. SIMPSON. This, I am told, is not our project. This came out of the Office of Advanced Research and Technology and I will get you the answer on that if you would like.

Mr. WYDLER. Well I have been in contact with NASA about it already Dr. Simpson, but I mean, this is one of the things that I can't understand. It is a contract for research of the future of American transportation and to my mind this is just one more illustration of where we are going far afield from what we set out to do.

However, let me ask you this, Dr. Simpson: The developments in these fields are in some form or other NASA's version of a Depressed Areas Act?

Dr. SIMPSON. No, sir.

Mr. WYDLER. No; how does it differ?

Dr. SIMPSON. Well it differs technically in that we don't put any funds into a depressed area as such—we could not.

We don't do anything with reference to loaning money for the creation of jobs per se. The only thing we do, and our basic goal is to effect as quickly and as efficiently as possible the use of the research and development effort results and, secondly, to do this in a way that local interests can take up in a substantial way for the long run.

Mr. WYDLER. Well when you talk about these regions or areas you say that there is no definitive setup of regions or areas, but you always indicate that they are sort of informal regions or something of this type. What is the basis of these regions—what are these regions made up of?

Dr. SIMPSON. Well in the majority of cases I suppose we think of a metropolitan region, but we can think of the Midwest, to take an example, as a general region.

Mr. WYDLER. The Midwest would be one region?

Dr. SIMPSON. Yes, but let me say this, that you can think of Cleveland or Pittsburgh, or Chicago area as sub-metropolitan regions.

Mr. WYDLER. Or Detroit?

Dr. SIMPSON. Or Detroit.

Mr. WYDLER. I notice, in other words, and maybe it is just coincidental, that you seem to mention these regions as regions that are having a great deal of difficulty with unemployment problems.

Dr. SIMPSON. No; California, Oakland.

Mr. WYDLER. Well; that was the exception.

Dr. SIMPSON. We have a grant, not out of these funds, but we have a grant in which MIT undertakes to work on this problem, but from another source of funds.

Mr. ROUSH. Mr. Wydler, if you will pardon this interruption, we have Members who have to leave at this time and the House is now in session so we are going to have to interrupt this hearing.

I am wondering, Dr. Simpson, if you would be available next week?

Dr. SIMPSON. Yes, sir.

Mr. ROUSH. Possibly Tuesday?

Dr. SIMPSON. Yes, sir.

Mr. ROUSH. We have tried to arrange for this afternoon but it is again impossible for certain Members to be here.

We do want everyone to have the opportunity to speak to you about this, and our counsel will be contacting you.

Dr. SIMPSON. Yes, sir.

Mr. ROUSH. So, unless there is some disagreement on the part of Members, we will adjourn at this time and will meet again to conclude this discussion if necessary.

Thank you very much, Dr. Simpson and gentlemen. The committee stands adjourned.

(Whereupon, at 12:15 p.m., the subcommittee was adjourned.)

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